Research on Order Selection Problem under C2M Model Based on Capacity Constraints

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Abstract:
C2M is a new business mode which connect customers and manufacturers directly. The C2M production and sales model has received more and more attention and developed rapidly in recent years. The order selection problem of enterprises adopting the C2M model has also become an important issue. In this paper, we study the order selection problem of C2M enterprises, describe the order selection system. And then, we establish a model with the objective of maximizing enterprise profit and the constraints of enterprise capacity and delivery deadline. To verify the reliability of our model, we introduce a practical example, and solve the problem by LINGO.

Keywords: *C2M, Company Profit, Capacity Constraints, Order Selection, Linear Planning*

1. INTRODUCTION

C2M Mode (Customer to Manufacturer) has been a popular Internet-based personalized manufacturing and production and marketing method in recent years, however, in the face of multi-species, small batch and multi-batch customization of customer orders, companies using C2M mode faces greater challenges in order selection [8]. How to select orders for companies in C2M mode is a very important issue.

Many scholars have conducted research on issues related to the C2M model in the past. Jian, S. discussed the effect of VR of artificial intelligence on this kind of clothing business model from three aspects of product manufacturing end, client end, and shopping experience under C2M clothing customization mode [4]. H. -p. Tian established a supply chain game model from three aspects: no information sharing, information sharing with free, information sharing with cost sharing, and discussed the value of customer information in the C2M model [2]. Yuan Xin studied the product service supply chain strategy under C2M group buying model, explored the pricing and group buying strategies of the two product-service supply chains, analyses the differences between them and other product (service) supply chains, and puts forward the transformation and upgrading path of manufacturers relying on C2M group buying mode [6]. Liu, C. et al. discussed the realization of the information sharing value of two-level supply chain composed of manufacturers and distribution companies under the mode of manufacturer's self-built Internet platform, they constructed two Profit distribution model, one was based on collaborative decision-making and the other was based on independent decision-making between enterprises [5]. Yang, Bo. discussed the C2M model, the current status of C2M development in the field of e-commerce such as clothing and automotive, and the main problems exposed in the development from the C2M model to the C2B model [7]. C. Li and W. Li analysed the model of the personalized customization system in the Internet era, and constructed the basic system of personalized customization in the Internet era from the aspects of base layer, service layer, data layer, technology layer and production layer, and summarizes the management suggestions for the continuous optimization and development of personalized customization system [1]. Many researchers are focused on the development of the C2M model and its transformation.

There are also some research results on order selection and scheduling optimization for companies in C2M mode. Zhang Yazhou et al. combined enterprise capacity, order margin, delivery time, and late delivery rate with the decision- making on order acceptance, and established the order acceptance decision- making model with capacity constraint to discuss how the different late delivery rates affect order margin [9]. Hu Qi discussed the C2M model of unitary production, taking into account worker learning effects, consumer demand characteristics, and human factors reliability in the

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manufacturing process in order to arrange scheduling solutions [3]. Zhao Ruimin et al. applied the improved TOPSIS method to process orders in a hierarchical manner, and took into account the constraints of limited production capacity, delivery time and production sequence to complete the step-by-step screening and scheduling of orders in the pursuit of maximizing enterprise profit, and the results showed that the proposed algorithm model has good computational and optimization performance [10].

There is less literature on order selection and production planning management in C2M mode combined with actual cases. In this paper, we consider order selection under the enterprise capacity constraint, and select orders that can be produced by ourselves in the pursuit of maximizing enterprise profit.

2. C2M ORDER SELECTION SYSTEM

For those companies using C2M mode, when they face the capacity limits, their order selection system can be described as figure 1.

When those companies are faced with a large number of customized orders, they will evaluate these orders firstly to measure if they have the capacity to meet the demand of the orders, the specific situation can be described as follows:

(1) If they have sufficient capacity, and with the pursuit of maximizing profit, they will produce these orders by themselves;

(2) If their capacity is limited, they will choose to resupply capacity whether or not:

(a) If they choose to produce by themselves and don't resupply capacity, in order to maximize profit

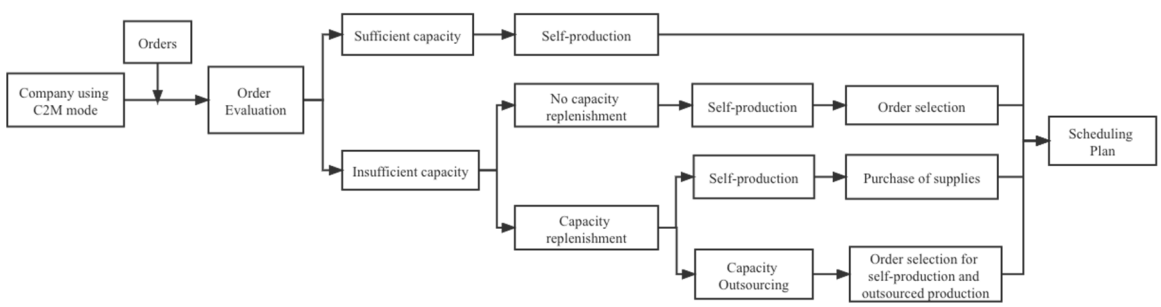

Figure 1: The Order Selection System of Companies Using C2M Mode

while meeting delivery deadline, they will select orders to decide the orders they can produce, and then, they will plan the production and scheduling;

