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DEVELOPING EFFECTIVE MANUFACTURING STRATEGIES FOR PRODUCT MIX DECISIONS VIA THEORY OF CONSTRAINTS: A CASE STUDY

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ABSTRACT

One of the most important problems that today's companies face the optimum product mix decision problems to maximize their profit level. Theory of constraints is one of the methods that can be used to solve these problems. In contrast to the traditional methods, TOC ensures superiority by determining the product mix. In this study, different manufacturing strategies are analyzed in the way of total income and gross profit within a firm manufacturing three types of products. Five different manufacturing strategies are investigated. Finally, it is found that the best strategy is TOC strategy according to total income and gross profit.

Keywords: Manufacturing strategy, product mix decisions, theory of constraint,

ÖZ

Günümüzün en önemli problemlerinden biri, firmaların kâr seviyelerini en büyükleyecek olurlu ürün karması problemleri ile karşı karşıya kalmalarıdır. Kısıtlar teorisi, bu tür problemleri çözmede kullanılabilecek yöntemlerden biridir. Geleneksel yöntemlerin tersine, kısıtlar teorisi bu problemlerin çözümünde üstünlüğe sahiptir. Bu çalışmada farklı üretim stratejileri toplam gelir ve brut kar yoluyla üç tip ürün üreten bir firma için analiz edilmiştir. Beş farklı üretim stratejisi incelenmiştir. Sonuç olarak kısıtlar teori yaklaşımının toplam gelir ve brut kâra gore en iyi strateji olduğu bulunmuştur.

INTRODUCTION

The TOC demonstrated an implementation of common systems in the optimization of manufacturing. TOC utilizes the company's constrained actions to divert manufacturing and process development determinations. Companies adopted the TOC to increase efficiency and quality, and also decrease stock, lead time and cycle time (Kee & Schmidt, 2000).

TOC finds the most influential factors affecting performance in a negative way, manages and eliminates these factors to improve the performance of system (Goldratt & Cox, 1992). Main topic of this theory is that each firm has a constraint at least, and constraints should be eliminated (Ünal et al., 2005). TOC sustains to be actively used in industry because of its respectable potential to define throughput problems; to assistant as a guide to solve the throughput problems; and to produce considerable improvements in productivity and efficiency (Pegels & Watrous, 2005).

This study was performed in a manufacturing firm. In order to increase profitability, constraints emerging from production process were determined. Then five different strategies related which product mix should be used in manufacturing process were investigated. These strategies are (1) Produce the highest demanded product primarily. (2) Produce the highest priced product primarily. (3) Primarily produce product with the highest unit gross profit. (4) Produce equal quantity from each product. (5) Prioritize products according to TOC approach and then produce.

This paper constructed as following; first a literature survey about product mix decisions and TOC is performed.Then TOC and its fundementals are explained. Following this, case study in a company which produces three different types of keys is performed. Finally, paper is ended with results and discussion.

LITERATURE REVIEW

Simons Jr and Simpson III (1997) aimed "to advance the state of research on constraint scheduling in several ways". They presented the solution algorithm integrated by the Goldratt Institute in their production software. Finally, they link this algorithm to alternative methods in constraint scheduling. Bengtsson and Olhager (2000) modelled the selection of a product mix by integrating the TOC and the activity-based cost (ABC) with the capacity of production-related facilities. They demonstrated that management's power over labour and overhead resources determine that the TOC and ABC cause optimal product-mix decision, and they developed a general model of the product-mix decision. Draman et al (2002) used a simple Gedunken experiment to asses the differences between strategy-driven product mix decisions based on TOC accounting and traditional cost accounting. These decisions include four strategies; contraction, market share, product quality and cost leadership. They used these strategies to provide a guidance and direction to develop strategic decisions for product mix by using traditional and TOC approaches. Lea and Fredendall, (2002) examined how three types of management accounting systems (ABC, throughput accounting and traditional cost accounting) and two methods (TOC and linear programming) to determine product mix interaction in both the short term and the long term to influence the manufacturing performance of two shops (a flat, and a deep product structure) in a highly automated industry with significantly high overhead content. Sheu et al (2003) reviewed and compared the concepts of TOC and ABC. They discussed the managerial impacts of the two theories in various decisions such as pricing, make-or-buy and product mix. They found that ABC and TOC can provide management with better performance measurement of diverse production activities. Pegels and Watrous (2005) used TOC methodology in a detailed case study of the bottleneck in the manufacturing process. The bottleneck in this case was the mold-changing operations, consisting of a plastic injection process for heavy-duty truck-lighting systems components.

