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The price of responsiveness: Cost analysis of change orders in make-to-order manufacturing

Jukka Uskonen [a,1], Antti Tenhiälä [b,*]

[a] Aalto University, Department of Industrial Engineering and Management, Otaniementie 17, 02150 Espoo, Finland
[b] IE Business School, Calle de María de Molina 12-5, 28006 Madrid, Spain

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ABSTRACT

The ability to produce goods according to customers' specifications may be an important competitive advantage, but it exposes manufacturers to the risk of customers requesting changes in their specifications during the fulfillment of their orders. Manufacturers often accept these change orders in the name of customer service despite the fact that they incur additional costs. This study uses empirical data and activity-based costing to explore the real values and the accrual mechanisms of change orders' costs. The results show that the total costs are considerable, but the analyses also reveal opportunities for cost savings through the categorization of change orders, time fencing techniques, and improvements in information processing.

1. Introduction

Responsiveness to customers' varying requirements has become a crucial source of competitive advantage for many modern manufacturing companies (Fisher, 1997; Wong et al., 2006). Due to increased demand for customized products, manufacturers have developed tools and practices to accommodate customers' unique requirements into their product offerings (Forza and Salvador, 2002). While this kind of responsiveness enables manufacturers to charge premium prices, it also exposes them to new kinds of uncertainties. A particularly difficult challenge is coping with customers who request changes in specifications during the fulfillment of their orders (Partanen and Haapasalo, 2004). Such requests are understandable because customer requirements may vary over time, and there is always some lead time in which changes can occur when products are made or assembled to order.

The question of whether to accept mid-process changes in order specifications poses a dilemma for many make-to-order (MTO) manufacturers. Most companies consider it to be an important part of their customer service and a natural extension of their pursuit of responsiveness (Danese and Romano, 2004). However, change orders are known to incur costs that are very hard to estimate in advance, and in most cases, it is difficult to charge the customers for these costs (Riley et al., 2005). Although this dilemma has been acknowledged in the literature, to the best of our knowledge, none of the earlier studies have disclosed what factors determine the costs of change orders, or how those costs could be best mitigated. Studies in the construction industry have shown that the overall costs are often considerable (O'Brien, 1997), but detailed analyses in the manufacturing industries have been lacking.

This article aims to develop an understanding of the behavior of change orders' costs by identifying their constituents and accrual mechanisms. For that purpose, this study employs the methods of *activity-based costing* (ABC) and a multisource dataset from an in-depth case study. The case company is a mid-size machinery manufacturer that produces customized refrigeration cabinets for grocery retailers. The explorative analyses of this study necessitate triangulation between different kinds of data (Jick, 1979); qualitative data such as interviews, process mapping, and work observations were necessary in identifying the cost elements. Meanwhile, objective data from the company's information systems were necessary to quantify and model the costs of individual changes. The findings are discussed in general terms, and the costs are measured in relative values in order to avoid the context-specificity of the results, which is often a concern in single-case studies (Yin, 2003). The conclusions of this article are formulated as three generalized propositions that can be tested in practice as well as in other studies in different kinds of manufacturing environments.

The paper is structured as follows: first, we review the existing literature on the management of change orders. Then we present research questions that aim to address the gaps identified in the literature. This is followed by a description of our cost analysis methodology and research design. Finally, we present the results of the analyses and conclude with propositions for further research and practical implementations.

* Corresponding author. Tel.: +34 91 568 9600.
E-mail addresses: jukka.uskonen@aalto.fi (J. Uskonen), antti.tenhiala@ie.edu (A. Tenhiälä).
[1] Tel.: +358 50 300 5750.

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2. Literature review

2.1. Responsiveness as an ability to adopt change orders

The concept of *responsiveness* has a number of different meanings in the literature of manufacturing management. In addition to the capability of satisfying varying customer requirements (Fisher, 1997; Wong et al., 2006), the concept has also been defined as the speed of fulfilling customized orders (McCutcheon et al., 1994; Salvador and Forza, 2004). It has also been viewed in more general terms as the overall capability to seize business opportunities (Kritchanchai and MacCarthy, 1999) and has been discussed in more specific terms as the ability to swiftly confirm the specifications and delivery dates of customers' orders (Pibernik, 2005). Yet another stream of research has focused on defining the different constituents of responsiveness (Holweg, 2005; Reichhart and Holweg, 2007). While all of the varying perspectives have their merits, in this study, responsiveness will be considered as the capability to satisfy wide-ranging and frequently changing customer requirements. The acid test of that kind of responsiveness is the ability to adopt customers' change requests that occur after the initial entry of their orders.

