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Short-Term Budgeting, Resource Allocations, and Capacity Cost

Chapter 1 introduced the notion of flexible and committed resources. Organizations buy and use flexible resources, such as materials and supplies, in the quantities they require. The cost of flexible resources depends on how much is used, which, aside from loss or waste, equals the amount bought. By contrast, the supplies of committed resources, such as machinery and skilled employees, are not variable in the short run. Committed resources provide the capacity to perform many organization activities. Unlike the cost of flexible resources, the cost of committed resources depends on how much is acquired, not on how much is used.

Because committed capacity is not variable in the short run, short-run planning attempts to use committed capacity in the most productive way. As we will see in this chapter, when a committed resource constrains further short-run expansion (that is, further use of flexible resources), that resource has associated with it an opportunity cost reflecting the lost profits that would otherwise have resulted from further production.

This chapter considers the short-run use of committed capacity and the financial results from using committed capacity effectively. We will use an example that is rich enough to illustrate a full range of important issues. Once we have the example in place, we will explore issues relating to short-run resource allocation to forecast financial results.

THE EXAMPLE

Shannonville Cabinets manufactures and sells five types of large steel electrical cabinets. Annual sales of cabinet 1 are made uniformly through the first and last four months of the year. Annual sales of cabinet 2 are made uniformly through the last six months of the year. Annual sales of cabinet 3 are made uniformly through the first six

months of the year. Annual sales of cabinet 4 are made uniformly throughout the year. Annual sales of cabinet 5 are made in equal amounts in June and December. Production is on a just-in-time basis. That is, the amount produced in any month equals the amount sold in that month. The exception is cabinet 5, for which production occurs uniformly through the year. Shannonville Cabinets maintains a minimum cash balance of $50,000 and finances any short-term working capital requirements with a line of credit. Interest is charged each month at the rate of 0.5% of the opening line of credit balance that month. On average, bad debts amount to 5% of sales revenues.

Workers initiate the production process by removing sheet steel from storage, transporting the steel to the cutting area, and inserting the sheet steel into a programmable cutting machine. After the machine cuts the cabinet parts from the sheet steel, the parts are moved to an assembly area where the cabinets are built. The cabinets are then moved to a shipping area for packaging and shipping.

The following are the characteristics of the five cabinets. The amount of work required by each of the cabinets in each activity area is shown as the number of work units.

CABINET	SELLING PRICE	MATERIALS & LABOR COST	SCHEDULING RESOURCE UNITS	MOVING RESOURCE UNITS	SETUP RESOURCE UNITS	CUTTING RESOURCE UNITS	ASSEMBLY RESOURCE UNITS	SHIPPING RESOURCE UNITS
C1	$14,000	$1,300	2	7	3	3	2	4
C2	$20,000	$1,600	4	3	4	6	5	4
C3	$19,000	$1,500	5	2	6	4	3	7
C4	$15,000	$1,450	3	5	7	2	4	2
C5	$22,000	$1,750	6	4	5	6	5	3
Capacity costs			$70,000	$170,000	$260,000	$800,000	$650,000	$150,000
Monthly capacity units			2,600	3,000	3,500	2,900	2,400	3,200
Flexible cost per unit used			$180	$300	$780	$900	$720	$240

SHORT-TERM PLANNING AND BUDGETING

Note that each resource has a certain capacity that is available for production (measured in appropriate capacity units). In addition, each unit of used capacity also requires a certain amount of flexible resources, principally materials and supplies, whose unit costs are reported in the bottom row of the table. With this information, planners at Shannonville Cabinets can choose a production plan to achieve some objective and then forecast the financial consequences of that production plan.

ACTIVITIES, RESOURCE USE, AND COSTS

This example illustrates the nature of the issues facing short-run production planners. Each product consumes varying amounts of the six constraining factors of production. Two elements of cost associated with each of the factors of production are: a committed cost, which is fixed in the short run and does not vary with use; and a flexible cost, which varies in proportion to the amount of the factor that is used[1]. Each factor of production, or activity, has a unique flexible cost, which we assume is known to the production planners. The facility-sustaining costs, which are unrelated to activity levels, are $12,000,000 per year and are incurred and paid in equal monthly amounts.

We can develop the following table, which summarizes the calculation for each product's contribution margin (CM, net selling price less flexible cost).[2]

	C1	C2	C3	C4	C5
Price	$14,000	$20,000	$19,000	$15,000	$22,000
Material	1,300	1,600	1,500	1,450	1,750
Scheduling	360	720	900	540	1,080
Moving	2,100	900	600	1,500	1,200
Setup	2,340	3,120	4,680	5,460	3,900
Cutting	2,700	5,400	3,600	1,800	5,400
Assembly	1,440	3,600	2,160	2,880	3,600
Shipping	960	960	1,680	480	720
Total	$11,200	$16,300	$15,120	$14,110	$17,650
CM	$ 2,800	$ 3,700	$ 3,880	$ 890	$ 4,350

OPTIMIZING THE USE OF SHORT-TERM RESOURCES

Equal Sales Objective

Suppose that the initial production plan seeks to make the annual sales of all products equal. This objective results in the following planned level of operations and profit[3].

Shannonville Cabinets
Summary of Optimal Solution
Equal Annual Production Units Objective

Income	$ 51,903	Product	Units
		C1	1,309
Sales (net)	$111,919,500	C2	1,309
Flexible costs	$ 97,363,420	C3	1,309
Capacity costs	$ 2,100,000	C4	1,309
Other costs	$ 12,000,000	C5	1,309
Interest costs	$ 404,177	Total	6,545

continued

Resource	Units Available	Maximum Used
Scheduling	2,600	2,400
Moving	3,000	2,782
Setup	3,500	3,109
Cutting	2,900	2,673
Assembly	2,400	2,400
Shipping	3,200	2,727

In this production plan, the Assembly Department is used to capacity. Since this department constrains any additional production, efforts to expand productive capacity, either through acquiring additional resources or through launching initiatives to improve the efficiency of existing resources, would focus on increasing capacity in the Assembly Department.[4]

Total Sales Objective

Instead of planning production and sales by projecting past numbers, suppose that the planners at Shannonville Cabinets choose a production plan that maximizes total annual sales given existing capacity. Using this criterion, the planners at Shannonville Cabinets would choose the following production plan.

Shannonville Cabinets
Summary of Optimal Solution
Maximize Total Sales Objective

		Product	Units
Income	$2,393,761	C1	1,826.2
Sales (net)	$116,500,278	C2	1,427.4
Flexible costs	$99,673,341	C3	1,588.7
Capacity costs	$2,100,000	C4	568.2
Other costs	$12,000,000	C5	1,355.0
Interest costs	$353,176	Total	6,745.4

Resource	Units Available	Maximum Used
Scheduling	2,600	2,600
Moving	3,000	3,000
Setup	3,500	3,170
Cutting	2,900	2,884
Assembly	2,400	2,400
Shipping	3,200	3,200

Short-Run Profit Objective

Finally, suppose that the criterion used by the planners at Shannonville Cabinets is to maximize the income provided by the production plan. In this case, the chosen production plan would be as follows.

