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Determinants for Order-Fulfilment Strategies in Engineer-to-Order Companies: Insights from the Machinery Industry

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Abstract

Recent empirical studies have refined our understanding of engineer-to-order (ETO) situations, supporting the existence of different order-fulfilment strategies based on the degree of customer involvement in the engineering and production activities, which differs depending on the strategic fit with the environment in which the company operates. Despite the importance of this finding, limited attempts have been made to comprehensively understand the determinants for this strategic choice in ETO companies. To overcome this gap, this study aimed to investigate the sources of differentiation between the environments that ETO companies can face and the ways of reacting to strategically fit the order-fulfilment strategy. Therefore, this research analysed the existing literature through a contingency theory lens and performed a multiple case-study research in a specific ETO sector, i.e. the machinery industry. The study identified five different order-fulfilment strategies implemented in the machinery industry to provide different product families to the market. For each strategy, the different environment characteristics were defined, and the performance outcome was measured, explaining the rationale for the positioning of the product families in different strategies. The findings of this study have two main contributions. First, the study contributes to theory by deepening and refining the analysis of contingencies for choosing different order-fulfilment strategies in the ETO context. Second, the study provides practical guidelines to ETO companies that want to adapt their order-fulfilment strategies to the unexpected or planned changes in their environment.

Keywords. Engineer-to-order, Machinery industry, Order-fulfilment strategy, Customer order decoupling point, Case-study research

1 Introduction

Order-fulfilment strategy is defined as the method by which a company responds to a customer order, i.e., the activities performed from sales inquiry to the delivery of the product (Kritchanchai and MacCarthy, 1999; Lambert and Cooper, 2000; Shapiro et al., 1992). Thus, choices with respect to strategy are related to the location of the customer order decoupling point (CODP), which separates the forecast-driven and order-driven activities (Hoekstra and Romme, 1992; Sharman, 1984; Wemmerlöv, 1984; Wortmann, 1983). Various possible order-fulfilment strategies can be identified based on the CODP location (Lampel and Mintzberg, 1996): from pure customised engineer-to-order (ETO) strategies, in which products are designed and produced according to customer specifications, to pure standardised make-to-stock (MTS) strategies, in which products are delivered from finished goods (Wortmann et al., 1997).

ETO companies can choose among different order-fulfilment strategies. Previous studies have suggested that ETO companies perform different activities after the customer places the order, e.g. modify existing designs or develop an entirely new one for every customer order (Gosling and Naim, 2009). Typically, ETO companies perform some engineering and manufacturing activities both before and after order arrival (Adrodegari et al., 2015). The traditional understanding of ETO situations, i.e., companies designing and producing each product from scratch following customer specifications (Caron and Fiore, 1995), has been recently refined for a more comprehensive understanding (Gosling et al., 2017; Willner et al., 2016). Different archetypes have been identified depending on the degree of design standardisation and the consequent amount of engineering and production work performed after the order is placed.

When considering order-fulfilment strategies in ETO companies, the traditional conceptualisation of CODP is problematic. Seminal CODP studies (Hoekstra and Romme, 1992; Sharman, 1984; Wortmann, 1983) considered engineering as a part of a linear sequence of activities that can be performed before or after CODP. However, to maintain their competitiveness, ETO companies perform different order-fulfilment strategies, thus facing the particular challenge of having to integrate and manage both order-driven and forecast-driven engineering and production activities (Cannas et al., 2019). Hence, following a two-dimensional approach for CODP positioning by defining both the amount of engineering and production work to be performed before and after order placement is a promising method (Dekkers, 2006; Wikner and Rudberg, 2005).

The choice of the order-fulfilment strategy represents a significant decision for ETO companies, given its serious implications for performance in terms of lead time, price, flexibility, and quality (Olhager, 2003). This is even more relevant in the recent competitive arena, where ETO companies claim to offer high product variety in a short time (André and Elgh, 2018; Cannas et al., 2018; Haug et al., 2009; Kristjansdottir et al., 2018; Sylla et al., 2018). High level of customisation can increase costs and lead times. Because ETO companies leverage on a range of different product customisation choices, some products are highly customised, while others can be more standardised (Hicks et al., 2000; McGovern et al., 1999). Furthermore, the implications for standardisation and efficiency in ETO companies of anticipating engineering activities have been underlined by very recent studies that analysed the application of lean, modularity, and product platform techniques in more detail (André and Elgh, 2018; Birkie and Trucco, 2016; Johansson and Elgh, 2019; Johnsen and Hvam, 2018).

Many complex engineering projects are plagued by delays and cost overruns (Flyvbjerg, 2014). Practical examples can be found in the media concerning construction, aerospace, capital goods, and shipbuilding industries; e.g., the project for the International Space Station was completed six years late and was 186% over-budget (Forbes, 2018); the Boeing 787 Dreamliner was billions of dollars over-budget and was three years behind schedule (Forbes, 2013). Despite the above, literature on providing adequate support to ETO companies for choosing the appropriate order-fulfilment strategy is limited (Sandrin et al., 2018).

The CODP positioning along the continuum of activities of the production process has been demonstrated to be contingent upon a set of external and internal factors: market, product, and production process characteristics (Van Donk, 2001). Research on the classification of ETO companies based on the extent to which they exploit existing designs or explore new knowledge demonstrates that the process depends on the environment that they have to adapt to (Cannas et al., 2019; Dekkers, 2006; Gosling et al., 2017; Semini et al., 2014; Wikner and Rudberg, 2005; Willner et al., 2016). These studies have made significant efforts to integrate engineering processes in the CODP concept by empirically analysing the application of this concept to complex ETO realities. However, none of these studies provides a comprehensive and specific framework related to the determinants for CODP positioning in both the engineering and production processes.

Consequently, providing practical guidelines to support ETO companies while choosing the appropriate order-fulfilment strategy is difficult. For example, should a producer of ETO products aim to develop a fulfilment strategy that delivers customised products reusing existing designs or should the producer create more standard offerings by pursuing modular principles? The response to this question could depend on the environment the ETO company operates in. The solution would help understand whether the current order-fulfilment strategy supports the achievement of the desired performance outcome (Haug et al., 2009; Kristianto et al., 2013; Schoenwitz et al., 2017).

Hence, in this study, the authors aim to understand the sources of differentiation between the environments that ETO companies can face and how ETO companies react to strategically fit the order-fulfilment strategy in the environment. Therefore, the study seeks to explore and explain this phenomenon by answering the following research questions:

RQ1. What are the determinants for the order-fulfilment strategy choices within ETO companies?

RQ2. How can ETO companies fit their order-fulfilment strategies to different environments?

To achieve this aim, the authors first reviewed previous literature related to CODP positioning through a contingency theory lens. Based on the literature review, the initial framework of the study was developed, and the current state-of-the-art method and research gaps were identified. Then, a multiple case-study research was conducted in a specific ETO sector, i.e. the machinery industry. The remainder of this paper is organised as follows. Section 2 presents the literature review, and Section 3 defines the research methodology. Section 4 and Section 5 present the results of the case studies. Section 6 discusses the results, and Section 7 provides the conclusion of the research, presenting the main implications and limitations of the study.

2 Literature review

2.1 Order-fulfilment strategies in ETO companies

The first studies related to CODP-based order-fulfilment strategies dated back to the 80s and the 90s (Hoekstra and Romme, 1992; Sharman, 1984; Wemmerlöv, 1984; Wortmann, 1983). In this period, the increasing demand for innovative products triggered the movement towards more customised manufacturing systems (Wortmann, 1992) and marked the beginning of a new industrial paradigm, i.e. mass customisation (Davis, 1989; Pine, 1993). Accordingly, a continuum of order-fulfilment strategies was demonstrated based on the point of customer involvement (Lampel and Mintzberg, 1996), i.e. the CODP location, from pure standardisation (i.e. MTS) to pure customisation (i.e. ETO), including segmented standardisation, i.e. delivery-to-order (DTO), customised standardisation, i.e. assembly-to-order (ATO), and tailored customisation, i.e. make-to-order (MTO). Since these seminal studies were conducted, CODP positioning was introduced as a strategic choice.

Further studies included engineering activities into the CODP framework. Among others, in their taxonomy of order-fulfilment strategies, Amaro et al. (1999) included the degree of design customisation, in line with the study of Mintzberg (1988), from “pure” (engineer completely new designs) to “tailored” (adapt existing designs), “standardised” (combine existing options), and “none” (take the design as it is). They stated that there are no reasons to assume a one-to-one correlation between the activities performed after the customer places the order and the degree of design customisation. Thus, they increased the number of order-fulfilment strategies according to the different potential combinations of these two dimensions. Similarly, four different ideal ETO types has been proposed by Hicks et al. (2001), which analysed the new phenomenon of more standardised modular designs.

These studies were considered to not be sufficient to cover the gap between theory and practice existing in the ETO literature. Indeed, Rahim and Baksh (2003), who analysed the differences between ETO and MTS, affirmed that the literature is too focused on MTS, whereas ETO requires ad-hoc frameworks that show a structured approach to manage both engineering and production processes and include the possibility of concurrency between the engineering and production activities.

To fulfil this gap, as underlined by Gosling and Naim (2009) and Dekkers et al. (2013), the two-dimensional (2D) CODP concept was introduced in the literature (Dekkers, 2006; Wikner and Rudberg, 2005), which extended the applicability of the CODP concept to a more comprehensive view. 2D-CODP defines a broader order-fulfilment strategy, where companies choose (i) the number of engineering activities to perform to order and (ii) the number of production activities to perform to order. Thus, it also decouples the engineering process and considers the possibility of hybrid and overlapping strategies, where engineering adaptations of existing designs are performed to order in concurrency with production activities.

Since the seminal studies on 2D-CODP, some studies have been conducted to classify the order-fulfilment strategies by empirically analysing ETO companies. Veldman and Alblas (2012) analysed different engineering fulfilment strategies employed by two ETO companies, based upon a specific technology, pre-defined sub-functions and solution principles, and pre-defined finished goods. Semini et al. (2014) empirically analysed different engineering customisation strategies in shipbuilding design: (i) customised design, where most of the engineering activities are performed to order and (ii) standardised design, where most of the engineering activities are performed to forecast, based on standardisation and modularisation. Additionally, different engineering standardisation and automation strategies were identified by Willner et al. (2016) based on the engineering complexity and the production volumes, and different products of seven companies were classified within them. The application of the decoupling concept to the engineering process was further developed by Gosling et al. (2017), who investigated eight cases in different ETO projects. They showed that engineering decoupling choices cover a continuum of nine potential strategies. Recently, based on a review of the literature, Cannas et al. (2019) categorised different order-fulfilment strategies in a structured 2D-CODP framework, which was validated through empirical insights of a multiple case-study research in the machinery industry. They showed that the focus of managerial approaches to manage and coordinate engineering and production processes, before and after the decoupling point, varies depending on the decoupling strategy chosen.

