Theory of Constraints

Follow the Five Steps Process:

* Two Products, P and Q.
	+ Demand for P and Q are 100 and 50, respectively.

Purchased Part

$5 / unit

RM1

$20 per

unit

RM2

$20 per

unit

RM3

$20 per

unit

$90 / unit

100 units / week

$100 / unit

50 units / week

P:

Q:

D

15 min.

D

5 min.

C

10 min.

C

5 min.

B

15 min.

A

15 min.

B

15 min.

A

10 min.

Raw Material = RM

Product P: Demand is $90 / unit and 100 units / week.

Raw Material 1, $20 per unit, passes through department A for 15 mins and department C for 10 mins.

Raw Material 2, $20 per unit, passes through department B for 15 mins and department C for 5 mins.

Raw Material 1 and 2 meets up at department D and all together spends 15 mins in this department. Department D costs $5 per unit.

* $45 ($20 / unit for RM 1, and $20 / unit for RM 2, and $5 purchased part / unit) goes into product P.
	+ $45 is cost of raw material per unit.
* $90 sales price per unit for 100 units / week = demand.
* All together, Product P requires 15 mins in department A, B, C (10 mins + 5 mins), and D.

Product Q: Demand is $100 / unit and 50 units / week.

Raw Material 2, $20 per unit, passes through department B for 15 mins and department C for 5 mins.

Raw Material 3, $20 per unit, passes through department A for 10 mins and department B for 15 mins

Raw Material 2 and 3 meets up at department D and all together spends 15 mins in department D.

* $40 ($20 / unit for RM 2, and $20 / unit for RM3) goes into product Q.
	+ $40 is cost of raw material per week.
* $100 / unit for 50 units / week = demand.
* All together, Product Q requires 10 mins in department A, 30 mins in department B, 5 mins in department C, and 5 mins in department D

Total operating expenses per week is $6,000.

* Includes $2,000 administrative costs for the manager who works as operations, finances, and marketing manager
* $4,000 non-administrative costs for the 4 operators working at the work centers A, B, C, and D.
* Time available at each work center is 2,400 mins / week.

How many units of product P and product Q should we produce to maximize our total profit?

What Product to Produce? Cost World Solution

**Sales View:** Suppose you are the sales manager and you will be paid a 10% commission on the sales Price. What product do you recommend to produce?

* P: Sales Price = $90 🡺 commission /unit = $9 (10% commission)
* Q: Sales Price = $100 🡺 commission /unit = $10 (10% commission)
	+ A sales manager will want to produce product Q because they will make a $1 more in commission / unit in comparison to product P ($10 in Product Q - $9 in Product Q = $1)

**Cost Accounting View- Standard Costing:** Overhead – operating expense - is $6000 per week.

Standard cost accounting is a Generally Accepted Accounting Principle (GAAP). It attempts to absorb all the overhead costs of production into the product cost using a **single cost driver**. Usually the **overheads are directly allocated among the various products in proportion to the cost driver of direct labor cost.**

The choice of the cost driver depends on the nature of the business.

* We look to see how much our cost is in direct labor cost and we allocated overhead based on that.
* Here we say our choice of cost driver is direct labor cost.

We assume our operating expense is allocated in proportion to the potential market (50 for P +100 for Q =150). If we can satisfy all the demand, then overhead is $6000/150 units = **$40** per unit of product. If the total demand is not satisfied, overhead per unit of product is > $40.

* If we can fulfill the demands of 150 units, then our overhead cost is $40 / unit.
* If we cannot fulfill the demands of 150 units, then our overhead cost is greater than $40 / unit.

Product Cost-Standard Costing P Q

Material 5+20+20 = $45 20+20 = $40

Operating Expense $40 $40

Standard Costing Total Cost 40+45 = $85 40+40 = $80

* Based on Standard Costing Total Cost, we would produce product Q because it has a lower operating cost, $80, in comparison to product P, $85.

**Activity Based Costing (ABC).** ABC is an alternative accounting principle. Instead of direct allocation the overhead costs to the products, **overheads are first allocated to activities, and then activity costs are allocated to the products.**

* You allocate overheads to activities, THEN the activity costs are allocated to the products.
* In ABC operating expenses can be allocated to activities on several levels. For example: plant level, batch level, product level, so on.

