Crispy Critters

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Problem Outline

Background

Crispy Critters, Inc. (CCI) is a start-up biotechnology firm that has developed genetically engineered critters capable of disassembling and decomposing abandoned automobiles. However, the firm faces a challenge: their genetic engineering techniques also produce a harmful type of critter that preys on the beneficial car-eating critters. CCI has discovered a baking method as a second step to improve the quality of mix, ensuring the good critters outnumber the harmful ones and effectively decompose cars.

Project Objective

The ultimate goal is to devise a production and labor strategy for both the production step and the baking step that maximizes profit for CCI while ensuring the production of a abundant and viable product mix. This involves a detailed analysis of production costs, output rates, labor utilization, and the interplay of various factors that influence the profitability and efficiency of the production process.

LP formulation

Decision Variables

- # grams of environment A we process
- # grams of environment B we process
- # grams of Agent 1 applied to critter mix harvested from environment A
- # grams of Agent 1 applied to critter mix harvested from environment B
- # grams of Agent 2 applied to critter mix harvested from environment A
- # grams of Agent 2 applied to critter mix harvested from environment B
    - And then the overtime applied for each of the above

LP formulation

Constraints:

- 1000 grams of environments A and B can be processed in regular time, and 400 grams can be processed in overtime
- The amount of agent that can be applied to critter mix harvested from environment A is equal to the number of grams of critter mix harvested from environment A
  - The same goes for critter mix harvested from environment B
  - A maximum of 800 grams of Agents 1 and 2 can be applied in regular time, and 300 grams can be applied in overtime.
  - After applying agents 1 and 2 on critter mix harvested, there should be at least 40% good critters, and a max of 7% bad critters

Optimal Solution

Production Allocation

(Gram)	Environment A	Environment B
Normal Time	196.88	803.12
Overtime	0	400.00

Total gram after harvest: 952.8736

(A:44% harvest ratio, B:72% harvest ratio)

Agent Work Allocation

(Gram)	Agent 1	Agent 2
FromA_Normal Time	86.62	0
FromA_Overtime	0	0
FromB_Normal Time	107.00	606.37
FromB_Overtime	152.87	0

Quality after bake: 40% Good 7% Bad 33% Dead

Total Revenue: $95,287.36

Total Cost: $39,630.55

Total Profit: $55,656.81

This is the optimal solution for the production, which maximizes the total profit while meeting the product quality standard. With a total of **952.8736 grams** of harvested product, the solution generates a **profit of $55,656.81**

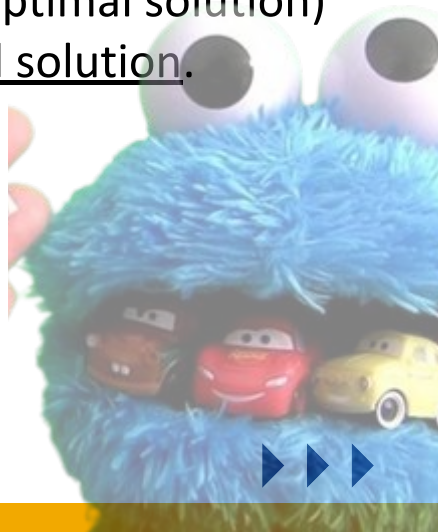
Please prepare raw material and budget based on the table and cost statistics

Sensitivity Analysis

Objective Function

- **Agent 2 not used on environment A:**
  - It is not economical to use "Agent 2" in "Environment A". This could be due to its cost, the quality mix it provides, indicating that improvement on these two factors can potentially increase the use of resource agent2 in environment A

- **The parameters of Harvest A is sensitive to changes:**
  - Harvest_A decision cell has a comparatively narrow Lower Bound and Upper Bound interval (coefficient value decrease by 11 or increase by 2.79 would result in the change in optimal solution)
  - Small changes in *Harvest Amount in Environment A* could lead to a different optimal solution. This means that if the estimation of costs or benefits associated with this variable is uncertain, the overall solution might not be reliable.



