RELEVANT COSTS IN PRODUCT MIX DECISION MAKING

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ABSTRACT

Activity-based costing (ABC) and the theory of constraints (TOC) have different perspectives on the relevant costs in product-mix decisions. This research suggests the integration of the two models as a proper model of the product mix decision. According to this model, the optimal product mix is decided using ABC costs except for setup costs, and then the minimal setup cost is established using the Drum-Buffer-Rope (DBR) technique. By this integration, this research aims to overcome the limits of the previous accounting research, which results from the superficial understanding of the actual production fields and their cost implications.

KEYWAORDS: product mix decision, ABC, theory of constraint

OVERVIEW

Today with the increased global competition coupled with rapid changes in product life cycle, it has been necessary to reinforce both the product and price competitiveness. That is to say, the management should pursue the rational resource allocation and continuous improvement through the product mix decisions. To accomplish this object, managers need to understand production process and its cost implications.

Several research efforts have been devoted to evaluating different perspectives on the relevant costs in product mix decisions. (Kee, 1995; Malik and Sullivan, 1995; Goldratt, 1990) Malik and Sullivan studied effectiveness of using ABC in product mix decisions. Kee also argued that the use of multiple-cost drivers and tracing cost at the structural level enables ABC to more accurately specify the relationship between resources used in production activities and the products they are used to produce. Especially, Kee asserted that the relevant costs in the product mix decisions include batch- and product-level costs as well as unit-level costs. Setup and ordering costs at the batch-level and engineering costs at the product-level were included as relevant costs in the product mix example he made. He derived the optimal solution through the mixed-integer programming model.

This paper agrees that Kee correctly established the programming model using ABC costs except for setup costs. He assumed that in order to implement his product mix decision model, it is imperative to derive setup costs in advance. To do this, the number of setup is invariably determined while the production volumes of each product are decided by the optimal mix. For example, when the production volumes of three products are 10,500, 10,000 and 30,100 units, the number of setup should be fixed such as 12, 10, and 61.

This assumption, however, is inconsistent with the actual operation of factories. Under the given product mix, several choices of job schedule are possible for each product, and the number of setup is different depending on which choices are made. For example, if the optimal mix of product A and B is 100 and 30 units, and the production volume per batch is 20 and 10 units, production schedules such as AAAAABBB, AAAABABB, AAAABBAB … BBBAAAAA are all possible. There are a corresponding number of set-ups for each schedule, thus setup costs vary for each schedule.

In addition, it is necessary to have setup-hour requirements in the constraints of Kee’s programming model. In his model, a specific amount of time (per week) is required for setup activity. This requirements, however, is inconsistent with the philosophy of the advanced manufacturing technology (AMT). One major objective of the AMT is to increase the ratio of processing time to throughput time, that is, to decrease non-value-added activity in the manufacturing process. Therefore, the AMT does not allow separate time for non-value-added activity such as setup. According to the AMT, setup time should be considered as trade-off with processing time and thus, as more time is spent for setup, less time is used for processing.

On the other hand, the theory of constraints (TOC) has a different perspective regarding the cost implications in the production mix decision. The TOC considers only direct material costs as relevant and others as irrelevant. The optimal product mix thus is attained only with the knowledge of the contribution margin without having other cost information. A previous research (MacArthur (1993)) has proposed that the ABC is applicable in various situations whereas the TOC is applicable in the very limited situation where all costs except for direct material are fixed. Further, the TOC philosophy is consistent with the AMT in that the TOC does not allow separate time for setup and tries to maximize processing time by the establishment of the scheduling plan called drum-buffer-rope (DBR).

Based on the above argument, we found that the setup cost is suggested not to be included as relevant costs in the product mix decision since the setup cost should not be determined together with the optimal mix. , In addition, one important concept from the TOC (i.e., job scheduling) should be considered if ABC is to be properly used in various product mix decisions. Since the job scheduling is determined after the optimal product mix is decided, the job scheduling has an effect on setup costs.

