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Customer enquiry management and product customization

An empirical multi-case study analysis in the Italian capital goods sector

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Abstract

Purpose – The customer enquiry management (CEM) process is of strategic importance in engineer-to-order contexts but existing literature does not adequately describe how firms support delivery date setting and order acceptance decisions in practice. This paper seeks to explore how and why the CEM process varies between companies in the capital goods sector, thereby taking a contingency theory approach.

Design/methodology/approach – Multi-case study research involving 18 Italian capital goods manufacturers in four industrial sectors. Face-to-face interviews with senior representatives have been conducted. Companies have been grouped into five clusters, based on similarities in their CEM decision-making modes, to aid analysis.

Findings – Three contingency factors were found to be particularly relevant in determining CEM modes: degree of product customization, flexibility of the production system, and uncertainty of the context. These factors affect the choice of specific CEM decision-making modes. However, a high level of cross-functional coordination and formalization of the process were found to constitute best practices whatever the contingency factors.

Research limitations/implications – The research focuses on companies belonging to the Italian capital goods sector – findings may differ in other countries and sectors.

Practical implications – The results indicate that all firms, including small and medium-sized companies, should implement high levels of cross-functional coordination and formalization in their CEM practices, in order to improve their performance. For other aspects of the CEM process, including supplier and subcontractor monitoring, the company context will indicate whether these aspects are required, according to a need of matching the approach to CEM with specific sets of contingency factors.

Originality/value – This paper provides a rare insight into the CEM processes found in practice.

Keywords Customer service management, Customization, Delivery dates, Italy

Paper type Research paper

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Introduction

The current competitive landscape places manufacturers under increasing pressure to provide products and services that meet the particular requirements of individual customers. Many authors have acknowledged that in non-make-to-stock (non-MTS, i.e. customized) contexts, such as the engineer-to-order (ETO) capital goods sector, the ability to deal with increasingly differentiated requirements is crucial (Philipoom and Fry, 1992; Hicks *et al.*, 2000b; Ray and Jewkes, 2004). To quote competitive, reliable and realistic delivery dates (DDs) in this context, the customer enquiry management (CEM) process takes on strategic importance and has a large impact on firm performance (Kingsman *et al.*, 1993; Konijnendijk, 1994; Hicks *et al.*, 2000a; Watanapa and Techanitisawad, 2005). CEM can be defined as the process which takes place from the receipt of a customer enquiry to the processing of a confirmed order, including: determining whether the company wishes to make a bid for the enquiry; preparing cost and lead time estimates; and, determining the price and lead time to bid (Kingsman *et al.*, 1996). The CEM process is described by many authors as: multi-stage; cross-departmental; requiring close interactions with customers; and, a process in which the degree to which it can be formalized depends on the specific context (Hendry, 1992; Kingsman *et al.*, 1993; Konijnendijk, 1994; Kingsman, 2000).

Despite the practical importance of this topic, Ebben *et al.* (2005) explain that the relevance of bid preparation and related decisions has been neglected by the literature and underestimated in practice. A review of the literature supports this view and demonstrates that the CEM process has received far less attention than other production planning and control stages in non-MTS contexts (Kingsman *et al.*, 1996). The scarce homogeneity of non-MTS contexts and the difficulty of formalizing implicit decision mechanisms for managing customized product enquiries make it difficult to develop methods with general validity (Hicks and Braiden, 2000). As a result, the few existing CEM models: have been proposed with reference to specific cases (Vanwelkenhuysen, 1998); lack broad applicability; and, are rarely suitable for complex production systems (e.g. in capital goods manufacturing). In addition, the available literature does not sufficiently describe the often *ad hoc* managerial practices actually employed by firms and the integrating mechanisms supporting cross-functional coordination at the enquiry stage (Moodie and Bobrowsky, 1999). Therefore, there is much scope for further research.

Through a multi-case study approach, this research investigates current practices supporting the CEM process in the capital goods sector, which is characterized by high uncertainty and high customization (Hicks *et al.*, 2000a). Given that the delivery lead time is one of the most fundamental order-winning criteria in MTO and ETO contexts (Konijnendijk, 1994; Hicks *et al.*, 2000b; Hicks *et al.*, 2001), we focus on DD setting decisions, including the degree and nature of cross-functional coordination involved in the decision-making process.

The remainder of the paper is organized as follows. We begin with a review of the relevant literature followed by a justification of our research methodology. The conceptual model adopted as a starting point for this study is then presented before the findings of the study are discussed for five clusters of cases. The impact of alternative modes of CEM on performance is then discussed before the paper concludes.

Literature review

The main methods of supporting the DD setting process presented in the literature are described in what follows before cross-functional coordination is briefly discussed. Finally, the most relevant empirical studies concerning non-MTS industrial contexts are presented.

DD setting in non-make-to-stock contexts

In general, DDs are either estimated from an exogenous or an endogenous perspective. *Exogenous* methods consider DDs to be external to production planning activities, supporting order acceptance decisions and allowing the firm to evaluate order acceptance with certain DD specifications. Most exogenous methods proposed in the literature are at a low-level, i.e. scheduling approaches, and refer to deterministic contexts, with low uncertainty (Calosso *et al.*, 2003). Among the non-deterministic approaches, key contributions are made by Wullink *et al.* (2004) and Ebben *et al.* (2005). Firstly, Wullink *et al.* (2004) propose an analytical model for resource-loading problems that deals with the uncertainties that MTO companies face during order negotiation. Secondly, Ebben *et al.* (2005) develop a simulation model of a generic MTO job shop to test the performance of four-order acceptance methods ranging from straightforward to sophisticated.

Endogenous methods treat the DD as an output of production planning. A number of contributions deal with DD assignment problems at a scheduling level in job shops (Lawrence, 1994; Enns, 1995; Vandaele *et al.*, 2002). High level capacity planning problems are addressed by some of the approaches to DD management (Park *et al.*, 1999; Kingsman, 2000; Corti *et al.*, 2006; Stevenson and Hendry, 2006). The heuristic algorithm proposed by Park *et al.* (1999) is focused on capacity tests at an aggregate level. The distinctive feature of the models developed by Kingsman (2000) to manage dynamic capacity planning, and by Corti *et al.* (2006) to set reliable DDs, is the introduction of a probabilistic workload that considers orders waiting for customer confirmation. Stevenson and Hendry (2006) developed an aggregate load-oriented workload control concept followed by an empirical research project in a small to medium-sized MTO company.

With regard to capacity management problems, some authors deal with order promising and capacity allocation in tightly constrained systems in an integrated way. For example, Sridharan (1998) discusses three alternative dynamic approaches for the effective management of capacity: capacity rationing in order acceptance, improved coordination mechanisms, and subcontracting. Subcontracting is also incorporated in the models proposed by Kamien and Li (1990) and Bertrand and Sridharan (2001).

Some approaches proposed in recent years (Easton and Moodie, 1999; Moodie and Bobrowsky, 1999; Moses *et al.*, 2004) consider aspects that had been neglected by previous research but which have practical relevance. These include: individual order-specific characteristics, existing prior order commitments and the negotiation process with customers. However, all of the above research takes a primarily theoretical approach to proposing alternative methods of setting DDs. An outstanding issue remains: to investigate the extent to which these concepts are, or could be, used both in general practice, and in the capital goods sector in particular.

Cross-functional coordination in non-make-to-stock contexts

The CEM process often involves complex trade-offs (e.g. between price and delivery lead time), requiring inter-disciplinary expertise (Kromker *et al.*, 1997; Jin and Thomson, 2003). In particular, setting short and reliable DDs requires ongoing coordination between the sales and marketing and production departments at the enquiry stage (Kingsman and Mercer, 1997). The difficulty of managing the, often conflicting, objectives of these functions is highlighted by many authors. Crittenden *et al.* (1993) propose several categories of integrating mechanisms which aim to reduce the potential conflicts (e.g. organizational design, communication, and group decision support systems). Kate (1994) investigates alternative coordination mechanisms between production and sales activities at an operational level, identifying two extreme approaches for order acceptance (integrated and hierarchical coordination). St John and Hall (1991) identify possible coordination instruments, including formalized control procedures. The role of formalization in supporting cross-functional coordination is also highlighted by other authors, such as Javorsky and Kohli (1993) and Welker (2004).