Sensitivity Analysis

Constraint Sensitivity

- **Resources utilization**:
  - Most resources are utilized at 100% rate
  - Except the *Agent* resources: 89.5% of the *Total Agent Work Amount* is utilized in the optimal function, having 147.13 units not being utilized.

- **Constraints that influence profit:**
  - *Maximum 7% Bad Quality*: allowing every unit increase on the 7% constraint would increase profit by $965.23
  - *Minimum 40% Good Quality:* strengthening one more unit on 40% standard would decrease profit by $147.03
  - *Allowable Production Amount* is at maximum: allowing more production per week would result in new optimal solutions in decision cells

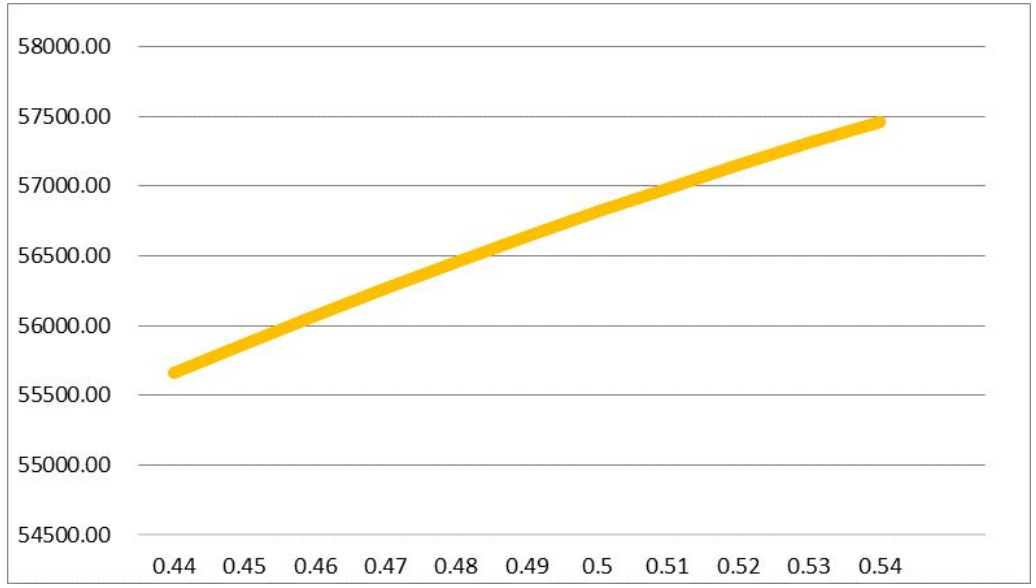
- **Non-binding Constraints:**
  - Loosening the following constraints will not result in increase in profit: *Harvest Amount in Environment A*, *Overtime Total Production*, *Total Agent Work Amount*, *Total Overtime Agent Work Amount*