Consequently, this paper aims to introduce the integrated product mix decision model that does not explicitly include setup costs. However, this paper argues that it is correct method to consider setup cost implicitly in the product mix decision model. In the integrated model, programming model using ABC is employed except for setup costs, and then the TOC scheduling plan is applied with regard to setup costs. Especially, this paper argues that an integration of ABC and the TOC is required for the proper modeling of the product mix decisions.

In addressing this objective, the effectiveness of the integrated model will be evaluated under the artificial production line. This paper explaines that setup costs have some implications to consider in the product mix decisions. These implications are considered in terms of the objective function and constraints of the programming model, and are explained with the example he has used. Through the integrated model, this paper aims to overcome the limitations of the existing accounting research, that is, the superficial understanding of the actual production fields and their cost implications.

AN ARTIFICIAL PRODUCTION LINE

To explain the integrated production mix decision model, this paper uses the production line, which Goldratt (1986) designed to explain the TOC. This line deals with the product mix decision on existing products and the flow of production is depicted in figure 1.

Product Flow Information

The rectangular in the figure represents the job operation, with the former number representing the required machine and the later number in parenthesis representing processing time. The oval represents the raw materials required for the production, with numbers denoting the purchase price. Works-in-process (WIP) exist on this production line because it deals with the product mix of existing products. Initially, 25, 15 and 10 units of WIP stay at B3, E2 and F3, respectively.

The line produces three kinds of products using four kinds of raw materials and five kinds of machines. Some data on machines are depicted in Table 1. The market demand for product X, Y and Z is 40, 80 and 40 units per week each, and the sales price is $180, $240 and $180 each. It is assumed that this company is able to sell as much as the markets demand.

<Figure 1> Flow of production

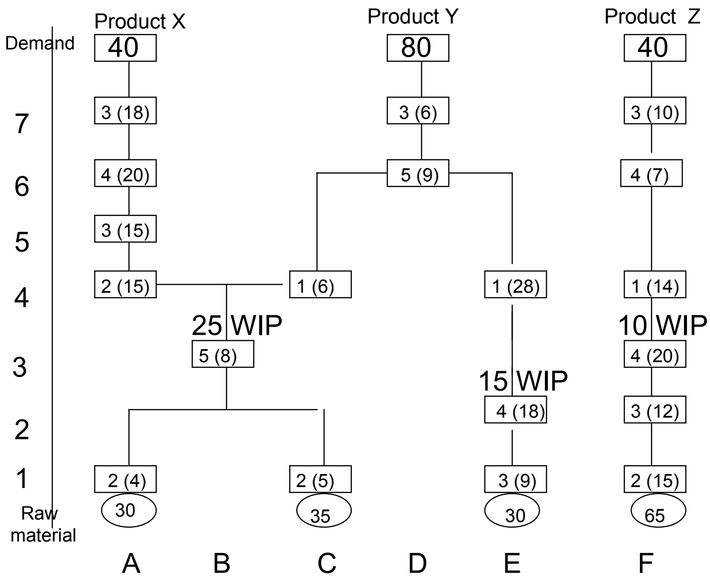

Table 1: machine information in production line

Machine	Number of machines	Capacity/ week	Required set-up time
Machine1	1	2,400 min.	15 min
Machine2	2	2,400 min.	120 min
Machine3	2	2,400 min.	60 min
Machine4	2	2,400 min.	30 min
Machine5	1	2,400 min.	0 min

Product Cost Information

According to ABC, the costs of products passed through the production line are as follows.

1) ***Unit-Level Cost***

Direct material cost

- The direct material cost of product X, Y, and Z is $65, $95 and $65 each as presented on the production line.

Direct labor cost

- The direct labor time is the same as the processing time of each product.

- The production line is assumed semi-automatic, requiring operators to operate machines.
- The hourly wage is assumed$12.5 for all operators.

Variable manufacturing overhead cost

- The variable manufacturing overhead cost is assumed $10 per machine hour.

2) *Batch-Level Cost*

- The batch size of product X, Y, and Z is 10, 15, and 10 units each, setup cost is $22.5 per setup hour and 2,400 minutes of setup time is available per week.

