

Aggregate Planning

SCM4330/BZAN3310

Flow Analysis

Workers flow:

- $\text{number available workers} = \text{beginning workers} + \text{number hired} - \text{number fired}$

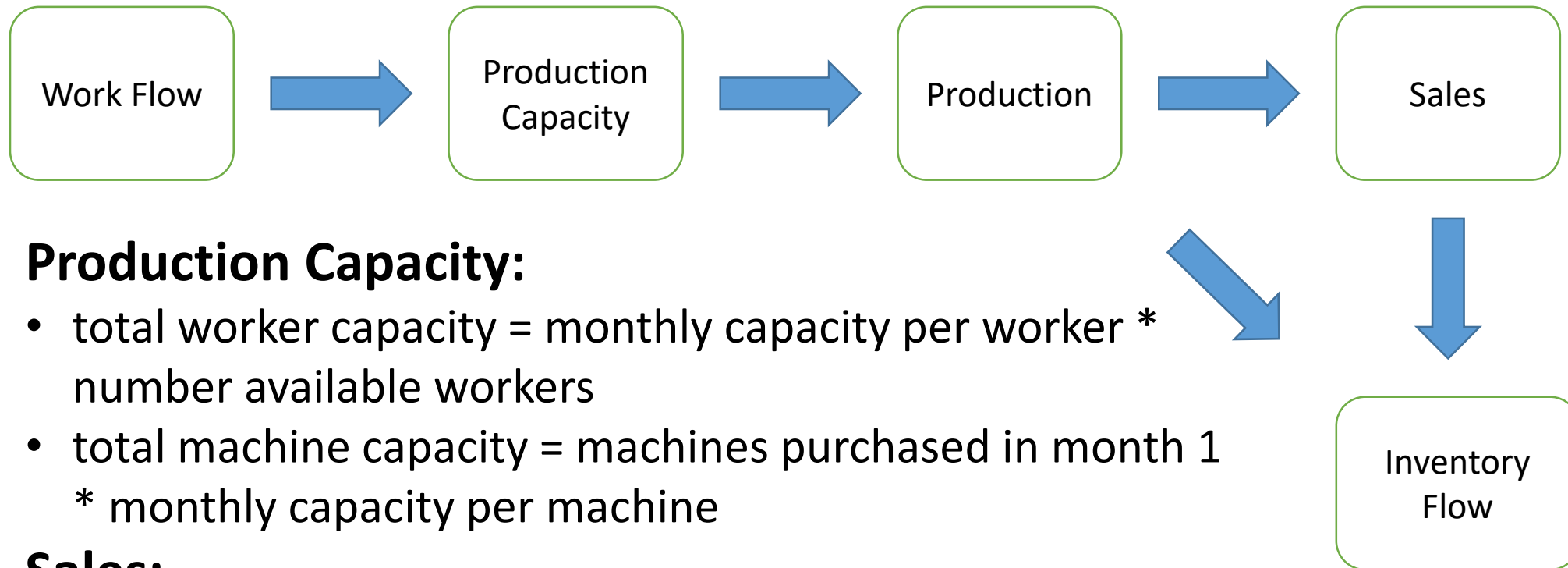
Inventory flow:

- $\text{end of month inventory} = \text{beginning of month inventory} + \text{number produced} - \text{sold amount}$

Cash flow:

- $\text{end of month cash} = \text{beginning of month cash} + \text{revenue} - \text{total costs}$