2.2 *Linking order-fulfilment strategies and performance outcomes*

The order-fulfilment strategy aims to satisfy customer expectations in terms of flexibility, time, price, and quality performance (Olhager, 2003). However, these different performance outcomes imply a trade-off: to achieve high flexibility, costs and lead times are increased, and vice versa (Barlow et al., 2003). Consequently, the literature suggests that an operation cannot excel simultaneously on all performance measures and a company must define which key performance indicators will be used for its success and focus on it (Chase et al., 2001). Therefore, the order-fulfilment strategy should be implemented against the criteria that are important to the customer (Hallgren and Olhager, 2006; Olhager, 2010).

In the traditional connotation, CODP positioning is considered to depend on the balance between (i) competitive pressure, which pushes companies through forward shifting to improve delivery and price performance, and (ii) product cost (inventory management cost) and design complexity (customisation options offered to the market), which push companies through backwards CODP shifts to increase the customer service level (Hoekstra and Romme, 1992; Olhager, 2003; Sharman, 1984). Literature suggests findings an optimal balance between performance and eliminate trade-offs by applying intermediate positions in the engineering and production CODP frameworks (Rudberg and Wikner, 2004). The aim is to be "lean" before the customer order, i.e. efficiency as the winning criterion, and "agile" after the order, i.e. effectiveness as the winning criterion, or the hybrid "leagile", i.e. both efficiency and effectiveness as the winning criteria, in case of intermediate CODP positioning choices (Aitken et al., 2002; Christopher and Towill, 2001; Mason-Jones et al., 2000; Naylor et al., 1999).

The recent literature demonstrates that this assumption can also be appropriate for the 2D-CODP perspective and requires further analysis (Wikner and Rudberg, 2005). Therefore, the following studies analysed this topic and demonstrated that design reutilisation and standardisation in engineering work, i.e. forward shifting of the engineering CODP, reduces design costs and the total lead time, whereas design customisation, i.e., backward shifting of the engineering CODP, increases the uniqueness and complexity of the design (i.e. innovativeness) as well as the lead times (Dekkers, 2006; Gosling et al., 2017). Recently, Cannas et al. (2019) empirically analysed the performance outcome of different order-fulfilment strategies in ETO companies, demonstrating that they have an impact on five performance aspects, including the traditional measures of time, price, and flexibility and the innovativeness of technology. They also included a new performance measure pertinent to the ETO sector, i.e., reliability, which refers to the extent of risk for early unexpected defects after sales. In particular, this study proves that, when the engineering and production activities are mostly performed after CODP, the performance outcome is the capability to always meet customer requirements for customisation and provide high technological innovation; vice versa, when the engineering and production activities are mostly performed before the CODP, competition is very high, and competitive prices are required along with short lead times and high reliability.

2.3 Aligning order-fulfilment strategy to environment

When choosing the order-fulfilment strategy, scholars agree that "one size does not fit all" (Jonsson and Rudberg, 2014; MacCarthy, 2013; Olhager, 2010; Schoenwitz et al., 2017; Van Donk and Van Doorne, 2016; Willner et al., 2016). According to the theory of manufacturing strategies, the company should always align the market, product, and process choices to achieve good business performance, consistently with the degree of product customisation (Sousa and da Silveira, 2018)

In literature regarding logistics and manufacturing, CODP positioning has been considered to be dependent on (i) the relationship between the production lead time (P) and the delivery lead time (D), i.e., P/D ratio; and (ii) a set of contextual factors characterising the external and internal environment where the company operates (Hill, 1993; Hoekstra and Romme, 1992; Olhager and Wikner, 2000; Van Donk, 2001). A conceptual model was developed in the literature (Hallgren and Olhager, 2006; Olhager, 2003) to define all factors affecting CODP positioning and explain the motivations for backward or forward shifting. The factors were assigned in three categories: market, product, and production-related factors. High demand volatility and low product volumes, as well as high product range and customisation requirements, are considered market characteristics that make it impossible to provide products on an MTS basis. The production lead time is affected by the product structure (such as modularity, material profile, and breadth and depth of the structure of the product) and the production process characteristics (such as the number of planning points, production process flexibility, and position of bottlenecks). This conceptual model represents an important basis to study the consequences of shifting the stock point through material flow (see for example: Hedenstierna and Ng, 2011; Liu et al., 2015; Sun et al., 2008).

In literature related to supply chain management, Fisher (1997) was the first to introduce a model to match supply, product, and demand and meet the needs of both the end consumers and the supply chains. In this study, the design of lean (i.e., physically efficient) or agile (market-responsive) supply chains was defined by matching with functional (i.e. predictable demand) and innovative (i.e. unpredictable demand) products, respectively. Following studies (Aitken et al., 2002; Christopher and Towill, 2001, 2002, 2000; Mason-Jones et al., 2000; Naylor et al., 1999) related the lean and agile supply chain concepts to the CODP framework, associating the two paradigms to different order-fulfilment strategies. The lean paradigm has been associated with supply activities performed before the CODP, whereas the agile paradigm refers to supply activities performed after the CODP. Accordingly, these works identified more than two distinguishing classes of supply chains and included the "leagile" concept, i.e. the possibility of combining the lean and agile paradigms when companies apply hybrid standardisation and customisation strategies, such as the ATO one. In this sense, a taxonomy for defining the optimal strategy was proposed by Cristopher et al. (2006). This study enriched the model previously proposed, analysing the supply chain design for global operations, and defined three key factors affecting the strategic fulfilment choice: (i) supply characteristics (short/long replenishment lead time); (ii) product characteristics (special/standard); and (iii) demand characteristics (predictable/unpredictable).

All these studies have contributed to support companies in facing the continuously changing market conditions and the increasing pressure on multiple competitive priorities. However, they present some limitations. The models proposed mainly focused on the production dimensions and material flow, being very general regarding engineering dimensions and design flow. In addition, they did not consider any interfaces between engineering and production and considered these processes to be sequential. Therefore, these studies cannot be considered suitable to reflect the complexity that the ETO reality entails, where the products include different degrees of standardised and customised bill of materials (BoMs) and engineering and production processes are strongly interconnected (Bozarth and Chapman, 1996; Giesberts and van der Tang, 1992; Hicks et al., 2000; Konijnendijk, 1993).

Some studies investigating the order-fulfilment strategies in ETO companies have suggested the possible environmental factors that may affect them. In particular, the environmental factors suggested to affect the order-fulfilment strategies in the context of ETO can be grouped into three categories: (i) market-, (ii) product-, and (iii) process-related factors (Hallgren and Olhager, 2006; Olhager, 2003). With respect to market-related factors, Schoenwitz et al. (2017) showed the importance of the alignment of customer preferences with product design and process configuration. Market-related factors refer to the average annual units sold, market growth, general market changes, and customer requirements (Willner et al., 2016). With respect to product-related factors, Semini et al. (2014) proposed product customisation/variety and modularity. Additionally, Willner et al. (2016) indicated that engineering complexity is a determinant of CODP positioning. With regards to process-related factors, with the addition of engineering dimensions, the P/D ratio has been demonstrated to be not sufficient anymore: the inclusion of the engineering lead time is required (Wikner and Rudberg, 2005). In this case, the literature suggested that the major factor affecting positioning is the relationship between the total lead time, which includes the engineering and production lead times, and the delivery lead time (Dekkers, 2006). In particular, Wikner and Rudberg (2005) considered the sum of engineering and production lead times as affected by a “delta value”: the value is null if they are sequential or negative if they overlap. Moreover, Gosling et al. (2017) claimed that the engineering decoupling choice is contingent upon the engineering process characteristics, i.e., the abilities and capabilities of the engineering resources with respect to knowledge.

2.4 Research gaps

In conclusion, the recent studies, and in particular, the most recent one by Cannas et al. (2019), can be considered very helpful to increase our understanding regarding engineering and production decoupling configurations in the ETO sector, as well as their performance outcomes. Cannas et al. (2019) considered all the previous literature to develop and empirically refine a 2D-CODP framework, which classifies the different order-fulfilment strategies employed by ETO companies. In addition, they categorised the performance outcomes of different 2D-CODP positioning choices. However, no attention was paid to the contextual factors influencing the choices of 2D-CODP positioning. In particular, this study, as well as the previous ones, did not consider the environment where the companies operate and the characteristics of their products and processes. Therefore, our research focusses on this specific gap, i.e. the determinants for order-fulfilment strategy choices. Regarding this issue, Table 1 summarises the different approaches found in the extant literature.

Table 1. Summary of the literature review on determinants for order fulfilment strategies

Literature stream	Key References	CODP positioning perspectives	Determinants for order fulfilment strategies: set of contextual factors characterising the external and internal environment where the company operates
Production literature	Hill, (1993); Hoekstra and Romme, (1992); Olhager and Wikner, (2000); Van Donk, (2001); Olhager (2003); Hallgren and Olhager, (2006)	The CODP positioning depends on a set of market, product and production characteristics that affect the relationship between the production lead time (P) and the delivery lead time (D), i.e., the P/D ratio.	*Market characteristics*: demand volatility (predictable vs unpredictable), product volumes (low vs high), product range (narrow vs wide) and customisation requirements (low vs high)
			Product characteristics: modular designs (not modular vs modular design), material profile (V, A, T or X), breadth and depth of the product structure (low vs high)
			Production characteristics: number of planning points (little vs great), production process flexibility (low vs high), position of bottlenecks (upstream vs downstream)
Supply chain management literature	Fisher, (1997); Naylor et al., (1999); Mason-Jones et al., (2000); Christopher and Towill, (2000, 2001, 2002); Aitken et al., (2002); Cristopher et al. (2006)	The CODP positioning depends on a set of supply, product and demand characteristics that affect the need for lean, agile or leagile supply chains.	*Demand characteristics*: demand volatility (predictable vs unpredictable)
			Product characteristics: product type (functional vs innovative)
			Supply characteristics: replenishment lead time (short vs long)
Engineer-to-order (ETO) literature	Wikner and Rudberg (2005); Dekkers (2006);	The CODP positioning depends on a set of market,	*Market characteristics*: average annual units sold (low vs high), market growth or generally market changes

	Semini et al. (2014); Willner et al. (2016); Schoenwitz et al. (2017); Gosling et al. (2017)	product and process characteristics that affect the relationship between the total lead time (engineering plus production lead times) and the delivery lead time.	*Product characteristics*: product customization (low vs high), product variety (low vs high), modularity (not modular vs modular design) and engineering complexity (low vs high)
			Process characteristics: abilities and capabilities of the engineering resources in relation to knowledge (low vs high)

The results show that while recent work is very helpful in increasing our understanding of order-fulfilment strategies in the ETO sector, a gap still exists between theory and practice when analysing engineering and production coordination to support ETO companies in adapting their order-fulfilment strategies to the market (Mello et al., 2017; Sandrin et al., 2018). As transpires from the review of the literature and the synthesis in Table 1, in the CODP positioning field, some limitations still need to be solved. The main focus of the recent studies has been on the customisation choices in the engineering process, with little attention being paid to the interactions with production. Consequently, the determinants for positioning were mainly related to product design and market characteristics, without deeply analysing process dimensions. This implies the need to consider the process characteristics, especially in terms of coordination, to understand which strategies suitable to specific situations and avoid late design changes and production rework (Mello et al., 2017, 2015a, 2015b).