Mehra et al. (2005) compared TOC and traditional accounting performance measures in a process industry by using a simulation-based approach. Study of Wu et al. (2006) aimed to solve the product mix decision problem for a mixed-yield scenario involving the simultaneous production of high-yield and low-yield products. They developed a nonlinear mathematical program in order to model the decision problem. In another study, Karataş (2012) and Razi & Karatas (2016) used nonlinear and linear programs to determine the optimal mix and allocation of resources for a decision problem. Bhattacharya et al. (2008) outlined a fuzzy approach using fuzzy linear programming (FLP) with a suitably designed smooth logistic membership function (MF) for finding fuzziness patterns at disparate levels of satisfaction for TOC-based product mix decision problems. Utku et al (2011) examined the importance of the theory of constraints compared to the conventional cost accounting in making adequate product mix decisions. They performed an application in a chemistry industry to determine product mix decisions and their effect on profitability by comparing the theory of constraints variable costing method with the full costing method in respect to the throughput approach, the contribution margin approach and the unit profit approach respectively.

THEORY OF CONSTRAINTS

Theory of constraints (TOC) is a management philosophy which is developed by Dr. Eliyahu M. Goldratt in the beginning of 1980s. Its point of origin is that performance of each firm is determined by constraints and each firm has a few constraints at least (Ruhl, 1996). According to Atwater & Gagne (1997) a constraint is “everything limiting system performance”, and TOC is a management philosophy which focuses improvement by means of managing constraints in the system.

TOC concentrates on system improvement. A system is referred as a series of interdependent processes. A chain is an analogy for a system. The chain is a group of interdependent links working together toward the overall objective. The constraint is a weakest link in the chain. The performance of the oceralle chain is limited by the strength of the weakest link (Nave, 2009). TOC consists of five steps, these are indentify the constraints, exploit the constraint, subordinate non constraints, elevate the constraints, repeat the process with the new constraints. (TOC, 2008)

Basics of the TOC can be grouped into five principles (Womack & Flowers, 1999);Systems and processes are like chains, There is a constraint at least. The weakest link of the chain is called as a bottleneck. When the weakest link is strengthen, output of the system increases. Constraints can be classified according to reasons (such as market constraints, resource constraints, capacity constraints, political constraints etc.) Any improvement performed in non-constraint resources or processes do not influence system performance.

Huff (2001) defined TOC as a production management approach which determines and manages constraints during the manufacturing processes, and any constraint can be “anything that limits a system from achieving higher performance relative to its goal.” Basic point of TOC is that, contrary to traditional thinking, each constraint provides an improvement opportunity. TOC evaluates constraints positively, because constraints define performance of a system, and elimination of constraints step-by-step increases system performance (Spencer & Cox, 1995). Any internal situation in the firm can be a constraint or bottleneck. In this case, a constraint occurs internally in the firm such as a machine with limited capacity. Also a constraint can be derived from external situations such as a market limit that would restrict total sales (Huff, 2001).

The TOC reviews manufacturing processes and organizations as “chains”. The overall performance of the system is merely determined by the weakest link. TOC aims to define the weakest link (constraint) in manufacturing processes, and than strengthen this weakest link which is no longer the limiting factor in determining the strength of the chain (or process) (Pegels & Watrous, 2005). In manufacturing processes, TOC focused on the process that slows the speed of product through the system (Nave, 2009).

The TOC optimizes efficiency of the whole system. The optimal efficiency for the production system can be reached by defining and feeding constraints. The optimization outcomes are summarized as minimizing stocks, reducing cycle times, reducing manufacturing expenditures, and yielding more aggressive and accurate customer delivery times. Feeding a constraint becomes significantly more difficult when the process is highly reentrant, and the constraint tools are met many times in the process at different process rates (Rippenhagen & Krishnaswamy, 1998).

Before defining the constraint, two prerequisites should be ensured to acquire perspective in terms of analyses (Coman & Ronen, 1995); (1) Identify the system and its aim, (2) Specify how to measure the aim of the system.