Shannonville Cabinets
Summary of Optimal Solution
Maximize Contribution Margin Objective

Income	$3,126,478	Product	Units
		C1	2,003.6
Sales (net)	$113,876,758	C2	1,325.8
Flexible costs	$96,253,725	C3	1,531.5
Capacity costs	$2,100,000	C4	0.0
Other costs	$12,000,000	C5	1,645.6
Interest costs	$396,555	Total	6,506.6

Resource	Units Available	Maximum Used
Scheduling	2,600	2,600
Moving	3,000	2,965
Setup	3,500	2,969
Cutting	2,900	2,900
Assembly	2,400	2,291
Shipping	3,200	3,200

Note that this approach creates the largest value, about $3,126,000, for short-run profit as reported in the income cell, because the production plan for this approach explicitly took this as the performance measure to maximize. Note also that the optimality of this production plan is based on the planners' understanding of the revenues and materials cost of each of the five products, the flexible costs and availability of each of the resources required for production, and the consumption of each activity by each product. Also we have assumed that there is no opportunity to change the resource supply (that is, the level of committed resources).

OPPORTUNITY COSTS, CAPACITY COSTS, AND THE THEORY OF CONSTRAINTS

As we have seen in the Shannonville Cabinets example, a production constraint limits an organization's ability to increase its income.[5] In this sense, we can say that the constraining factor of production reflects an opportunity cost for the organization because it prevents further expansion and profits. In theory, we should increase the supply of the constraining factor of production as long as the resulting increase in capacity costs is less than

the opportunity costs avoided by further expansion. In the long-run sense, this is a capital-budgeting problem in which the initial cost is the increase in capacity cost and the future cash flows represent the annual increase in incremental profits provided by expanding the constraining factor of production.

In the last 10 years, the management and management accounting literatures have devoted attention to Eliyahu Goldratt's theory of constraints.[6] He claims that most manufacturing organizations have a single binding constraint, whereas the Shannonville example indicates that three resources—scheduling, cutting, and shipping—are binding at the optimal solution when the objective is to maximize the short-run contribution margin. Advocates of Goldratt's theory of constraints believe that such multiple binding constraints arise more in academic examples than in the real world.[7] The theory of constraints is based on identifying which resource at any given time is the primary constraint on additional production. The theory of constraints simplifies the optimization approach but gains considerable focus by encouraging active management of this single constraining factor of production. Theory of constraints practitioners increase throughput, and therefore profit, by relieving the constraining, or bottleneck, factor of production. They do this in two ways.

1. Increase the supply of the constraining factor of production by reducing downtime on this resource through effective scheduling and buffering of this resource and by continuous process improvement
2. Reduce the demand on the constraining factor of production by reengineering products so that they use less of that factor of production, or shift the product mix so that additional resources use less of the constraining resource and more of resources with current excess capacity.

The theory of constraints takes the existing production capacity as given and looks for ways to improve the organization's performance within that capacity endowment. The theory of constraints is a short-run operations strategy that does not consider either where the capacity came from or how or when it might be expanded.[8] The idea is to focus on one bottleneck at a time, eliminate that bottleneck's constraint on throughput, and then turn to the next factor constraining production. Resource management and decisions about process improvements and product mix involve a continuous process of evaluating the impacts on bottleneck resources and striving to continuously eliminate one bottleneck after another to increase production throughput.

THE ISSUE OF MULTIPLE RESOURCES

The discussion in the preceding section relating to opportunity costs is meaningful when there is a single factor constraining production. However, things get much more complicated, and therefore, less obvious, when there are multiple factors constraining production.

If we consider the production plan associated with the objective of maximizing contribution margin or, equivalently, income, we see that the optimal plan calls for the full use of scheduling, cutting, and shipping resources. The optimal production plan does not

call for the full use of either the moving, setup, or assembly resources. The process that is followed when there is a single constraining factor of production—which is to expand production until the constraining factor of production is used up—does not work when there are multiple factors of production. First, an optimal production plan can be found only if all the constraining factors of production are considered simultaneously. Second, if the supply of one resource is increased, the optimal production plan will change, and that change, in turn, may lead to a different group of resources now constraining production.

To illustrate, return to Shannonville Cabinets and study the optimal plan when the objective is to maximize short-term income. Note that the scheduling, cutting, and shipping resources are fully used. Therefore, to expand output and profits, the planners would have to increase one of the constraining factors of production. Suppose that Shannonville Cabinets can rent a cutting machine for one year. The rental cost will be $200,000 and will increase monthly capacity to 3,100. Before we go any further, look back at the existing solution and try to guess whether this project should be undertaken.

Here is the optimal solution when monthly cutting capacity increases to 3,100 units.

Shannonville Cabinets
Summary of Optimal Solution
Maximize Contribution Margin Objective—Increase Cutting Capacity

Income	$3,463,373	Product	Units
		C1	1,964.1
Sales (net)	$116,258,032	C2	1,474.5
Flexible costs	$98,301,383	C3	1,551.3
Capacity costs	$2,100,000	C4	0.0
Other costs	$12,000,000	C5	1,632.5
Interest costs	$393,277	Total	6,622.4

Resource	Units Available	Maximum Used
Scheduling	2,600	2,600
Moving	3,000	3,000
Setup	3,500	2,968
Cutting	3,100	3,027
Assembly	2,400	2,400
Shipping	3,200	3,200

Notice that the new plan calls for a different production level for every product and that profits increase by $338,440, which is the value of increasing the monthly availability of the cutting resource from 2,900 to 3,100 units for one year.

Study the resource use under the new optimal plan paying particular attention to the use of the cutting capacity. Note that the optimal plan does not call for the full use of the increase in the cutting availability. With the increase in the cutting capacity, other resources are now constraining production. Note, though, that the increased profits of $338,400 provided by increasing the cutting availability far exceeds the $200,000 rental cost of that capacity.

Effects of Reengineering and Continuous Improvement on Profitability

In addition to decisions about capital investment and expansion, planners can use this type of planning model to predict the effect of reengineering or continuous improvement. For example, suppose that a product design team consisting of marketing, purchasing, design, manufacturing, and accounting personnel undertook to improve the design of cabinet 1 so that it could be manufactured more easily. This design team changed the design of cabinet 1 so that it now requires only 2, 2, 1 (down from a level of 3, 3, 2) units in setup, cutting, and assembly, respectively. We can show that the expected benefit in the first period from this redesign is to increase profits from $3,124,933 to $8,234,070, an increase of more than 160%—and this is the benefit just in the first year. Presumably the benefit would extend beyond the first year.

By studying this example we can see that product and process redesign not only improves profits by reducing the cost of the resources that cabinet 1 consumes, but also, by using fewer resources that are constraining production, the redesign increases profits by freeing up resources that Shannonville Cabinets can use to produce other products. For this reason, management tools that focus on reducing the use of constraining resources have a twofold effect on income.

THE ROLE OF COST INFORMATION IN ALLOCATING SHORT-TERM RESOURCES

The choice of the optimal allocation of the constraining factors of production depends critically on the estimates of the parameters used in the model. Misestimates of the planning parameters—in this case, selling prices, flexible costs, the use of resources by individual products, and resource availability—will result in opportunity losses as planners make suboptimal resource allocations.

Because we are focusing on information that would likely be provided to the planners by the management accounting system, we will illustrate how errors in cost estimates lead to opportunity losses. Suppose that, because of costing system limitations, the estimated flexible costs of using the resources are different from the actual amounts. For example, suppose that the flexible cost of using scheduling, moving, setup, cutting, assembly, and shipping were estimated as $189, $308, $646, $851, $612, and $204.[9] The following exhibit shows the estimated contribution margins (CM) resulting from those estimates.