In the ABC of our example, administrative cost is allocated based on the time spent on each product.

Our manager spends 80% of his time on P ($1600) and 20% on Q ($400).

* Manager’s salary is $2,000 a week. That means 80% of $2,000 is $1,600 and 20% of $2,000 is $400.

Perhaps because product P is a new product and needs more operations/marketing efforts.

These costs are then allocated to the units of products based on the potential number of units produced. **$1600/100 = $16 (P) and $400/50 = $8 (Q**).

* Remember, demand for product P is 100 units / week and the demand for product Q is 50 units / week.
* The costs that are allocated to the units of products based on the potential number of units produced is $16 / unit for product P and $8 / unit for product Q.
* If I produce less than 100 units of product P, then my cost will be greater than $16 / unit. If I produce less than 50 units for product Q, then my cost will be greater than $8 / unit.

Non-administrative costs are allocated based on the potential number of units produced. Total Market P (100) and Q (50). If you refer back to the earlier slides, you will recall that the non-administrative cost is $4,000. 150 is the total market demand between Product P and Product Q.

$4000 /150 = 26.7 per unit.

 P Q

Material 45 40

Operating Expense- Admin 16 8

Operating Expense- Non-Admin 26.7 26.7

ABC Total Cost 87.7 74.7

* Based on Activity Based Costing (ABC) total cost, we would choose to produce Product Q at $74.70 / unit over Product P at $87.70 / unit.

What Product to Produce (Continue):

**Finance View:** Suppose you are the financial manager and are in favor of the product with more profit per unit.

**Standard Costing**  P Q

Sales Price $90 $100

Total Costs $85 $80

Gross Income $5 $20

* In the perspective of Standard Costing, the financial manager is in favor of producing product Q given the higher gross income.

**ABC Costing** P Q

Sales Price $90 $100

Total costs $87. 7 $74. 7

Gross Income $2.3 $25.3

* In the perspective of ABC Costing, the financial manager is also in favor of producing Q given the higher gross income.

Don’t forget that in both Activity Based Costing (ABC) and Standard Costing, what we did is that we allocated fixed cost onto the use of products.

Looking at only the variable cost, we look at the perspective of marginal profit.

**Marginal Contribution**

P: Profit Margin = $90 – $45 (Pure Variable Cost) 🡺 Profit Margin= $45

Q: Profit Margin = $100 – $40 (Pure Variable Cost) 🡺 Profit Margin= $60

* Salary of the manager and the operator costs are not variable costs. Administrative and non-administrative costs are not variable costs. We assume that they are variable costs, and when we treat them like variable, it is likely we will make a mistake.
* However, even from the perspective of profit margin, profit margin of product P is $45 and profit of Product Q is $60. Therefore, when looking at the perspective of profit margin, we will still prefer to produce product Q.

What Product to Produce (Continue):

**Production View:** Minutes of production or profit per minute of production time.

* Production managers may look at mins per production and profit per min of production.

Referring back to the chart earlier:

 Total Time of

 Production:

   

In regards to Total Time of Production, Production manager will choose product Q at 50 mins over product P at 60 mins.

In regards to profit / minute, production manager will choose product Q at $1.20 profit / minute over product P at $0.75 profit / minute.

Produce product Q. If you have enough capacity, then produce product P.

For 50 units of Q, you need 50 (30) = 1,500 min. On B, leaving 900 min. on B, for product P.

* Market demand for product Q is 50 units.
* If I need to make 50 units of product Q, then I need 30 mins of activity B. Therefore, I need 1,500 mins of activity B to produce product Q.
	+ Remember, time available at each work center is 2,400 mins / week.
		- Therefore, Capacity of 2,400 mins – amount of mins needed to produce pr oduct Q at activity B 1,500 mins = 900 mins. (2,400 mins – 1,500 mins = 900 mins).
	+ Each unit of P requires 15 minutes on B. So, we can produce 900/15 = 60 units of P.

Therefore, if we sell 50 units of Q and 60 units of P, we get 50($60) +60($45) = $5,700 per week.