While cross-functional coordination has received much attention, most contributions can be criticised. Firstly, most are either too broad or refer implicitly to repetitive manufacturing. Secondly, most focus on coordination problems at a strategic level, neglecting short-term cross-functional interfaces, as highlighted by Sawhney and Piper (2002).

Empirical studies in non-make-to-stock contexts

Most of the work in this area is simulation-oriented; few empirical studies have emerged. Rare exceptions include: Konijnendijk (1994), Hicks and Braiden (2000), Hicks *et al.* (2000a, b), Hicks *et al.* (2001), Welker (2004), Welker and De Vries (2005), Hendry *et al.* (2007b), and Soepenberg *et al.* (2007). Studies by Konijnendijk, Hicks and Welker are of particular relevance; their results are described below.

Konijnendijk (1994) discusses the interdependence of marketing and manufacturing and the resulting coordination requirements in ETO companies, based on an exploratory telephone survey and five case studies. Several coordination mechanisms at the tactical or operational level are proposed; however, further research is required to analyze in greater depth the impact of contingency factors (such as company size and product features) on coordination requirements and on the solutions identified.

The impact of contingency factors is considered by Hicks *et al.* (2000a) and Hicks *et al.* (2001). From case research, a model is presented which groups business processes in the capital goods industry into three categories: non-physical, physical and support processes. ETO companies are then classified by the structure of their physical processes. Results show that realizing the advantages to be gained from research and development, engineering design and suppliers depends upon knowledge and information sharing during the tendering process. Tendering is found to be a key business process in the analyzed cases and the relevance of cross-functional coordination is highlighted. Further research is needed to identify specific mechanisms to achieve coordination depending on the contingency factors identified. Other strategic issues relevant to the competitiveness of capital goods manufacturers are identified by Hicks and Braiden (2000) through a survey of non-MTS companies (followed by simulation experiments). Results suggest that capacity constraints have a considerable impact on manufacturing performance, highlighting the importance of capacity planning; the consistency of production plans with constraints could be improved by implementing formalized planning systems.

Welker (2004) and Welker and De Vries (2005) conducted multi-case study research to analyze the effects of formalization on the responsiveness of the ordering process in five companies. Analysis focussed on three dimensions (logistical decision making, information processing and organizational setting) and identified four-order processing patterns. Results show that the formalization of logistical control and the formalization of information processing activities have a positive influence on the responsiveness of the ordering process without compromising efficiency.

Assessment of the available literature in non-make-to-stock contexts

The existing literature fails to adequately describe the methods employed by firms in practice throughout the CEM process. Important new contributions could be made by:

- examining coordination mechanisms adopted by organizations (depending on specific contingency factors) as a means of identifying CEM best practices; and
- identifying what DD setting approaches are currently being used by firms in practice and evaluating the true practical relevance of the theoretical methods found in the literature.

This paper seeks to fill these gaps by taking a contingency theory approach to CEM, looking at how CEM varies according to the different contexts found in the capital goods sector.

Research methodology

The main objective of this study is to develop a deeper understanding of the managerial practices supporting CEM towards theory building regarding this phenomenon. The case method is a powerful means of building new and more elaborate theory; Voss *et al.* (2002) argue that the case method allows questions of *what*, *how*, and *why* to be answered, in order to fully understand the complexity of an object of analysis. Hence, the case research method has been adopted with the following research questions:

RQ1. *What* considerations underlie company choices concerning CEM modes in different industrial contexts?

RQ2. *What* is the impact of specific approaches to the CEM process on company performance in different contexts?

According to the structural contingency theory and the "one best fit" principle, there should be a fit between organizational processes and the environment (Burns and Stalker, 1961). Configurations that match the environmental requirements should lead to more successful performance than those that do not (Hicks *et al.*, 2001). Given the importance of contingency factors, a multi-case study research strategy has been implemented. This allows for an in-depth investigation of the effects of several business and environment factors on company choices and performance to be conducted.

Multi-case selection procedure

This research focuses on capital goods manufacturers in Northern Italy, all of which are characterized by an ETO production strategy. A total of 18 cases have been chosen so that a compromise is reached between depth of study, usually greater for small sample sizes, and the external validity and generalizability of results, increased by choosing large samples (Voss *et al.*, 2002). Cases have been selected according to theoretical replication logic, so that they produce contrary results but for predictable reasons (Yin, 2003; Eisenhardt and Graebner, 2007).

To create breadth and depth in the selection of cases, some company features were studied at the research design stage. For example, cases were carefully selected to include firms of differing size and enterprise structure. Turnover varies from 4 to 90 million euros; three of the sampled companies can be classified as small (<50 employees), fourteen as medium-sized firms ($50 <$ employees < 250) and one as a large company (employees > 250). This is consistent with the fact that SMEs are the most common context in Italian industry. Nine firms are independent companies; the others belong to multinational groups sharing decision-making policies and management procedures.

The companies belong to four sectors:

(1) tool machinery (e.g. transfer, pressing and profiling machinery: seven companies);

(2) plastic and rubber machinery (e.g. calendar and pressing machinery: five companies);

(3) textile machinery (e.g. spinning, weaving, and printing machinery: four companies); and

(4) packaging machinery (e.g. food packaging and bottling machinery: two companies).

Features of the individual companies, sorted according to industry sector, are summarized in Table I.

Questionnaire design, data collection and analysis procedure

A research protocol has been designed in order to aid the reliability and validity of data, including procedures for field work and research reporting, as detailed in Gillham (2000) and Yin (2003). Data have been collected through face-to-face semi-structured interviews with senior representatives from each company. In most cases, multiple respondents were interviewed to improve construct validity. In total, 30 managers were interviewed across the 18 companies. By job title, the respondents were: managing directors (4 respondents), production managers (12 respondents), sales managers (9 respondents), purchasing managers (3 respondents) and engineering managers (two respondents; Table I). In most of the cases, the managers responsible for DD setting have been interviewed. These have been identified before the interviews based on information gathered from some preliminary contacts with different members of the organizations. Interviews were transcribed to aid analysis before final reports were drafted.

Interviews were conducted using a predefined questionnaire with three main sections. The first section includes questions regarding general features of the company (e.g. strategic objectives, type of customers, critical success factors, CSFs) and characteristics of the products (e.g. modularity and type of customization). The second section covers production characteristics, focusing on the level of system flexibility, the network of suppliers and subcontractors, and the planning process. The third section investigates CEM, including general process features (e.g. process stages, required resources, degree of differentiation, order acceptance policy), information processing (e.g. input and output information, software tools supporting the process), organizational features (e.g. responsibility for DD setting and cross-functional

Table I.
Characteristics of companies interviewed

Sector	Company	Product	Turnover (million €)	Employees	Orders per year	Belonging to a group	Interviewees
Tool machinery	A1	Transfer machinery	15	160	12	Yes	Sales manager Production manager
	A2	Press machinery	7	50	15	No	Sales manager
	B2	Wire drawing machinery	50	200	200	Yes	Production manager Engineering manager
	B3	Grinding machinery	80	150	70	Yes	Managing director Production manager
	C2	Press machinery (metal)	65	300	100	Yes	Production manager Engineering manager
	D6	Vertical turning and milling machinery	50	130	25	No	Sales manager
	E2	Press and printing machinery	10	65	40	No	Production manager Purchasing manager
Plastics/rubber machinery	B1	Press machinery (plastics)	90	215	300	Yes	Production manager Sales manager
	B4	Plastics and rubber machinery	25	110	25	Yes	Managing director

(continued)

Table I.

Sector	Company	Product	Turnover (million €)	Employees	Orders per year	Belonging to a group	Interviewees
	C1	Machinery for tyre manufacturing	40	160	20	No	Production manager Production manager Purchasing manager
	D5	Extruding machinery (plastics)	4	20	25	No	Sales manager
	E1	Plastics machinery	60	200	50	No	Production manager
Textile machinery	D1	Texturizing machinery	12	65	25	Yes	Sales manager Production manager
	D2	Synthetic fibres working machinery	7	60	10	No	Sales manager Purchasing manager
	D3	Knitwear machinery	20	200	100	No	Managing director
	D4	Finishing machinery	10	40	30	No	Managing director Sales manager
Packaging machinery	A3	Bottling machinery	25	115	80	Yes	Sales manager Production manager
	C3	Packaging machinery for food and beverage	30	60	100	Yes	Production manager

coordination mechanisms), supply chain relationships (e.g. with suppliers, subcontractors and customers), and finally, the impact of the CEM mode on company performance (in terms of DD reliability). The questionnaire has been supplemented by the collection and analysis of secondary data, such as: archives of past tenders, production plans, and company websites. Collecting secondary data is one way in which the research has sought to increase validity and create triangulation (Voss *et al.*, 2002; Eisenhardt and Graebner, 2007).