A constraint in a production system can be anything limiting the system to achieve its goal or a desired performance level. TOC is a production management technique that identifies and manages constraints in the system. TOC has three principles for production: “(1) to increase throughput, (2) to decrease operating expenses, and (3) to decrease inventory” (Huff, 2001). When companies are “making money”, they are creating value-added at a faster rate than their expenditures rate. In order to calculate "making money," TOC uses three measures; (1) Throughput, (2) Operating expense, (3) Inventory. These measures are called as global operational measures (Moore and Scheinkopf, 1998).

(1)Throughput (T) is defined as the rate at which the organization generates money through sales or interest (Ricketta, 2007) .Firms earn money by selling their products. In order product/ services. Firms have to pay money to their vendors for materials/services required for producing products/services. Thus they create value-added for customers. This "value-added" is called as throughput (Moore and Scheinkopf, 1998). Throughput is computed by using equation 1;

$$\textit{Throughput (T)} = \textit{Sales} - \textit{Raw material costs} \tag{1}$$

(2) Operating expense (OE) is defined as all of the money the organization spends in order to turn inventory into throughput. Operating expense includes all of the expenses that we typically accept "fixed." (Moore and Scheinkopf, 1998). It contains direct labor, rent and labor, plus selling, general and administrative costs (Ricketta, 2007)

(3) *Inventory (I)* defined as all money invested in things intended for (Ricketta, 2007). It is defined with a more comprehensive definition as "the money that the system spends on things it intends to turn into throughput or the money the system spends on things it intends to sell". (Moore and Scheinkopf, 1998). It contains totally variable costs such as material, plus resources used in production such as land, machines, trucks and computers (Ricketta, 2007).

The TOC metrics of *T*, *I*, and OE provide alignment between local actions and the global aim of fulfillment "more money now and in the future" (Berry and Smith 2005).

Additionally, three following measurements can be accepted as global measurements that are mentioned above. They contain Net Profit, ROI and cash flow (Mabin & Balderstone, 2003).

$$\textit{Net Profit (NP)} = \textit{Throughput (T)} - \textit{Operating Expenses (OE)} \tag{2}$$

$$\textit{Return on Investment (ROI)} = \textit{Net Profit (NP)} / \textit{Inventory (I)} \tag{3}$$

These financial performance measures are a distinct measure of money moving into and out of the manufacturing system in time. Thus, a preferred optimum operating condition for the firm is to focus on what influences the “total” system and not just what influences a “part” of the system. This situation is called as the global optimum (Moore & Scheinkopf, 1998).

THE CASE STUDY

The case study is performed within a Turkish manufacturing company. The company manufactures three types of keys as Product Z, Product F and Product T. Raw material costs for three products were determined according to the used weights of grams in a product and kilogram prices of raw materials. Prices and costs are in Turkish Liras (TL). Manufacturing operations for three products are composed of three processes: (1) plastic-injection, (2) metal-cutting and pressing, and (3) assembling. All operations are performed by three operators. Sales prices of products are; *3.68 TL* for Product Z; *1.68 TL* for Product F; 3.90 TL for Product T. Production stages and raw material costs are shown in Figure 2. Daily demands of products are; 1800 units for Product Z, 2200 units for Product T, 2400 units for Product F. Operating expenses are 10570.0 TL

Finding constraints of the system: In order to find constraint process/operation, firstly, the workloads of manufacturing processes are calculated. Then the workloads and capacities of the processes/operations are compared. Then processes which their workloads exceed their capacities are determined as constraints/bottlenecks. If number of constraints more than one, the process with the highest workload is determined as CCR.

Unit processing times of all products for each operation are presented in Table 1. All processing times determined as second and they are illustrated as sec. Product Z provided after stages of frame, button, cover, fixing, plug, pad, sub-mechanism, body and product. Total unit processing time for Product Z is 36.84 sec. Product F transforms a product after stages of frame, button, cover, piston, pad, sub-mechanism and product. Total processing times for Product F is 35.12 sec. Product T transforms a product after stages of frame, button, cover, fixing, plug, pad, sub-mechanism, body and product. Total unit processing time for Product T is 44.62 sec.

