

A Review on the Classification of the Make-To-Order Manufacturing Companies

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ABSTRACT

Given the distinct differences in characteristics, it is clear that companies in the Make-to-order (MTO) sector will need to use different operation processes than those in the Make-to-stock (MTS) sector. Yet much of the universalistic literature assumes that all companies should adopt practices that apply to MTS. For example as argued by Muda et al (2003;2002a;2002b), "it is the customer rather than the supplier that has responsibility for the design of products". These companies do not deal with the same type of new product development and so a product/family focus, as advocated in much of the universalistic literature, is less relevant to the MTO sector. The most comprehensive lists used to define MTO are presented by Amaro et al. (1998). Amaro's version MTO's taxonomy consisted of three dimensions. This definition draws together many of the ideas presented by other authors in the MTO field, and other important areas such as World Class Manufacturing. Therefore, to test the usefulness of Amaro et al. (1998) taxonomy in the MTO sector, the next step is to look at Amaro et al. (1998) taxonomy in more detail through several cases study evidence. This study will also explore the issue of whether the Amaro's et al. (1998) taxonomy is adequate to cover the variety of company types within the MTO SME's sector.

Keywords: Make-to-order, Make-to-stock, World Class Companies

INTRODUCTION

Given modern manufacturing philosophies and the ability to reduce lead times, the use of finished goods inventories is declining in some manufacturing sectors. This has meant that the labels MTS and MTO are becoming a little confused as the MTS label is somewhat inappropriate for some mass producers and mass customisers that now claim to manufacture goods on a 'make-to-order' basis, holding little, if any, finished goods inventory. However, the MTS operation remains distinct from MTO as the products in MTS companies are designed by the company prior to receiving the customer orders. They are mostly standard products that can be produced in large quantities and stocked if it is economical to do so. The customer may purchase the product directly from inventory at a retail outlet or at the factory distribution centre. In some cases, products can be modified according to a customer requirement, and therefore are not produced until an order is placed, but nonetheless there is a large degree of similarity between products. In contrast, the MTO company manufactures a wider variety of products in relatively low volumes. Products are always manufactured to customer design and specification and therefore the production can only start after the customer places an order, as instruction from the customer is required. Even where the company specialises in a type of product, the volumes are low even at the component production stage as the product size and material specifications tend to vary enormously. To win an order, the company has to compete with other companies on the basis of price and the delivery date. Muda et al (2003), Hendry et al. (1993) claim that in some cases the customer may specify the price he is willing to pay and ask whether the manufacturer can do it and what would be the delivery time, or the customer may specify a delivery time and ask for a price, or ask for both. Table 1 compares some of the characteristics of the two groups MTO and MTS as set out by Muda et al (2003;2002a;2002b), Hendry et al. (1993), Hill (1993, 1995), and Amaro et al. (1999).

Given these distinct differences, it is clear that companies in the MTO sector will need to use different operations processes than those in the MTS sector. Yet much of the universalistic literature assumes that all companies should

adopt practices that apply to MTS. Therefore there is a need to develop a set of WCM advice that is aimed at the MTO sector specifically. In order to do this, it is first necessary to develop an understanding of this sector of industry.

Table 1: A comparison of MTO and MTS companies

MAKE TO ORDER COMPANIES	CHARACTERISTICS	MAKE TO STOCK COMPANIES
Few standard products	Product or customer families	Product/family focus
Few regular customer	Customers	Having regular customers
Many suppliers	Suppliers	Few suppliers
Multi-task machinery and flexible workforce	Resources	Specialist machinery and workforce
Demand is volatile and can rarely be predicted	Product Demand	Demand for standard products can be forecast
Based on receipt of customer orders. Cannot be planned in advance.	Capacity Planning	Based on forecast demand. Planned well in advance. Adjusted later if necessary
Vital for customer satisfaction. Agreed with customer	Production lead times	Unimportant to customer. Can be set internally
Negotiated with customer before production commences	Prices	Fixed by the producer

The Diversity of the MTO Sector

MTO companies have many special characteristics and comprise a complex sector that cannot just be grouped into one. The following section classifies MTO companies into several types, and describes the characteristics of each type.

a. The differences between ATO and MTO/ETO

One way to classify non MTS companies is by looking at the amount of processing the product required after the company receives the customer order. At one end of the spectrum is the Assemble-to-order (ATO) company. These companies manufacture a fairly standard product or option module, according to its demand forecast and then assemble a specific combination or package of modules after receiving the customer's order. At the other end of the manufacturing spectrum is the MTO company. This company does not begin processing the material for and components of the product until it has received an order from a customer.