Before collecting data, a conceptual model was developed based on the literature, as described in the following section. This provided the starting point for exploring how contingency factors affect decisions concerning CEM and the impact of these choices on company performance. Data analysis has been carried out by applying the proposed conceptual model to each case and conducting qualitative causal analysis, following the approach described by Voss *et al.* (2002). Cross-case analysis has then been conducted (Miles and Huberman, 1994), and clusters of companies formed based on common CEM modes. This allowed us to identify patterns. The existing theory, such as from Welker (2004), has been considered during the analysis.

Conceptual model

The conceptual model (Figure 1) consists of:

- CEM;
- contingency factors (which may influence this process); and
- measures of company performance.

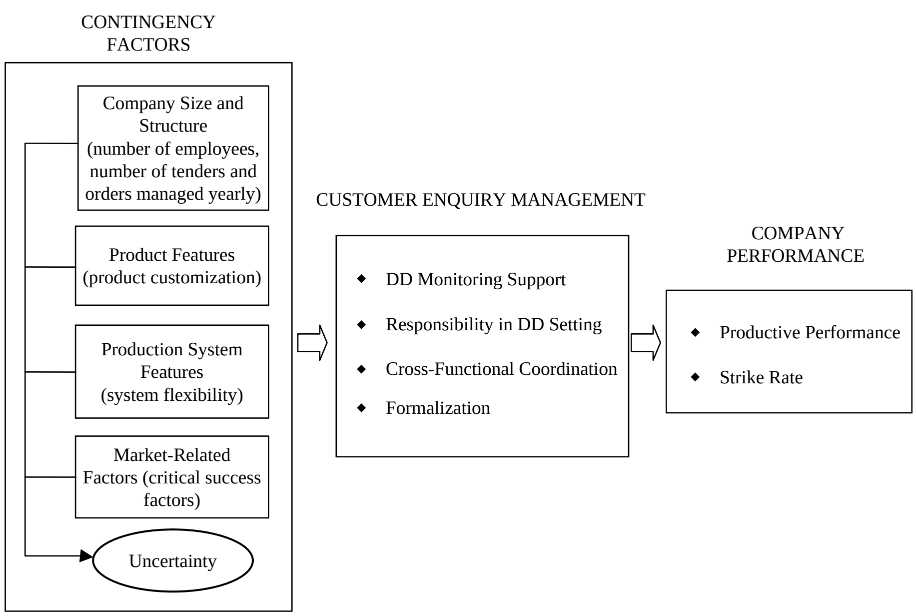

Figure 1.
Conceptual model and research framework

Each part of the model is described in turn below:

- *CEM.* The following strategic and operational decision-making choices within CEM are identified: DD monitoring support (Enns, 1995), responsibility for DD setting (Javorsky and Kohli, 1993), cross-functional coordination (St John and Hall, 1991; Crittenden *et al.*, 1993) and formalization (Javorsky and Kohli, 1993; Welker, 2004). Alternative methods are used for each of these four elements. For example, responsibility for DD setting can either rest with sales, with production (also referred to as operations in the literature) or be shared by both departments. These alternative methods are referred to as "decision-making modes" in the rest of this paper and are described when first introduced in the discussion of the empirical evidence.
- *Contingency factors.* Contingency factors that may impact the CEM process include both environment and business factors, such as: company structure (Hicks *et al.*, 2001), product features (Mikkola and Skiøtt-Larsen, 2004; Skipworth and Harrison, 2006), production system features (Koste and Malhotra, 1999; D'Souza and Williams, 2000; Vokurka and O'Leary-Kelly, 2000), market-related features (Kingsman *et al.*, 1996) and the uncertainty of the context (Davis, 1993; Muntslag, 1994). *Company structure* is analyzed in terms of company size (turnover and number of employees), number of orders per year, and activity configuration. Activity configuration refers to the degree of vertical integration along the value chain, i.e. the number of activities (engineering, manufacturing, and assembling) that are performed in-house rather than outsourced. Analysis of *product features* focuses on the most representative type of product for each company. Product structure is characterized by possible modularity and the percentage of standard components. Product customization is described by the way in which customization is achieved. Customization may be due, for example, to a different configuration of common parts; to some truly customized parts; or, to a completely new design. *Characteristics of the production system* that are of relevance for structuring the CEM process include: the positioning of the order penetration point and the level of system flexibility, which relates to volume flexibility. This analysis focuses on actual flexibility, rather than potential flexibility, and considers it as a relative attribute, as opposed to an absolute one. For this purpose, the level of system workload is taken into account and 12 flexibility options (internal and external) that are adopted by companies in the medium and short term are identified. These options can be used in order to provide volume flexibility in the order acceptance policy and in DD setting for specific orders. Internal flexibility options include:
  (1) overtime;
  (2) shifts;
  (3) multi-skilled operators;
  (4) overlapping operations;
  (5) reallocating operators between work centres;
  (6) producing normally outsourced components/sub-assemblies in-house; and
  (7) re-planning production.

External flexibility options include:

(8) temporary workers;

(9) subcontracting engineering activities to other firms;

(10) subcontracting assembling activities to other firms;

(11) subcontracting manufacturing activities to other firms; and

(12) reducing supplier lead times.

Market-related factors include the main CSFs, such as: lead time (in terms of both responsiveness and reliability); price; quality; technical features of a product; service; customization. For *uncertainty of the context*, three distinct categories for sources of uncertainty can be identified: demand uncertainty, process uncertainty, and supplier uncertainty. Possible sources of uncertainty referring to each single area have been monitored during the analysis. For demand, two elements are taken into account: product demand in terms of volume (at an aggregate level or per product type) and specific customer orders in terms of customer confirmation time and customer requirements after order confirmation. For internal and external processes, the following three elements are monitored: resource availability for engineering activities; resource availability for manufacturing activities; resource availability for assembling activities. For supply, supplier lead times are taken into account. Only certain factors among those aforementioned will be relevant to the analysis, as will be explained in the following.

- *Measures of company performance.* Two aspects of company performance are affected by decisions related to CEM. Firstly, productive aspects, which include both efficacy (e.g. delivery lead time, responsiveness and delivery reliability: Hicks and Braiden, 2000) and efficiency measures (e.g. system utilization rate: Hendry *et al.* (2007a)). Secondly, economic aspects, which include order profitability and the strike rate percentage, that is, the proportion of the quotations that become firm orders (Kingsman *et al.*, 1993). The analysis herein focuses primarily on productive efficacy measures, considered the most relevant for exploring the relationship between a company and its customers (Hicks *et al.*, 2000a). However, some efficiency measures, such as the system utilization rate, have been monitored during the analysis to exclude possible cases characterized by a close inter-relationship between efficacy and efficiency indicators (e.g. cases with a very low utilization rate and very good efficacy performance). Note that the system utilization rate does not differ significantly across most of the cases analyzed; moreover, in cases where the utilization rate is lower, poor efficacy performance has been found. The following two indicators have been considered as effective measures of DD setting performance: average delay in percentage terms compared to the delivery lead time and average percentage of delayed orders. The strike rate percentage is also taken into account and considered as additional information to the aforementioned indicators. As the strike rate may be influenced by both endogenous (the profit margin and the lead time quoted) and exogenous factors (customer characteristics, size of the potential order, and the bidding policies of competitors; Kingsman *et al.*, 1993; Kingsman and Mercer, 1997), this indicator will be particularly relevant if the strike rate is attributable to superior on-time and/or timely delivery performance.

Clusterization of cases

The CEM decision-making modes have been monitored for each of the cases. As contingency theory suggests that there should be a fit between the CEM process and situational variables, similar contingency factors are expected to be linked to the same patterns in terms of CEM decision-making modes across the cases. To aid analysis and discussion, the eighteen companies interviewed have been clustered into five groups according to their CEM decision-making modes. In order to identify similarities, a four-point scale (low, low-medium, medium-high, and high) has been used to classify the levels of cross-functional coordination and formalization characterizing each case. The procedures adopted to classify these two variables are illustrated in what follows through the use of examples.

