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A New Set of Principles for Pursuing the Lean Ideal in Engineer-to-Order Manufacturers

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Abstract

For many years, lean production has been successfully applied in large companies producing high volumes of standardized products. However, companies which operate in dissimilar environments have yet to expose a suitable model for pursuing the lean ideal, adapted and fine-tuned to the diverse characteristics demonstrated by producers of, for example, highly customized, engineer-to-order products. The aim of this paper is to examine the evolution of lean principles with the primary goal of converging towards a new set of principles that are more clearly aligned for the deployment of lean in engineer-to-order manufacturers. We take insight in lean production, lean project management, and lean product development in order to develop a set of principles which we suggest is more clearly suited for the deployment of lean thinking in engineer-to-order manufacturers. Firstly, we use literature review in order to examine the most prevalent lean principles in the extant literature, and we apply qualitative content analysis in order to propose a new set of principles. We then adopt a multiple-case study approach in order to validate the derivation of the new principles in the context of two, distinct engineer-to-order environments. Our findings highlight a transition from the traditional lean production model to a more contemporary, innovative approach for pursuing the lean ideal in the context of ETO manufacturers.

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1. Introduction

Lean production can be described as both a philosophy and a set of tools and techniques that aims to identify and eliminate all waste in manufacturing operations. Though it was never intended for Lean to be the antithesis of mass production, it certainly is the antithesis of large-lot production [1]. Thus, at least in the traditional sense, Lean can be thought of as an alternative way of organizing mass production. As such, [2] defines Lean as a term given to a family of related methodologies that seek to streamline production processes. It is generally agreed amongst researchers and practitioners that Lean was developed from the methods and working practices of the Toyota Production System (TPS), with its roots in the continuous flow thinking and moving assembly line concept of Henry Ford. Due to the fact that Lean has indeed emerged from the high volume production environments of global automotive OEMs, for example, it is no surprise that there have been difficulties in applying such methods in environments that demonstrate much higher levels of variation in both products and processes, and experience demand for much lower volumes, such as one-of-a-kind products. Indeed, if we consider the basic principles of mass and flow production [3], it becomes clearer for us to identify the need to reconsider Lean in the context of low volume, high variety manufacturing: (a) Mass production demands mass consumption, and (b) Flow production

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requires continuity of demand. Low volume, high variety (e.g. ETO) producers exhibit neither *mass consumption* nor *continuity of demand*, thus, in order to develop "Lean" working practices that are much better suited to this type of production environment, we assert that the fundamental lean principles be re-examined in the context of such low-volume, high variety producers. To summarize, Lean has been variously understood over time, first as a new and better way to make things, then as a way to design and make things, and more recently as a fundamental management philosophy defined by the ideal pursued. The lean ideal can be stated thusly: *providing customers (both internal and external) with exactly what they need to accomplish their purposes, with no waste*; where we define waste as *anything that incurs a cost of any kind, the elimination of which does not reduce the value delivered* [4]. Therefore, in this paper, we attempt to develop a new set of principles in order to answer the general question: *How to pursue the lean ideal in the ETO context?*

2. The Customer order decoupling point

In order to distinctively define what we interpret as ETO, we shall first consider the concept known as customer order decoupling point (CODP). CODP is a concept that is used to distinguish between different market interaction strategies in manufacturing [5, 6]. The CODP separates the part of the material and information flow that is based on firm customer orders from the part that is based on forecasts and speculation [5]. In general, four different strategies are distinguished based on different CODP positions [7]: ***Make-to-stock (MTS); Assemble-to-order (ATO); Make-to-order (MTO);*** and ***Engineer-to-order (ETO).***

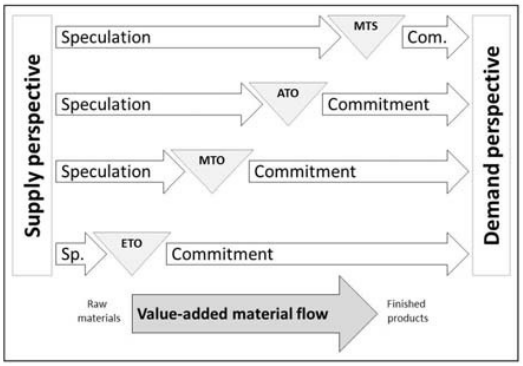

Fig. 1. The Customer Order Decoupling Point Concept [8].

Fig. 1. illustrates the positioning of the CODP in each of the four main strategies, relative to each other. As we see it, there are in fact two conflicting interests when deciding where to position the CODP. Firstly, a company may desire to become less reliant upon the use of forecasts, thus there is a desire to shift the CODP from right to left in the figure. On the other hand, a company may want to reduce lead times, which would often require a shift of the CODP from left to right, in order to move the decoupling point closer to the market and ultimately closer to the customer. This is certainly true of MTO/ETO companies. For example, [9] clearly states that a competitive priority in the MTO/ETO sector is often shorter lead times. However, though there is no doubt that the majority of successful applications of lean manufacturing have occurred at companies that produce high volumes of standardized products in fairly low varieties (these types of company have often been able to combine lead time reduction through the application of lean flow techniques with a lower emphasis on the use of forecasts by moving from MTS to ATO), there does remain a recognizable distinction between such high volume, low variety MTS/ATO environments and the more challenging low volume, high variety environments present in make-to-order (MTO) and engineer-to-order (ETO) producers. As customers are nowadays demanding more and more customized products with shorter life cycles, we choose to focus our investigation only on ETO manufacturers that represent those companies at the extreme left of the scale, offering the most bespoke, customer-specific products on the market - see Fig. 1. Furthermore, we consider ETO manufacturers that either adapt existing designs, or develop completely new designs from scratch, in response of a confirmed customer order. We do not consider MTO producers that use standardized, existing designs, as these companies already benefit from reduced lead times due to the fact that the design and engineering phase is not required in response of customer orders. As such, it is fair to assume applicability of some traditional lean concepts in the context of MTO companies, as the very existence of standardized designs assumes some constancy of mass consumption and continuity of demand.

3. A classification scheme for ETO manufacturers: Characteristics and challenges

ETO refers to the strategy by which design, engineering and production do not commence until after a customer order is confirmed. In terms of the product-process characteristics of this type of environment [e.g. 10], the products are customer specific, highly customized items produced in low volumes (often one-of-a-kind), and processes are typically non-repetitive yet labor intensive, often demanding highly skilled labor. As such, ETO companies cannot accurately forecast demand, order materials and produce in advance, or effectively apply batch production methods [11].

The earlier CODP means that a greater degree of customization can be offered in an ETO setting, albeit at the cost of longer lead times and increased uncertainty. In fact, ETO manufacturers endure uncertainty across a number of dimensions, including uncertainty in product specification and mix; process specification uncertainty; and volume uncertainty [12, 13]. Because of the extent of uncertainty experienced by ETO manufacturers, planning and control becomes more complex and difficult for these companies, as does the pursuit of the lean ideal. This is particularly true when we further consider the concept of uncertainty in