In an ATO environment, the companies usually produce end items with many options from relatively few major assemblies and components, after customer orders are received. This approach addresses two competitive priorities, customisation and fast delivery time. The classic example is the car manufacturer (see Markland *et al.* (1998)). Operations hold the major assemblies and components in stock until a specific order comes in. After receiving orders from a car dealer, the manufacturer specifies the exact build schedule for the automobiles. The schedule is based on the options ordered by the customers – engine types, transmission types, air conditioning, standard versus digital control panel, leather cloth, interior options and so on. The many components of assembling the automobiles would have been

ordered or started into production before receiving the dealers' orders based upon demand forecasts (Markland *et al.* (1998)). Hence, the major operation that remains after the order comes in is assembly.

In the MTO environment, the firm does not begin processing the material for and components of the products until after it receives the order. This approach provides a high degree of customisation. The company competes on the basis of product customisation and serves its customer base by providing unique and/or highly specialised items. MTO operations cover a range of activities. In the pure engineering-to-order company (ETO), the order arrives before the design stage (Kingsman *et al.* (1993)). The customer normally describes the functions and characteristics required in the product they have. The company has to produce a design and specification. The customer order may be for just the design stage or for both design and manufacture. These companies usually make one-off products. Another type of company is the sub-component MTO company, where the customer may supply the design and it is only necessary to configure how to make it with the machines and skills in the company (Kingsman *et al.* (1993)).

In these MTO/ETO companies, every order may be very dissimilar to the others. These companies may sell a skill to perform certain types of operations rather than selling actual products. In this case there may still be some repeat production for the same customer and the provision of spares. Alternatively the company may offer a variety of specialist products and allow varying degrees of customisation of the components (e.g. safety doors – bullet proof, sound proof). However every thing that is made by this type of company is only made after the order has been accepted.

However the general classification above is not enough to explain all types of non-MTS manufacturing operations. A more detailed classification of the manufacturing operations comes from Hill (1993) who categorised the non-MTS operations into five types as given below:

Design to order – new product response where companies design and manufacture a product to meet the specific needs of a customer;

Make to print - some customers require companies to make-to-print (i.e. make a product in line with a given drawing). In such markets, lead-times only include raw-materials purchase/ supply and manufacturing. They do not include design but some customer –induced redesign during the process will often be involved;

Engineer-to-order – changes to standard products are offered to customers and only made to order. Lead times include the relevant elements of engineering design and all manufacturing;

Make-to-order – concerns manufacturing a standard product (any customisation is nominal and does not increase total lead-times) only on receipt of a customer order or against an agreed schedule or call off;

Assemble to order- components and sub-assemblies have been made to stock. On receipt of an order (or against an agreed schedule or call-off) the required parts are drawn from work in progress/component inventory and assembled to order.”

Unfortunately Hill (1993) uses the terms ETO and MTO with different meanings from those more commonly used in the operations literature, which is a major disadvantage of his framework (Amaro *et al.* (1999)). Hill's (1993) definition of MTO and ETO is concerned with the manufacture of standard products only on receipt of a customer order or against an agreed schedule, whilst most of the literature describes MTO and ETO companies as producing highly customised products.

b. Amaro et al.'s (1999) taxonomy of MTO companies

Thus, Amaro *et al.* (1999) presented a more detailed taxonomy of the non-MTS companies based on three major dimensions as below:

1. The degree of product customisation either; pure, tailored, standard and non- customisation. (Refer to Table 2).

Table 2: The degree of product customisation

<i>Pure</i> <i>Tailored</i> <i>Standardised</i> <i>Non-Standard Product</i>	<i>Make a new design</i> <i>Change/modification to an existing design</i> <i>Choose from a set of design options</i> <i>Take existing design as is</i>
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Pure Customisation: A design developed from scratch for each customer. The customer notifies the characteristics and specifications he wishes to have. The company then has to produce a design based on specifications given by the customer. Irani *et al.* (1997) claim that to produce these products a highly flexible production capability is required, which implies versatile manufacturing equipment and multiskilled employees, both of which must be capable of performing many different tasks. They do not have a standard product range but maintain competitive advantage by selling their engineering capabilities (Kingsman *et al.* 1993).