The degree of *cross-functional coordination* at the customer enquiry stage has been analyzed by monitoring two elements: the departments involved in CEM decision making (sales, production, engineering, purchasing), and the integrating mechanisms adopted to support information exchange (Table II). For the latter element, the following four categories of integrating mechanisms are considered:

(1) telephone, e-mail system, paper;
(2) direct face-to-face contact;
(3) cross-functional meetings; and,
(4) information systems (fully integrated or partially integrated systems supporting CEM).

The coordination level is classified as high for companies in cluster B {B1, B2, B3, B4} and cluster C {C1, C2, C3}, all characterized by the maximum number of departments being involved and the maximum number of integrating mechanisms being in use. The coordination level is medium-high for companies in cluster A {A1, A2, A3} and cluster E {E1, E2}. In cases A1-A3 all four departments are involved at the customer enquiry stage but not all formal communication mechanisms are used. In cases E1-E2, although engineering and purchasing are not involved in CEM decision making, a close integration between sales and manufacturing is fostered through the used of three types of integrating mechanisms, including cross-functional meetings. Companies in cluster D {D1, D2, D3, D4, D5, D6} are characterized by a low-medium level of cross-functional coordination: apart from the sales manager, no other departments are systematically involved at the enquiry stage; however, the sales department can contact other departments by telephone, via e-mail and through direct contacts when needed.

The degree of *formalization* characterizing CEM has been analyzed by monitoring two elements: the way in which coordination is achieved and the degree to which the procedures and rules adopted at the customer enquiry stage are defined (Table II). For the former element, coordination may be achieved:

- At a structural level through pre-planned exchanges of information (e.g. cross-functional meetings or task forces) and information systems (fully integrated systems or partially integrated systems supporting CEM).
- In an informal way through direct contacts and information sharing on demand.

For the latter element, this study has analyzed whether procedures at the enquiry stage are clearly defined (i.e. with steps/rules for decision making). The level of formalization

Cluster	Company	Cross-functional Coordination: Departments Involved: Sales	Manufacturing	Engineering	Purchasing	Subtotal	Integrating Mechanisms: Telephone, E-mail, Paper	Direct Contacts	Cross-Functional Meetings	Information Systems	Subtotal	Overall Assessment	Formalization: Cross-functional Coordination: Pre-Planned Information Exchange	Meetings	Information Systems	Subtotal	Procedures: Steps of CEM Process	Decision-Making Rules	Subtotal	Overall Assessment
Cluster A	A1	X	X	X	X	4/4	X	X			2/4	M-H				0/3	X		1/2	L
	A2	X	X	X	X	4/4	X	X			2/4	M-H				0/3	X		1/2	L
	A3	X	X	X	X	4/4	X	X			2/4	M-H				0/3	X		1/2	L
Cluster B	B1	X	X	X	X	4/4	X	X	X	X	4/4	H	X	X	X	3/3	X	X	2/2	H
	B2	X	X	X	X	4/4	X	X	X	X	4/4	H	X	X	X	3/3	X	X	2/2	H
	B3	X	X	X	X	4/4	X	X	X	X	4/4	H	X	X	X	3/3	X	X	2/2	H
	B4	X	X	X	X	4/4	X	X	X	X	4/4	H	X	X	X	3/3	X	X	2/2	H
Cluster C	C1	X	X	X	X	4/4	X	X	X	X	4/4	H	X		X	2/3	X		1/2	M-H
	C2	X	X	X	X	4/4	X	X	X	X	4/4	H		X	X	2/3	X		1/2	M-H
	C3	X	X	X	X	4/4	X	X	X	X	4/4	H		X	X	2/3	X		1/2	M-H
Cluster D	D1	X				1/4	X	X			2/4	L-M	X			1/3	X		1/2	L-M
	D2	X				1/4	X	X			2/4	L-M	X			1/3	X		1/2	L-M
	D3	X				1/4	X	X			2/4	L-M	X			1/3	X		1/2	L-M
	D4	X				1/4	X	X			2/4	L-M	X			1/3	X		1/2	L-M
	D5	X				1/4	X	X			2/4	L-M	X			1/3	X		1/2	L-M
	D6	X				1/4	X	X			2/4	L-M	X			1/3	X		1/2	L-M
Cluster E	E1	X	X			2/4	X	X	X		3/4	M-H		X		1/3	X		1/2	L-M
	E2	X	X			2/4	X	X	X		3/4	M-H		X		1/3	X		1/2	L-M

Table II.
Levels of cross-functional coordination and formalization for the companies interviewed (L, low; M, medium; H, high)

has been classified as high for companies B1-B4, where all information exchanges are pre-planned (either by telephone, e-mail system, paper on fixed dates or by weekly cross-functional meetings) and information systems (ERP systems in three of the cases) are adopted. Furthermore, procedures are clearly defined (e.g. for direct contact with the customer, for coordination with other internal departments or supply chain partners, for negotiation with the customer, for analyzing possible flexibility options) with rules for decision making at each step (e.g. the specific conditions for taking into account possible internal or external flexibility options, such as an eight-day minimum deviation of the planned DD from the DD required by the customer in B2). While some defined steps can be identified in all of the cases analyzed, specific rules to manage standard and non-standard scenarios have not been found in any other cases within the sample. Companies C1-C3 are characterized by a medium-high level of formalization as two of the three possible formalized integrating mechanisms are adopted in these cases, including partially or fully integrated information systems. The level has been classified as low-medium for several companies D1-D6 and E1-E2, where only one formalized tool supporting integration can be found (i.e. cross-functional meetings for companies E1-E2 or telephone and e-mail system at fixed dates in addition to on-demand contacts for the remaining companies). Finally, the formalization level is low in companies A1-A3, where information exchanges are usually managed on-demand.

Considering the limited size of the sample, it has to be noted that clusterization is mainly aimed at supporting the analysis of a rich data set rather than obtaining representative clusters. The CEM decision-making modes characterizing each cluster are shown in Table III.

The contingency factors characterizing each of the identified clusters (A-E) were then analyzed to verify internal homogeneity (or lack of homogeneity). Three contingency factors from the conceptual model were found to be homogenous within each cluster; these are therefore considered particularly relevant for explaining similarities in the CEM decision-making modes: product customization; system flexibility; and, uncertainty of the context. Contingency factors and distinguishing features characterizing each cluster are presented in Table IV.

A three-point scale (low, medium, high) has been adopted to classify the contingency factors. For example, three levels have been adopted to describe the degree of *product customization*, each level corresponding to a possible way in which customization can be achieved (Table V):

(1) low (L) product customization: different configurations of common parts with some limited customization;

(2) medium (M) product customization: some truly customized parts (largely based on previous projects); and

(3) high (H) product customization: a completely new design.

For *system flexibility*, three levels (low, medium, high) have been adopted based on the total number of flexibility options (both internal and external) used by each company in the medium and short term (Table VI). For instance, the level is low for A2, where the use of external flexibility options is minimized (to reduce costs). The only sources of flexibility are overtime and using additional shifts together with some flexibility deriving from suppliers. On the contrary, the level of flexibility is high for D1, where almost all the internal and external flexibility options (apart from producing normally

Table III.
Decision-making modes for the identified clusters

DD monitoring support	Responsibility for DD setting	Cross-functional coordination	Formalization
Lead times			
Workload			
Subcontractors			
Suppliers			
Cluster A			
Detailed analysis	Sales	Medium-high	Low
Systematic			
None			
Occasional			
Cluster B			
Standard	Shared by all departments	High	High
Systematic			
Systematic			
Systematic			
Cluster C			
Detailed analysis	Production	High	Medium-high
Systematic			
None			
Systematic			
Cluster D			
Standard	Sales	Low-medium	Low-medium
Occasional			
None			
None			
Cluster E			
Standard	Production	Medium-high	Low-medium
Systematic			
Occasional			
Occasional			

outsourced components/sub-assemblies in-house) can be used when setting DDs and making order acceptance decisions. The level of flexibility has been classified as high also for companies D2-D4, for which workload flexibility is guaranteed by a usually low utilization rate. However, it is noted that workload flexibility mainly refers to equipment availability rather than workforce.

For the level of *uncertainty*, each of the three pos sible sources of uncertainty (demand, process, and supply) were first assessed separately (based on the number of uncertain factors identified during the interviews which relate to each of the three categories). Then, a qualitative assessment was undertaken to classify the degree of uncertainty of the context a company operates in at an aggregate level (low, medium or high). The main source of uncertainty has also been specified (Table VI).