Flow Analysis



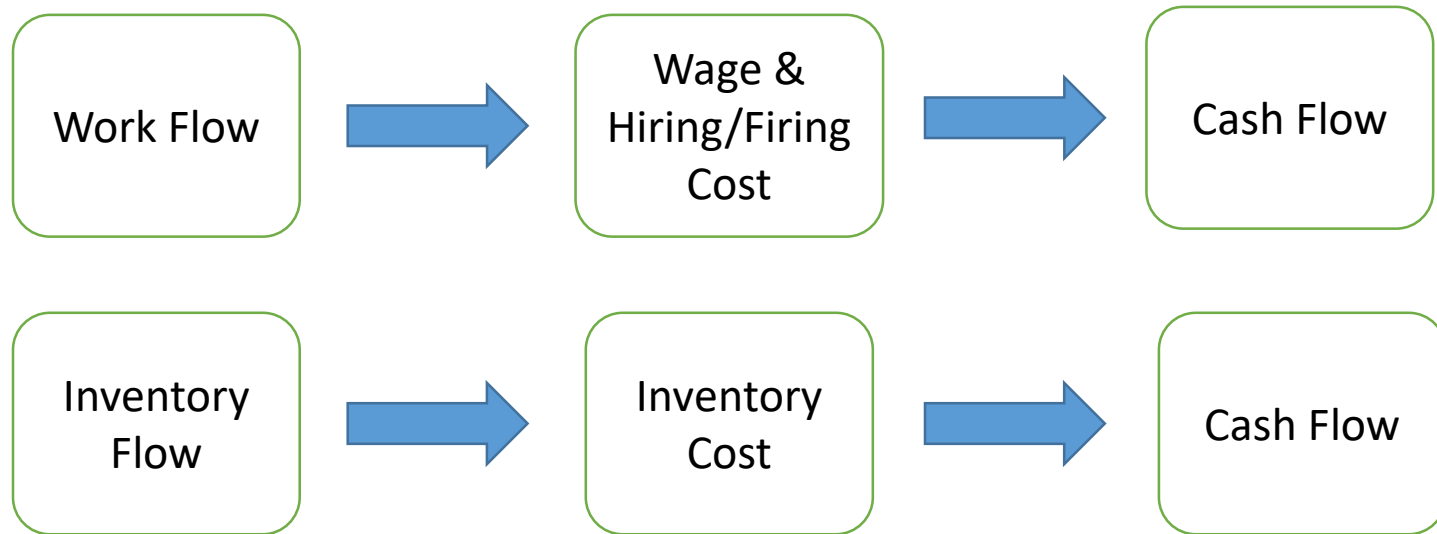
Production Capacity:

- total worker capacity = monthly capacity per worker * number available workers
- total machine capacity = machines purchased in month 1 * monthly capacity per machine

Sales:

- demand after advertising (sold amount) = original demand + advertising money spend / Ad cost to increase demand by 1

Flow Analysis



Costs

- $\text{cost of machines} = \text{machines purchased in month 1} * \text{cost of buying a machine}$
- $\text{hiring cost} = \text{number hired} * \text{hiring cost per worker}$
- $\text{firing cost} = \text{number fired} * \text{firing cost per worker}$
- $\text{wages} = \text{number available workers} * \text{monthly worker wage}$
- $\text{advertising cost} = \text{advertising money spent}$
- $\text{holding cost} = \text{end of month inventory} * \text{holding cost per product per month}$
- $\text{raw material cost} = \text{number produced} * \text{raw material cost per mTune}$

Profit

- $\text{revenue} = \text{sold amount} * \text{selling price per mTune}$

Profit

- $= \text{SUM}(\text{revenue}) - \text{SUM}(\text{total costs}); \text{ or}$
- $= \text{end of month cash in month 6} - \text{initial cash}$

Solver Parameters

Set Objective:

To: ☒ Max ☐ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

\$B\$16 = integer
\$B\$20:\$G\$21 = integer
\$B\$25:\$G\$25 >= \$B\$27:\$G\$27
\$B\$27:\$G\$27 <= \$B\$29:\$G\$29
\$B\$32:\$G\$32 <= \$B\$34:\$G\$34
\$B\$41:\$G\$41 >= \$B\$43:\$G\$43
\$B\$59:\$G\$59 >= \$B\$61:\$G\$61

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

Solving Method
 Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Total worker capacity \geq Number produced

Total machine capacity \geq Number produced

Advertising Spent \leq Maximum advertising

Constraint:

End of Month Inventory ≥ 0

is equivalent to

Init Inventory + Production \geq Sales

End of month cash ≥ 0

Solver Table 1

- At what firing cost would the model suggest to not fire any workers?
- Varying firing cost from \$5,000 - \$15,000 with increment \$500, show the **total** number of workers are fired

Parameters for oneway table

Specify the following information about the input to be varied and the outputs to be captured.

