A TOOL TO CONTROL ON TIME DELIVERY AND CAPACITY USE FOR PRODUCTION DEPARTMENTS THAT PRODUCE TO CUSTOMER ORDER AND FACE HIGHLY VOLATILE DEMAND.

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Introduction

Production departments that manufacture components for the capital goods industry often face highly volatile demand. They produce a wide range of technologically similar products, with varying demand rates and limited life cycle length. On top of that, production must respond the order intake of their customers, which can be very irregular. As a result, the number of orders places per day or week varies a lot over time, as does the amount of production capacity needed to produce these orders. One way to cope with this is to maintain a very high level of capacity or to work overtime if needed. However, this can be very costly. Another way to solve this would be to keep all products to stock, and maintain stock levels such that capacity use can be smoothed. However, this could also be very costly, in particular in view of the high risk of obsolescence for products with low demand or close to the end of their life cycle.

This report describes a tool that can be used to combine these two approaches in an optimal way. The tool support the split up of the product portfolio in fast movers and slow movers. Customer orders for slow moving products have priority over customer orders for fast moving products when releasing production orders to the shop. As a result, production orders for fast movers might be delayed at times where capacity is insufficient, and be ready after the agreed customer order lead time. To cope with this, for fast moving products some stock is kept which enables on time delivery of such customer orders. The tool supports the calculation of the release delays for the fast movers in function of available capacity, and the stock levels for the fast moving products needed to attain a specified aggregate on time delivery target.

Scope

The tool considers the range of products produced by a component manufacturing shop for one or more customers. The customers are Original Equipment Manufacturers who outsource part of their component manufacturing to subcontractors, and place orders for delivering one or more items of a product to be delivered within an agreed lead time. The delivery lead time is a long term agreement between OEM'ers and the supplier. Apart from the customer orders.

The supplier runs a production department for the manufacturing of the customer products. The production department consists of a number of production facilities that are used for performing the processes that transform raw materials into the customer products. Over the medium term, one of these facilities act as a bottleneck for production, that is: this facility will be the first to fully loaded if the yearly demand for products would be proportionately scaled up.

The supplier wants to know what the capacity level of the bottleneck facility should be, which product should be marked as fast movers, and which stock level to use for each of the fast movers. The tool supports the evaluation of possible decisions on each of these three dimensions, and in doing so, supports the search for an optimal solution which minimizes the sum of capacity costs and stock holding costs under a specified on time delivery target.

The tool

The tool consists of three modules. Module 1 takes as an input a table of the weekly demand per product over the last year (50 weeks), D(i,t), and tables which give for each product the amount of capacity (in minutes), on the bottleneck facility required to produce a batch of products. The first table

gives the fixed setup time for a batch, S(i), and the second table gives the variable time required per product item, V(i).
Using these two tables, module 1 first converts the weekly demand per product per week into weekly demand for capacity per product, C(i,t). Next, module 1 calculates for each week the total demand for capacity, CW(t), and for each product the total demand over the year DY(i). Then the module sorts the products in order of decreasing yearly demand. Thus, product nr. 1 is the product with the highest yearly demand, product nr. 2 is the product with the second highest yearly demand, and so on. The products in the weekly demand table, and the weekly demand for capacity table, are sorted in the same order. Next, the total yearly demand for capacity per product, C(i), and the total aggregate demand for capacity per year, CYR, and the average aggregate demand for capacity per week, CWR, are calculated.

The user next enters two numbers: CWA, the available capacity per week on the bottleneck facility, and PE, the allowed percentage of weeks in which not all production orders for slow movers resulting from customer orders placed in that week, can be released due to capacity shortage in that week. Then the user enters an integer number, k; all products with product number <= I belong to the initial set of fast movers, and all products with product number >I belong to the initial set of slow movers. Next, module 1 calculates for each week the total amount of capacity needed by the products in the initial set of slow movers, CWS(t), and counts the number of times that CWS(t) exceeds CWA. This number is denoted as F(k,CWA).
Now if F(k,CWA)/50 < PE, then using this split up in slow movers and fast movers would satisfy our requirement that the probability that all slow movers can be immediately released to the shop floor would be satisfied, but it might be that we could achieve the same with a smaller subset of fast movers, leading to lower stocks. To check this we decrease k with 1 and repeat the procedure until we arrive at a k that no longer satisfies the requirement. We now increase k with 1 and have found the optimal split in fast movers and slow movers.
If in the first check F(f, CWA) > PE, then we increase k with1 and repeat the procedure until we arrive at a k that satisfies the requirement. We again have found the optimal split in fast movers and slow movers. Note that the split depends on the value of CWA entered. Higher values of CWA lead to smaller subsets of fast movers and lower stock cost.