Although less relevant, company size/structure and market related features can also explain some differences within clusters, and are referred to where relevant. A full discussion of the links between contingency factors and CEM decision-making modes follows in the next section. Note that, in many cases, the combined impact of multiple contingency factors is important to the explanation of company choices.

Table IV. Contingency factors and performance of the identified clusters

Cluster (X1-XN: companies in the cluster)	Cluster contingency factors	Distinguishing feature(s) of cluster	Cluster performance		
			Strike rate (percent)	Average delay (percent compared to delivery lead time)	Delayed orders (percent)
A (A1-A3)	Low system flexibility Medium uncertainty (high demand uncertainty) Low product customization	Highly informal companies	13	14	20
B (B1-B4)	Low system flexibility High uncertainty (high process uncertainty, supply uncertainty) Medium product customization	Highly formal and integrated companies	31	4	5
C (C1-C3)	High system flexibility Low uncertainty (low demand and process uncertainty, though with supplier uncertainty) High product customization	Highly customer driven companies	18	11	10
D (D1-D6)	High system flexibility Low uncertainty Low product customization	Highly flexible companies	24	12	23
E (E1-E2)	High system flexibility High uncertainty (high process uncertainty, supplier uncertainty) Medium product customization	Highly flexible companies operating in very uncertain contexts	15	8	18

Table V.
Levels of product customization for the companies interviewed (L, low; M, medium; H, high)

Company	Product customization	Qualitative assessment
Cluster A		
A1	Different configuration of common parts plus some limited customization	L
A2	Different configuration of common parts plus some limited customization	L
A3	Different configuration of common parts plus some limited customization	L
Cluster B		
B1	Some truly customized parts	M
B2	Some truly customized parts	M
B3	Some truly customized parts	M
B4	Some truly customized parts	M
Cluster C		
C1	New design	H
C2	New design	H
C3	New design	H
Cluster D		
D1	Different configuration of common parts plus some limited customization	L
D2	Different configuration of common parts plus some limited customization	L
D3	Different configuration of common parts plus some limited customization	L
D4	Different configuration of common parts plus some limited customization	L
D5	Different configuration of common parts plus some limited customization	L
D6	Different configuration of common parts plus some limited customization	L
Cluster E		
E1	Some truly customized parts	M
E2	Some truly customized parts	M

Factors influencing CEM modes

In this section, *RQ1* is discussed, which considers the influence of contingency factors on CEM modes. The main patterns identified for each of the four elements of CEM are discussed below.

DD monitoring support

The DD monitoring support can be divided into four issues, as illustrated in Table II. *Firstly*, the lead time setting mode can either be based on an average standard lead time or be calculated using detailed analysis for each new enquiry. The method of performing detailed analysis varies in sophistication depending on the support system, which is also linked to the level of formalization characterizing CEM. For instance, fully or partially integrated systems are available in companies belonging to cluster C (characterized by medium-high formalization) to support lead time setting in a coordinated way between departments. On the contrary, in cluster A (characterized by low formalization), the analysis is not supported by formal capacity requirements planning; lead times are mainly based on estimations by the sales manager with

Cluster	Company	System Flexibility: Internal Flexibility: (1) Overtime	(2) Shifts	(3) Multi-skilled Operations	(4) Overlapping Operations	(5) Reallocating Operators	(6) Producing in-house	(7) Re-planning Production	Subtotal	External Flexibility: (8) Temporary Workers	(9) Subcontracting Engineering	(10) Subcontracting Assembling	(11) Subcontracting Manufacturing	(12) Reducing Supplier Lead Times	Subtotal	Overall Assessment	Uncertainty: Demand: Volume	Customer Confirmation	Customer Requirements	Subtotal	Process: Engineering	Manufacturing	Assembling	Subtotal	Supplier: Supplier Lead Times	Overall Assessment
Cluster A	A1		X			X			2/7				X	X	2/5	L	X	X	X	3/3			X	1/3		M
	A2	X	X						2/7					X	1/5	L	X	X	X	3/3			X	1/3		M
	A3	X		X					2/7					X	1/5	L	X	X	X	3/3				0/3		M
Cluster B	B1	X				X			2/7				X		1/5	L	X			1/3	X	X	X	3/3	X	H
	B2			X		X			2/7	X					1/5	L		X		1/3	X	X	X	3/3	X	H
	B3	X				X			2/7		X				1/5	L	X			1/3	X	X	X	3/3	X	H
	B4	X							1/7	X	X				2/5	L	X			1/3	X	X	X	3/3	X	H
Cluster C	C1	X	X	X	X			X	5/7	X		X	X		3/5	H				0/3	X			1/3	X	L
	C2	X	X	X	X	X		X	6/7	X		X	X		3/5	H				0/3	X			1/3	X	L
	C3	X	X	X	X	X		X	6/7	X		X	X		3/5	H	X			1/3				0/3	X	L
Cluster D	D1	X	X	X	X	X		X	6/7	X	X	X	X	X	5/5	H	X			1/3			X	1/3		L
	D2					X			1/7						0/5	H	X			1/3	X			1/3		L
	D3					X			1/7						0/5	H				0/3		X		1/3		L
	D4					X			1/7						0/5	H	X			1/3			X	1/3		L
	D5	X	X	X	X	X		X	6/7	X			X	X	3/5	H	X			1/3				0/3		L
	D6	X	X	X	X	X		X	6/7	X	X	X	X	X	5/5	H	X			1/3	X			1/3		L
Cluster E	E1	X	X		X	X		X	6/7	X		X	X		3/5	H	X	X		2/3	X	X	X	3/3	X	H
	E2	X	X		X	X	X	X	6/7			X		X	2/5	H	X		X	2/3	X	X	X	3/3	X	H

Table VI. Levels of system flexibility and uncertainty for the companies interviewed (L, low; M, medium; H, high) interaction with other departments if needed. Historical data are usually used to support this purpose; a product configuration system is also available in A1. Average standard lead times are usually used at the enquiry stage if products involve moderate customization and design activities are limited (as in cluster D). If products are highly customized and require extreme re-design, detailed analysis is usually conducted to set lead times for specific orders (as in cluster C, where products cannot be classified into well-defined families). The impact of product customization needs to be taken into account together with the level of demand uncertainty, as shown by clusters A, B, and E:

- Even though the degree of customization of products offered by companies in cluster A is low, companies carry out detailed analysis. This is explained by the fact that customers often require tight DDs and demand uncertainty is high compared to other clusters, which makes the system workload highly variable and average lead times unreliable. Given that DDs are considered an order winner, detailed analysis seems reasonable.
- Even though the degree of customization of products offered by companies in clusters B and E is medium, the companies quote based on average standard lead times. In the case of cluster B, this is explained by low demand uncertainty, which makes this approach quite reliable and allows firms to plan part of the production for stock. In the case of cluster E, this is explained by the fact that system flexibility is very high.

Therefore, this study has found a link between the approach taken to lead time setting and the levels of product customization and demand uncertainty (which impact jointly on the ability to quote manufacturing lead times).

Secondly, the level of workload monitoring involved in lead time setting is either systematic or occasional. Most clusters systematically monitor the internal workload at the enquiry stage. The purpose of this is to calculate DDs when detailed analysis is used for DD setting (as in clusters A and C) or to check that "normal" conditions prevail when using standard lead times to set the DD (as in clusters B and E). In some of the cases analyzed (e.g. company A1), a time limit after which the bid lapses exists; a new quotation is then made. Companies C1, E1 and E2 take potential orders characterized by high confirmation probability into account when answering new customer enquiries. However, due to the low average strike rates, most of the firms in the sample prefer not having a time limit, thereby implementing a sort of overbooking strategy. Only cluster D conducts workload analysis occasionally. All the companies belonging to cluster D are characterized by a very high level of system flexibility. They can be divided into two groups according to the source of flexibility, as follows:

(1) Companies D2-D4 are from the textile sector and are experiencing increasing competition from Middle and Far East manufacturers. Interviewees from the companies do not perceive a need to check workloads at the enquiry stage as the utilization rate of work centres is very low, meaning this is not a DD setting constraint. For example, the Managing Director in D3 explained that:

> [. . .] while ten years ago the capacity requirements were typically much higher than the available capacity, nowadays enquiries are hardly ever rejected. This may happen only when customer requirements are too different compared to the previous projects or the associated profit margins are really low.