None of the existing studies provided a comprehensive understanding of the contingencies driving 2D-CODP positioning, as previously performed in production-focused CODP literature. Consequently, there is no guidance for ETO companies to understand what order-fulfilment strategy should be implemented to suit different contextual factors. Therefore, a profound analysis of the market, product, and process characteristics is required. These characteristics, at the moment, represent a “black-box” for the ETO industry that requires to be opened to deeply understand the dynamics of 2D-CODP positioning. Consequently, our research aims at filling these gaps by integrating the literature that explores the ETO strategies with the ones related to the CODP concept, as suggested by Gosling and Naim (2009) and Dekkers et al. (2013). The goal is to build an initial framework of contingencies driving these applications and empirically explore it through research of multiple case studies.

3 Methodology

This study applies an abductive approach that combines both theoretical and empirical insights. The goal of the study is to refine the existing theory with new concepts by interpreting an individual phenomenon in a contextual framework, offering a new perspective (Kovács and Spens, 2005). Accordingly, the study follows a non-linear process: the results are obtained through a combination of literature and practice through back and forth exchanges (Dubois and Gadde, 2002). Therefore, the literature review performed has been combined with direct empirical observations through a case-study research, which is considered a good method to refine theory based on empirical evidence (Eisenhardt, 1989). According to suggestions of the recent literature on case-study research (Hancock and Algozzine, 2016; Voss et al., 2016; Yin, 2018), the study has been conducted following five steps: first, we defined what we wanted to study based on a literature review, i.e. the research framework and constructs (subsection 3.1); second, we defined how we wanted to study it, i.e. case-study design (subsection 3.2); third, we defined whom we wanted to study, i.e. case selection (subsection 3.3); fourth, we defined how to acquire the information, i.e. data collection (subsection 3.4); fifth, we defined how to analyse the information we acquired, i.e. the data analysis (subsection 3.5). Figure 1 summarises the steps followed in this study.

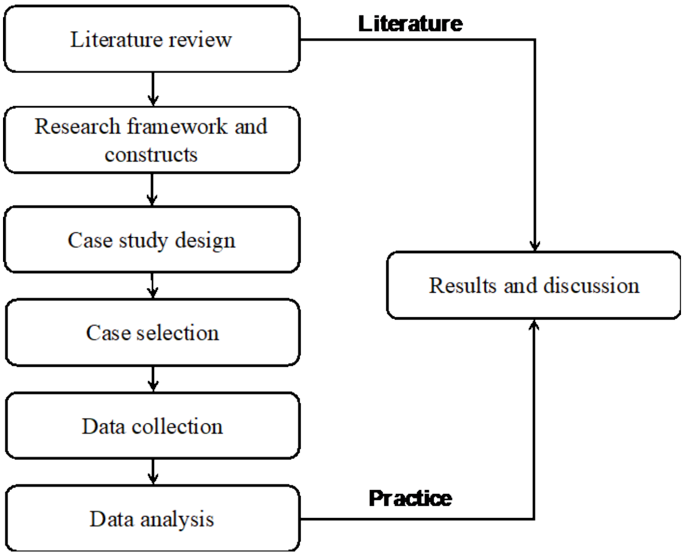

Figure 1. Summary of the research steps

3.1 Research framework and constructs

The first step in the case-study research consisted of defining a “road map” of the route that the study aimed to follow to aid the researchers in collecting answers to the research questions (Hancock and Algozzine, 2016). This was possible by developing an organised research framework, presented in Figure 2 and Table 2.

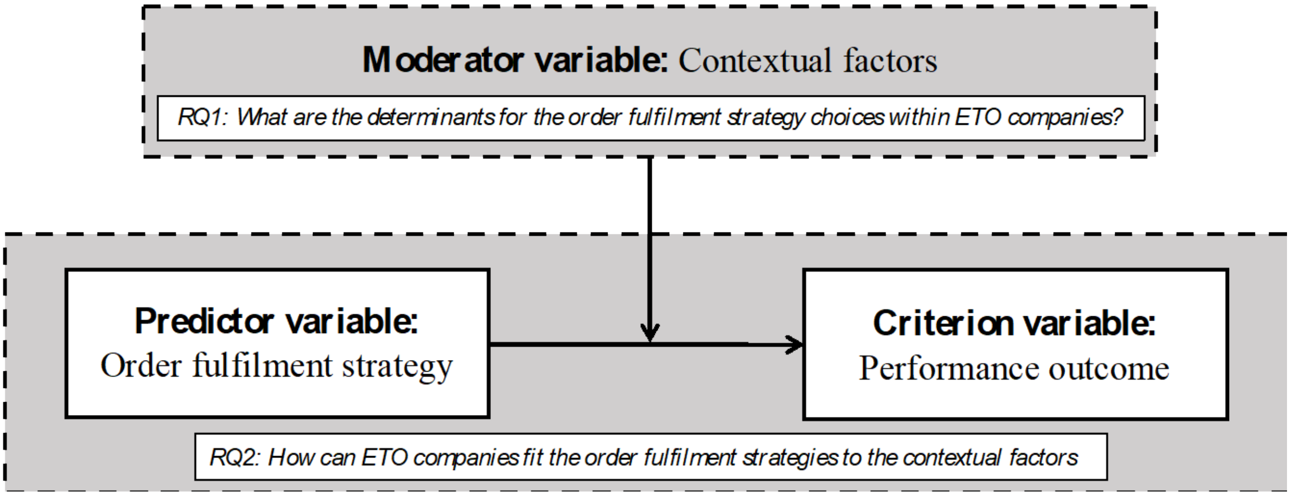

Figure 2. Conceptual framework: a moderation fit perspective of determinants for order fulfilment strategies in ETO companies

Table 2. Research framework constructs and measures

Construct	Variables	Definition	References
Predictor variable: Order fulfilment strategy	Engineering fulfilment strategies	Number of engineering activities to perform when the customer order arrives: (i) Research, (ii) Develop, (iii) Design, (iv) Modify (major changes); (v) Modify (minor changes), (vi) Combine	*Sharman, 1989; Hoekstra and Romme, 1992; Wortmann, 1992; Lampel and Mintzberg, 1996; Amaro et al. (1999); Hicks et al. (2001); Wikner and Rudberg, 2005; Dekkers, 2006; Veldman and Alblas (2012); Semini et al. (2014); Willner et al. (2016); Gosling et al. (2017); Cannas et al. (2019)*
	Production fulfilment strategies	Number of production activities to perform when the customer order arrives: (i) Purchase, (ii) Make, (iii) Finalize, (iv) Assemble, (v) Deliver	
Moderator variable: Contextual factors	Market	Environmental variables outside from the organizational system that are not subject to direct control of the company and affect the system with which the company interacts and interfaces (i.e., aggregate market and single customer characteristics and requirements)	*Hill, (1993); Hoekstra and Romme, (1992); Fisher, (1997); Naylor et al., (1999); Mason-Jones et al., (2000); Olhager and Wikner, (2000); Christopher and Towill, (2000, 2001, 2002); Van Donk, (2001); Aitken et al., (2002); Olhager (2003); Wikner and Rudberg (2005); Hallgren and Olhager, (2006); Cristopher et al. (2006); Dekkers (2006); Semini et al. (2014); Willner et al. (2016); Schoenwitz et al. (2017); Gosling et al. (2017)*
	Product	Resource variables over which the company has direct control, and on which can operate in the long term to produce the needed changes, and represent the characteristics of the product offered to the market (i.e., modularity, customisation opportunities, structure, etc.)	
	Process	Resource variables over which the company has direct control, and on which can operate in the long term to produce the needed changes, and represent the characteristics of the internal processes, including both the production and the engineering activities and their interfaces	

Criterion variable: Performance outcome	Price	Ability to provide the customers with a product price lower than the average price required by competitors within the market	*Sharman (1984); Hoekstra and Romme (1992); Naylor et al., (1999); Mason-Jones et al., (2000); Christopher and Towill, (2001); Aitken et al., (2002); Olhager (2003); Wikner and Rudberg (2005); Dekkers (2006); Gosling et al. (2017); Cannas et al. (2019)*
	Time	Ability to provide customers with the desired product in short and reliable time from the receipt of the order to the delivery	
	Flexibility	Ability of the company to make adjustments in what and how much it realises, based on specific customer requirements	
	Reliability	Ability to provide customers with a product in line with their expectations in terms of low risk for unexpected defects after sales	
	Innovativeness	Ability of the company to provide customers with unique designs and up-to-date technologies	

The research framework built a conceptual foundation for the empirical study and supported it in defining the concepts that were to be studied, i.e. the key constructs and variables and the assumed relationships among them (Voss et al., 2016).

The literature review confirmed what the contingency theory claims; i.e. there is a need for a strategic fit with different types of environments (Lawrence and Lorsch, 1967; Luthans and Stewart, 1977; Thompson, 1967). The contingency perspective of CODP positioning is based on the concept of “fit as moderation”, which needs to be well clarified so that it can be operationalised within the research framework and validated through empirical data (Venkatraman, 1989). According to the moderation perspective, the impact of the order-fulfilment strategy implemented by the company (i.e. the predictor variable) on the performance outcome (i.e. the criterion variable) depends on the alignment with a set of contextual variables (i.e. the moderator variable). Consequently, the constructs of the research framework, shown in Figure 2, include the main object of study, organised according to the classification of contingency theory models (Sousa and Voss, 2008).

Then, Table 2 lists these constructs and the variables to measure them, providing detailed definitions, and specifies the references based on the literature review presented in Section 2. Reading them through a lens of contingency theory, the order-fulfilment strategy represents the strategic choice made by the company with respect to 2D-CODP positioning: a set of strategies can be identified depending on the number of engineering and production activities performed after the order With regards to contextual factors, market-related factors can be considered environmental variables that are not subject to direct control by the company and affect the system with which the company interacts. In contrast, product- and process-related factors can be defined as resource variables over which the company has direct control but that can change only in the long-term and with substantial efforts. Finally, the performance outcome represents the dependent measure that can be used to assess the fit between the contextual factors and order-fulfilment strategy and includes the traditional performance measured in CODP literature: price, time, flexibility, reliability, and innovativeness.