If planners use these contribution margins to choose production levels, they will choose the production plan and profits shown in the following exhibit. Note that the resulting profit is $3,071,080, which is $53,853 less than the profit that would have resulted from the production plan that would have been chosen if the actual flexible costs had been known.[10] Therefore, inaccurate cost information creates opportunity losses in production planning.

Organizations are most unlikely to know flexible costs with certainty and therefore are likely to experience opportunity costs from planning with inaccurate cost informa-

	C1	C2	C3	C4	C5
Price	$14,000	$20,000	$19,000	$15,000	$22,000
Material	1,300	1,600	1,500	1,450	1,750
Scheduling	378	756	945	567	1,134
Moving	2,156	924	616	1,540	1,232
Setup	1,938	2,584	3,876	4,522	3,230
Cutting	2,553	5,106	3,404	1,702	5,106
Assembly	1,224	3,060	1,836	2,448	3,060
Shipping	816	816	1,428	408	612
Total	$10,365	$14,846	$13,605	$12,637	$16,124
CM	$ 3,635	$ 5,154	$ 5,395	$ 2,363	$ 5,876

Shannonville Cabinets
Summary of Optimal Solution
Maximize Contribution Margin Objective—Faulty Flexible Cost Data

Income	$3,071,080	Product	Units
		C1	1,695.1
Sales (net)	$113,583,140	C2	1,492.9
Flexible costs	$96,039,106	C3	1,685.8
Capacity costs	$2,100,000	C4	0.0
Other costs	$12,000,000	C5	1,542.8
Interest costs	$372,954	Total	6,416.6

Resource	Units Available	Maximum Used
Scheduling	2,600	2,600
Moving	3,000	2,744
Setup	3,500	2,964
Cutting	2,900	2,900
Assembly	2,400	2,311
Shipping	3,200	3,200

Income is computed using the actual values of the flexible cost of using the resources.

tion. Often this opportunity loss is exacerbated when organizations use crude costing systems.

To illustrate, suppose that Shannonville Cabinets does not maintain detailed flexible cost information by activity but rather includes all flexible factory-related costs in a single cost pool. If you look at the optimal solution from the original problem when the objective was to maximize contribution margin, you will see that the total production cost is $46,247,743. Of the total production cost, $9,900,886 is related to materials, leaving a

balance of $86,346,857 related to the flexible cost of using capacity. Given that the total production is 6,504.1, the average flexible cost is about $13,300 per unit. Suppose that, based on past production, the planners at Shannonville Cabinets estimate the production cost as $13,300. If we use this estimate of flexible cost, the following product contribution margin estimates would result.

	C1	C2	C3	C4	C5
Price	$14,000	$20,000	$19,000	$15,000	$22,000
Material	1,300	1,600	1,500	1,450	1,750
Flexible	13,300	13,300	13,300	13,300	13,300
Total	$14,600	$14,900	$14,800	$14,750	$15,050
CM	−$ 600	$ 5,100	$ 4,200	$ 250	$ 6,950

If this information were used for planning, Shannonville Cabinets would choose the following production plan with the following profits.

Shannonville Cabinets
Summary of Optimal Solution
Maximize Contribution Margin Objective—Crude Costing System

Income	$2,576,947	Product	Units
		C1	0.0
Sales (net)	$112,298,930	C2	1,772.8
Flexible costs	$95,066,768	C3	1,791.4
Capacity costs	$2,100,000	C4	0.0
Other costs	$12,000,000	C5	2,214.4
Interest costs	$555,215	Total	5,778.6

Resource	Units Available	Maximum Used
Scheduling	2,600	2,600
Moving	3,000	1,625
Setup	3,500	2,714
Cutting	2,900	2,880
Assembly	2,400	2,400
Shipping	3,200	2,644

You can see that using this crude costing system has resulted in an opportunity loss of $547,980 because the cost data are obscuring product contribution margins.

You should not conclude from this example that a costing system that is more detailed—in this case—one that computes the cost of individual activities, will always give better results than a crude costing system, for example one that uses only one cost estimate. First, the cost of a detailed costing system may outweigh the opportunity losses saved by making decisions with that costing system. Second, the more detailed costing

system may be incompetently designed and managed, resulting in costs that are even more misleading than those obtained by the crude system. However, in general, one would hope and expect that the value of improved costing will outweigh its costs.

BUDGETING OPERATIONS

Production and Resource Use

Once an organization has developed its short-run plan, it can project the operating and financial consequences of that plan over a short-run planning horizon, usually one year. In particular, planners are interested in developing estimates of cash flows and resource requirements so that they can arrange to meet capacity and financing requirements in a systematic way.

Based on the assumptions in this example and that sales will take place uniformly during the year, the table on page 44 shows the production plan chosen when the objective is to maximize short-run profit.

Note how the production plan provides details about resource use that are not obvious from the overall solution. For example, no resource is used to capacity in all months. This fact provides insights to production planners that suggest a possibility of exploring other production or sales patterns that might even out the demand on resources. More generally, detailed production plans provide insights that would guide plans to provide for scheduling machine maintenance and holidays and for hiring and training personnel. Recall, however, that these are estimates based on the planning estimates of resource use and availability. If those estimates prove inaccurate, as inevitably they will, the actual results will differ from the plan.

Cash Flows

A major item of interest in short-term planning is the projection of cash flows expected to result from the production plan. Planners use cash flow projections to identify when they will have excess cash to invest in short-term income opportunities or when they will have to rely on short-term financing such as a bank loan or line of credit to meet the cash needs from operations.

Suppose that Shannonville Cabinets expects that sales collections will be made as follows:

1. Collected in the month of sale: 65%
2. Collected in the month following the month of sale: 20%
3. Collected in the second month following the month of sale: 10%
4. Never collected: 5%

Total dollar sales in November and December of the previous year were $3,000,000 and $5,000,000, respectively. With these assumptions, we can compute the statement on page 45 of projected (pro forma) cash flows that follow from the optimal production plan.

Note that this cash flow projection and financing plan maintains the minimum cash balance at $50,000, as required. The line of credit balance increases in the period January through May, decreases in June and July, then increases during the period August through November, and then decreases in December. The chronic positive balance in the line of

SCHEDULE OF MONTHLY RESOURCE USE

	SCHEDULING	MOVING	SETUP	CUTTING	ASSEMBLY	SHIPPING
Production C1	2	7	3	3	2	4
Production C2	4	3	4	6	5	4
Production C3	5	2	6	4	3	7
Production C4	3	5	7	2	4	2
Production C5	6	4	5	6	5	3
Cost per unit of capacity used	180	300	780	900	720	240
Capacity costs	$70,000	$170,000	$260,000	$800,000	$650,000	$150,000