Table 1: Unit processing times for products

Product	Plastic injection (sec)							Metal cutting and pressing (sec)		Assemble	Total unit time per product
	Frame	Button	Cover	Fixing	Plug	Piston	Pad	Sub mechanism	Body	Product	
Z	3.22	3.43	1.96	1.78	4.03	-	1.92	6.32	5.02	9.16	36.84
	6.89	6.02	1.96	1.78	4.03	-	1.92	7.44	5.02	9.56	44.62
F	8.41	5.21	1.96	-	-	2.02	2.65	8.89	-	5.98	35.12

Required time or work load of each process is calculated by multiplying demand of each product and unit processing time of each processes as presented in Table 2. Processes of frame, button, sub mechanism and assemble are bottlenecks because their workloads exceeds their capacities. Assemble process is determined as CCR because it has the highest workload.

Table 2: Finding CCR Bottleneck

Product	Plastic injection							Metal cutting and pressing		Assemble
	Frame	Button	Cover	Fixing	Plug	Piston	Pad	Sub mechanism	Body	Product (sec)
Z	5796	6174	3528	3204	7254	-	3456	11376	9036	16488
T	15158	13244	4312	3916	8866	-	4224	16368	11044	21032
F	20184	12504	4704	-	-	4848	6360	21336	-	14352
Work Load (sec)	41138	31922	12544	7120	16120	4848	14040	49080	20080	51872
Capacity (sec)	28800	28800	28800	28800	28800	28800	28800	28800	28800	28800
	Bottleneck	Bottleneck						Bottleneck		Bottleneck CCR