(2) Companies D1, D5 and D6 are characterized by a very wide range of flexibility options that can be implemented during order processing in order to fulfil predefined DDs. This allows D1 to focus on producing competitive bids (both in terms of DD and price), irrespective of the workload. The sales manager explained that:

> [. . .] delivery lead times lower than the ones theoretically needed have to be quoted to the customer in order to compete in the market. This leads us to take some risks and adopt some special actions, like obtaining components before order confirmation by the customer.

Company D6 differs as it systematically monitors the workload at the enquiry stage but does not consider the output as a constraint for accepting new orders. This is explained by the high level of system flexibility and the wide range of flexibility options that can be implemented by the company during order processing in order to fulfil predefined DDs; the habit of carrying out a monitoring activity reflects past conditions such as lower production flexibility and higher demand. However, D6 has been grouped in cluster D as this is the only difference in CEM modes compared with the other five companies.

Thirdly, the extent to which the availability of subcontractors is checked at the enquiry stage is either systematic, occasional or there is no monitoring at all. For three of the clusters (B, C and E), this is closely related to the levels of uncertainty and flexibility; for cluster A, this reflects company objectives. In cluster B, where process uncertainty is the highest and external flexibility is very low, firms monitor availability systematically. In cluster E, where there is high process uncertainty but several flexibility options, firms monitor availability occasionally. In clusters C and D, where there is low uncertainty (demand and process) and high system flexibility, firms do not monitor the availability of subcontractors at all. In cluster A, the availability of subcontractors is not monitored because the company tend to minimize the use of subcontracting and focus on in-house capacity related issues.

Fourthly, the monitoring of suppliers at the customer enquiry stage is closely related to the level of uncertainty surrounding supplier lead times and the flexibility of suppliers. In general: the higher the level of supplier flexibility, the less important it is to monitor capacity availability; and, the greater the uncertainty surrounding supplier lead times, the more important monitoring/contacting suppliers during the CEM process becomes. In clusters B and C, where there is high supply uncertainty and low supplier flexibility, firms systematically monitor suppliers. The purchasing manager in C1 explained that:

> [. . .] in the case of customized components, suppliers are always contacted at the enquiry stage. As DD reliability is strategically important for customers, the suppliers' workload needs to be known, especially in the case of long and/or highly variable delivery times.

In contrast, in cluster D, where there is the lowest supply uncertainty, firms do not systematically monitor suppliers. In clusters A and E, firms monitor supply availability only occasionally. In cluster A, most components are quite standard, delivery lead times are reliable and suppliers are relatively flexible. In cluster E, although supply lead times can be long and variable, there is high system flexibility and customers that will tolerate small delays.

Based on these results, detailed analysis for DD setting is carried out in the capital goods sector if:

- products are highly customized and endogenous lead times need to be set using detailed workload analysis (as in cluster C);
- there is limited product customization but high demand uncertainty and low system flexibility, meaning endogenous lead times need to be set using detailed workload analysis (as in cluster A); and
- it is important to check for "normal" conditions when standard lead times are being used to quote DDs (as in clusters B and E).

Supplier and/or subcontractor monitoring are included in detailed analysis only if there is high supply uncertainty or low supply flexibility. Even then, there is a sizeable gap between theory and practice: most of the methods being developed in the literature (Moodie and Bobrowsky, 1999; Moses *et al.*, 2004) are far more sophisticated than those used in the cases studied and require more information than is available in practice. When there is uncertainty (even low uncertainty, such as in clusters C and D) it is difficult to formalize and quantify the CEM process; the production planner in C2 argued that: "learning by experience is vital to setting reliable DDs" while the production manager in A1 stated that: "the chance of actually getting an order is estimated based on sales manager's feeling". Similarly, the sales manager in D5 explained that: "a simulation module is available to evaluate alternative DD setting decisions, but it is not used. Owing to the high level of information uncertainty, qualitative estimations are preferred". Non-deterministic models that require aggregate data (Park *et al.*, 1999; Wullink *et al.*, 2004) seem more suitable to the contexts analyzed.

Responsibility for DD setting

The following discussion is organized into three parts according to responsibility for DD setting (sales, production and shared):

(1) *Sales.* Firms in clusters that entrust responsibility to the sales department are usually small with low product customization and limited activities of product design linked to customization. As a result, the sales manager can use previous bids/projects to make a decision. For cluster D, the low system utilization rate and the objective of maximizing turnover make knowing production plans in detail of minor importance when setting DDs. For cluster A, it is claimed that entrusting responsibility to the sales department reflects high demand uncertainty (including product specifications), which makes it important to interact with customers when making decisions. The sales manager in A1, for example, described the CEM process as very long and highly complex:

> [. . .] the average time needed for order confirmation is 12 months but the process may last 24-30 months. During this period interactions and meetings with customers are really frequent and the ability of the sales manager to understand customer requirements is of primary importance for order confirmation. The market is highly competitive and the average strike rate is 10 percent only.

Note that a very long time needed for order confirmation is a common feature among all the companies analyzed, especially for those belonging to cluster A. In clusters D and A, the monitoring activity is simplified and considered to be relatively easy because the availability of subcontractors is not checked and the capacity of suppliers is only checked occasionally. If problems do arise, in most cases the sales manager can consult other departments. Hence, results suggest a link between two decision-making modes: responsibility for DD setting and DD monitoring support (Figure 2 and the discussion on cross-functional coordination below).

(2) *Production*. Firms in clusters that entrust responsibility to the production department are typically characterized by high or medium product customization, requiring a close relationship between engineering and manufacturing. High product customization in particular requires an efficient production cycle and the impact of customization on manufacturing lead times to be estimated. It is also important to consider the impact of production flexibility on production planning, a task often carried out by the production manager. The monitoring activity at the enquiry stage is quite complex for clusters C and E as it includes checking supplier availability. The production manager in C3, for example, described the DD setting process as:

> [. . .] a multi-dimensional issue which requires consideration of customer requirements, the level of workload in the system and the flexibility options that are available. The evaluation needs carrying out from both a time and cost point of view.

(3) *Shared*. In cluster B, characterized by medium product customization and low system flexibility, responsibility for DD setting is shared among all departments. The low number of options available to achieve flexibility means that these firms must come to an arrangement that guarantees both effectiveness and efficiency for all departments. The production manager in B1, for example, said that: "interactions among different departments . . . are useful for highlighting problems and possibilities for improvement". High supplier and process uncertainty and the high number of orders per year do not allow the sales department to determine DDs without consulting production. Moreover, monitoring the availability of resources is claimed to require all departments to be involved as it includes systematically checking: the internal workload, suppliers and sub-contractors.

There is a clear link between responsibility for DD setting and product customization (Figure 3), with low product customization leading to responsibility being assigned to sales alone and medium or high product customization requiring the production department to have responsibility (either alone or jointly with sales). However, there is no clear pattern to explain when responsibility should be shared rather than assigned to one department alone. For example, part of the rationale of companies in cluster A to

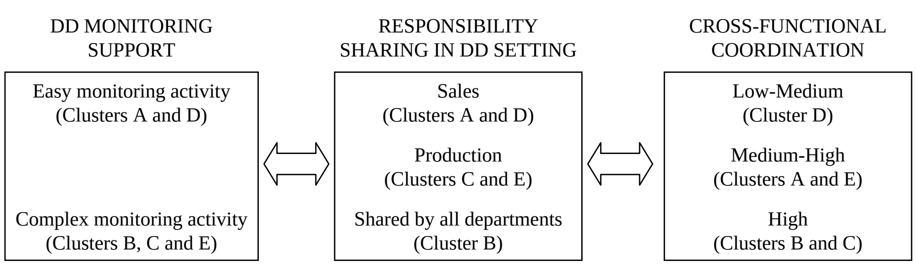

Figure 2.
Links between CEM decision-making modes

assign responsibility to sales is high demand uncertainty (including customer requirements), which makes it important to interact with customers when making decisions. However, issues of uncertainty in product specifications surely require the direct involvement of production. Similarly, the arguments for production alone taking responsibility in clusters C and E include the need to look at system flexibility. Although it is acknowledged that production is better able to assess these options, it could be argued that sales need to be involved in order to gauge the impact of possible options on the competitiveness of the DD that is determined. It may be that in the end, the department that is primarily responsible for DD setting is less important and what counts more is the degree and nature of cross-functional coordination that is achieved. Therefore, it is important to consider how these elements interrelate and whether certain patterns of behaviour lead to better business performance.