3.2 Case-study design

The methodology applied in this study is a multiple case-study research. The exploratory aim of this study makes the collection of data from multiple cases preferable because it increases the external validity of the findings (Yin, 2018). However, the population addressed belongs to one industry in one country, i.e. the Italian machinery industry, to increase the control of variations within the population by limiting the research domain (Voss et al., 2016). The Italian machinery industry was selected for three main reasons. First, the companies operating in the machinery industry design and manufacture capital goods, which are considered as well are representative of ETO issues (Adrodegari et al., 2015; Cannas et al., 2019; Dekkers, 2006; Veldman and Alblas, 2012). Second, Italian companies are among the world's top producers and exporters in the machinery industry because of high customisation and flexibility, and a high level of technological innovation (source: Federmacchine, 2017). Third, the challenges that the Italian machinery industry faced in recent decades because of globalisation make this population representative of the research problem. In particular, the emerging markets of the Asia-Pacific region, offering low costs and short lead times with low added value, have had a significant impact on the global competitive environment. In 2016 (source: Goh, 2017), the percentage distribution of the global machinery production was approximately $680 billion in the Asia-Pacific area (49.1%), $406 billion in the European area (29.3%), and $299 billion in the Americas (21.6%). The key players changed, and many companies not only in Italy but also in the entire European area, according to McKinsey & Company (2016), are struggling to face this global pressure and are contemplating if the actual strategies applied in product development and production are sufficient to keep pace with recent developments.

3.3 Case selection

The complete list of companies operating in the Italian machinery industry was obtained from the database "AIDA" (https://aida.bvdinfo.com/), and only medium and big companies (according to EU recommendation 2003/361) were selected to ensure that the companies performed both engineering and production processes. The unit of analysis of the study was the product family because a company can implement more than one strategy to provide different product families to market.

Within this pre-defined list, the case selection carefully followed theoretical reasons, based on a replication logic (Miles and Huberman, 1994): literal replication, i.e. companies were selected based on the expectation that they have similar contextual variables and performance outcomes because they offer product families that employ the same engineering and production decoupling configuration (i.e. the order-fulfilment strategy); and theoretical replication, i.e. companies were selected based on the expectation that they have different contextual variables and performance outcomes, but for predictable reasons, i.e. they offer product families that employed a different order-fulfilment strategy. Accordingly, in line with the main hypothesis of the study, the companies were selected to ensure maximum variation within the population and subgroups were found to compare and identify common patterns. This information was found in the reports developed by national industrial associations (Federmacchine, UCIMU, Amaplast, etc.), the Italian National Institute of Statistics (ISTAT), university or consultancy reports, and company websites. Moreover, the authors had experience in the machinery sector because of previous research projects conducted.

In total, eleven Italian machinery industry companies were selected, all recognised to be market leaders and located in Northern Italy, which is a relevant geographical area in terms of the impact on the total Italian machinery industry turnover. Eleven companies were considered sufficient, according to the replication logic applied because they provided 24 cases and a good number of literal and theoretical replications, i.e. similar and rival order-fulfilment strategies, which strengthen and support the findings of the study (Yin, 2018). In Table 3, the case-study overview is presented. The percentage between brackets, next to the case studies, shows the total impact of the products analysed on the turnover.

Table 3. Case study overview

Company	Length of the interview, number of interviewee/s and role of the interviewee/s	Turnover 2017 [million €] / Number of employees 2017		Sector	Case study [Product family - % of impact on the turnover]
A	*2 hours and 30 minutes interview to 4 interviewees*: engineering manager and 3 production department employees	75	175	Plastic and rubber machinery	A1 = standard-customised bender machines (100%)
B	*2 hours and 30 minutes interview to 2 interviewees*: engineering manager, production manager	94	115	Plastic and rubber machinery	B1 = modular injection moulding machines (70%); B2 = standard-customised injection moulding machines, (20%); B3 = customised injection moulding machines (10%)
C	*2 hours interview to 2 interviewees:* engineering manager and production manager	44	140	Plastic and rubber machinery	C1 = special extruders machines (100%)
D	*3 hours interview to 3 interviewees:* engineering manager, senior sales manager & production manager	109	180	Plastic and rubber machinery	D1 = standard-customised extruders machines (80%); D2 = modular extruders machines (10%); D3 = customised extruders machines (5%); D4 = standard extruders machines (5%)
E	*4 hours interview to 4 interviewees:* engineering manager, project manager, sales manager, production manager	247	685	Machine tool	E1 = Customised laser cutting machines (60%); E2 = standard-customised laser cutting machines (40%)
F	*2 hours interview to 1 interviewee:* plant manager	74	320	Machine tool	F1 = customized milling machines (60%); F2 = standard-customised milling machines (20%); F3 = standard milling machines (10%); F4 = special milling machines (10%)

G	*2 hours and 30 minutes interview to 2 interviewees:* engineering manager and production manager	37	205	Machine tool	G1 = customised laser cutting machines (70%); G2 = standard-customised laser cutting machine (30%)
H	*2 hours interview to 1 interviewee:* plant manager	13	50	Machine tool	H1 = Customised milling machines (60%); H2 = standard-customised turning and milling machine (30%); H3 = modular turning and milling machine (10%)
I	*1 hour and a half interview to 2 interviewees:* product manager and sales manager	35	105	Machinery for the soap production and confectionery	I1 = special soap production and confectionery machines (90%); I2 = modular soap production and confectionery machines (10%)
J	*1 hour and a half interview to 1 interviewee:* process engineering manager	91	275	Machinery for food, beverage and tobacco processing	J1 = modular chocolate production and confectionery machines (100%)
K	*2 hours interview to 2 interviewees:* engineering manager and production manager	200	420	Textile machines	K1 = standard-customized winding machines (100%)

3.4 Data collection

Data collection was performed through multiple data collection methods to ensure the presence of different sources of evidence (Stuart et al., 2002). The primary source was face-to-face interviews (source 1), which were always performed by at least two researchers. The questionnaire was organised as a semi-structured interview to maintain a logical order, while collecting open comments. The protocol was organised based on the constructs (i.e. order-fulfilment strategy, contextual factors, and performance outcome) defined in the research framework presented in Subsection 3.1 (see Figure 2 and Table 2). Importance was given to spontaneous deviations to preserve possible contradictory views with respect to the initial framework (Stake, 1995). The interviews were always recorded and transcribed. Based on the cultural context of the study, and the fact that both the participants and the researchers that conducted the cases spoke the same non-English native language, the interviews were conducted entirely in Italian. Therefore, careful attention was paid while translating from Italian to English to maintain the validity of findings (the details of the translation procedure are reported in the next section).

The participants were experts in the engineering and production processes (e.g. plant manager, operations manager, engineering manager, and project manager), who were well aware of the current situation and issues, and each case lasted 4 h on an average. Multiple interviews are missing in some cases because of constraints beyond the researchers' control, i.e., the availability of the company and its human resources. To overcome this issue and avoid the subjectivity typical of single respondents (Voss et al., 2016), the use of different sources was essential: (i) direct observations (source 2) during plant and engineering department tours; (ii) company's website and official documents available in the web (source 3); and (iii) product catalogue and other internal documents (source 4). This additional information helped in obtaining rigorous results because of the triangulation of evidence (Hays, 2004). The case-study protocol used to collect data is shown in Appendix 1.

3.5 Data analysis

Data were analysed by implementing a content analysis approach. Coding was executed manually by the authors: they independently read and coded the transcriptions and then discussed the results to reach a common understanding of the responses. Finally, triangulation with additional insights from secondary data was performed to enrich the findings and overcome possible missing information. In this phase, maximum attention was paid to maintain the interpreted and communicated meaning in the findings (English language) as close as possible to the meaning expressed by the interviewees (Italian language). According to the recommendations provided by van Nes et al. (2010), data analysis was conducted in the original language as much as possible (first step coding) to avoid limitations in the analysis and reduce the influence of studying the contents in another language. Second, when translation was required (second step coding and discussion of results), multiple in-depth discussions among the authors were performed to find the best translation, through fluid descriptions and various English formulations. It is important to underline that the research team included, since the beginning, one native English researcher who was an expert in the field.

Content analysis allowed us to explore the differences between cases and search for patterns to compare with the initial tentative conceptual framework developed from the literature (Almutairi et al., 2014). The interviews and documents were systematically analysed by evaluating the material and classifying the contents in the analytic categories taken from the literature and refined, enriched, and extended, with additional insights obtained from empirical findings. In this sense, the main categories used to classify the literature were the ones related to the main constructs of the research framework (i.e. order-fulfilment strategy, contextual factors, and performance outcomes). A detailed description of all the cases within each construct and variable has been provided in structured tables (see Appendix 2).

The scoring method used for analysis was based on a relative and qualitative evaluation, with respect to the market analysed, as is performed in qualitative research based on a small number of companies analysed. Given the exploratory nature, the final patterns could not be defined before the study but emerged from the collected data (Sinkovics, 2017). Therefore, the construct measures were continuously validated during the study, checking their consistency in the subsequent interviews and calling back the companies if any unreliable measure emerged. In this way, the researchers assured the coherence of the analysis and the possibility to reach general conclusions.

Finally, to ensure the maximum transparency, the study illustrates the chain of evidence from raw data to interpretation through a careful documentation of the data analysis provided in Appendix 2, which shows a complete example of the data analysis performed for case H1. In Section 4, we report the results from the cases in detail with the support of interview quotes (Caniato et al., 2018; Yin, 2018).

4 Order-fulfilment strategy and contextual factor alignment

4.1 Understanding order-fulfilment strategies across the ETO case studies

The first output of the data analysis is the classification of the case studies according to the order-fulfilment strategy implemented. Within our case studies, the data suggest that the companies implemented different order-fulfilment strategies to provide their product families to the market. Figure 3 shows the final classification of the cases based on the number of engineering and production activities performed to order. Classification is based on the 2D-CODP positioning matrix proposed by Cannas et al. (2019) for classification of product families provided by companies operating in the machinery industry. This choice was made because the framework of Cannas et al. (2019), as anticipated in the literature review section, can be considered the most recent and comprehensive to date. Indeed, it classifies all the previous literature on ETO order-fulfilment strategies (as, for example, Dekkers, 2006; Gosling et al., 2017; Wikner and Rudberg, 2005; Willner et al., 2016) and includes new decoupling strategies identified through an extended qualitative field study in the machinery industry.