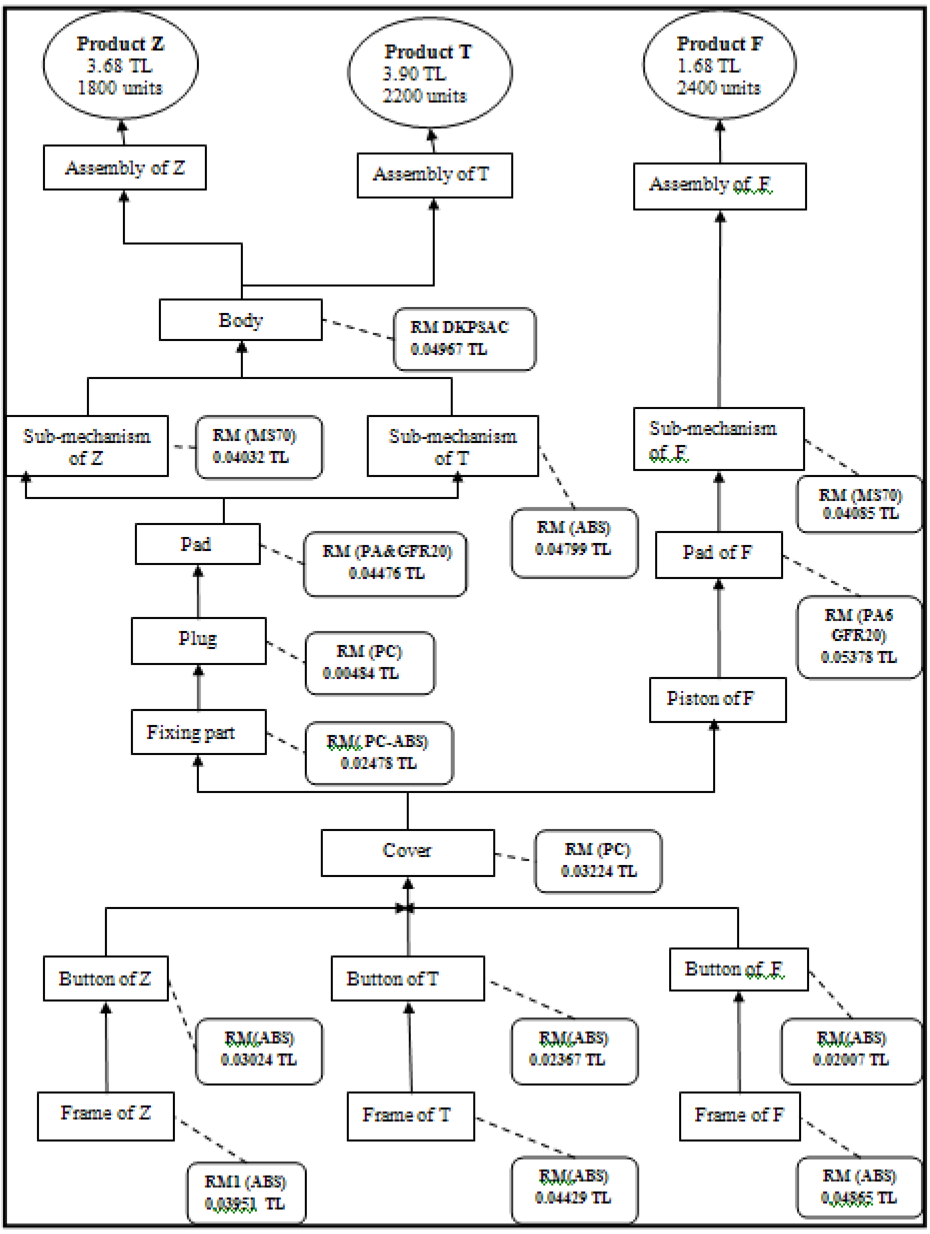

Figure 1: Process flows of Product Z, Product T and Product F

Total raw material costs are calculated according to all kinds of raw materials and their used amount for each product. Total raw material cost of Product Z is 0.26636 TL, Product T is 0.27224 TL, Product F is 0.19642 TL as shown in Table 3. Sales price of Product Z is 3.68 TL. Sales price of Product F is 1.68 TL. Sales price of Product T is 3.70 TL.

Table 3: Raw material costs for Products

	Raw material→	**ABS**	**PC**	**PC-ABS**	**PA6 GFR20**	**MS 70**	**DKP SAC**	**Unit raw material cost (TL)**
Product Z	Weight of grams	21.89	6.51	4.64	8.98	3.84	45.34	**0.26636**
	Price (TL/kg)	1.79	3.2	3	2.8	10.50	0.83	
	Item cost (TL /product)	0.09999	0.03702	0.02478	0.04476	0.04032	0.04967	
Product T	**Raw material→**	**ABS**	**PC-ABS**	**PC**	**ABS**	**PC-ABS**	**PC**	**Unit raw material cost (TL)**
	Weight of grams	21.33	4.64	6.51	8.98	4.57	45.34	**0.27224**
	Price (TL/kg)	1.79	3	3.2	2.8	10.50	0.83	
	Item cost (TL /product)	0.06798	0.02478	0.03708	0.04476	0.04799	0.04967	
Product F	**Raw material→**	**ABS**	**PC**	**Polyamide 46**	**PA 6 GFR20**	**MS 70**		**Unit raw material cost (TL)**
	Weight of grams	21.57	5.66	0.18	10.79	3.89		**0.19642**
	Price (TL/kg)	1.79	3.2	2.6	2.8	10.50		
	Item cost (TL /product)	0.06872	0.03224	0.00083	0.05378	0.04085		

APPLICATION OF DIFFERENT MANUFACTURING STRATEGIES FOR THE CASE STUDY

Companies can apply different strategies when preparing their production plans. While applying these strategies, most important considering factor is profit. Companies target maximum earnings and profit while determining their product mix. In the case study, five different strategies were investigated. These five strategies are sequenced and explained as following.

Strategy 1. Market based strategy-Produce the highest demanded product primarily.

In this strategy, manufacturing priority is given to the most demanded product. Company produces three different products; Product Z, Product F and Product T. Among these products, Product F is the most demanded product with 2400 units demand per day as presented in Table 4. In this situation all demand of Product F is produced. The rest of time is used to manufacture Product T which has second highest demand of 2200. In this time, daily production capacity of Process Assemble is 28800 sec (60x60x8). Required capacity to produce 2400 units of F is 14532 sec (2400x5.98). Rest of the capacity to produce T is 14448 sec (28800-14532). Production quantity of T is 1511 (14448/9.56). Total sales is calculated as 9926.1 TL (5894.1 + 4032.0) and, total raw material cost is calculated as 882.8 TL (Turkish Lira) (411.4 + 471.4), net income is 9043.3 TL (9926.1 - 882.8). Net profit is calculated as -1525.8 TL (9043.3 - 10570). Firm loses money.

Strategy 2. Produce the highest priced product primarily

This strategy is used by salesman while marketing products. The highest priced product is produced primarily. Product T has the highest sales price (3.9 TL). Therefore Product T is produced firstly. All demand of Product T is produced, and then respectively, Product Z with sales price of 3.78TL, Product F with sales price of 1.68 are produced as presented in Table 4. In this time, daily production capacity of assemble process is 28800 sec (60x60x8). Required capacity to produce 2200 units T is 21032 sec (2200x9.56). In rest of the capacity to produce Z is 7768 sec (28800 - 21032). Production quantity of Z is 848 (7768 / 9.16). Total sales are calculated as 11785.6 TL and, total raw material cost is calculated as 824.8 TL (225.9+598.9). Income is calculated as 10960.8 TL. Net profit is calculated as 390.8 TL (10960.8-10570.0).