2.2. Importance of adopting change orders

Most MTO manufacturers consider change orders to be an inherent part of their business. Manufacturers typically sympathize with the fact that the conditions in customers' own environments may change during the time that is needed to fulfill the orders (Danese and Romano, 2004). This is especially the case in the manufacturing of capital goods. For example, in the production of construction materials, the turbulent conditions of construction sites translate to frequent changes in customers' plans and schedules (O'Brien, 1997). Such changes often necessitate modifications to the technical specifications and the delivery dates of the manufacturers' products (Vrijhoef and Koskela, 2000).

The difficulty in preventing change orders from occurring arises from the fact that it is often hard to determine whether the changes result from customers' behavior or from the manufacturer itself. Manufacturers usually acknowledge the difficulty of eliciting customers' real needs at the time of the initial order entry (Huffman and Kahn, 1998). Miscommunications or mistakes occurring at that point may result in a need for modification at some later phase in the order fulfillment process (Hegde et al., 2005). It is normally preferable to execute such modifications than to deliver products that are not suitable for the customers' intended use. Furthermore, many of the customer-originated changes are quite similar to the ordinary engineering change orders, which the manufacturers face anyway (Tavcar and Duhovnik, 2005).

One particularly good motivation to accept change orders is given in a study by Hendricks and Singhal (2003). Its results show that if disagreements about the contents of customers' orders hit the news, then the market values of publicly traded manufacturing companies will immediately drop by about 13%. Moreover, this plunge in the share value is accompanied with a considerable reduction of sales (Hendricks and Singhal, 2005). Hence, it is often the safest choice to try to accommodate customers' change requests as soon as they are received.

2.3. Costs of adopting change orders

While the importance of adopting change orders appears to be widely acknowledged, the costs of the modifications have seldom been studied in detail. In the classic model of "the hidden factory," the change transactions are counted as non-value-adding activities, and they are estimated to contribute up to 40% of manufacturers' overhead costs (Miller and Vollmann, 1985). More recent figures can be found from studies in construction industry, in which cost and time overruns are relatively common, and one of their main causes are mid-process changes in the project plans (Williams et al., 2003). The primary drivers of these unexpected costs are the additional activities and the overtime work that are necessary to execute the changes (Hanna et al., 2004). The total costs of the change orders vary from 5% to 15%, depending on the size and the type of the project (Riley et al., 2005). The overall annual costs of change orders in the U.S. construction industry have been estimated as 13–26 billion dollars (Gunduz and Hanna, 2005).

Despite the fact that only rough figures about the costs of change orders have been offered in the literature, many companies have made significant investments to reduce the amount of changes. The most intuitive response for that purpose is to reduce the lead time of order fulfillment so that changes have less time to occur (Partanen and Haapasalo, 2004). Effective solutions include at least the following: the use of standardized components, modular products, and product platforms (Salvador and Forza, 2004; Hoover et al., 2001). In customized production, these solutions enable the postponement of product differentiation, which reduces order fulfillment lead times (Krajewski et al., 2005), and also gives customers more time to finalize their specifications, thus reducing the need for subsequent change orders (Forza et al., 2008). In order to evaluate the profitability of investments in these solutions, it would be valuable to have a clear understanding about the real nature of change orders' costs.

3. Research questions

Due to the paucity of research on the costs of change orders, we designed an empirical inquiry to shed light on how the costs of change orders are composed and how they behave over time. This objective is served by seeking answers to the following research questions:

RQ1: What are the critical factors that determine the costs of change orders?

RQ2: How does each critical factor influence the costs of change orders?

RQ3: What are the annual total costs of being responsive to customers' change orders?

RQ4: How the costs of change orders could be reduced without deteriorating the responsiveness perceived by the customers?

4. Activity-based costing of change orders

4.1. Consumption of resources by activities

In this study, the method of analyzing the costs of change orders follows the principles of *activity-based costing* (ABC). The ABC methodology was originally developed to replace traditional costing systems, whose ability to deal with indirect costs were claimed to be inadequate (Cooper, 1987, 1988). As the name implies, the logic of ABC is focused on activities instead of the cost centers, which are the main components in the traditional costing systems. When building an ABC model, the first step is to identify the activities that consume the resources of the organization (Kaplan and Cooper, 1998). The most typical activities in manufacturing organizations are the operations of the production, sales, and procurement processes. The most typical resources include materials, labor, support functions, and all necessary overhead, such as the heating and lighting of facilities.