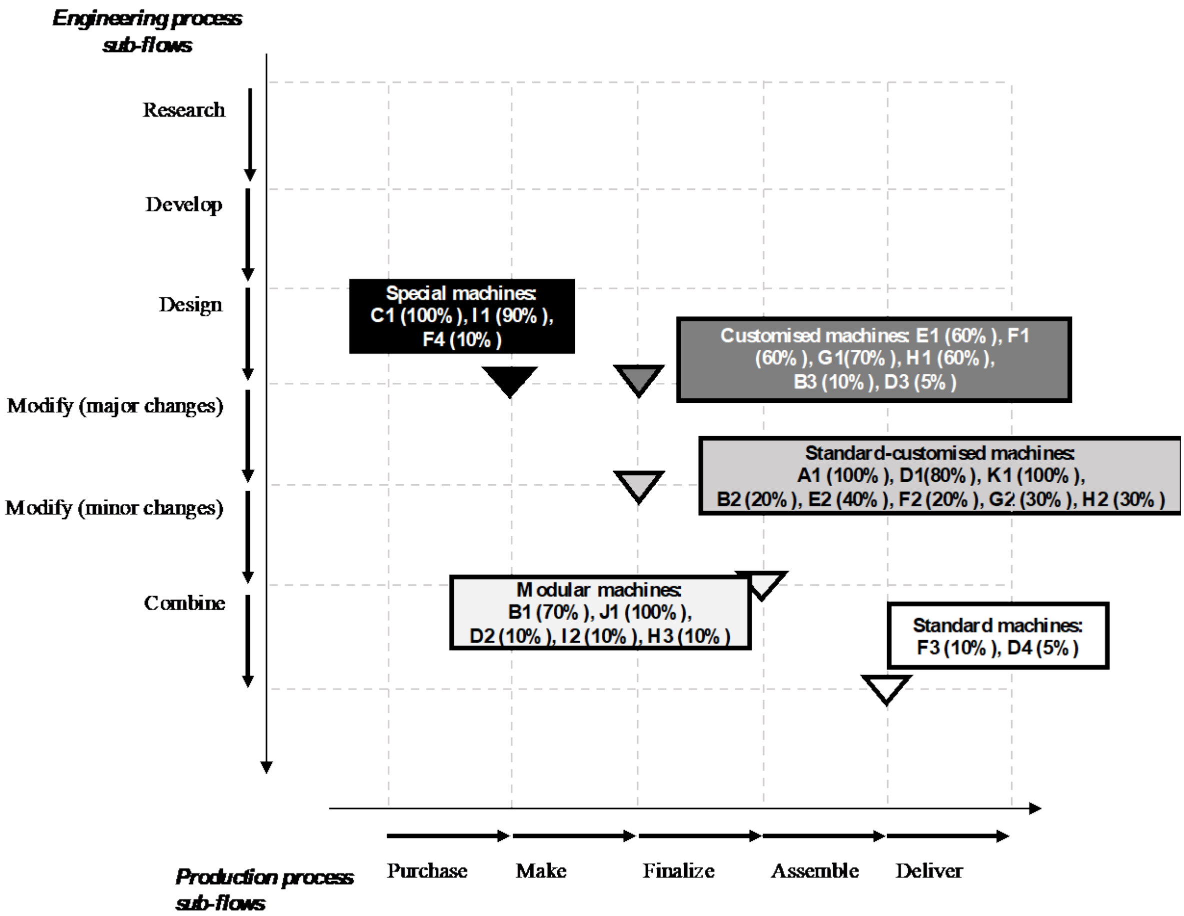

Figure 3. Classification of the cases in the 2D-CODP framework (adapted from Cannas et al., 2018a)

The engineering process activities to be performed can be divided into two main sub-processes: (i) research and development, which involves the research, testing, and prototyping of a new product concept; and (ii) design of product BoM, including the list of components required to build the machine along with the technical specifications, the instructions for production processes, and the instructions for final assembly. In the cases analysed, research and development are always performed to forecast along with the design of the "general" BoM because the new products are first presented to industrial fairs (Plast, BI-MU, etc.). Adaptations of the product BoM can then be performed completely to order (with major modifications, adapting the existing components to order, or eliminating/adding components), partially to forecast (with minor modifications or only final combinations to order) or completely to forecast (by taking the design as it is). In contrast, the production process activities to be performed can be divided into three main sub-processes: (i) purchase, which involves the procurement of raw materials; (ii) manufacturing, which involves the physical realisation of the components, either produced internally or outsourced to specialised suppliers; and (iii) assembly, which involves the assembly of components. In the cases studied, the procurement of raw materials is always performed to forecast. The manufacturing and assembly, instead, can be performed completely to order (MTO), partially to forecast (finalise the production/procurement of customised components to order or assemble to order), or completely to forecast (MTS).

Five different order-fulfilment strategies were been identified from "special" to "standard". Figure 3 shows that standard machines represent an unusual strategy in this sector; only two cases were related to this strategy and to a small percentage of the product portfolio. In addition, special machines are related to a small number of cases (only three), but two out of three are related to the more than 90% of the product portfolio. In contrast, intermediate strategies, i.e. "customised", "standard-customised", and "modular", are the most applied ones. Product family F4 is characterised by "special" machines, whereas product family F3 is characterised by "standard" machines. According to the plant manager of company F, "*F4 is the most customised case. The engineering department, in collaboration with the sales department, develops the concept of the machine starting from the catalogue but applying technical modification to more than 70% of the product BoM and producing all the components to order […] In the case of F3, instead, the design is taken as it is from the product catalogue, and the production and assembly activities are planned to forecast*". Product family H1, described in Appendix 2, is characterised by "customised" machines. This implies that the engineering activities after the order consist of a major modification of some existing components (30% on average, in this specific case), while manufacturing activities can only partially start before the order by purchasing or producing the strategic components. In contrast, the order-fulfilment strategy for products belonging to a product family such as H2 is "standard-customised". This denotes that the products are already designed and introduced in the product portfolio but are slightly modified after the order to achieve specific requirements. Consequently, according to the plant manager of company H, "*the minor modifications of design allow the company to produce all the components of the BoM to forecast and produce or adjust the customised components to order*". Finally, product family H3 is characterised by "modular" products, which means that they are already designed and introduced in the product portfolio and only finalised to order based on the combination of the design options to obtain the desired BoM configuration. Consequently, according to the plant manager of company H, "*because of the high engineering standardisation level, in this case, the company prefers to perform the manufacturing activities of the components completely to forecast*".

4.2 Market-related factors

Table 4 shows the results obtained from the analysis of the cases in terms of market-related factors.

Table 4. Overview of the market-related factors in the case studies

Construct	Variable	Definition	Special machines (cases C1, I1, F4)	Customised machines (cases E1, G1, F1, H1, B3, D3)	Standard-customised machines (cases A1, D1, B2, E2, F2, G2, H2, K1)	Modular machines (cases B1, J1, D2, I2, H3)	Standard machines (cases F3, D4)
Market-related factors	Customer product knowledge	Customer's technical and functional knowledge of the customer	High technical and functional knowledge	High technical and functional knowledge	Little technical knowledge and high functional knowledge	Little technical and functional knowledge (or none)	Little technical and functional knowledge (or none)
	Customer size	Big multinational companies vs medium/small subcontractors	Multinational companies	Multinational companies	Multinational companies and subcontractors	Medium/small subcontractors	Medium/small subcontractors
	Demand variety	Probability of customer requirements for changes after the order	80%-100%	60%-80%	40%-60%	20%-40%	0%-20%

The evidence of cases shows that the order-fulfilment strategies implemented by the companies are aligned to different customer typologies. One of the factors characterising the different customer typologies is knowledge, which has been measured by all companies as technical knowledge, i.e. experience and know-how in the actual development of the machine, and functional knowledge, i.e., experience and know-how in the utilisation of the machine in a qualitative rating scale from "high" to "low/none". "*If the customer has low technical knowledge, we have a higher degree of freedom in developing the machine using the existing technical specifications and we can reduce the number of engineering and production activities performed to order"* (D's engineering manager). Another factor to consider when companies align the order-fulfilment strategy to the market is the customer size. The customer size is measured by all companies, distinguishing from multinational companies and medium/small subcontractors. "*There are two types of customers, big customers, which are multinational companies that demand high flexibility and customisation but accept premium prices and longer delivery lead times, and the smaller, cost-conscious subcontractors want a quick product delivery to satisfy a current market trend"* (E's sales manager). Finally, demand variety represents an important market factor to consider. Demand variety is measured by all companies as a percentage by evaluating how many customers, out of ten, on an average ask for changes after the order. "*We have customers that often change their minds after the order. In this case, it is better to wait for the order before performing engineering and production activities; otherwise, we face the risk of reworking the components many times"* (G's engineering manager).

In particular, as shown in Table 4, to respond to knowledgeable and demanding multinational customers, it is necessary to implement special or customised strategies. In fact, they leverage the flexibility they still have on design and production to accommodate customer needs. In contrast, standard and modular strategies are implemented for subcontractors that choose the product from the catalogue looking for the desired product functionalities and have little or none technical knowledge. In the case F4, for example, "*A big customer, with high technical know-how and experience related to the product, defines the desired technical specifications and often asks for changes. Eight to nine customers out of 10 ask for changes after the order*. […] *In case F3, customers are small subcontractors who are not specialised in specific production activities because they depend on the market trends. They have little (or none) experience and knowledge related to the product and express only a preference for general functionalities. In this case, the probability for later changes is almost null: we provide*

F3 as it is, without any changes" (F's plant manager). There are also intermediate cases, such as H2, where "*the customers interested in the product family are a mixture of both big multinational companies and small subcontractors, which search for high-precision machines in a short lead time and at a competitive price. They ask for some technical specifications but mainly express preferences for specific functionalities. In this case, on an average, 4-5 customers out of 10 require changes after the order*" (H's plant manager).

4.3 Product-related factors

Table 5 shows the results obtained from the analysis of the cases in terms of product characteristics.

Table 5. Overview of the product-related factors in the case studies

Construct	**Variable**	**Definition**	**Special machines (cases C1, I1, F4)**	**Customised machines (cases E1, G1, F1, H1, B3, D3)**	**Standard-customised machines (cases A1, D1, B2, E2, F2, G2, H2, K1)**	**Modular machines (cases B1, J1, D2, I2, H3)**	**Standard machines (cases F3, D4)**
Product-related factors	Technology life-cycle	Stage of the product family technology in the life-cycle	New / Emerging	Growing	Growing	Mature	Mature
	Customisation opportunities	Customisation options proposed to the customer when the order arrives	No catalogue or catalogue used only as guideline	Catalogue supported by modular, additional and superior options	Catalogue supported by modular and additional options	Catalogue supported by modular options	Only catalogue
	Modular design	Modular product structure	No	Partially modular	Partially modular	Completely modular	No

For the product, considering the technological life-cycle is important for the cases analysed. All the interviewed people referred to the life-cycle new/emerging, growing, or mature. "*New technologies make it necessary to maintain high customisation because they are still not as stable as the mature ones, and it is difficult to forecast customer needs*" (A's engineering manager). Family F4, for example, is characterised by new/emerging technologies: "*the customer asks for new technical characteristics and functionalities. The innovation typically consists of increasing the production capacity with the same machines. This means finding new geometries to improve materials, to change components, etc. Thus, it is highly certain that new components and major modifications will be added, and it is better to wait for the customer order to manufacture the product*" (F's plant manager). In contrast, family H3 is related to mature and stable technologies. "*H3 demand is easy to forecast and the risk of uncertainty is low. This makes it possible to rely on design modularity and a combination of modules, in case of changes in the design requirements*" (H's plant manager).