Table 4: Strategies for all products

Products	STRATEGY 1 Product Z	STRATEGY 1 Product T	STRATEGY 1 Product F	STRATEGY 1 Total	STRATEGY 2 Product Z	STRATEGY 2 Product T	STRATEGY 2 Product F	STRATEGY 2 Total	Product Z
Demand	1800	2200	2400		1800	2200	2400		1800
Unit Sales price(TL)	3.78	3.9	1.68		3.78	3.9	1.68		3.78
Unit Material cost(TL)	0.26636	0.27224	0.19642		0.26636	0.27224	0.19642		0.26636
Unit production time(sec) in	9.16	9.56	5.98		9.16	9.56	5.98		9.16
Unit gross profit									3.514
Manufacturing priority	3	2	1		2	1	3		2
Production quantity	0	1511	2400		848	2200	0		848
Total production time (sec)	0	14448	14352	28800	7768	21032	0	28800	7768
Sales (TL)	0	5894.1	4032.0	9926.1	3205.6	8580	0	11785.6	3205.6
Raw material	0	411.4	471.4	(882.8)	225.9	598.9	0	(824.8)	225.9
Income(TL)	0	5482.6	3561.6	9043.3	2979.7	7981.1	0	10960.8	
Operating expenses(TL)				(10570.0				(10570.0)	
Net profit(TL)				**-1525.8**				**390.8**	

	STRATEGY 4 Product Z	STRATEGY 4 Product T	STRATEGY 4 Product F	STRATEGY 4 Total	STRATEGY 5 Product Z	STRATEGY 5 Product T	STRATEGY 5 Product F	STRATEGY 5 Total
Demand	1800	2200	2400		1800	2200	2400	
Unit Sales price(TL)	3.78	3.9	1.68		3.78	3.9	1.68	
Unit Material cost(TL)	0.26636	0.27224	0.19642		0.26636	0.27224	0.19642	
Unit production time(sec)	9.16	9.56	5.98		9.16	9.56	5.98	
Throughput					3.514	3.628	1.484	
Throughput per unit time in					0.384	0.379	0.248	
Manufacturing priority	1	1	1		1	2	3	
Production quantity	1166	1166	1166		1800	1288	0	
Total Production Time (sec)	10680.5	11146.9	6972.6	28800	16488	12312	0	28800
Sales(TL)	4407.4	4547.4	1958.9	10913.7	6804.0	5022.7	0.0	11826.7
Raw material	310.6	317.4	229.0	857.0	479.4	350.6	0.0	(830.1)
Income(TL)	4096.9	4229.9	1730.3	10056.7	6324.6	4672.1	0.0	10996.6
Operating				(10570.0				(10570.0)
Net profit(TL)				**-513.3**				**426.6**

Strategy 3. Primarily produce product with the highest unit gross profit.

In this approach, raw material costs are considered. Unit gross profits of each product are calculating by using equation 6.

$$\textit{Unit Gross Profit} = \textit{Unit Sales Price} - \textit{Unit material cost} \qquad (6)$$

Three products are sorted according to unit gross profit values. As regard to this strategy, product with the highest unit gross profit is produced primarily. Product T is produced primarily because of that it has the highest unit gross profit of 3.62 as shown in Table 8. Firstly, all demand of Product T is produced, then, respectively, demand of Product Z with unit gross profit of 3.51, and demand of Product F with unit gross profit of 1.48. Results are same with Strategy 2 as presented in Table 4. Net profit is calculated as 390.8 TL.

Strategy 4. Produce equal quantity from each product.

In this approach, there is an assumption that balanced production is made and accordingly each product is produced equal quantity as presented in Table 4. Any sequencing is not important. According to daily capacity, 1166 (28800/ (9.16+9.56+5.98)) units from each product are produced. Total sales are calculated as 10913.7 TL. Total raw material cost is calculated as 856.5 TL. Net income is calculated as 10056.7 TL. Net profit is calculated as -513.3 TL. Firm loses money.

Strategy 5.Prioritize products according to TOC approach and then produce.