Input cell:

(Optional) Descriptive name for input:

Values of input to use for table

☒ Base input values on following:

Minimum value:

Maximum value:

Increment:

☐ Use the values from the following range:

Input value range:

☐ Use the values below (separate with commas)

Input values:

Output cell(s):

Note about specifying output cells: The safest way to select multiple output cells or ranges is to put your finger on the Ctrl key and then drag as many output cell ranges as you like. This will automatically insert commas between the ranges you select.

Calculate total number of workers are fired in K21 by formula:

=SUM(B20:G20)

Solver Table 2

- At what Advertising effectiveness (currently at \$10 per additional unit) would the model not advertising?
- Varying Ad cost to increase demand by 1 from \$10 to \$100 with increment \$10, show **minimum** advertising spending.

Parameters for oneway table

Specify the following information about the input to be varied and the outputs to be captured.

Input cell:

(Optional) Descriptive name for input:

Values of input to use for table

☒ Base input values on following:

Minimum value:

Maximum value:

Increment:

☐ Use the values from the following range:

Input value range:

☐ Use the values below (separate with commas)

Input values:

Output cell(s):

Note about specifying output cells: The safest way to select multiple output cells or ranges is to put your finger on the Ctrl key and then drag as many output cell ranges as you like. This will automatically insert commas between the ranges you select.

Calculate minimum ad spending by formula:

=MIN(B32:G32)

Solver Table 3

- How much would you be willing to pay for each 1% increase in worker productivity? (potentially by training or reorganizing)
- Varying Monthly Capacity Per Worker Percentage from 1% - 20% with 1% increment, show profit.

	A	B	C	D	E
1	Manufacturing mTunes				
2					
3	Initial cash	\$100,000			
4	Initial employees (Month 1)	15			
5	Monthly Capacity Per Machine	900			% change
6	Monthly Capacity Per Worker	600	=D6*E6+D6	600	0%
7	Holding cost Per Product Per Month	\$2			
8	Cost of buying a machine (Month 1)	\$3,000			
9	Raw material cost per mTune	\$6			

1. Input initial value 600 in D6
 2. Use E6 as percentage change
 3. Set formula in B6 as = D6*E6+D6
- Now changing value in E6 can vary “monthly capacity per worker” by certain percentage

Parameters for oneway table

Specify the following information about the input to be varied and the outputs to be captured.

Input cell:

(Optional) Descriptive name for input:

Values of input to use for table

☒ Base input values on following:

Minimum value:

Maximum value:

Increment:

☐ Use the values from the following range:

Input value range:

☐ Use the values below (separate with commas)

Input values:

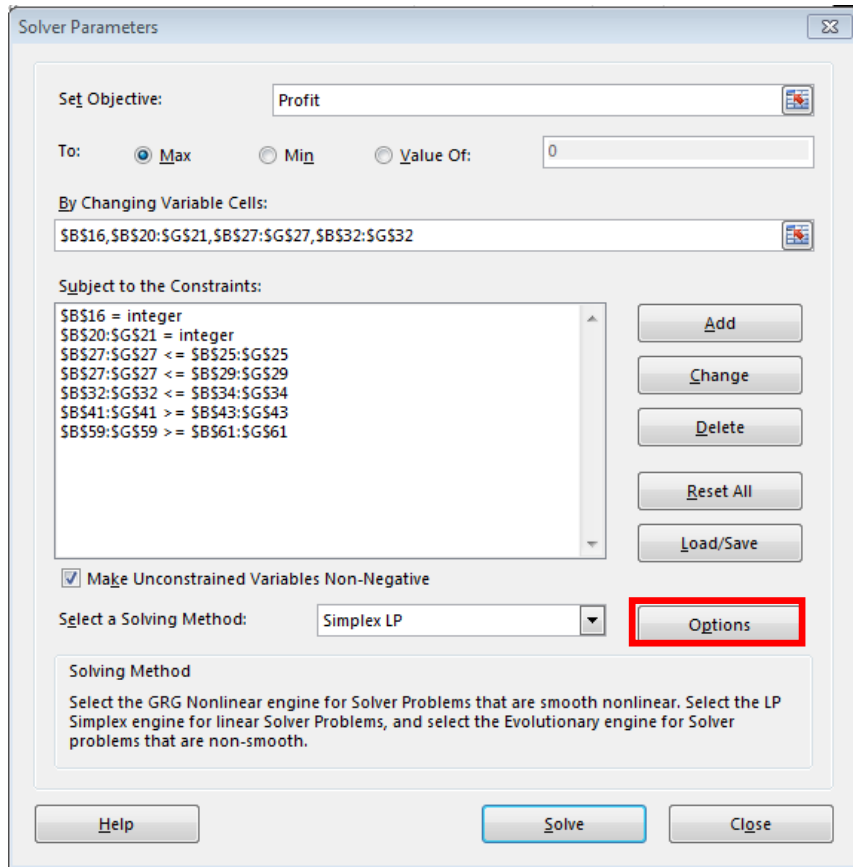
Output cell(s):