Note that where internal workloads are systematically monitored, production has some or all the responsibility for DD setting in all cases except cluster A. In cluster A, although the internal workload is monitored to calculate the DD using an endogenous approach, sales has sole responsibility. This is thought to be possible because of the limited size of the control problem for most companies in cluster A, allowing an efficient exchange of information without the direct involvement of production. This supports the argument that the issue of cross-functional coordination may be more important than which department is responsible for DD setting.

Cross-functional coordination

Analysis has shown that: when responsibility is shared, there is very high cross-functional coordination (cluster B); when the production department takes responsibility there is medium-to-high cross-functional coordination (clusters C and E); and, when the sales department takes responsibility the level of cross-functional coordination can be low (cluster D). Therefore, this study has found a link between cross-functional coordination and responsibility for DD setting (Figure 2). Cluster A provides an exception as it has medium-to-high cross-functional coordination despite sales taking sole responsibility. Overall, it can be concluded that where the responsibility was given to one department alone, and the reasons for this were questionable (as discussed in the previous section for clusters A, C and E), there is medium-to-high cross-functional coordination in all cases. This may make the decision-making mode for the responsibility of setting DDs less important.

High demand uncertainty, together with a low level of system flexibility, seems to explain why cluster A provides an exception to the link between cross-functional coordination and responsibility in DD setting. Analysis also suggests that uncertainty has a strong impact on the degree of cross-functional coordination and the mechanisms

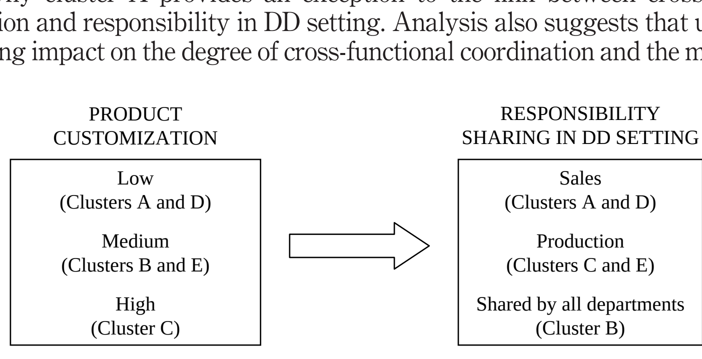

Figure 3.
Impact of contingency factors on responsibility sharing in DD setting

adopted to achieve coordination for clusters B, D and E (Figure 4). In general, the higher the uncertainty, the higher the level of cross-functional coordination achieved. Cluster C, characterized by low uncertainty, is the exception to the above as coordination is high. This is explained by high product customization, making it necessary to develop close relationships between production and the other departments (particularly if the product configuration process is not formalized, as explained by the purchasing manager in C1). Therefore, while uncertainty remains the most important consideration, product customization also contributes to explaining the need for cross-functional coordination at the enquiry stage.

Formalization

In general terms, the more departments involved in the CEM process and the more aspects that need to be monitored for DD setting, the higher the degree of formalization needed to create an efficient process. For cluster B, characterized by a shared responsibility for DD setting, high cross-functional coordination and a complex monitoring activity, there is a high level of formalization. For cluster D, characterized by responsibility for DD setting being entrusted to sales, low cross-functional coordination and a simpler monitoring activity, there is a low-to-medium level of formalization.

This study has also found a link between formalization, company size and type(s) of uncertainty. For example, formalization is low in cluster A, where companies are small-to-medium sized, where there are a limited number of orders each year and there is high uncertainty (demand and customer requirements) which makes it difficult to formalize decision-making procedures. The sales manager in A1 explained that:

> [. . .] communication inside the company is kept quite informal in order to guarantee high flexibility. The organization needs to be agile to deal with the high information uncertainty related to customer requirements.

In contrast, in cluster B, formalization is high as companies are large and there are a high number of orders, meaning informal control of the CEM process is impractical. Furthermore, the main sources of uncertainty are process and supply (rather than demand), making it easier to formalize procedures and rules at the enquiry stage.

Impact of CEM modes on company performance

This section considers *RQ2* and asks: what is the impact of the alternative CEM modes on company performance? The performance of the five clusters for the efficacy

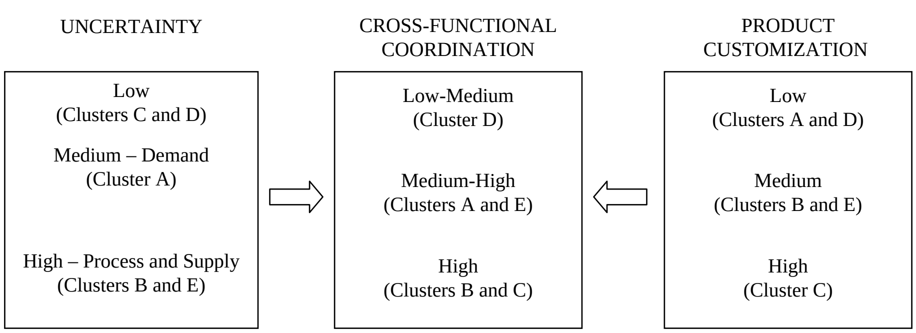

Figure 4. Impact of contingency factors on cross-functional coordination

measures is summarized in Table IV, while Table VII shows these measures for each company interviewed. It can be seen that cluster B has the best business performance results, followed by clusters C and E; while clusters A and D have the poorest performance indicators.

Data suggest that high cross-functional coordination at the enquiry stage is an effective means of minimising delays. This supports the findings of Hicks *et al.* (2000a, b), particularly with regard to the involvement of procurement in tendering. Clusters B and C, with the highest levels of cross-functional coordination, have both the lowest number of delays (cluster B) and the shortest delays; they proactively involve several departments and share information at the enquiry stage, using many sources of information to set realistic and reliable DDs. In contrast, cluster D, with the worst percentage of delayed orders has the lowest level of cross-functional coordination. Several of the managers interviewed argued that it is important that departments have the ability to interact directly with one another throughout the whole quotation phase; this allows both customer requirements and internal constraints to be taken into account. Therefore, it is concluded that, although company choices can be explained based on specific sets of contingency factors (Figure 4), the level of cross-functional coordination required does not depend on the contingency factors identified, but that higher levels will lead to better performance irrespective of the company context. Furthermore, clusters B, C and E deliver more reliably than cluster D, despite the higher level of product customization (high for cluster C and medium for clusters B and E).

Similarly, the level of formalization achieved seems to be closely related to performance, with the best performing cluster (cluster B) having the highest level of formalization and the lowest level of formalization being associated with one of the poorest performing clusters (cluster A). Therefore, again, it is concluded that evidence

Table VII.
Performance of companies interviewed

	Company	Company performance Average delay	Average DLT (month)	Average delay (percentage compared to DLT)	Delayed orders (percent)	Strike rate (percent)
Cluster A	A1	1 month	12	8	30	10
	A2	20 days	6	11	10	8
	A3	2 weeks	2	23	19	20
Cluster B	B1	2 weeks	12	4	7	20
	B2	1 week	4	6	8	35
	B3	-	12	0	0	38
	B4	1 week	7	3	3	32
Cluster C	C1	3 weeks	8	9	12	15
	C2	2 weeks	9	5	9	8
	C3	2 weeks	3	15	9	30
Cluster D	D1	10 days	3	11	15	20
	D2	1 month	8	13	30	55
	D3	1 week	1	23	40	10
	D4	2 weeks	3	16	25	10
	D5	10 days	3	11	10	25
	D6	2 months	14	14	15	10
Cluster E	E1	2 weeks	6	8	20	15
	E2	2 weeks	6	8	10	15

suggests that desirable levels of formalization do not depend on the contingency factors. It is argued that formalized procedures, organizational setting and information sharing reduce the need to achieve integration by lateral relations and direct informal contacts. This has a positive impact on the efficiency of CEM, as argued by Welker (2004). A high level of formalization usually leads to high monitoring and control of the process, which can help to reduce delays.