In this strategy, TOC approach is used. Unit throughput per unit time in CCR for each product is calculated by using equation 7 and equation 8 .

$$\textit{Unit Throughput} = \textit{Unit sales price} - \textit{Unit material cost} \qquad (7)$$

$$\textit{Unit throughput per unit time in CCR} = \frac{\textit{Unit Throughput}}{\textit{Processing time in constraint}} \qquad (8)$$

Then products are sorted according to throughput per unit time. Then Product Z with the highest throughput value (0.384) is produced primarily (Product Z), Respectively Product T (0.379), and Product F (0.248). Product Z is produced 1800 units. In this time, daily production capacity of assemble process is 28800 sec (60x60x8). Required capacity to produce 1800 units Z is 16488 sec (1800x9.16). Rest of the capacity to produce T is 12312 sec (28800-16488). Production quantity of T is 1288 (13312/9.56). Total sales is 11826.7 TL, total raw material cost is 830.1TL. Net profit is calculated as 426.6 TL.

Results of five strategies are summarized in Table 5. As seen Table 5, the best strategy is Strategy 5, TOC approach. According to these results, Application of the TOC approach provides the highest profit value of 426.6 TL when it compared with other strategies. Company should manufacture 1800 units of Z, 1288 units of T because this mix provides maximum throughput.

Table 5: Strategies and provided results

Strategy	**Sequencing**	**Z (units)**	**T (units)**	**F (units)**	**Net Profit (TL)**
Strategy1	F(2400),T(2200), Z(1800)	-	1511	2400	-1525.8
Strategy 2	T(3.90), Z(3.78), F(1.68)	848	2200	-	390.8
Strategy3	T(3.62), Z(3.51), F(1.48)	848	2200	-	390.8
Strategy 4	-	1166	1166	11666	-513.3
Strategy 5	Z (0.384), T (0.379), F (0.248)	1800	1288	-	426.6

RESULTS AND DISCUSSION

This study evaluates difference between strategy driven product mix decisions based on TOC cost approach, and traditional cost approach. This study is performed in a manufacturing company. The company produces three types of keys. In this study "assemble" process determines system's output, and it is system constraint. So system performance is related to "assemble" process. Firm developed five different strategies; Strategy 1 (Market based strategy-Produce the highest demanded product primarily); Strategy 2 (Produce the highest priced product primarily); Strategy 3

(Primarily produce product with the highest unit gross profit); Strategy 4 (Produce equal quantity from each product), and Strategy 5 (Prioritize products according to TOC approach and then produce). Five different strategies were analyzed according to revenue and gross profit. A summary of evaluation results of five strategies presented in Table 11. A review of this table leads to following conclusion. According to Strategy 1, manufacturing priority should be given to the most demanded product. In this strategy all demand which belongs to Product F is produced. It is the worst strategy for profit and revenue amongst other strategies. Strategy 2 is mostly used by salesman, in this strategy product with the highest price is produced first. Strategy 2 doesn't consider cost factor and capacity factor. Strategy 3 considers raw material costs. Strategy 3 gives importance to unit gross profit and the product with the highest unit gross profit is produced first. For both of Strategy 2 and Strategy 3, Product T is produced at first. These two strategies determine production rank of products in the same sequence. Strategy 4 insists on balanced production, and each product is produced equal quantity. If firm gives importance to product variety, it may choose this strategy. But Strategy 4 is not enough for performance targets such as higher profit and revenue,

Strategy 5 uses TOC approach. According to TOC, the constraint's capacity determines system performance. Revenue, and throughput per unit time for each product is calculated. As a result, it is the best strategy in other strategies. Obtained results from our study supports the TOC theory.

In this study, with only three products, the alternative product mix decisions are very limited and the impact of the constraint's limited capacity on alternatives can easily defined. Approach used in this study is very practical when number of different products is low. When number of different products is much larger, definition of the constraint is more difficult.

From this research, we can see how TOC based approach can affect product mix decisions. Decisions based on TOC approach produces significant effects of firm's financial performance when compared with decisions using traditional cost approaches.

TOC contains a new set of performance measures. These measures link together strategic objectives and operational capabilities. This paper uses the set of performance measures (throughput, inventory and operating expense) defined by Golddratt. Thus this paper provides support for that these measures provide a direct link between local production capabilities of the constraints and the organizational performance.

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