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Sales and Production Plan												
C1 sales	249.4	249.4	249.4	249.4	0.0	0.0	0.0	0.0	249.4	249.4	249.4	249.4
C2 sales	0.0	0.0	0.0	0.0	0.0	0.0	221.7	221.7	221.7	221.7	221.7	221.7
C3 sales	256.0	256.0	256.0	256.0	256.0	256.0	0.0	0.0	0.0	0.0	0.0	0.0
C4 sales	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C5 sales	0.0	0.0	0.0	0.0	0.0	821.4	0.0	0.0	0.0	0.0	0.0	821.4
C1 production	249.4	249.4	249.4	249.4	0.0	0.0	0.0	0.0	249.4	249.4	249.4	249.4
C2 production	0.0	0.0	0.0	0.0	0.0	0.0	221.7	221.7	221.7	221.7	221.7	221.7
C3 production	256.0	256.0	256.0	256.0	256.0	256.0	0.0	0.0	0.0	0.0	0.0	0.0
C4 production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C5 production	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9
Resource Use												
Scheduling units	2,600.0	2,600.0	2,600.0	2,600.0	2,101.3	2,101.3	1,708.4	1,708.4	2,207.1	2,207.1	2,207.1	2,207.1
Moving units	2,805.2	2,805.2	2,805.2	2,805.2	1,059.5	1,059.5	1,212.8	1,212.8	2,958.5	2,958.5	2,958.5	2,958.5
Setup units	2,968.4	2,968.4	2,968.4	2,968.4	2,220.3	2,220.3	1,571.5	1,571.5	2,319.6	2,319.6	2,319.6	2,319.6
Cutting units	2,593.4	2,593.4	2,593.4	2,593.4	1,845.3	1,845.3	2,151.9	2,151.9	2,900.0	2,900.0	2,900.0	2,900.0
Assembly units	1,951.2	1,951.2	1,951.2	1,951.2	1,452.4	1,452.4	1,793.2	1,793.2	2,292.0	2,292.0	2,292.0	2,292.0
Shipping units	3,200.0	3,200.0	3,200.0	3,200.0	2,202.5	2,202.5	1,297.7	1,297.7	2,295.2	2,295.2	2,295.2	2,295.2

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Inflows												
This month's sales	5,430,568	5,430,568	5,430,568	5,430,568	3,161,270	14,907,101	2,882,734	2,882,734	5,152,033	5,152,033	5,152,033	16,897,865
Last month's sales	1,000,000	1,670,944	1,670,944	1,670,944	1,670,944	972,698	4,586,800	886,995	886,995	1,585,241	1,585,241	1,585,241
Sales two months ago	300,000	500,000	835,472	835,472	835,472	835,472	486,349	2,293,400	443,498	443,498	792,620	792,620
Total collections this month	6,730,568	7,601,512	7,936,984	7,936,984	5,667,686	16,715,272	7,955,884	6,063,130	6,482,526	7,180,771	7,529,894	19,275,726
Outflows												
Flexible Costs												
Materials	947,717	947,717	947,717	947,717	623,531	623,531	594,369	594,369	918,555	918,555	918,555	918,555
Other flexible costs	8,131,828	8,131,828	8,131,828	8,131,828	5,663,031	5,663,031	5,436,382	5,436,382	7,905,180	7,905,180	7,905,180	7,905,180
Total flexible cost outflows	9,079,545	9,079,545	9,079,545	9,079,545	6,286,562	6,286,562	6,030,752	6,030,752	8,823,734	8,823,734	8,823,734	8,823,734
Committed Costs												
Total committed cost outflows	116,667	116,667	116,667	116,667	116,667	116,667	116,667	116,667	116,667	116,667	116,667	116,667
Other Costs												
Interest costs	0	17,328	30,388	41,836	53,342	62,286	16,037	12,075	17,557	34,934	48,907	61,204
Other costs	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Total other costs	1,000,000	1,017,328	1,030,388	1,041,836	1,053,342	1,062,286	1,016,037	1,012,075	1,017,557	1,034,934	1,048,907	1,061,204
Total outflows	10,196,211	10,213,539	10,226,600	10,238,048	7,456,570	7,465,515	7,163,456	7,159,494	9,957,958	9,975,335	9,989,308	10,001,605
Net cash flow	(3,465,643)	(2,612,027)	(2,289,615)	(2,301,064)	(1,788,885)	9,249,757	792,428	(1,096,364)	(3,475,433)	(2,794,564)	(2,459,414)	9,274,121
Financing												
Opening cash balance	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Cash before financing	(3,415,643)	(2,562,027)	(2,239,615)	(2,251,064)	(1,738,885)	9,299,757	842,428	(1,046,364)	(3,425,433)	(2,744,564)	(2,409,414)	9,324,121
Opening line of credit balance	0	3,465,643	6,077,670	8,367,286	10,668,349	12,457,234	3,207,477	2,415,048	3,511,412	6,986,845	9,781,409	12,240,823
Money borrowed	3,465,643	2,612,027	2,289,615	2,301,064	1,788,885	0	0	1,096,364	3,475,433	2,794,564	2,459,414	0
Money repaid	0	0	0	0	0	9,249,757	792,428	0	0	0	0	9,274,121
Ending line of credit balance	3,465,643	6,077,670	8,367,286	10,668,349	12,457,234	3,207,477	2,415,048	3,511,412	6,986,845	9,781,409	12,240,823	2,966,702
Ending cash balance	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000

credit may suggest that Shannonville Cabinets should seek a permanent source of financing for its operating cash needs. The expectation with short-term financing such as a line of credit is that the line of credit balance will be zero at some point during the year.

SUMMARY

In this chapter we have introduced the notion of short-term planning. We have studied

1. How capacity resources can constrain the short-run operating plan
2. Some planning alternatives that managers might choose
3. The financial and operating results from choosing a short-term operating plan

Choosing and projecting the short-run plan provide planners with several important insights. First, they identify what capacity resources are constraining production and provide a prediction of the increased profits that would result from increasing capacity. In this sense, the short-term production plan provides short-term guidance for focusing on improvement activities, such as reengineering and continuous improvement, and long-term guidance in the capital budgeting process that would project the benefit of acquiring more capacity.

Second, short-run planning provides some insight into the opportunity losses that might result from using inaccurate cost estimates to choose a short-term plan. Computing the opportunity loss from using inaccurate cost information to choose an optimal short-term production plan is impossible because the organization will never know its true costs. However, the sensitivity of the short-run production plan to changes in cost estimates will provide a sense of whether the production plan would change dramatically if cost estimates changed. Combined with the knowledge of the conditions when more accurate costing systems are likely to result in significant changes in estimated costs, a topic that we will consider in Chapter 5, planners can identify situations when cost studies would likely improve short-run profitability.