* After factoring in operating expense ($6,000), we **LOSE $300**
	+ Remember, the $60 and $45 in the formula above is the contribution margin, which is the difference between sales price and raw material cost, for product Q and product P respectively.

Identify the Constraint(s). Can We Meet the Demand of 100 Ps and 50 Qs?

Can we satisfy the demand?

Resource requirements for 100 P’s and 50 Q’s:

* Resource A: **100 × 15 + 50 × 10 = 2000** minutes
* Resource B: **100 × 15 + 50 × 30 = 3000** minutes
* Resource C: **100 × 15 + 50 × 5 = 1750** minutes
* Resource D: **100 × 15 + 50 × 5 = 1750** minutes
* We input the information above to identify whether our production at each activity, department, work center or station exceeds our capacity or not.
* The numbers in the second column above (15, 15, 15, 15) are the mins required at each work station for product P.
* The numbers in the fourth column above (10, 30, 5, 5) are the mins required at each work station for product Q.
* Remember, the capacity for ALL activity is 2,400 mins / week.
* Resource A, C, and D are all less than the capacity of 2,400 mins / week. Whereas, Resource B is greater than the capacity of 2,400 mins / week.
* Since Resource B is greater than 2,400 mins / week, we cannot produce 100 Ps and 50 Qs. Therefore, in cost world, the first things that comes to our mind is to look at each of the resources that did not exceed capacity (A, C, and D) and fire one of these three resources (people) because we don’t need their full capacity. And therefore, our cost will come down and we will become more profitable. But that is under the perspective of cost world.

Cost World

* Three shortcomings in the cost world: Costs can be reduced at most by what they are. For example, if cost is $100, then you can only reduce it at most by $100. Downsizing is a threat to workforce. They will try to resist these layoffs. Thinks locally; you don’t think about the total perspective, an increase in the cost of an engine of $30 would have decreased the cost of the transmission by $80. The center producing the engine is reluctant to do so. The center producing the engine don’t want to increase the price of the engine to bring down the price of the transmission because they are measured based on their own performance rather than the total system performance.
* Instead of strengthening the weakest link (improving Throughput in the throughput world), we focus on improving efficiency at the current level of performance (improving Operating Expenses in the cost world). The system and the process works within chains connected by links. The process is as strong as its weakest link. What happens is that all stations will be producing at the level of the weakest link. Therefore, instead of one weak link, you will 10 weak links or as many weak links as there are links.
* Chain of 10 links, each with carrying capacity of 100 lbs. except for one with only 50 lbs. Looking for cost reduction, we cut out portions of each strong link; make an efficient chain; every link is carrying exactlysame load.
* The enterprise is now locked into the current performance level; it now has ten links, any one of which can break.
* In the future, if improved performance is desired, it will have to work all ten links in the chain. This will not be an easy job to do.
* If business picks up, it will be harder to recruit employees due to the fear of being fired in the next downsize.

Throughput World – Exploit the Constraint: Find the Best Solution

Throughput world does not want to reduce cost. It wants to increase throughput. It wants to improve the quality of graduates at CSUN. It wants to increase the rate of graduate at CSUN. It does not want to reduce the cost.

If you recall from the earlier slide (Identify the Constraint(s). Can We Meet the Demand of 100 Ps and 50 Qs?) you will remember that the bottleneck of the process is Resource B at 3,000 mins / week, when the capacity for all resources is 2,400 mins / week.

Resource B is Constraint - Bottleneck

Product P Q

Profit Margin 45 60

Resource B mins (the bottleneck) needed: 15 30

Profit per min of Bottleneck 45/15 =**3** 60/30 =**2**

* Under Throughput World, Product P profits $3 per min of bottleneck, while Product Q profits $2 per min of bottleneck.
* Therefore, Product P has a higher capacity to bring money into our company. Furthermore, we make Product P our first priority and we produce as much Product P as we can.
* In perspective of Per unit of bottleneck, Product **P** creates more profit than Product **Q**
* Produce as much as **P**, then **Q**
* For 100 units (remember, the demand for product P is 100 units / week) of P, need 100 (15) = 1,500 mins on B, leaving 900 mins (capacity of 2,400 mins – 1,500 mins on resource B for product P: 2,400 – 1,500 = 900) on resource B for product Q.
* Each unit of Q requires 30 minutes on B. So, we can produce 900/30 = 30 units of Q.
	+ With 900 mins on resource B for product Q, we can produce as much as 30 units of Q / week.
* If we sell 100 units of P and 30 units of Q, we get 100(45) +30(60) = $6,300 per week.
	+ After factoring in operating expense ($6,000): $6,300 - $6,000 = $300. You will **Profit** **$300**!