Moreover, customisation opportunities affect the order-fulfilment strategy, and it is measured by all companies as the range of choices provided to the customer: only catalogue with standard products; catalogue and modular options (fundamental characteristics of the product that increase the perception of variety); catalogue, modular, and additional options (not fully needed but make the customer satisfied); catalogue, modular, additional and superior options (delighters that exceed customer expectations); and complete customisation with no catalogue or catalogue only as a guideline. "*If the variety in terms of customisation opportunities is high, the company increases the range of choices for the customer. Thus, it is hard to forecast the demand and keep stock of components and spare parts because the stock holding cost would be excessive. In contrast, a reduction of customisation opportunities decreases the variety along with the uncertainty*" (D's engineering manager). For instance, the product family H1 is composed of 8 different products in the catalogue: 6 products in H2 and 2 products in H3. Each of the products is proposed with different options. To confirm this, the plant manager showed a set of internal documents containing the technical specifications (i.e. the different design options proposed to the customer when the order arrives): "*We propose to the customer different options: modular options, additional options, and superior options. As can be seen, the H1 document contain about 90 pages characterised by all modular, additional, and superior options; the H2 document has about 50 pages characterised by modular and additional options; and finally, the H3 document has 20 pages characterised by only modular options*". In case of F3 and F4, "*F3 is composed of only two different machines without any* *option/variants. The machines are provided as they are in the catalogue with their fundamental characteristics. In contrast, F4 has almost infinite customisation opportunities; the only constraint is the milling technology. In this case, we use the catalogue only as a guideline, and we fulfil the order exploiting experience and knowledge*" (F's plant manager).

Finally, modular product structure is an important factor. The companies refer to it as non-existent, partial, or complete. The modular product structure was identified as a common characteristic of all product families offered by company H. In particular, H1 and H2 are partially modular and H3 is completely modular. All companies that have intermediate configurations (i.e. customised, standard-customised, and modular machines) leverage on modules to anticipate some engineering and production activity before the order and adapt the remaining ones to order. Interestingly, all cases of pure customised (i.e. special machines) and pure standardised (i.e. standard machines) configurations have been identified as non-modular. In these cases, modularity is not considered worthy because as stated by company F, "*the level of design modularity helps to increase production responsiveness, but it also increases cost. This is because it is necessary to (at least) duplicate the production activities but use only a part of what is produced. In addition, if the customer order is always different, 100 pieces with 48 holes each could be produced to obtain the highest possible modular interface in the assembly activities, but then, only 2 holes could be exploited for each order. In this case, the modular configurability is reduced, producing the holes to order, with longer lead times but leading to a lot cost savings*".

4.4 Process-related factors

Table 6 lists the process factors related to each different order-fulfilment strategy. The cases analysed defined the sales and engineering process structure, production flexibility and sales, and engineering and production interface as important factors affecting the order-fulfilment strategy choice.

Table 6. Overview of the process-related factors in the case studies

Construct	Variable	Definition	Special machines (cases C1, I1, F4)	Customised machines (cases E1, G1, F1, H1, B3, D3)	Standard-customised machines (cases A1, D1, B2, E2, F2, G2, H2, K1)	Modular machines (cases B1, J1, D2, I2, H3)	Standard machines (cases F3, D4)
Process-related factors	Sales process structure	Degree of freedom given to sales resources in proposing solution to the customer during the negotiation	The sales process is loosely structured, with high degrees of freedom.	The sales process is loosely guided by a procedure with high degrees of freedom.	The sales process is guided by a procedure with limited degrees of freedom.	The sales process is guided by a procedure with no degrees of freedom	The sales process is guided by a procedure with no degrees of freedom
	Engineering process structure	Degree of freedom given to engineering resources in designing the solution to order	The engineering process is loosely structured, with high degrees of freedom.	The engineering process is loosely guided by a procedure with high degrees of freedom.	The engineering process is guided by a procedure with limited degrees of freedom.	The engineering process is guided by a procedure with no degrees of freedom	The engineering process is guided by a procedure with no degrees of freedom
	Production flexibility	Production capabilities to manage unexpected requirements for reworks in a short time after the order	The production department is flexible to solve very quickly requirements for reworks	The production department is flexible to solve quickly requirements for reworks	The production department can solve requirements for reworks but affecting the delivery lead time	The production department can solve requirements for reworks but heavily affecting the delivery lead time	The production department is not flexible to requirements for reworks

Sales, Engineering and Production interface	Level of need for inter-functional interfaces after the order	Need for continuous exchanges of information and warning, and synchronous communication between the functions	Need for exchanges of information and warning, and synchronous communication between the functions involved in the major changes	Need for exchanges of information and warning, and synchronous communication between the functions involved in the minor changes	Limited need for exchanges of information and warning, and synchronous communication between the functions	Sporadic exchanges of information and warning, and asynchronous communication between the functions

All case studies highlight that the structure of sales and engineering processes is related to the degree of freedom given to the resources in proposing solutions. A qualitative scale has been defined, ranging from “loosely structured processes with high degrees of freedom” to “process guided by a procedure with no degrees of freedom”. In this sense, data show that the higher the customisation, the looser the structure of the sales and engineering processes. “*The engineering process of product F4 does not follow any specific procedures so that it is possible to completely meet customer requirements. Therefore, the salesmen and engineers act with a high degree of freedom while being aware of the impact of their decisions on the other supply chain processes and the entire value chain. In contrast, in the case of F3, sales and engineering departments deal with standard machines based on mature technologies. Therefore, they apply rigorous procedures, with no need to consider the impact of their choices on the other departments*” (F’s plant manager). In the intermediate strategies, instead, there is always a procedure but with different degrees of freedom. In this sense, the plant manager of company H showed us the internal procedure followed by the sales and engineering departments: “*As you can see, it is divided into various sections: the performance that the machine must guarantee, the technical characteristics, the sales plan, and the list of various configurations already provided to the market. These different configurations are planned and proposed to the customer, and each of them corresponds to a specific budget of costs and lead times. This document helps the salesmen and engineers understand the impact of each machine configuration to the entire supply chain. Then, in the case of H1, the choice is to maintain a high degree of freedom in changing the initial characteristics while being aware of the impact on the value chain. This freedom is lower for H2 and null for H3”*.

All companies consider production flexibility as the capability to manage unexpected requirements for rework in a short time after the order. They use a qualitative scale to assess this factor, comparing them with the market average and following a particular classification: “very quick in managing reworks”, “quick in managing reworks”, “managing reworks with negative impact on delivery lead times”, “managing reworks with heavy negative impact on delivery lead times”, or “not managing reworks”. This factor was found to be very important in case of highly customised strategies. “*We are accustomed to late and unexpected design changes and production reworks. Therefore, we organise our production activities to be flexible and ready to face reworks very quickly”* (I’s production manager). Instead, the standard and modular order-fulfilment strategies are less ready to face reworks, and the impact on lead times is higher. For example, in the case H3 "*the company completes all the procurement and production activities of the modules before the customer order. This reduces the production flexibility and means that in the case of special requirements included in the customer order, what has been purchased/produced is not suitable anymore. The reworks heavily affect the delivery lead time*".

Finally, sales, engineering, and production interfaces are relevant factors that the companies measure because of the need for exchange of information and warning and synchronous communication. They refer to it by a qualitative rating that ranges from "continuous need" to "limited" to "sporadic". An important finding is that the higher the customisation, the more important it is to continuously engage the interfaces and synergy among the departments and to employ synchronous communication (i.e. simultaneously and in real time such as face-to-face meetings or calls) after the order. For example, according to case F, "*improving the interface between the sales, engineering, and production departments is fundamental in the case F4 to facilitate overlapping activities and to reduce delivery lead times. For example, we leverage on a real-time data sharing between the functions, which are important to increase the visibility and traceability of the information related to order management. This implies a reduction of errors and consequently a reduction of costs and lead times because of real-time problem solving and workloads balancing optimisation*" (F's plant manager). In contrast, in the case of high standardisation, the interfaces among the departments after the order are sporadic and asynchronous (i.e. not live and deferred, such as emails).

5 Performance outcomes and strategic fit

The insights from the case-study research confirm the initial assumption that ETO companies focus their efforts in carefully aligning their order-fulfilment strategy to the contextual factors to achieve the desired performance outcomes. The relevant outcomes of the strategic alignment between strategy and context for good performance are time, price, flexibility, reliability, and innovativeness, and the companies interviewed assess them by referring to each product family, with respect to the market average (0 – not competitive, 1 – low competitive, 2 – on market average, 3 – competitive, 4 – very competitive).

If the fully customised strategy (i.e. special machines) is implemented to address the right market segment (i.e. niche market, composed by knowledgeable and demanding customers), supported by the suitable product (i.e. innovative and customised product) and processes (i.e. loosely structured but highly flexible and strongly aligned), the final performance outcome expected is the capability to always meet customer requirements for customisation, i.e. high flexibility, and provide them with high innovativeness in terms of technologies. This justifies the premium price and longer delivery lead times, compared with competitors. Moreover, the customer accepts the risk of unexpected defects because the number of errors increases in new designs, and there is a lack of previous feedbacks from the production department and suppliers. "*When the customer asks for F4, he asks for a new machine model, which is a special machine. The competition is based on technology and flexibility. This is the most complicated case; the machine does not exist yet. In addition, of course, in the initial phase, the sales department leverages the engineering department to understand the machine, the feasibility, etc. Therefore, the costs will be higher, and all the subsequent steps will be much slower, making the delivery lead time longer than 10 months. For example, the purchasing department may have to buy things for the first time, and there may be new production cycles*".

In contrast, standard machines meant for a stable market (i.e. predictable customers with no specific requests) that must be served with mature and standardised products and supported by not flexible but highly structured processes. This alignment aims to assure the capability to achieve high performance in terms of price, delivery lead times, and reliability, at the expenses of flexibility because the customer requirements for customisation are never met and innovativeness because the technology is already mature. "*Product family F3 addresses a market segment where the product is not required with special technological skills. Instead, it opens up a world of competitors larger and more aggressive than F4. The competition is no longer based on technology but on price and delivery lead time, as well as reliability. We exploit our standard product configurations and standard procedures to achieve this goal*" (F's plant manager).