ENDNOTES

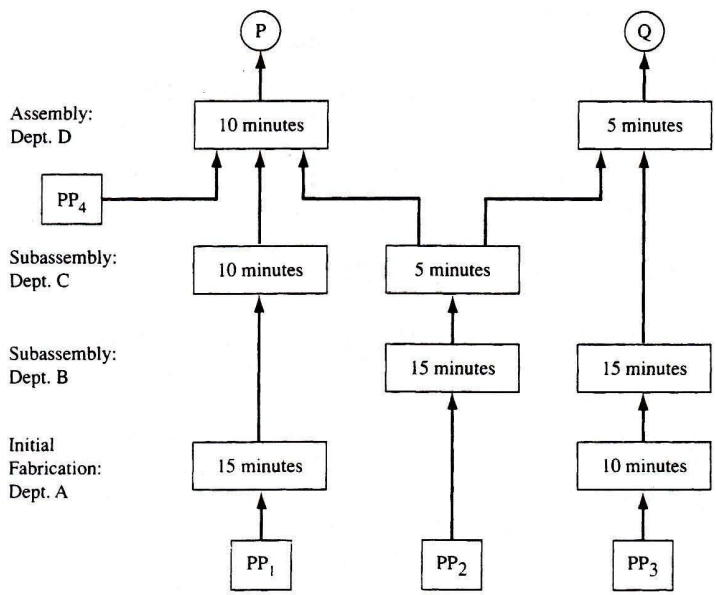
1. For example, the flexible cost relating to moving would include the cost of fuel for forklifts and the cost of casual labor hired by the hour. The flexible cost associated with shipping would include the cost of packaging materials.
2. For now we are interested only in presenting the optimal plan under different planning assumptions. Later, we will develop the details of where the plan numbers came from and will discuss the spreadsheet, so the interested reader will be able to verify these results.
3. The optimal solutions reported in the table titled Summary of Optimal Solution were found using Excel's solver tool, which finds a noninteger solution. Readers familiar with programming methods will recognize that rounding optimal noninteger solutions to integer solutions will not guarantee optimal integer results. However, we have adopted this approach in the interest of using a programming tool (Excel) that is likely to be available to the greatest number of users. Moreover, it is possible that the solution found by Solver, which uses a searching rather than an optimizing algorithm to find the solution, may not be the optimal solution for the problem.
4. We used the Excel spreadsheet **amach2.xls** to develop this and the other plans described in this chapter. If you are interested in following along with this development you should ask your instructor for a copy of this spreadsheet. To begin, you might open the spreadsheet and try inserting different production values in spreadsheet columns E9 through E13. You need to compare columns C18 through C23 with columns D18 through D23 to verify that your tentative production plan has not violated any capacity constraints.

5. Although the Shannonville Cabinets example considers only manufacturing constraints, in practice, organizations face constraints in all areas of their operations including supply, logistics, selling, and financing. In addition, organizations may experience subtler, often hidden, constraints relating to people and technological skills. We have chosen to focus on production constraints here because they are the most obvious to observe and the simplest to conceptualize. However, the general issues raised in this discussion regarding production constraints apply equally to all types of constraints.
6. See Eliyahu M. Goldratt and Jeff Cox, *The Goal: A Process of Ongoing Improvement*, (2nd rev. ed). (New York, NY: North River Press, 1992).
7. If planners follow the approach of expanding output until the first production constraint is encountered, a single resource will always constrain production.
8. But, within its assumptions, the recommendations provided by the theory of constraints are both persuasive and defensible.
9. These values were chosen randomly on the interval of plus or minus 20% of the value used in the previous examples, which we are assuming are the true underlying costs.
10. This damage is compounded when organizations use a cost-based formula—for example, cost-plus—to compute prices.

■ *PROBLEMS*

2-1 Scheduling a Bottleneck Resource

The OPT Company produces two products, P and Q. The production processes for the products are shown below:



Product P sells for $140 per unit, and product Q sells for $120 per unit. Up to 100 units per week can be sold of P, and up to 50 units per week can be sold of Q. The unit costs of each of the four purchased parts are:

Purchased Part	Unit Cost
PP_1	$35
PP_2	40
PP_3	30
PP_4	15

PP_2 is processed through Departments B and C and is required for the final assembly stage of both P and Q. The time (in minutes) required to process each component in each department is shown in the diagram above.

Each department—A, B, C, and D—has one worker, who is paid $18 per hour *worked*. The work in each department is highly specialized, so workers cannot be transferred from one department to another. The plant operates only one shift (40 hours) per week, and no overtime is permitted.

Committed cost is assigned to products at the rate of $36 per direct labor hour.

Required

(1) Compute the flexible and committed costs of products P and Q.
(2) Supposing that productive capacity is allocated based on profit per unit, determine what production plan would apparently yield the highest weekly profits. What are the profits associated with this production plan?
(3) What production plan maximizes weekly profits?
(4) How, if at all, would your response to Requirement 3 change if workers were paid whether they worked or not?
(5) Suppose that a costing study concludes that the committed cost of P is $10 and of Q is $33. How, if at all, would this information change your response in Requirement 3? Does this information have any relevance?
(6) How, if at all, would your response to Requirement 3 change if workers are cross-trained and can work in any department?

2-2 *Scheduling a Production Plan*

Alberton Fisheries Limited (AFL) is an integrated fish products company. AFL operates a small fleet of trawlers. When the trawlers land their catch, AFL can sell the whole (round) fish or process the fish itself.

The processing operation begins by removing the head, tail, skin, bones, and insides of the fish (these byproducts are called offal), leaving two fillets. The fillets represent about 65% of the weight of the whole fish. All the offal is processed into a fertilizer whose net realizable value is zero. In fact, AFL began the fertilizer-manufacturing operation to provide a way of disposing of the offal.

The disposition of the fillets depends on the quality. There are three quality grades used. On average, 40% of the fillets are grade 1, 40% are grade 2, and 20% are grade 3. The grade 1 fillets are sold as fresh fish if there is a market; otherwise they are downgraded to grade 2. The grade 2 fillets are used to prepare gourmet entrées that are sold directly by AFL or, under other names, by other distributors. The process involves cooking the fish and then packing the fillet with other products into a container, which is then frozen. If there is an excess supply of grade 2 fillets, the grade 2 fillets are downgraded to grade 3.

The grade 3 fillets are used either to produce the processed line of products such as breaded fish sticks, or they are frozen into blocks to be stored for future use or sold.

The processing facility can handle a maximum batch of 120,000 pounds of fish. Any trawler load in excess of this amount has to be sold at whatever price it will fetch, because the excess fish would spoil before they could be processed.

The cost of processing a batch of fish has two components. There is a flexible cost of $0.40 per pound of whole fish processed. This cost is related entirely to the unloading and filleting operations and comprises wages paid to the factory workers and other flexible costs. In addition, there is a committed cost of $15,000 per batch processed; this cost is related to factory depreciation, administrative charges, and salaries.

For fish sold fresh, the only other costs beyond filleting are the flexible packaging costs, which average $0.20 per pound, and the flexible shipping and handling costs, which average $1.50 per pound. AFL is currently receiving $5.00 per pound of fresh fish.

The maximum amount of fish that can be cooked and frozen per batch is 50,000 pounds. The flexible cost of cooking and freezing is about $0.35 per pound of fish, irrespective of whether the fish will be sold as an entree or as a processed product.

For the entree products, the average flexible cost of additional items included with the fish is $2.00 per pound of fish packaged, and the flexible packaging cost is $0.40 per pound of fish. Because the entrees, the processed fish products, and the frozen blocks are sold FOB, AFL's factory, there are no shipping costs associated with any of these products. AFL is currently receiving $4.60 per pound of fish sold as an entree.

For the processed products, the average flexible cost of additional material included with the fish is $0.20 per pound of fish package, and the packaging cost is about $0.15 per pound of fish. AFL is currently receiving $2.20 per pound of fish sold as a processed food product.

The flexible cost of freezing the fillets into blocks is about $0.20 per pound. The current market price for frozen blocks is about $1.20. The production manager has advised the marketing manager that she can use about 10,000 pounds of frozen blocks next week and will be willing to pay up to $1.25 per pound for the blocks.