THE INTEGRATED PRODUCT MIX DECISION MODEL

Based on the above reasoning, the integrated product mix decision model is developed. The coefficient of the objective function is obtained from ABC model except for setup costs are included in the integrated model. Since setup costs are not determined together with the optimal mix, they are not included in the objective function. IN addition, setup time is not included in the constraint because it is considered as trade-off with processing time. The constraints are the five machines as well as the market demand per each product.

Thus, the integrated model is as follows:

Objective function

$$\textbf{\textit{Max}} \quad 83.1X_1 + 110.1X_2 + 85.7X_3$$

Constraints

$$\begin{array}{llllll}
\text{Machine time} & & 34X_2 & + 14X_3 & \leq & 2{,}400 \\
 & 24\,X_1 & + 9\,X_2 & + 15X_3 & \leq & 4{,}800 \\
 & 33\,X_1 & + 15X_2 & + 22X_3 & \leq & 4{,}800 \\
 & 20\,X_1 & + 18X_2 & + 27X_3 & \leq & 4{,}800 \\
 & 8\,X_1 & + 17X_2 & & \leq & 2{,}400 \\
\text{Market demand} & X_1 & & & \leq & 40 \\
 & & X_2 & & \leq & 80 \\
 & & & X_3 & \leq & 40
\end{array}$$

Where,

X_i : production volume i= 1, 2, 3 (integer)

The solution of the above model results in the operating income of $12697.40, producing 40 units of product X, 54 units of product Y and 40 units of product Z. However, since this solution does not consider setup time (or cost), which is actually dependent on the production schedule, the actual optimal solution is less than the solution above. In order to obtain optimal mix as much as possible, the company should minimize setup time of constraining resource, which is Machine 1. The company applies DBR technique in the TOC, and limits setup activities of Machine 1 to 6 times.[1] Thus, the actual optimal operating income is the \$12,367.10 and the product mix is 40 units of product X, 51units of product Y, and 40 units of product Z.

THE COMPARISONS

The consequences of the TOC, ABC and the integration of the two theories are as follows.

Table 2: the comparison of the TOC, ABC, and the integrated model

	ABC model	TOC model	Integrated model
Product X	0	40	40
Product Y	60	51	51
Product Z	20	40	40
Operating income	\$7,453.75	\$9,395	\$12,367.1

One of the reasons why the operating income of the TOC is higher than that of ABC is that the TOC does not allow separate cost for set-up whereas ABC allows setup cost, which is \$866.25 in the example. In addition, the reason why the operating income of the integrated model is higher than that of TOC is that the direct labor and variable overhead cost is considered as a variable cost (supplied as needed) in the integrated model whereas they are considered as a fixed cost (supplied in advance of usage) in the TOC.

SUMMARY AND CONCLUSIONS

Activity-based costing (ABC) and the theory of constraints (TOC) have emerged with regard to the cost implications. However, these tow approaches have different perspectives on relevant costs in the product-mix decision. Whereas the TOC considers only the direct material costs as relevant costs, ABC includes unit-, batch- and/or product- level costs as relevant depending on the situation. Thus, product mix decision process using ABC is right except for setup costs.

According to the TOC, setup costs are determined after the scheduling plan called

[1] In the TOC model, the contribution margin per constraining resource of product Z (115/14) is greater than that of product Y (145/34). In the integrated model, the operating income per constraining resource of product Z (85.7/14) is greater than that of product Y (110.1/34). Thus, two models provide the same optimal mix, which results in the same job scheduling, i.e., six numbers of set-up activities.

DBR is established. The numbers of setup and resultant setup costs are determined based on the job scheduling which is determined after the optimal product mix is decided. That is, setup costs are not determined together with the optimal mix, but determined after the mix is decided. Therefore, setup costs are suggested not to be included as relevant costs in the product mix decision. In this respect, the approach of the TOC is appropriate. The TOC, however, is applicable in the very limited situation where all costs except for direct material are fixed.

Based upon the above differences between ABC and the TOC, this paper suggests the integrated product mix decision model. According to this model, the optimal product mix is decided using ABC costs except for setup costs, and then the minimal setup cost is established using the DBR technique. In the context of the programming model, setup costs should not be included in the objective function and constraints. By this integration, this research aims to overcome the limits of the previous accounting research, which results from the superficial understanding of the actual production fields and their cost implications.

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