Coffee Roasting Model

An Inventory Management Model

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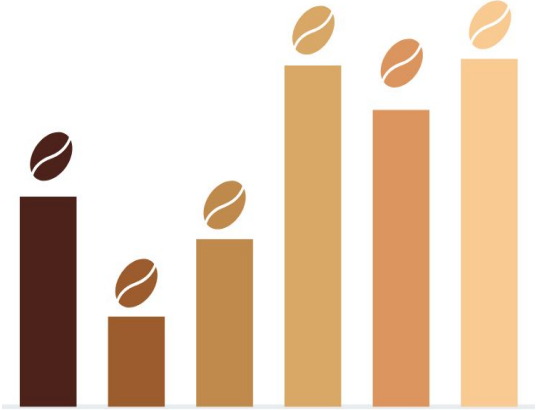
What is the Coffee Roasting Process ?

Coffee roasting transforms green coffee into a finished roast. The coffee bean undergoes a series of stages enabling it to successfully crack open with flavor and aroma. This makes up its roast profile



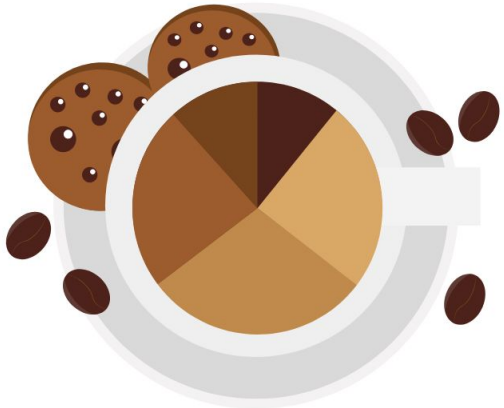
This process is completed using a Roaster, which takes in beans using a hopper, drops them into a heated rotating drum, and then drops them into a cooling tray once complete

Operating efficiently means optimizing this process in two critical ways: **Inputs** and **Outputs**

Coffee Roasting Inventory Management

Inventory models minimize costs for coffee roasting operations by optimizing **Production capacity** and **Replenishment** based on:

- (1) Decision Variables
- (2) Demand Forecast
- (3) Constraint management
- (4) Objective Function



This facilitates effective inventory management for input & output goods involved in the roasting process.

Replenishment Model Features

Using Replenishment as the decision variable, a model can be formulated using the following parameters:

- **Demand forecast**
- **6-month period**
- **Inventory**
- **Bag Cost**

Constraints to be managed consist of:

- **Replenishment minimum**
- **Budget**
- **Storage Capacity**

The **objective function** adds together the monthly bag replenishment cost over the six-month period.

Production Model Features

Using Production as the decision variable, a model can be formulated using the following parameters:

- **Demand forecast**
- **6-month period**
- **Labor & Holding costs**
- **Inventory**

Constraints to be managed consist of:

- **Labor**
- **Storage Capacity**
- **Safety Stock**

The **objective function** is the summation of labor costs and holding costs over the six-month period.

Assumptions

- Demand forecast over a six-month period with constant ordering
- Constant price for beans throughout the six-month period
- Uniform roast time for all origins

Replenishment Model

The model minimizes cost by finding the optimal monthly replenishment amounts satisfying Demand, Budget, Replenishment, and Capacity constraints. This provides the expected cost structure for the period for a specific origin of bean used in production

Guatemala									
		month 1	month2	month 3	month 4	month 5	month 6	Objective (Min):	$19,500.00
	Beg Inventory	10	10.00	10.00	10.00	10.00	7.00		
	Demand	4	6	6	6	7	7		
	End Inventory	6	4	4	4	3	0		
	Replenishment	4.00	6.00	6.00	6.00	4.00	0.00		
	Total Cost:	$3,000.00	$4,500.00	$4,500.00	$4,500.00	$3,000.00	$0.00		

When performing this for all origins involved in the roasting process, there is a total objective cost of **$89,249.**

Analysis (Budget)

Current budget allocation is predicted by finding the average number of bags and multiplying it by its cost. However, a sensitivity analysis shows how much this allocated budget can be reduced through optimal allocation.

BI10	Max Budget	3000	0	0	1E+30	3000
BI11	<=	4500	0	0	1E+30	4500
BI12	<=	4500	0	0	1E+30	6000
BI13	<=	4500	0	0	1E+30	7500
BI14	<=	3000	0	0	1E+30	10500

3000	<=	4500
4500	<=	6000
4500	<=	6000
4500	<=	6000
3000	<=	6000

3000	<=	3000
4500	<=	4500
4500	<=	4500
4500	<=	4500
3000	<=	3000

A total of $12,000 can be cut out of the allocated budget for roasting Guatemala and be allocated for something else that may need extra cash.