Required

The captain of one of the trawlers has just radioed in that she will land in two days with about 140,000 pounds of fish. The marketing manager has advised you that he can sell a maximum of 30,000 pounds of whole fish, 25,000 pounds of fresh fish,

28,000 pounds of fish as entrees, 25,000 pounds of fish as processed, and 22,000 pounds of fish sold in frozen blocks. (The last amount does not include the 10,000 that the production manager has offered to take.) The marketing manager has also advised you that whole fish can be sold for $1.25 per pound. What is the optimal disposition of this catch?

2-3 *Planning the Conversion of Raw Materials into Finished Products*

Williams Lake Forest Products (WLFP) is an integrated products firm. Planning for the period's activities begins with the wood lot. The maximum amount of raw wood that can be harvested during this period is 12,000,000 units. Wood is harvested in batches of 1,000,000 units. The cost of harvesting is $400,000 per batch plus $3 per unit of wood harvested.

When the raw wood has been harvested, it is graded. On average, about 50% of the raw wood harvested grades out as sawmill-quality wood, 30% grades out as plywood-quality wood, and 20% grades out as pulp-quality wood.

Sawmill-quality wood can be sold, sent to the sawmill for sawing into lumber, or downgraded into plywood-quality wood. Raw sawmill-quality wood can be sold on the open market in batches of 1,000 units for $5,000 per batch.

The sawmill processes wood in batches of 100,000 units. The cost per batch processed in the sawmill is $80,000 plus $2 per unit of wood processed. The availability of saws limits the capacity of the sawmill to 3,000,000 units of wood, or 30 batches. Each 1,000 units of wood processed through the sawmill yields product that can be sold for $7,000.

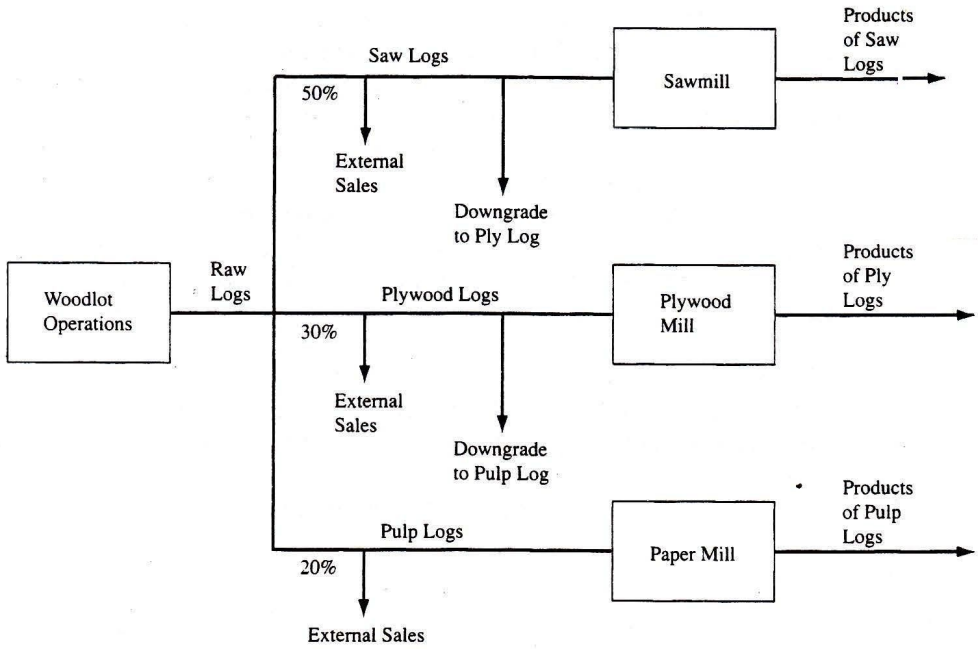
The plywood-quality wood can be sold, downgraded to pulp-quality wood, or sent to the plywood mill to be made into plywood. Raw plywood-quality wood can be sold in the open market in batches of 1,000 units for $4,000 per batch.

The plywood mill processes wood in batches of 150,000 units. The cost per batch processed in the plywood mill is $90,000 plus $3.10 per unit of wood processed. The capacity of the peeling operation limits the capacity of the plywood mill to 3,750,000 units of wood, or 25 batches. Each 1,000 units of wood processed through the plywood mill yields product that can be sold for $8,000.

The pulp-quality wood can be sold or sent to the paper mill to be made into various paper and cardboard products. Raw pulp-quality wood can be sold in the open market in batches of 1,000 units for $3,000 per batch.

The paper mill processes wood continuously. Therefore, no batching operation occurs in the paper mill. The flexible cost per unit of wood processed in the paper mill is $1.15. The capacity of the paper mill is limited to 4,000,000 units of wood. Each 1,000 units of wood processed through the paper mill yields product that can be sold for $5,000.

The accompanying diagram summarizes the operations of WLFP.



The Marketing Department has advised that the maximum number of 1,000-unit batches that can be sold during the upcoming period of each of the commodities is:

Saw logs unprocessed	600
Plywood logs unprocessed	700
Pulp logs unprocessed	500
Saw logs processed	3,000*
Plywood logs processed	4,000
Pulp logs processed	5,000

**This number represents the maximum amount of sawmill products that can be sold based on processing 3,000 batches of saw logs.*

Required

Determine the best production plan for the upcoming period.

2-4 *Choosing a Product Mix*

Sheet Harbor Chemicals (SHC) manufactures chemicals used in the paint industry. The process involves three departments.

Chemical A, which is purchased for $4 per liter, is processed through Department 1

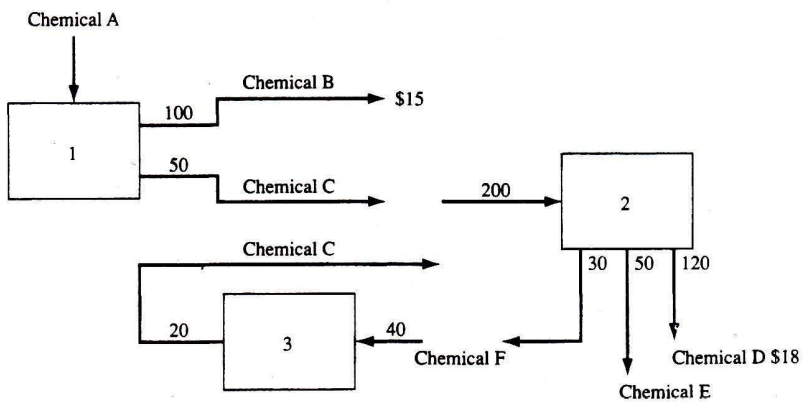
in batches of 150 liters. Each batch of chemicals processed through Department A produces 100 liters of chemical B and 50 liters of chemical C.

Chemical B is sold for $15 per liter. Chemical C is used in Department 2 to produce chemicals D, E, and F. Department 2 processes chemical C in batches of 200 liters. Each batch processed through Department 2 produces 120 liters of chemical D, 50 liters of chemical E, and 30 liters of chemical F.

Chemical D is sold for $18 per liter. Chemical E is a waste product that is donated to the local municipality to be spread on gravel roads to keep down dust. Chemical F is a hazardous waste product that must be disposed of at a cost of $8 per liter. Alternatively, chemical F can be processed through Department 3 to produce chemical C.

Department 3 processes chemical F in batches of 40 liters. Each batch of chemical F processed produces 20 liters of chemical C. In the past, this operation has had a tendency to build up stocks of chemical C. The maximum storage capacity for chemical C is 1,000 liters.

The accompanying diagram summarizes the production activities at SHC.