Exploit the Constraint: Find the Throughput World’s Best Solution

How much additional profit can we make if market for P increases from 100 to 102; by 2 units?

* We need 2(15) = 30 more minutes of resource B.

Therefore, we need to reduce 30 minutes of the time allocated to Q and allocate it to P.

For each unit of Q we need 30 minutes of resource B.

* Therefore, we produce one unit less Q

For each additional P we make $45, but $60 is lost for each unit less of Q.

* Therefore, if the market for P is 102 our profit will increase by $45(2)-$60 = $30
	+ $45 is the profit margin of product P. 2 is the number of units we will increase for product P. And $60 is the profit margin of product Q. Therefore, because the number of units for product P is increasing by 2, you then increase the profit margin by a multiple of two while subtracting the profit margin, the loss, of 1 unit of product Q (to allocate the resources to produce 2 extra units of product P) which is $60. Again, plug it all in and you get **$45(2) - $60 = $30.**
* Furthermore, if the market demand increases to 102 and we increase our production to meet the new demand of product P, we will increase our profits by $30.

Lessons Learned

* Decision should promote a growth strategy. Throughput World: Profit Maximization. Limited only by our imaginations.
	+ We should think of increasing throughput. NOT decreasing cost.
	+ The impact of improving throughput is profoundly bigger then the impact of reducing cost.
* Think globally not locally. There is one or at most few constraint(s) determines limiting a system to achieve its best. Link Performance of each subsystem (Marketing, Finance, Operations, etc) to the performance of the total system.
	+ Don’t go and find local system. Because if one system performance is exceeding beyond expectation, it still does not improve the total system because it is crucial to improve the weakest link. Remember, your supply chain process is as strong as your weakest link.
* Just like the links of a chain, the processes within the enterprise work together to generate profit for the stakeholders.
* The chain is only as strong as its weakest link.
* There is one or at most few constraint(s) determines limiting a system to achieve its best. Exploit the constraint(s). Go and Exploit the Constraint– Find the best way to use the constraint and elevate it.
* Operating expenses – including human recourses - are fixed costs. Do not treat them as variable costs. Do not assign them to the units of products.
	+ Do not treat SUNK COST as VARIABLE COSTS.
	+ Do not treat administrative and non-administrative cost as variable costs.
	+ Do not treat human being costs as variable costs.
	+ If it doesn’t have very high correlation with production, then it should not be considered as variable cost.
	+ Put the sunk costs aside, and make a decision based on contribution margin (that is what brings money into the company).
		- Remember, contribution margin is the difference between **sales price** and **pure variable costs** (i.e. Raw Material, which has a direct correlation with the volume of production)
	+ Then see if what you bring inside the company can cover fixed costs or not.

The Five Step of Theory of Constraint (TOC) Focusing Process

Step 1: Identify the System’s Constraint(s)

* + - Example: in this example, department B does not have the capability of satisfying the demand. Demand is bounded by the capability of the constraint.
		- Constraint can be considered a policy constraint.

Step 2: Determine how to Exploit the System’s Constraints

* + - We should find that constraint and find the best way of utilizing that constraint.

Step 3: Subordinate Everything Else to that Decision

* + - Make all other other subsystems…

Step 4: Elevate the System’s Constraints

* + - If there is nothing else we can do to improve the present situation and we have improved it to the best possible level, the best physical use, and the best financial use of that situation, that constraint is now generating the best amount of money, the best throughput system, the next step is to elevate the system’s constraints (i.e. physical constraint. You currently have two machines, you may go and buy a third machine. i.e. #2 if it is a marketing constraint, then you may expand your marketing internationally).

Step 5: If a Constraint Was Broken in previous Steps, Go to Step 1

**Performance of subsystems to be linked to the performance of the total system.**

**The 5-Steps in a continuing Process.**