With regard to the joint impact of cross-functional coordination and formalization of CEM on company performance, responsibility for DD setting seems to be relevant when the corresponding levels of the above two factors are different, such as for clusters A and E. These two clusters are characterized by medium-high coordination and low or low-medium formalization, but cluster E is characterized by higher performance in terms of delivery reliability. The fact that the sales department is responsible in companies belonging to cluster A while responsibility is entrusted to production (whose knowledge of resource availability and internal workload is usually higher) in cluster E may explain this result.

For other aspects of CEM, it is argued that several alternative choices concerning a decision-making mode may all lead to good performance with reference to different contingency factors (across and within clusters). Hence, this is a complex and multi-dimensional issue. For example, performance in clusters B and C is good despite company choices being quite different (depending on contingency factors). Firms belonging to cluster B, characterized by high uncertainty (process and supply) and low system flexibility, use average standard lead times to define DDs and systematically monitor external resource availability. Firms belonging to cluster C, characterized by low uncertainty and high system flexibility, do not monitor the capacity of subcontractors but carry out detailed and systematic analysis to set lead times and define DDs.

Analysis has also shown that there may be differences between the most suitable practices even for companies belonging to the same cluster. For example, in cluster D choosing to monitor the system workload occasionally only at the enquiry stage and not to take into account the availability of external resources seems to be quite effective only for D5, whose performance is close to the sample average. D5 is the smallest firm within the sample and its main strength is a very high level of flexibility. This confirms that, *ceteris paribus*, the size of the control problem (i.e. the number of orders managed per year and/or the number of employees) may also have an impact on the level of performance achieved. The performance of D3, characterized by a large size of the control problem (i.e. 100 orders managed per year and 200 employees), is the worst performing company in the whole sample. The impact of the size of the control problem can also be highlighted in cluster A. Here, the worst performing company is A3, due to the fact that achieving informal coordination and assigning responsibility for DD setting to the sales department is difficult when the number of orders managed per year and/or the number of employees is large. In contrast, quite good performance in terms of DD reliability (compared to the sample average) is achieved by A2, which is a small-sized firm managing 15 orders per year.

All things being equal, a direct impact of contingency factors on company performance can also be identified. For instance, higher demand pulsing will make responding to customer requests effectively and efficiently more difficult compared to situations characterized by less demand variability. This may impact on performance of firms belonging to cluster D. Although this is not the focus of the analysis, it is a notable result that calls for further research, as will be highlighted in the conclusion.

As discussed, the strike rate percentage was largely considered as additional information to the indicators concerning DD reliability. Its analysis has been complemented by monitoring the main CSFs characterizing each case. To give some examples, when DD reliability is included among the three main CSFs listed by the interviewees, the strike rate could be argued to be attributable to superior on-time delivery performance. Therefore, by analyzing the average percentage of delayed orders, the average delay and the strike rate, it is possible to consider whether a relationship exists between delivery reliability and the strike rate (thereby implying CEM decision-making modes have an indirect impact on the strike rate). Reliability of delivery lead times is included among the three main CSFs characterizing B1 and B3. Even though its relevance in relative terms compared to other CSFs such as product customization cannot be evaluated, high strike rates are associated with very good DD reliability. This is particularly true for B3, which has the best performance in the sample in terms of DD reliability (no delays) and one of the best strike rates (38 percent).

Conclusion

This study has investigated the CEM process in the capital goods sector and analyzed links between contingency factors, CEM modes and company performance. The first research question asked: *what* considerations underlie choices concerning CEM modes in different industrial contexts? In answer to this question, several different CEM decision-making modes have been found to be linked to specific contingency factors and the reasons for these links have been explored. Table VIII summarizes the links found, whilst the discussion in the paper has explained the links in detail. Three contingency factors are suggested to be particularly important: the degree of product customization, the level of system flexibility and the level of uncertainty (including demand, process and supplier uncertainty).

The second research question asked: *what* is the impact of specific approaches to the CEM process on company performance in different contexts? The research provides some preliminary conclusions to this research question, and suggests that in some cases the choice of CEM mode does not affect performance. This is the case for most alternatives within the DD monitoring support; hence, the choices here seem to be dependent upon contingency factors (see the right hand column of Table V for one possible exception). In contrast, it is concluded that there is a link between higher levels of cross-functional coordination and better performance in terms of the reliability of DDs. Where this coordination is most formal, the best levels of performance were found. These preliminary results lead to the following two research propositions which are argued to apply whatever the contingency factors:

P1. Ceteris paribus, the greater the cross-functional integration that characterizes CEM, the better the company performance from a productive (i.e. delivery reliability) point of view.

P2. Ceteris paribus, the higher the formalization level that characterizes CEM, the better the company performance from a productive point of view.

Table VIII. Summarizing the links between CEM decision-making modes, contingency factors and company performance

CEM decision-making modes	Associated contingency factors (cluster providing evidence)	Link to company performance
DD monitoring support		
Lead times		
Detailed analysis	High product customization (C); or low system flexibility with high demand uncertainty and tight DDs required (A)	The DD monitoring support is not generally linked to company performance and can therefore be explained using the contingency factors identified, with the following exception: cluster D has poor performance and is the only cluster that monitors workload occasionally
Standard	Low product customization (D); or low demand uncertainty, possible to stock (B); or high system flexibility (E)	
Workload		
Systematic	To calculate DDs when detailed analysis is used for each order (A and C); or to check for normal conditions when using standard lead times for DD setting (B, E)	
Occasional	High system flexibility or low workload, hence no perceived need to check workload when using standard lead times for DD setting (D)	
Subcontractors		
Systematic	High process uncertainty and low subcontractor system flexibility (B)	
Occasional	High process uncertainty, but high subcontractor system flexibility (E)	
None	Low demand and process uncertainty and high system flexibility (C); or low use of subcontractors (A, D)	
Suppliers		
Systematic	High supplier uncertainty and low supplier flexibility (B, C)	
Occasional	Low supplier uncertainty with reliable lead times and a standard product and some supplier flexibility (A); or Some supplier uncertainty with lead times sometimes long, but high supplier flexibility (E)	
None	Low supplier uncertainty and high supplier system flexibility (D)	

(*continued*)

Table VIII.

CEM decision-making modes	Associated contingency factors (cluster providing evidence)	Link to company performance
Responsibility for DD setting		
Sales	Low product customization, low use of subcontractors, low supplier uncertainty leading to less monitoring during DD setting (A, D); and low workload utilisation (D)	The responsibility for DD setting is concluded to be less important than the degree of cross-functional coordination achieved
Production or shared by all departments	High or medium product customization and a more complex monitoring activity during DD setting (B, C, E)	
Cross-functional coordination		
Low-medium	Low uncertainty and sales alone is responsible for DD setting, for the reasons given above (D)	Higher levels of cross-functional coordination lead to higher levels of performance
Medium-high	Production is responsible for DD setting and high demand and process uncertainty (E) or sales is responsible and there is high demand uncertainty (A)	
High	When responsibility for DD setting is shared and there is high process and supply uncertainty (B); or production is responsible and there is high product complexity (C)	
Formalization		
Low	Small-to-medium company size with a limited number of orders per year and high demand uncertainty making formal meetings difficult (A)	Higher levels of formalization lead to higher levels of performance
Low-medium, medium-high	Low-to-medium cross-functional coordination is linked to low-to-medium levels of formalization (C, D, E)	
High	Larger companies with a larger number of orders per year and high cross-functional coordination making *ad hoc* meetings impractical (B)	

A further research gap is the need to explore whether the links found between contingency factors and CEM modes represent best practice in those contexts. In order to do this, further study into the business performance of firms is needed, which leads to the following proposition:

P3. Specific approaches to the CEM are more suitable for certain sets of contingency factors than others and will lead to better company performance in those contexts.

Furthermore, as results suggest that contingency factors may have a direct impact on company performance, future research could further investigate possible links between specific sets of contingency factors and performance.

The current research of the authors is focussed on extending this study into the UK capital goods sector, thereby adding a comparative perspective to the analysis, and testing the above propositions. Despite the need for further research, it is argued that the findings in this study have clear implications for research and practice. In particular, it is concluded that despite its strategic relevance, the significance of the CEM process, including the need to undertake workload monitoring using a formalized cross-functional approach, is often under-estimated in practice. In addition, analysis has shown that the use of models, decision-making tools and formalized control procedures in practice is still limited but that there is scope for wider adoption of systems aimed at increasing estimation reliability. A notable practical implication is that, although the size of the control problem may have an impact, a high level of formalization of CEM practices is beneficial not only for large companies but for small and medium-sized firms too.

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