Analysis (Storage Capacity)

Current Capacity is based on a holding area that is limited to 10 bags only. However, if not all the bags are needed for a specific origin, more room can be dedicated to other bags for origins that are needed. For instance, Guatemala can be reduced in the following ways

Max Inventory <=	10	0	10	1E+30	0
	10	0	10	0	4
	10	0	10	0	4
	10	0	10	0	4
	10	0	10	0	3
	7	0	10	1E+30	3

10	<=	10
10	<=	10
10	<=	10
10	<=	10
10	<=	10

10	<=	10
6	<=	6
6	<=	6
6	<=	6
7	<=	7
7	<=	7

Or, it shows decision-makers how business can expand to meet capacity while still optimizing workflow

Outcome of the Production Model

The model has provided us with the optimal batches to process during each month to meet all demand while staying within the constraints provided.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Roasting Inventory	42	22	40	95	94	66
Production	152	263.6666667	300	300	300	300
Demand	172	245	245	301	328	328
Ending Inventory	22	40	95	94	66	38
Labor Cost	$ 1,266.67	$ 2,197.22	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00
Holding Cost	$2,774.00	$2,715.60	$5,942.20	$8,307.40	$7,037.20	$4,584.40
Cost per Batch	$87.60	$87.60	$87.60	$87.60	$87.60	$87.60
Total	$4,040.67	$4,912.82	$8,442.20	$10,807.40	$9,537.20	$7,084.40
Objective:	$44,824.69					

Analysis (Labor Time)

Currently, our constraints allow the roastery to run at a cost of $**44,824.69** over the 6 month period. But it is possible to decrease the cost even more if certain decisions are made.

If the constraints on Labor Time are increased to 6200 minutes per month, (an addition of only 200 minutes)

- **It can save around $6000 from the total cost**

3040	<=	6000	
5273.33333	<=	6000	
6000	<=	6000	
6000	<=	6000	
6000	<=	6000	
6000	<=	6000	

3040	<=	6200	
5066.66667	<=	6200	
5606.66667	<=	6200	
6200	<=	6200	
6200	<=	6200	
6200	<=	6200	

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Roasting Inventory	42	22	30	65	74	56
Production	152	253.3333333	280.3333333	310	310	310
Demand	172	245	245	301	328	328
Ending Inventory	22	30	65	74	56	38
Labor Cost	$ 1,266.67	$ 2,111.11	$ 2,336.11	$ 2,583.33	$ 2,583.33	$ 2,583.33
Holding Cost	$2,774.00	$2,263.00	$4,175.60	$6,117.40	$5,723.20	$4,146.40
Cost per Batch	$87.60	$87.60	$87.60	$87.60	$87.60	$87.60
Total	$4,040.67	$4,374.11	$6,511.71	$8,700.73	$8,306.53	$6,729.73
Objective:	$38,663.49					

Analysis (Labor Time)

Based on the sensitivity report generated, we can see that adding minutes to the last month provides the most value.

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
H19	Time Capacity	3040	0	6000	1E+30	2960
H20		5273.333333	0	6000	1E+30	726.6666667
H21		6000	-4.38	6000	206.6666667	726.6666667
H22		6000	-8.76	6000	206.6666667	726.6666667
H23		6000	-13.14	6000	206.6666667	726.6666667
H24		6000	-17.52	6000	206.6666667	726.6666667

With a shadow price of **-17.52,** every minute added to Labor Time would save us 17.52 dollars, so it would make more sense to add more time to the later months instead of evenly throughout the months.

Analysis (Labor Time)

With our allotted time rearranged as such, the model shows how much more cost efficient this method than our initial thoughts.

3040	<=	6000
5066.66667	<=	6000
5306.66667	<=	6000
6200	<=	6200
6300	<=	6300
6400	<=	6400

With this we save around $9500 with less total minutes added

Labor Cost	$ 1,266.67	$ 2,111.11	$ 2,211.11	$ 2,583.33	$ 2,625.00	$ 2,666.67
Holding Cost	$2,774.00	$2,263.00	$3,518.60	$4,803.40	$4,628.20	$3,708.40
Cost per Batch	$87.60	$87.60	$87.60	$87.60	$87.60	$87.60
Total	$4,040.67	$4,374.11	$5,729.71	$7,386.73	$7,253.20	$6,375.07
Objective:	$35,159.49					

Analysis (Safety Stock)

Another way to minimize cost is removing the safety stock requirements for end inventory. A Sensitivity analysis on safety stock shows for every bag decreased in Month 1, $730 will be saved. For month 6, this figure jumps to $3,354. The allowable decrease for Month 1 is 2.6 Bags of produced coffee while month 6 is 1.24 bags of produced coffee.

H27	Safety Month 1	2.6	730	2.6	17.76	2.6
H28	Safety Month 2	4.84	0	3.6	1.24	1E+30
H29	Safety Month 3	11.44	0	3.6	7.84	1E+30
H30	Safety Month 4	11.32	0	4	7.32	1E+30
H31	Safety Month 5	7.96	0	4.6	3.36	1E+30
H32	Safety Month 6	4.6	3354.444444	4.6	4.36	1.24

Analysis (Safety Stock)

Compared to the original model, a total of $17,328 can be saved if safety stock is removed.

A Cross-examination of Safety vs No Safety shows how the number of bags are reduced to optimize cost

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Roasting Inventory	42	0	2	57	56	28
Production	130.3333333	247	300	300	300	300
Demand	172	245	245	301	328	328
Ending Inventory	0	2	57	56	28	0
Labor Cost	$ 1,086.11	$ 2,058.33	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00
Holding Cost	$1,825.00	$87.60	$2,584.20	$4,949.40	$3,679.20	$1,226.40
Cost per Batch	$87.60	$87.60	$87.60	$87.60	$87.60	$87.60
Total	$2,911.11	$2,145.93	$5,084.20	$7,449.40	$6,179.20	$3,726.40
Objective:	$27,496.24					

Month	Safety	No Safety	Constraint	
1	2.6	0.08	>=	2.6
2	4.88	0.32	>=	3.6
3	11.48	6.92	>=	3.6
4	11.36	6.8	>=	4
5	8	3.44	>=	4.6
6	4.64	0.08	>=	4.6

Questions?


Thank you