Note about specifying output cells: The safest way to select multiple output cells or ranges is to put your finger on the Ctrl key and then drag as many output cell ranges as you like. This will automatically insert commas between the ranges you select.

- The results are shown as below.
- Ideally, the profit should not decrease if we increase workers capacity. However, this is not the case here after we take the differences between profits.
- Thus, we need to adjust Excel solver's default setting

	A	B	C	D	E	F
1	Oneway analysis for Solver model in Model worksheet					
2						
3	Percent increase (cell \$E\$6) values along side, output cell(s) along top					
4			Profit			
5	0%	\$3,785,300				
6	1%	\$3,790,056	\$4,756	=B6-B5		
7	2%	\$3,796,888	\$6,832	=B7-B6		
8	3%	\$3,804,428	\$7,540			
9	4%	\$3,803,960	-\$468			
10	5%	\$3,809,050	\$5,090			
11	6%	\$3,808,360	-\$690			
12	7%	\$3,815,224	\$6,864			
13	8%	\$3,828,044	\$12,820			
14	9%	\$3,822,388	-\$5,656			
15	10%	\$3,830,580	\$8,192			
16	11%	\$3,830,746	\$166			
17	12%	\$3,831,308	\$562			
18	13%	\$3,840,104	\$8,796			
19	14%	\$3,843,584	\$3,480			
20	15%	\$3,853,700	\$10,116			
21	16%	\$3,845,948	-\$7,752			
22	17%	\$3,855,312	\$9,364			
23	18%	\$3,850,072	-\$5,240			
24	19%	\$3,858,678	\$8,606			
25	20%	\$3,865,080	\$6,402			

Solver Setting



The Solver Parameters dialog box is shown. The 'Set Objective' field contains 'Profit'. The 'To:' section has 'Max' selected. The 'By Changing Variable Cells:' field contains '\$B\$16:\$G\$20:\$G\$21,\$B\$27:\$G\$27,\$B\$32:\$G\$32'. The 'Subject to the Constraints:' list contains several constraints: '\$B\$16 = integer', '\$B\$20:\$G\$21 = integer', '\$B\$27:\$G\$27 <= \$B\$25:\$G\$25', '\$B\$27:\$G\$27 <= \$B\$29:\$G\$29', '\$B\$32:\$G\$32 <= \$B\$34:\$G\$34', '\$B\$41:\$G\$41 >= \$B\$43:\$G\$43', and '\$B\$59:\$G\$59 >= \$B\$61:\$G\$61'. The 'Make Unconstrained Variables Non-Negative' checkbox is checked. The 'Select a Solving Method:' dropdown is set to 'Simplex LP'. The 'Options' button is highlighted with a red box.

Solver Parameters

Set Objective: Profit

To: ☒ Max ☐ Min ☐ Value Of: 0

By Changing Variable Cells: \$B\$16:\$G\$20:\$G\$21,\$B\$27:\$G\$27,\$B\$32:\$G\$32

Subject to the Constraints:

- \$B\$16 = integer
- \$B\$20:\$G\$21 = integer
- \$B\$27:\$G\$27 <= \$B\$25:\$G\$25
- \$B\$27:\$G\$27 <= \$B\$29:\$G\$29
- \$B\$32:\$G\$32 <= \$B\$34:\$G\$34
- \$B\$41:\$G\$41 >= \$B\$43:\$G\$43
- \$B\$59:\$G\$59 >= \$B\$61:\$G\$61