(b) If they choose to produce by themselves and purchase some capacity, they will make the scheduling plan and material replenishment plan;

(c) If they decide to fight the lack of capacity with capacity outsourcing, they will select the orders which can be produced by themselves and make the decision of those outsourced production.

3. C2M MODEL UNDER CAPACITY CONSTRAINTS

3.1 Question Description

Companies using the C2M model select some orders for production in the face of a large number of orders arriving randomly in a planning cycle, with constraints such as capacity and delivery time, they will select orders and make scheduling plans for orders in the pursuit of maximizing corporate profit.

3.2 Model Assumptions

The model is built based on the following assumptions.

(1) The enterprise only produces these orders by themselves;

(2) In the production process of the order, there are no special circumstances occurring such as emergency order addition, equipment damage, etc.

(3) There are sufficient materials during the production of the order.

3.3 Symbol Definitions

The symbols involved in the model is defined as follows:

N: Total order quantity;

i: Order Number, $i = 1,2, \dots, N$;

j: The process number of order i, $j = 1,2, \dots, J_N$;

s_i: The 0-1 variable for whether order i is accepted;

p_i: The profit of order i in one program period;

d_i: The deadline of order i;

P: Total profit in one program period;

r: Workbench number;

R: Total workbench quantity;

wt_{ir}: The working hours for order i in workbench r;

l_r: The max capacity of workbench r;

w_r: The production costs in workbench r;

s_{ijr}: The 0-1 variable for whether process j of order i is produced in workbench r;

T: One planning period.

t: Processable time within a planning period.

3.4 Objective Function

Considering the actual situation in the production process, we take total profit maximization as the objective function with the following expression:

$$\max P = \sum_{i=1}^{N} s_i\, p_i - \sum_{r=1}^{R}\sum_{i=1}^{N}\sum_{j=1}^{J_i} s_{ijr}\, w_r wt_{ir}, \forall i, j, r$$

3.5 Constraints

3.5.1 Decision variable constraints

0-1 variable constraints:

$$s_i = \begin{cases} 1, \text{order i is accepted} \\ 0, \text{ order i is refused} \end{cases}, \forall i$$

$$s_{ijr} = \begin{cases} 1, \text{when j of i is produced in r} \\ 0, \text{ other} \end{cases}, \forall i, j, r$$

3.5.2 Delivery time constraints

Each order should be delivered before its deadline:

$$\sum_{j=1}^{J_i}\sum_{r=1}^{R} s_{ijr}\, wt_{ir} \le d_i, \forall i$$

Total processing time is less than the available processing time in a planning period:

$$\sum_{i=1}^{N}\sum_{j=1}^{J_i}\sum_{r=1}^{R} s_{ijr}\, wt_{ir} \le t$$

3.5.3 Capacity constraints

Working time on each workbench must be below its maximum capacity:

$$\sum_{i=1}^{N}\sum_{j=1}^{J_N} s_i wt_{ir} \le l_r, \forall r$$

3.5.4 Constraint relationships between 0-1 variables

Each process of each order can just be produced once:

$$\sum_{r=1}^{R} s_{ijr} \le 1, \forall i, j$$

Equation between 0-1 variables. Only when the process j of order i can be produced, order i will be accepted:

$$\sum_{r=1}^{R}\sum_{j=1}^{J_i} s_{ijr} = j * s_i, \forall i$$

4. AN EXAMPLE

4.1 Example data

To verify the reliability of this model, the example data from the literature [10] is used for validation, and the order attributes are shown in the table 1 below. The unit of profit is RMB, the delivery deadline is day and the production time of each process on each workbench is hour. The Attributes of each workbench are shown in the table 2, the unit of production costs on each workbench is RMB/h.