Module 2 calculates statistics of the delays (in weeks) of release of production orders of fast movers that results from the split of the product set in fast movers and slow movers produced by module 1. It first generates for each product i, a pattern of demand over 250 successive weeks, by randomly sampling for each of these weeks a number from the 50 demand realizations in the table D(i,t). This table is denoted as DR(i,t). Next, using the tables S(i) and V(i), it calculates the required capacity per product per week CWR(I,t). Then, using the split value k found with module 1, it calculates the weekly required capacity for slow movers, resulting in a table CWRS(t). Next, it calculates the weekly available capacity for fast movers CWAF(t) as follows:
Starting with week 1, it calculates CWA – CWRS(t). If this amount is non-negative, CWAF(t) = CWA – CWRS(t); otherwise CWAF(t) = 0. If this amount is negative, in this period insufficient capacity is available even for slow movers, the amount CWRS(t) – CWA is added to required capacity for slow movers in period t + 1, and the procedure is repeated for period t = 1.
The orders in the fast movers set are identified by two numbers: their product number and the number of the week in which the order is placed by the customer.(Production is to customer order, so production orders correspond to customer orders). Initially, all orders are assigned a provisional release delay value equal to 0 weeks. Next starting with week 1, production orders for fast movers in

that week are loaded in order of increasing processing time on the available capacity in that week, CWAF(t). All orders that can be loaded in this week, receive a definite release date equal to their provisional release delay at that time. All orders that cannot be released in this week are added with priority to the list of orders to be released the next week, and their provisional release delay is increased with one week.
This procedure is repeated week after week, until all fast mover orders in the 250 weeks have been loaded. After this procedure, for each order in the fast mover set a release delay has been obtained. Using these release delays, for each order in the fast mover order set over the 250 week period, an order completion date is determined by adding to the week number of the order the standard production throughput time (which for each product is assumed to be a specific number of weeks), plus the release delay of this order. This statistic is the outcome of module 2, and is the main input to module 3. Orders that cannot be loaded in the period of 250 weeks are not included in this statistics.

Module 3 takes the as input the weekly fast mover orders over the 250 week period, and generates due dates for these orders by assigning to each order a number equal to the number of the week in which the order is placed, plus the customer order lead time (in weeks), which is assumed to be a constant for all orders.
From these order due dates and the order completion dates from module 2, module 3 first calculates the number of orders for which the completion date exceed the due date. This number is divided by the total number of orders in the 250 week period, giving an estimate of the probability that an order is will not delivered on time, if no products are kept to stock. If this this probability does not exceed the target set by management, no stocks are needed. This may indicate that in module 1, the capacity level was set to high. If the probability exceeds the target value set by management, stocks are needed for one or more products. The tool assumes that for each product, customer orders are placed in multiples of a standard batch size, which may be different for different products. Thus, for each product, stocks should be kept in multiples of its standard batch size. Module 3 allows the user to enter for each fast mover product the number of batches to be kept to stock, and then calculates the number of orders delivered late, if stock is used to ship customer orders in time if the pertaining production order is late. The user should systematically search solution space by starting with specifying a stock of one batch for product number 1, and then let the module calculate the resulting probability of late delivery. If this probability exceeds the target value, the user should add a stock of one batch for product number 2, and again calculate the result. This procedure must be repeated until for the first time, the calculated probability is below the target value. The stocks that lead to this value are the stock levels that satisfy the delivery target given the capacity level value CWA specified in module 1. If the user finds the stock levels to high, he/she may enter a larger value for CWA in module 1, and repeat the procedures in the modules 1, 2, and 3, to arrive at the stock levels that satisfy the delivery target for this new value of the capacity level.