Tailored customisation: The products manufactured are based on modifications of an existing design or original design. The customer typically needs to describe the specification of the product to the firm. The modification may be in the form of changing the size or changing the processing capacity whereby the existing design remains.

Standardised customisation: Under this category, final products are provided through modular design in which various features can be added or removed from the basic design. The customer has to select a design from existing design options and then recapitulate any features he needed (either added or removed). In this environment, all processing work such as production routing, specification and design have all been determined.

Non-customisation: Where the manufacturer only produces products based on an existing design as is. An obvious reason for doing this after receipt of a customer order is that this is cheaper for expensive products for which there is an irregular, low demand.

2. The second dimension is the company responsibility for design, specification and the purchasing of materials. In some cases the customer provides all the design, specification and the purchasing. The term design refers to the fundamental idea of the product, often a rough set of drawings. Specification means a detailed drawing to support production and also the list of both technical requirements and of material to use.
3. Thirdly based on activities performed after receipt of an order. The list covers delivery, assembly, processing, routing, specification and purchasing. Routing means the path the product will follow in the shop floor and which machines to use and in which sequence.

Table 3: New Classification of non MTS (Cited from Amaro et al. (1999))

The Classification Categories	ETO 1	ETO 2	ETO 3	ETO 4	MTO 1	MTO 2	MTO 3	MTO 4	MTO 5	ATO 1	ATO 2
<i>Degree of customisation</i>											
Pure	/	/	/	/							
Tailored					/						
Standardised						/	/			/	
None								/	/		/
<i>Company responsibility for</i>											
Design	/				/	/	/	/	/	/	/
Specification	/	/			/	/	/	/	/	/	/
Purchasing	/	/	/		/	/	/	/	/	/	/
<i>Activities After Receipt of Orders</i>											
Delivery	/	/	/	/	/	/	/	/	/	/	/
Assembly	/	/	/	/	/	/	/	/	/	/	/
Processing	/	/	/	/	/	/	/	/	/		
Purchasing	/	/	/		/	/		/			
Routing	/	/	/	/	/						
Specification	/	/			/						
Design	/										

Based on the Amaro *et al.* (1999) taxonomy, MTO companies can be classified into eleven types as shown in Table 3. To date, the Amaro *et al.* (1999) taxonomy on MTO companies presents the most complete definition of MTO, illustrating the types of MTO based on three dimensions. Therefore Amaro *et al.*'s (1999) taxonomy will be used to

describe the MTO companies in this research. The MTO label, for the remaining sections of this thesis, will be used to describe the generic MTO manufacturers that cover ETO1 through to MTO3; ranging from pure, tailored to standardised customisation. It does not embrace any of the ATO companies, nor any companies that manufacture a standard product, even if that product is produced after the receipt of a customer order.

c. Repeat Business Customisers (RBC) and Versatile Manufacturing Companies (VMC)

Amaro *et al.* (1999) also argued that MTO companies can be split again by another dimension. This dimension is concerned with whether companies are involved in bidding for one-off orders or for a series of similar orders. "Repeat Business Customisers" (RBC) is used to describe a MTO firm who has to enter a bid once only for a series of similar orders. "Versatile Manufacturing Companies" (VMC) is used to describe companies in the alternative type of market in which each order is for a one-off product or one-off buying decision.

The RBC market "is the one where the competitive tender is to design and produce a product to meet regular and repeated need for a reasonable period into the future" (Amaro *et al.* (1999)). The competition and customisation is only during an initial customer purchase decision. After that, based on the agreement to supply the contract, the customer will place repeated orders with the same supplier. Generally RBCs are producing low product variety and have a small number of customers but high volumes per product.