Table 1: The Order Attributes

Order	Profit	Delivery Deadline	Process	Production time of each process on workbench 1	Production time of each process on workbench 2	Production time of each process on workbench 3
1	1121	3	3	14	7	8
2	1089	4	2	11	0	9
3	593	2	2	13	0	7
4	1325	5	3	9	14	10
5	1894	3	2	0	12	9
6	1351	1	3	11	8	10

Table 2: The Workbench Attributes

Workbench	1	2	3
Production Costs	40	20	30

4.2 Example solution

For this model, we set a planning cycle as T=5 days and 8 hours of working time per workbench every day. Since each operation of each order has the same production time on each workbench, we assume all the process of each order should be produced in the same workbench to save preparation. The solution is solved by LINGO software, running on a computer configured with Windows 10 Intel(R) Core (TM) i5-6300HQ CPU. The best results are obtained as shown below.

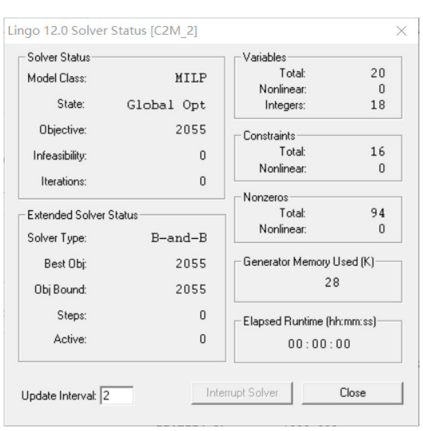

Figure 2: The Main Part of the Solution

S(1, 1)	0.000000	559.0000
S(1, 2)	1.000000	-701.0000
S(1, 3)	0.000000	-401.0000
S(2, 1)	0.000000	-209.0000
S(2, 2)	0.000000	2911.000
S(2, 3)	0.000000	-549.0000
S(3, 1)	0.000000	447.0000
S(3, 2)	0.000000	3407.000
S(3, 3)	0.000000	-173.0000
S(4, 1)	0.000000	-245.0000
S(4, 2)	0.000000	-485.0000
S(4, 3)	0.000000	-425.0000
S(5, 1)	0.000000	2106.000
S(5, 2)	0.000000	-1414.000
S(5, 3)	1.000000	-1354.000
S(6, 1)	0.000000	-31.00000
S(6, 2)	0.000000	-871.0000
S(6, 3)	0.000000	-451.0000

Figure 3: Solution of Decision Variables

As is shown by the results obtained from the above experiment, we should select order 1 and order 5. And order 1 should be selected to be processed on workbench 2 and order 5 on workbench 3. Within this plan, the total profit is the largest, at 2055 RMB.

5. EXPERIMENTAL ANALYSIS AND CONCLUSION

5.1 Experimental Analysis

From the above experiment, we verify the reliability of our model established in Section 2, and we obtained a good solution. By using this model, company managers can make order selections faster. It also makes fuller use

of the company's limited production capacity and maximizes profit.

5.2 Experimental Conclusion

In this paper, we discuss the order selection system of those companies using C2M mode, and explain the inner logic of their order selection. And then, we provide an in-depth description of one of the order selection strategies and using examples to model order selection considering capacity constraints and deadline constraints. At last, we solve the problem and offer the best program to verify the reliability of our model.

Our subsequent work will focus on a deeper level of order selection, in fact, many companies still consider future cooperation and penalties for late delivery when making order selections, and C2M mode is increasingly combined with different areas and plays different roles. And how to make scheduling plan after the order selection is also an important research thesis.

ACKNOWLEDGEMENTS

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APPENDIX

LINGO codes:

```
!data;
model:
sets:
order/1..6/:profit,d;
workbench/1..3/:w;
whether(order,workbench):wt,s;
endsets
data:
profit=1121,1089,593,1325,1894,1351;!profits of each order;
w=40,20,30;!cost of each order;
wt=42 21 24
22 200 18
26 200 14
27 42 30
100 24 18
33 24 30;!processing time of each order on each workbench;
d=24,32,16,40,24,16;!deadline of each order;
enddata
!to calculate the profits;
p=@sum(workbench(j):@sum(order(i):s(i,j)*profit(i)));
!to calculate the cost;
cost=@sum(workbench(j):@sum(order(i):s(i,j)*w(j)*wt(i,j)));
max=p-cost;
!constraints:deadline;
@for(order(i):@sum(workbench(j):s(i,j)*wt(i,j))<d(i));
@sum(workbench(j):@sum(order(i):s(i,j)*wt(i,j)))<40;
!0-1constraints;
@bin(s(1,1));@bin(s(1,2));@bin(s(1,3));
@bin(s(2,1));@bin(s(2,2));@bin(s(2,3));
@bin(s(3,1));@bin(s(3,2));@bin(s(3,3));
@bin(s(4,1));@bin(s(4,2));@bin(s(4,3));
@bin(s(5,1));@bin(s(5,2));@bin(s(5,3));
@bin(s(6,1));@bin(s(6,2));@bin(s(6,3));
!each order can just be produced once;
@for(order(i):@sum(workbench(j):s(i,j))<=1);
```

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