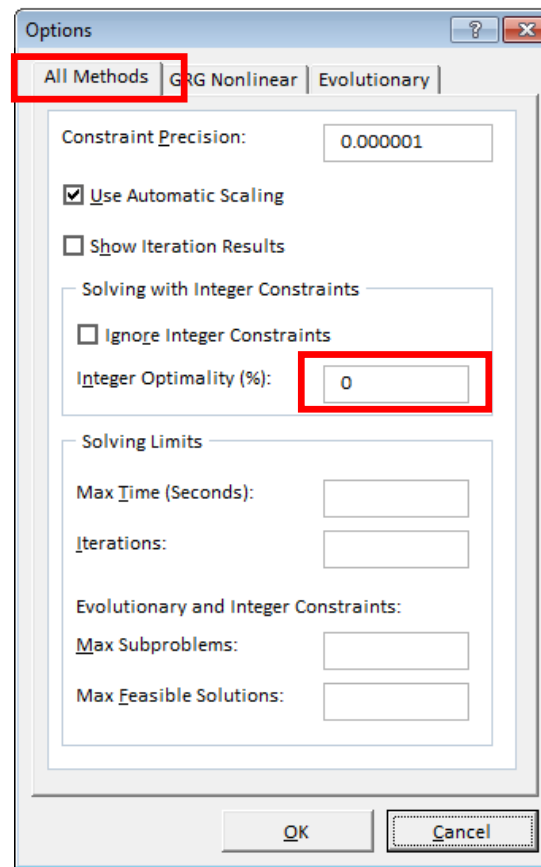
☒ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP

Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.



The Solver Options dialog box is shown. The 'All Methods' tab is selected and highlighted with a red box. The 'Constraint Precision' is 0.000001. The 'Use Automatic Scaling' checkbox is checked. The 'Show Iteration Results' checkbox is unchecked. The 'Solving with Integer Constraints' section has the 'Ignore Integer Constraints' checkbox unchecked. The 'Integer Optimality (%)' field is set to 0 and is highlighted with a red box. The 'Solving Limits' section has 'Max Time (Seconds)' and 'Iterations' fields. The 'Evolutionary and Integer Constraints' section has 'Max Subproblems' and 'Max Feasible Solutions' fields. The 'OK' and 'Cancel' buttons are at the bottom.

Options

All Methods GRG Nonlinear Evolutionary

Constraint Precision: 0.000001

☒ Use Automatic Scaling

☐ Show Iteration Results

Solving with Integer Constraints

☐ Ignore Integer Constraints

Integer Optimality (%): 0

Solving Limits

Max Time (Seconds):

Iterations:

Evolutionary and Integer Constraints:

Max Subproblems:

Max Feasible Solutions:

OK Cancel

1. Click Options in Excel solver
2. In Options window, typing 0 in Integer Optimality (%) box
3. Re-run Solver Table

Solver Table 3

	A	B	C	D	E	F
1	Oneway analysis for Solver model in Model worksheet					
2						
3	Percent increase (cell \$E\$6) values along side, output cell(s) along top					
4		Profit				
5	0%	\$3,785,300				
6	1%	\$3,790,056	\$4,756	=B6-B5		
7	2%	\$3,796,888	\$6,832	=B7-B6		
8	3%	\$3,804,428	\$7,540			
9	4%	\$3,805,604	\$1,176			
10	5%	\$3,809,050	\$3,446			
11	6%	\$3,810,876	\$1,826			
12	7%	\$3,815,224	\$4,348			
13	8%	\$3,828,044	\$12,820			
14	9%	\$3,828,700	\$656			
15	10%	\$3,830,580	\$1,880			
16	11%	\$3,832,868	\$2,288			
17	12%	\$3,835,588	\$2,720			
18	13%	\$3,840,104	\$4,516			
19	14%	\$3,843,584	\$3,480			
20	15%	\$3,853,700	\$10,116			
21	16%	\$3,853,700	\$0			
22	17%	\$3,855,604	\$1,904			
23	18%	\$3,857,544	\$1,940			
24	19%	\$3,860,516	\$2,972			
25	20%	\$3,865,080	\$4,564	\$3,989	=AVERAGE(C6:C25)	

- As expected, the profit increases as workers capacity increase.
- D25 shows that we would be willing to pay about \$3989 or less for a 1% increase in productivity.