The sales manager indicated that sales of chemical B cannot exceed 40,000 liters in the upcoming period, and sales of chemical D cannot exceed 15,000 liters.

The production manager advised that 8,000 labor hours are available for the upcoming period. Workers are paid $15 per hour worked. The production manager indicates that the labor hours required for each batch in Departments 1, 2, and 3 are 12, 18, and 15, respectively. Moreover, because of constraints related to the mixing vats and storage, the maximum number of batches in Departments 1, 2, and 3 are 700, 120, and 70, respectively. The other flexible costs per batch in Departments 1, 2, and 3 are estimated as $300, $825, and $120.

Required

Determine the optimal production plan at SHC for the upcoming period.

2-5

Yarker Computers manufactures workstations for the graphics design industry. At the moment, the company makes three computers with the following characteristics:

	COMPUTER 1	COMPUTER 2	COMPUTER 3
Selling price	$12,000	$11,000	$10,000
Flexible costs	$ 7,000	$ 8,500	$ 8,000
Contribution margin	$ 5,000	$ 2,500	$ 2,000

Computers require three major activities during their assembly. These activities consume committed resources. The following table shows the amount of each resource consumed by each computer, the capacity available of that resource, and the cost of each unit of that resource (computed by dividing the total committed cost by capacity).

	C1	C2	C3	CAPACITY	PER UNIT COST
Resource A	3	4	6	24000	$ 20
Resource B	5	6	2	36000	$200
Resource C	8	3	2	32000	$600

Required

(1) Choose a production plan that maximizes the short-run contribution to profits.
(2) Assume that Yarker Computers can adjust capacity levels for the committed resources. What is the optimal production plan?
(3) Assume that Yarker Computers does not keep track of the individual costs of the three resource types. Instead, all committed costs are combined into one account. This costing system estimates the committed cost for each computer by a number that is the average of the committed costs computed for each computer under the more complex costing system. Assume, as in Requirement 2, that committed costs are flexible. What would be the effect on decision making of using the average costing system?

2-6

Princess and Division is a firm of professional accountants. The firm consists of 10 partners, 30 associates, and 25 staff members. The firm provides two broad types of service to their clients: consulting and auditing. Each employee can work on either auditing or consulting services. The two types of services differ in terms of the mix of professionals used:

a. Auditing work requires two partners, four associates, and four staffpersons for every hour of work demanded by the client.
b. Consulting work requires three partners, two associates, and two staffpersons for each hour of work demanded by the client.

Princess and Division treats staff costs as committed costs. Partners earn, on average, $140,000 per year and work about 2800 hours. Associates earn, on average, $50,000 per year and work about 2000 hours. Staff members earn, on average, $20,000 per year and work about 1900 hours.

In addition to staff costs, Princess and Division has other committed costs amounting to $1,000,000 per year. These other committed costs are allocated to jobs based on employee hours worked using a rate equal to the committed cost divided by employee hours available. Princess and Division has other flexible costs, which are estimated as

a. $3 per hour of partner time worked
b. $12 per hour of associate time worked
c. $7 per hour of staff time worked

Princess and Division has developed a blended cost per hour of client time demanded using the following approach:

ITEM	PARTNER	ASSOCIATE	STAFF	TOTAL
Salaries	140,000 * 10	50,000 * 30	30,000 * 25	3,650,000
Hours worked	10 * 2,800	30 * 2,000	25 * 1,900	135,500
Flexible costs	10 * 2,800 * 3	30 * 2,000 * 12	25 * 1,900 * 7	1,136,500
Other costs				1,000,000
Total costs				5,786,500
Blended cost per hour				$42.70
Audit cost per hour	2 * 42.70	4 * 42.70	4 * 42.70	$427.05
Consulting cost per hour	3 * 42.70	2 * 42.70	2 * 42.70	$298.93

The market rate is $510 per client hour demanded for audit services and $340 per client hour demanded for consulting services.

For the upcoming year Princess and Division expects that demand will exceed capacity for both types of services. Therefore, Princess and Division is faced with the need to decide the optimal mix of jobs to offer.

Required

(1) Using the blended cost calculation, what is the optimal short-run production mix?
(2) What do you think is the optimal short-run production mix?
(3) Princess and Division has an associated firm—Johnson and Union—that will hire any Princess and Division employee at an hourly rate equal to that employee's annual salary divided by the annual hours worked. The $1,000,000 costs of Princess and Division remain committed. What is the optimal allocation of partner, associate, and staff hours under these conditions?
(4) Continuing the assumptions of Requirement 3, suppose that Princess and Division faces a demand for audit services of 1200 client hours each month in January through April inclusive and 600 client hours each month for the rest of the year. Princess and Division faces a demand for consulting services of 400 client hours each month. Assume also that the maximum amount of time that each person can work each month is 10% of the total annual hours, subject to the condition that total hours worked for the year cannot exceed the indicated number of annual work hours. What is the optimal allocation of partner, associate, and staff hours under these conditions?

■ CASES

CHOOSING A PRODUCT MIX* (C. HORNGREN)

Maria Jones has just earned a university degree in management. She has taken the position of assistant to the president at Roseville Engineering, which manufacturers tungsten carbide drill steels for the gold-mining industry.

Roseville Engineering manufacturers two types of drill steels. One has a steel rod of $\frac{3}{4}$-inch diameter and the other a diameter of 1 inch. The manufacturing takes place in three departments. In the tip-fabricating department, tungsten carbide tips are manufactured from powered wolfram. In the steel-forging department, the steel rods are slotted and prepared for the insertion of the tips. The assembly department puts the tips and steel rods together in a brazing process.

Each department has two severe general capacity limits. The first constraint prohibits further capital expenditure because of a very weak liquid position arising from past losses; the second is the local labor situation, which makes the hiring of more labor, or using overtime, virtually impossible. The capacity of each department is as follows:

Tip fabricating (Dept. A)	200,000 hours
Steel forging (Dept. B)	275,000 hours
Assembly (Dept. C)	350,000 hours

The treasurer has just completed the budget for the forthcoming year. Because of the renewed confidence in gold, the company is expected to operate at full capacity.

The treasurer has produced the following profit analysis of the two products, on which a major production decision was based:

	$\frac{3}{4}$-INCH	1-INCH
Selling price	$60.00	$70.00
Flexible Costs		
Tungsten carbide	2.00	3.00
Steel	3.00	4.00
Department A Labor	5.00	4.00
Department B Labor	8.00	12.00
Department C Labor	7.50	5.00
Flexible other factory & selling	4.00	6.00
Committed Costs		
Committed factory & selling	19.00	22.00
Total costs	48.50	56.00
Profit	$11.50	$14.00

The market survey performed by the sales manager showed that the company could sell as many of either type of rod as it could produce. However, the sales manager urged that the needs of three of the big gold mines must be satisfied in full, even though doing so meant producing a large number of the $\frac{3}{4}$-inch rods, which had less profit than the 1-inch rods. The quantities required by these three gold mines amounted to 200,000 $\frac{3}{4}$-inch rods and 200,000 1-inch rods.

Because the 1-inch rods are more profitable than the $\frac{3}{4}$-inch rods, the treasurer suggested that the remaining capacity be used to produce 1-inch rods. Based on this plan, the treasurer produced the following budgeted income statement for the forthcoming year.

Sales are expected to occur evenly throughout the year.