In the VMC market, every order is considered as an individual independent buying decision. The customers send every order as an enquiry to a group of potential suppliers regardless of whether it is for a new design of product or a standard product that has been bought before. To win an order, the company has to determine a price and a delivery lead-time to quote as an individual bid in response to each customer enquiry. "Each order generally requires different amounts of processing at its work centres and in a different sequence. These companies have to show versatility in their marketing, production planning, use of resources etc. over time in order to survive" (Amaro *et al.* (1998)). Normally, VMC companies manufacture high product variety in low volumes. To test the usefulness of Amaro *et al.* (1998) taxonomy, simple case study evidence has been collected.

CASE STUDY ILLUSTRATION

Company A is an 18-employee privately owned MTO company established in 1968. The company core business is in precision engineering, which primarily involves the manufacture of a wide variety of parts and products for many different customers. Examples of products are rollers, shafts, torsion bars and tubes up to 5 metres long. The company is considered to be a small size company, with 0.35 million net assets and 1.1 million turnover per year. Categorized as "pure customisation" MTO company, the customer is responsible for the product design and specification while the company is involved in purchasing the materials.

Company B, employing 14 people, is a privately owned MTO company in the furniture industry. It was established in 1970. The company is involved in manufacturing a wide variety of bespoke furniture for home kitchens, bedrooms and shops. The company orders came from two main sources; trade customers/retail and the individual customers. The company has twelve regular trade customers. However, the product is still bespoke furniture, even though the company is supplying to trade/retail customers. This is because all the products are for individual end customers designed for specific kitchens, bedrooms and shops. The Company is considered to be a very small company.

Company C, founded in 1983, is a 120-employee privately owned sheet metal engineering company. Registered as ISO 9002 in 1997, the company aim is to establish itself as a world class co-manufacturer in partnership with its customers. The company philosophy is to provide good quality MTO products backed by a continuing investment in people and high technology. The company is a manufacturer of high precision finished sheet metal components such as telephone brackets and metal casings for boilers. Eighty percent of the company activity is producing a bespoke product based on customer specifications and drawings. The customers provide the design and specification while the company is responsible for purchasing the materials. For another 15% the company makes modification to the customers' drawing while for another 5% it provides a new design.

Table 4: Classification of the MTO Companies based on the Amaro et al. (1999) Taxonomy

Companies	Customisation			Responsibility for					
	Pure	Tailored	Standard	Design		Specification		Purchasing	
				Customer	Company	Customer	Company	Customer	Company
A	/			/		/			/
B		/			/		/		/
C	/			/		/			/

Company Activities After Receipt of Order							
Companies	Delivery	Assembly	Processing	Purchasing	Routing	Specification	Design
A	/	/	/	/	/		
B	/	/	/	/	/	/	
C	/	/	/	/	/		

"The term design refers to the basic idea of the product, often a rough set of drawings. Specifications mean the set of detailed drawings to support production and also the list of both technical requirements and of materials to use. Routings means the definition of the actual path the product will follow in the shop floor: which machines to use in which sequence." (Amaro et al. (1999)).

The three companies involved in the case study research can be classified as follow:

1. *Company A*; the company can be classified as ETO3. It is a VMC because every customer's order is consider as an individual independent buying decision.
2. *Company B*; As shown in Table 4, Company B is MTO1. It is categorised as VMC because the company also has to determine a price and a delivery lead-time to quote as an individual bid in response to each customer enquiry.
3. *Company C*; Based on information in Table 4, Company C can be classified as ETO3. Categorised as RBC, the company is involved with a bidding process for a long-term contract with several delivery dates agreed with customers.

Table 5: Types of MTO companies

Classification	ETO2		ETO3		ETO4		MTO1		MTO2	
	Small	Medium	Small	Medium	Small	Medium	Small	Medium	Small	Medium
VMC			A				B			
RBC				C						

Table 5 shows the three types of companies involved in the study. Table 5 also shows that the company activities can be divided into two types of market, VMC and RBC.

CONCLUSION

This paper confirms that there are many differences exist among MTO companies, which is useful to fill a gap in the manufacturing literature that concentrates on the single characteristics of the traditional MTS sector. The paper demonstrates the three case study companies, two small companies and one medium sized; two are VMC, whilst one is RBC. In terms of Amaro's (1999) classification, two are ETO3, and one is an MTO1 company. This range of companies was thought to be necessary to explore the issue of whether the Amaro's (1998) taxonomy is adequate to cover the variety of company types within the MTO sector.

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