Finally, intermediate strategies allow companies to achieve a good compromise between different competitive proprieties. For example, H1 has a dominant market positioning; as the plant manager explained, "*it is a leader in a specialised market, where it is distinguished from competitors because of the possibility to provide state-of-the-art technologies that satisfy almost all customer requirements*". The price and delivery lead time are higher than those of competitors but reduced to the minimum only to justify the additional customised components; the price is 20% higher than the market average, and the delivery lead time is 5-8 months, depending on the extent and complexity of design modifications required by the customer. The risk of unexpected defects is related only to the components strongly modified and is usually not more than 30% of the product BoM. H2 has a strong market positioning, as the plant manager specified: "*H2 is among the leaders in a specialised market because of the capability* *to provide customers with economically complete machines with state-of-the-art technologies*". H2 partially meets the customer requirements for customisation and the price is competitive and comparable to the market average. Additionally, the delivery lead time is 2-4 months, based on the extent of design modifications required by the customer, and the risk for defects is contained because the changes applied to the existing design are only minor. Finally, H3, as the plant manager specified, "*is a follower in a specialised market considering the first three leading companies. It tries to accomplish the same product quality and precision at competitive prices for customers that need conventional machines in short lead times of 1-2 weeks at the most*". H3 rarely meets the requirements for customisation, and the innovativeness is small, but still offers a variety of general personalisation because of modularity. In addition, the risk for defects is almost null because it exploits mature technologies.

Figure 4 shows in detail the main results observed in the cases to help readers better understand the differences in performance outcomes of the range of order-fulfilment strategies within the same ETO industry, when well aligned with the context.

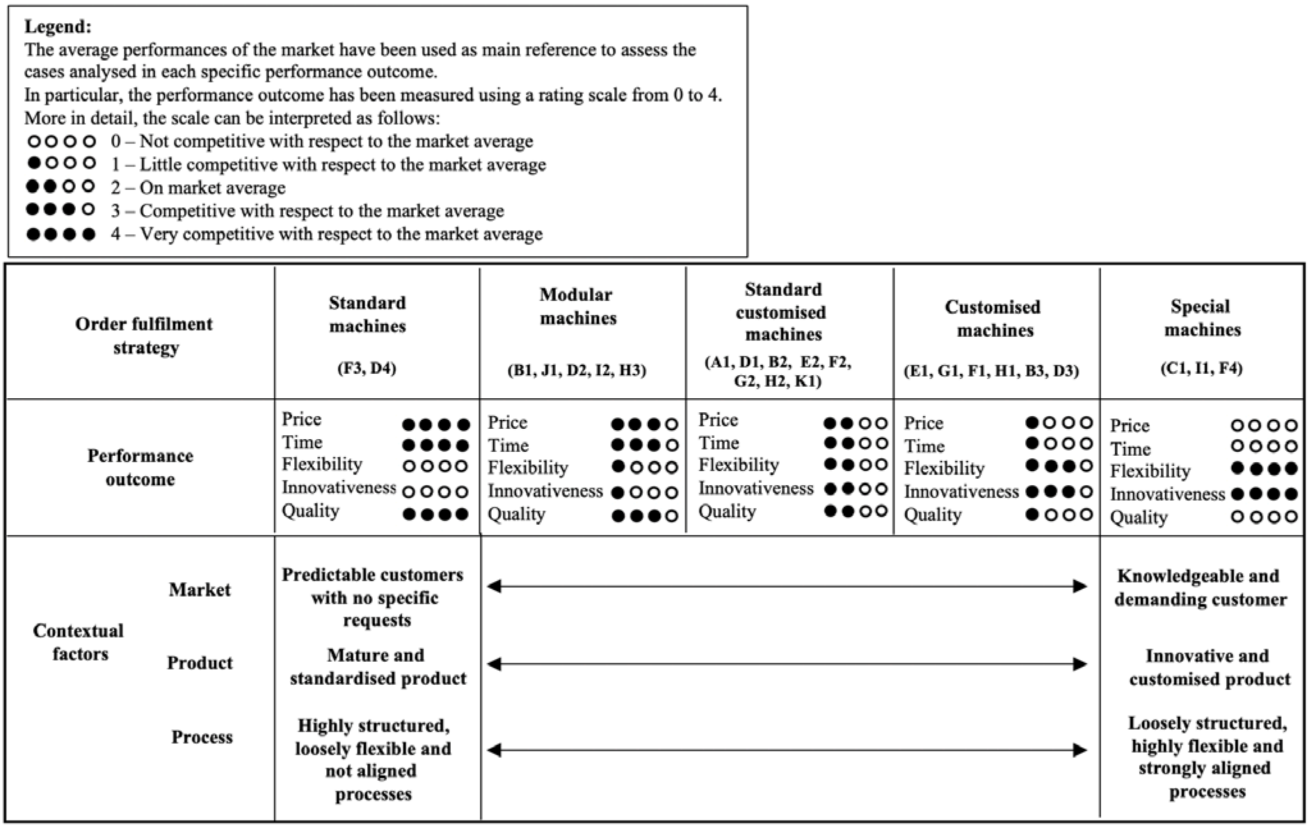

Figure 4. Overview of the performance outcomes of the strategic fit

6 Discussion

This study empirically investigated the order-fulfilment strategies implemented in 11 ETO companies through a contingency theory lens. Twenty-four different product families and five different order-fulfilment strategies were identified, i.e. standard machines, modular machines, standard-customised machines, customised machines, and special machines. For each order-fulfilment strategy, the sources of differentiation between the environments were defined and structured within the market, product, and process constructs, thus providing an answer to RQ1. Then, the performance outcome of each strategy was measured, explaining the rationale for the positioning of product families in different 2D-CODP locations, providing an answer to RQ2.

6.1 Answering RQ1: What are the determinants for the order-fulfilment strategy choices within ETO companies?

The results showed that the determinants for order-fulfilment strategy choices within ETO companies are contextual factors characterising the market (i.e. customer product knowledge, customer size, and demand variety), the product (i.e. technology life-cycle, customisation opportunities, and modular design), and the processes (i.e. sales and engineering process structure, production flexibility, and sales, engineering, and production interfaces).

The results confirm the validity and meaningfulness of classifying the determinants into market and product characteristics, as suggested by past CODP studies (Hallgren and Olhager, 2006; Olhager, 2003), and process characteristics as recently underlined by 2D-CODP and ETO studies (Dekkers, 2006; Gosling et al., 2017; Schoenwitz et al., 2017; Wikner and Rudberg, 2005). By opening the "black-box" of the market-, product-, and process-related factors, the existing literature has been refined to a greater level of detail for the ETO sector. Indeed, many factors identified and classified in Table 1 according to the three different literature streams (production, supply chain management, and ETO) were initially considered too general to become meaningful in distinguishing the different strategies employed by the companies analysed. Therefore, the study built on the existing literature and extended it by revisiting the existing determinants and developing additional factors, as explained below, to cater for the ETO context.

With respect to market-related factors, the average annual units sold and the market growth or changes, as introduced by the recent ETO literature, were too generic to describe and classify the market contextual factors of the companies analysed. In contrast, characteristics typically related to ETO and agile configurations by the production and supply chain management literature, i.e. unpredictable demand, low volumes, wide product range, and high customisation requirements, were confirmed to exist by all companies analysed for all product families. Thus, they were found to not act as determinants for order-fulfilment strategy choices in the machinery industry; rather, they appeared as qualifiers of the ETO sector where they operate. The companies interviewed underlined that their customers expect to be given high room for customisation and a wide range of choices. However, customers are diverse and have very different ways to interact with the machinery manufacturer when placing an order. In particular, they can be profiled in different groups based on three characteristics: (i) their knowledge regarding the product, (ii) their size, and (iii) their requirements for changes after the order. Therefore, the definition of a portrait of customers based on these characteristics is considered fundamental to make strategic decisions of order-fulfilment strategies for a product family. Therefore, this research introduced new factors, mostly related to the characteristics of every single customer: (i) the technical and functional product knowledge of the customer; (ii) the customer size; and (iii), the requirements for late changes after the order of the customer (demand variety).

With respect to product-related factors, all product families analysed in the study had complex deep structures. Thus, these two characteristics proposed by the production literature were not considered determinants for order-fulfilment strategy choices by the companies analysed; rather, they were considered peculiarities of the ETO products provided in the machinery industry. However, the other determinants did not differ from the literature. They built on the literature and confirmed the contingency of three variables: (i) modularity, as suggested by production and ETO literature; (ii) technology life-cycle (new technologies, which lead to innovative products, vs mature technologies, which lead to functional products), as suggested by the supply chain management literature; and (iii) the customisation opportunities offered to the customers, as suggested by the ETO literature.

With respect to process-related factors, on the one hand, the results differed from the literature regarding variables such as the number of planning points and bottlenecks, as well as the abilities and capabilities of the engineering resources, which were not considered by the companies analysed as characteristics that determine their order-fulfilment strategy choices. On the other hand, the findings confirmed the literature and built on the determinant of "production flexibility". If the production department is flexible to very quickly solve requirements for reworks, highly customised order-fulfilment strategies can be employed, whereas if it takes an increasing amount of time to react to unexpected changes, the standardisation of the order-fulfilment strategy should increase. In addition, new interesting insights emerged. First, the presence of standard procedures for the upstream processes (sales and engineering) were underlined as an important determinant for order-fulfilment strategy choices. Indeed, if the degree of freedom is high when proposing and designing the solution, i.e. the sales and engineering processes are loosely structured, it is an ideal condition for special machines, but it makes it very difficult to introduce standards in the products. Second, continuous inter-functional interfaces after the order (i.e. the exchange of information and warnings and synchronous communication) were underlined as not necessary when standard machines are provided, but were found to be very important in the case of special machines.

6.2 Answering RQ2: How can ETO companies fit the order-fulfilment strategies to contextual factors?

The findings from the cases demonstrated that the values of the determinants for order-fulfilment strategies gradually change based on the customisation level of the order-fulfilment strategy employed. From highly standardised to highly customised fulfilment strategies, (i) the market-related factors range from predictable customers with no specific requests to knowledgeable and demanding customers; (ii) the product-related factors range from mature and standardised products to innovative and customised products; and (iii) the process-related factors range from highly structured, loosely flexible, and not aligned processes and loosely structured, highly flexible, and strongly aligned processes. The fit of these characteristics with the suitable order-fulfilment strategy has been demonstrated to provide the desired performance outcomes, which range from very competitive prices, lead times, and reliability for highly standardised strategies to very competitive flexibility and innovativeness for highly customised ones.

By comparing the empirical results with the literature, we confirmed the existence of a trade-off between performance outcomes shifting from highly standardised to highly customised strategies, as underlined over the years by several production and ETO studies (Barlow et al., 2003; Cannas et al., 2019; Chase et al., 2001; Gosling et al., 2017; Rudberg and Wikner, 2004). In addition, the cases confirmed the current paradox of ETO companies aiming at multiple conflicting competitive priorities by implementing hybrid strategies and achieving the benefits of mass customisation (Mello et al., 2017; Sandrin et al., 2018). Additionally, the study brought innovativeness to the previous literature by adding the reasons for forward and backward shifting of the 2D-CODP. As already underlined in the literature review, this topic was under-researched by the previous literature, which deeply explored the dynamics of the shifting only in the one-dimensional framework (Hallgren and Olhager, 2006; Olhager, 2003).