	$\frac{3}{4}$-INCH	1-INCH
Sales (in units)	200,000	233,333
Sales (in dollars)	$12,000,000	$16,333,310
Flexible costs	5,900,000	7,933,322
Committed costs	3,800,000	5,133,326
Total costs	9,700,000	13,066,648
Profit	$2,300,000	$3,266,662

Jones, as her first assignment, is asked by the president to comment on the budgeted income statement. Specifically, the president feels that capacity might be better used with a different sales mix. He wants to know just how much it is costing the company in lost profits to supply the full needs of the three big gold-mining customers. He feels that it might be more profitable to produce only the 1-inch rods.

Jones gathers the following additional information before making her recommendations: Wolfram is purchased at $10 per kilogram (1,000 grams). The $\frac{3}{4}$-inch tips use an average of 200 grams, and the 1-inch tips 300 grams. The special alloy steel costs $4,000 per 2,000 pounds. The $\frac{3}{4}$-inch rods use 1.5 pounds, and the 1-inch rods 2 pounds. Direct-labor costs per hour follow:

Department A	$20.00
Department B	$16.00
Department C	$10.00

Tip fabricating (Department A) is a skilled process. The small tips require detailed work. Owing to the nature of the work, the labor is considered committed because it would be difficult to replace. Committed factory and selling costs have been allocated using the cost drivers thought to explain their behavior.

Required

If you were Jones, what would be your recommendations to the president?

*This problem is adapted from a problem prepared by C. Horngren for *Cost Accounting*, 5th ed. (Prentice Hall, 1982).

California Products Corporation: Analyze Product Profitability with Machine Constraints and Committed and Flexible Costs* (F. Kolaritsch, Adapted)

History

Several members of the Black family started the California Products Corporation in 1985. From 1985 to 1990, Product I was the only product produced, and, although profits were not high, they were sufficient to satisfy the family stockholders.

During 1990, the management of the California Products Corporation, mostly members of the Black family, decided to change from absorption costing to direct costing (flexible costing) upon the advice of a consulting firm. Product J was started into the production line in 1990 and Product K was started in 1994.

Since 1990, the company had losses or very small profits. The profit and loss statement for 1996 (see Table 1), shows that the company broke even during that year. At the board meeting, held shortly after the financial statements for 1996 were released, optimism was voiced concerning the future profit prospects of the company. The reasons given for this optimism were as follows:

1. Products J and K, it was believed, had overcome start-up troubles and finally found acceptance by the public.
2. Products J and K are both high contribution margin products (see Table 4).
3. During 1996 some overtime had been incurred, which it was claimed, cut into profits. It was anticipated that overtime would not be incurred next year.
4. The sales force had finally become convinced of the necessity of pushing Product K because of its high contribution margin.

The profit and loss statement for the year 1997 (see Table 2) was anything but encouraging to the management of the California Products Corporation. The company sustained a loss during that year and, paradoxically, had a considerable backlog of unfilled orders. The overtime was not eliminated, although the overall production in units of output decreased by 80,000 units (see Table 5).

The board meeting that followed the release of the 1997 financial statements was unfriendly, and everyone accused everyone else of incompetence. Without producing any evidence, the vice president in charge of sales accused the production people of gross inefficiency. Evidence was, however, introduced that indicated that sales had to be turned down because production could not supply the goods within the normal delivery time.

The vice president in charge of production accused the salespeople of pushing the wrong product. He pointed out that all the troubles started with the introduction of Product J and Product K. He also accused the vice president in charge of finances of "trickery" and stated that the contribution margin (see Table 4) was nothing except "fancy data" that would mislead everyone.

This meeting resulted in ill feelings among the various functional staff managers. The chairman of the board finally obtained their consent to call in a consulting firm to investigate what had happened and to suggest possible means of making the firm profitable.

An investigation into the flexible expenses, shown in Table 3, confirmed that they were correct and included a charge for normally expected overtime. The prices of the products had not been changed for several years, and there was no expectation that a price change was feasible in the next few years.

An investigation into the $821,000 committed expenses, shown in Table 1 and Table 2, showed that $440,000 was joint committed cost and that $381,000 was a separable committed cost attributable to the company's products as follows:

Product I	$71,000
Product J	200,000
Product K	110,000
	$381,000

An analysis of the joint committed costs of $440,000 showed them to be made up of

Manufacturing expenses	$50,000
Selling & administrative expenses	70,000
Depreciation:	
Machine A	100,000
Machine B	20,000
Machine C	200,000
	$440,000

Regardless of the above classification, the full amount of $821,000 was committed costs and had been properly classified by the company. Information gathered concerning the production process disclosed that each product had to be worked on by each of the three machines and that each of the three products required different machine times on the various machines. (The average production capacity of the machines is given in Table 6.)

It was estimated that each machine was operated about 1,800 to 2,200 hours during a normal year (practical capacity); that estimate takes into consideration things such as maintenance, repairs, and resetting. The maximum operational time one could expect from each of these machines during a given year without overtaxing them and incurring unreasonably high additional expenses was 2,200 hours.

TABLE 1 California Products Corporation Profit and Loss Statement Year 1996

	PRODUCT I	PRODUCT J	PRODUCT K	TOTAL
Sales	$1,860,000	$1,584,000	$412,500	$3,856,500
Flexible costs	1,503,500	1,232,000	300,000	3,035,500
Contribution margin	$ 356,500	$ 352,000	$112,500	$ 821,000
Committed expenses				821,000
Net profit				$ 0

TABLE 2 California Products Corporation Profit and Loss Statement Year 1997

	PRODUCT I	PRODUCT J	PRODUCT K	TOTAL
Sales	$1,620,000	$1,008,000	$742,500	$3,370,500
Flexible costs	1,309,500	784,000	540,000	2,633,500
Contribution margin	$ 310,500	$ 224,000	$202,500	$ 737,000
Committed expenses				821,000
Net loss				$ (84,000)

TABLE 3 California Products Corporation Variable Product Costs

	PRODUCT I	PRODUCT J	PRODUCT K
Materials	$2.50	$3.20	$2.90
Labor*	1.30	1.50	1.20
Indirect manufacturing expenses	.45	.50	.40
Selling & administrative expenses	.60	.40	1.50
Total	$4.85	$5.60	$6.00

**Includes reasonable allowance for normal overtime.*

TABLE 4 California Products Corporation Contribution Margins

	PRODUCT I	PRODUCT J	PRODUCT K
Sales price	$6.00	$7.20	$8.25
Cost	4.85	5.60	6.00
	$1.15	$1.60	$2.25

TABLE 5 California Products Corporation Products Sold (in Units)

	PRODUCT I	PRODUCT J	PRODUCT K
1996	310,000	220,000	50,000
1997	270,000	140,000	90,000

TABLE 6 California Products Corporation Average Product Output Capacity per Machine Hour* (in Units)

	PRODUCT I	PRODUCT J	PRODUCT K
Machine A	330	240	150
Machine B	380	215	170
Machine C	540	330	90

**Each machine could work at any given time on one product only.*

Required

(1) Choose the optimal production plan assuming that none of the committed costs is escapable even where there is zero production of one or more products.

(2) What is the value of an additional 200 hours of machine C?

(3) Determine whether your proposed solution in Requirement 1 remains optimal if the separable committed costs for products I, J, and K are escapable if there is no production of one or more of these products.