The results show that the companies analysed fit existing environments to strengthen specific competitive priorities and achieve definite market positioning (i.e. niche, dominant, strong, follower, or stable). In particular, for 2D-CODP positioning, the interfaces between engineering and production need to be carefully considered. In fact, the production standardisation increases hand in hand with engineering: the companies analysed leverage engineering standardisation to exploit economies of scale and learning curves in the sales, procurement, and production activities, implementing production strategies different from MTO with competitive costs and lead times. The efforts made, in this sense, are mainly related to (i) defining a product catalogue supported by modular design architectures and technology development efforts; (ii) investing in procedures to guide both the sales and engineering processes, without losing too much production flexibility and coordination between the functions; and (iii) facing new barriers in the market because of changes in customer characteristics, and the possible entrance of new customers.

7 Conclusion

The purpose of this study was to better understand the determinants of order-fulfilment strategies for ETO companies, and via our empirical study, to provide insights into how organisations in the machinery sector react to fit the order-fulfilment strategy into their environment to achieve the desired performance outcomes. The overview of the performance outcome, provided in Figure 4, is one of the main outputs of this study, which shows the determinants (i.e. the contextual factors) for order-fulfilment strategies in one specific ETO industry (i.e. the machinery industry). It also indicates the effects that the strategic fit of the order-fulfilment strategies with the contextual factors characterising the market, product, and processes of the companies analysed has on performance.

The contributions of this study are both theoretical and empirical. From the theoretical viewpoint, this study increased the understanding of the determinants for order-fulfilment strategies in ETO companies, and the reasoning for shifting from one strategy to another, exploring contingencies affecting the CODP positioning in the two-dimensional framework recently introduced by Cannas et al. (2019). Very little research has addressed these issues in the past, even if recent studies underlined the importance to explore the topic and deepen and refine the outdated production literature by addressing empirical data in the ETO area (Gosling et al., 2017; Willner et al., 2016). Previous studies on ETO have supported the idea of the “one size does not fit all” and on the importance of the strategic fit in stable and closed MTS context, but none of them provided a rich description of contingencies affecting this choice in the ETO context. The discussion of the findings in this show shows how the cases provide new insights, building on the literature and introducing new interesting concepts, which will progress the theory and knowledge of the ETO realities. The market-, product-, and production-related factors identified in the literature have been enriched with the inclusion of the engineering perspective and its integration with production. In addition, the company perspective has been substituted with the product family perspective, including the possibility of multiple strategies in the same company. This increases the effectiveness of the analysis in representing reality and reducing the gap between theory and practice. In conclusion, these results further the ETO research, renovating the seminal studies on CODP positioning (Hallgren and Olhager, 2006; Olhager, 2003) and providing foundations for future research on the topic.

From an empirical viewpoint, this study presents an example of the application of the 2D-CODP framework to the machinery industry, providing empirical evidence of its power in representing the order-fulfilment strategies employed in the real ETO context. In addition, this study provides practical examples of how companies leading different market segments in the machinery industry define their order-fulfilment strategies. The results show that this strategic choice is not pre-defined and unique, and the best optimal strategy does not exist. This can be translated into a practical tool for companies. In fact, the cases analysed exemplify how the contingency-based framework can be practically used, opening the "black-box" of the theoretical constructs and providing practical examples of what are the contextual factors suitable for each strategy and the performance outcome expectations. Moreover, the empirical study shows how the different order-fulfilment strategies can be compared, providing a model for strategic decision making. This study is the first attempt to help ETO managers understand if they are implementing the most suitable strategy for achieving the desired performance outcome and what are the key resources that must be improved when facing changes in their competitive environment to align the organisational goals to new desirable performances. This contribution supports decision making in the challenging phenomenon of ETO companies that are pursuing good performance in multiple conflicting competitive priorities shifting towards mass customisation strategies.

Finally, although this study has been carefully designed considering all the essential aspects for assuring high qualitative outcomes, some limitations exist, which are not under the control of the researchers, opening interesting opportunities for further research. The case-study research is a qualitative approach which is primarily exploratory. On the one hand, this method helped the researchers build and refine the extant theory; on the other hand, it limited the possibility of using measurable data to quantify the problem and perform statistical analysis. Therefore, the application of quantitative methodologies to the framework developed in this study is considered a relevant opportunity for future research, helping validate the findings obtained. In addition, even if the conceptual framework has been developed considering literature conducted in other industries, this study assessed it only in one specific industry and one specific country. Consequently, further research is welcome to endorse and extend the findings of this research by addressing other ETO sectors.

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Appendix 1: case study protocol

Source 1. Face-to-face interview	
General questions	Company introduction (turnover, employees, sector, product portfolio) Interviewee/s introduction (role in the company, main interests, experience) Description of the product families provided by the company to the market
Order fulfilment strategy	*Referring to each product family:* What are the engineering activities performed after the customer order? What are the production activities performed after the customer order?
Market-related factors	*Referring to each product family:* What are the characteristics of the environment (aggregate market, single customer, etc.) not subject to direct control of the company but with which the product family must interact and interface? Do they affect the choice of the order fulfilment strategy? If yes, how?
Product-related factors	*Referring to each product family:* What are the main characteristics of the product (modular design, customisation opportunities, structure, etc.)? Do they affect the choice of the order fulfilment strategy? If yes, how?
Process-related factors	*Referring to each product family:* What are the characteristics of the engineering and production processes in terms of human and non-human resources? Do they affect the choice of the order fulfilment strategy? If yes, how?
Performance outcome	*Referring to each product family:* Assess company's performance, with respect to the market average (0 – not competitive, 1 – low competitive, 2 – on market average, 3 – competitive, 4 – very competitive), related to: (1) ability to provide the customers with a product price lower than the average price required by competitors within the market; (2) ability to provide customers with the desired product in short and reliable time from the receipt of the order to the delivery; (3) ability of the company to make adjustments in what and how much it realises, based on specific customer requirements; (4) ability to provide customers with a product in line with their expectations in terms of low risk for unexpected defects after sales; (5) ability of the company to provide customers with unique designs and up-to-date technologies.

Source 2. Direct observations	
Plant tour	Direct observation of the production department during working shifts and the physical components/subassemblies/finished product of the families described, with the possibility to ask further questions about the product and process characteristics to the employees and/or managers of the production department
Engineering department tour	Direct observation of the engineering department during working shifts and the existing designs and information related to the product families described, with the possibility to ask further questions about the product and process characteristics to the employees and/or managers of the engineering department
Source 3. Official documents	
Company's website	General company information (e.g. strategy, mission, history); product catalogues and information brochures related to the solutions provided by the companies (e.g. product range, technical characteristics, machine performance, product comparison);
News and press	Up-to-date news related to the company or its products (e.g. new technologies launches, new markets addressed, yearly evaluations)
National database	Economic reports and balance sheets
Source 4. Internal documents	
Digital or paper materials	Internal documents used by the company to support the engineering and production activities (e.g. budget, procedures, projects)

Appendix 2: An example of data analysis outcome (case H1)

Construct	Variable	Case H1	Quotes from interview
Order fulfilment strategy	Engineering readiness	The design of the product BoM is finalised to order, by applying major modifications to some of the existing components	"*When the order arrives, we offer a set of predefined options to the customer. In addition, there are also requests related to options that we have not developed yet. Therefore, we adapt the existing design to the customer order with major modifications of 30% (on average) of the existing components of the BoM"*
	Production readiness	Manufacturing activities have been already performed to forecast only for the strategic components of the BoM	*"We procure before the order only what we call strategic components: namely the long-supply materials. When the order arrives, we complete the remaining production and assembly activities*."
Contextual factors	Customer product knowledge (Market)	Full technical and functional product knowledge	*"The customer has high know-how and experience related to the product and exactly identifies the technical and functional specifications that wants. In this case the company must satisfy the requirements, by providing those precise specifications*."
	Customer size (Market)	Multinational companies	"*The customers are big size companies (multinational companies) specialised in specific markets, with a high willingness to pay and wait for the added-value technology and flexibility."*

	Demand variety (Market)	From 60% to 70%	*"Requirements for changes from the customer are typical. Indeed, on average, six/seven customers out of ten require changes after the order"*
	Technology life-cycle (Product)	Growing technology	*"This product family is characterised by technologies in the growing phase, following the state-of-the-art solutions with a high degree of innovativeness, namely the frequency of introduction of innovative solutions."*
	Customisation opportunities (Product)	Broad set of design options proposed to the customer	*"There is a technical specification document of over 90 pages that contains a series of options that are already planned and developed in the catalogue based on what we expect that the customer wants or wishes to have"*
	Modular design (Product)	Partially modular	*"We can reuse some of the existing designs thanks to the fact that the machines are partially modular and share the same heads, tailstocks or spindles. Even the axle and the engine that is mounted on these machines is the same, obviously paying particular attention to the various dimensions of each machine."*
	Sales process structure (Process)	Guided by a procedure with high degree of freedom	*"The sales and engineering process are structured. We have a specific procedure to respect, entrusted to a project manager. All the functions participate to develop this document every year and sign it. Nevertheless, the degree of freedom in applying changes to the budget is high in case of H1, because all the functions are aware of the impact of their decisions on the value chain.*
	Engineering process structure (Process)	Guided by a procedure with high degree of freedom	
	Production flexibility (Process)	Flexible to solve quickly requirements for reworks	*"It often happens to the production department to receive requirements for changes after the order. Our production department is flexible and able to quickly solve them. In terms of cost, if the impact is negligible, the request is met, and the process continues. If the requests have a great impact, the costs necessary to satisfy the requests are charged to the customer, unless they are due to sales or engineering department errors."*
	Sales, Engineering and Production interface (Process)	Need for exchanges of information and warnings between the functions	*"There is a need for inter-functional interfaces after the order. Indeed, the major changes applied to the product design require to quickly and precisely translate the customer order, output of the negotiation, in engineering specifications and production and assembly instructions. To do this, for example, we have specific IT systems that help in fastening the functions alignment"*
Performance outcome	Time	From 5 to 8 months	*"H1 is characterised by complex machines and is very competitive in terms of customisation level. The lead time required to delivery these products are usually included within 4 to 8 months, because there are numerous engineering and production activities to perform to order. […] The flexibility that we offer with this product family is high, we cover almost all the customer requirements for personalisation. This allows us to propose a premium price, but we want to keep it still competitive: it is usually 20% higher than the market average."*
	Price	20% more than the market average (about 1.2 million)	
	Flexibility	Customer requirements for changes are almost always met	
	Innovativeness	State of the art technologies	"*H1 is characterised by state-of-the-art turning and milling technologies. It is composed by the so-called multitasking machines, which can work several pieces at the same time.*

			They have two spindles, the possibility of turning and milling and a tool change function.”
	Reliability	Modification to existing components never tested before	“*When major modifications are applied to the existing design, the technology reliability is negatively affected: the number of errors increase in new designs and the possibility to anticipate any production or procurement constraint decreases because of the lack of any previous feedback received from these processes*.”