Other Scenarios 1.1

Potential improvement in the harvesting process

Increasing the A harvest yield by an additional 10%

Increase in profit of $1803.66



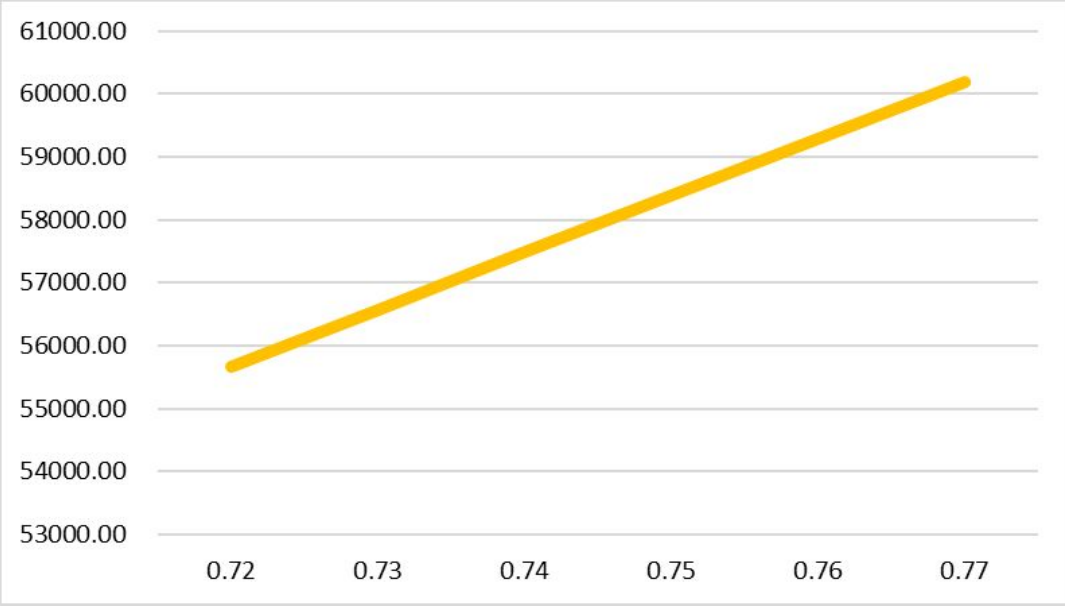
change	Harvesting ratio of A	Harvesting ratio of B	Profit
original	0.44	0.72	55656.81
+1%	0.45	0.72	55868.28
+2%	0.46	0.72	56071.79
+3%	0.47	0.72	56267.79
+4%	0.48	0.72	56456.70
+5%	0.49	0.72	56638.88
+6%	0.5	0.72	56814.69
+7%	0.51	0.72	56984.45
+8%	0.52	0.72	57148.49
+9%	0.53	0.72	57307.07
+10%	0.54	0.72	57460.47

Other Scenarios 1.2

Potential improvement in the harvesting process

Increasing the B harvest yield by an additional 5%

Increase in profit of $4524.64

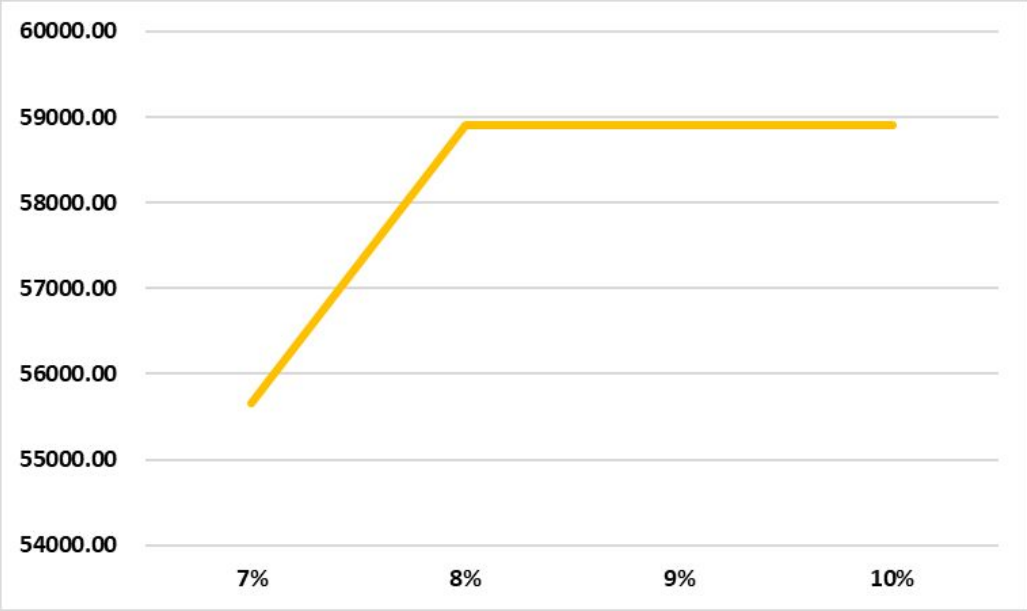


change	Harvesting ratio of A	Harvesting ratio of B	Profit
original	0.44	0.72	55656.81
+1%	0.44	0.73	56568.80
+2%	0.44	0.74	57477.23
+3%	0.44	0.75	58382.14
+4%	0.44	0.76	59283.53
+5%	0.44	0.77	60181.45

Other Scenarios 2.1
Increasing the allowable bad critters

Increasing the allowable bad critters from 7% to 10%

Increase in profit of $3243.19

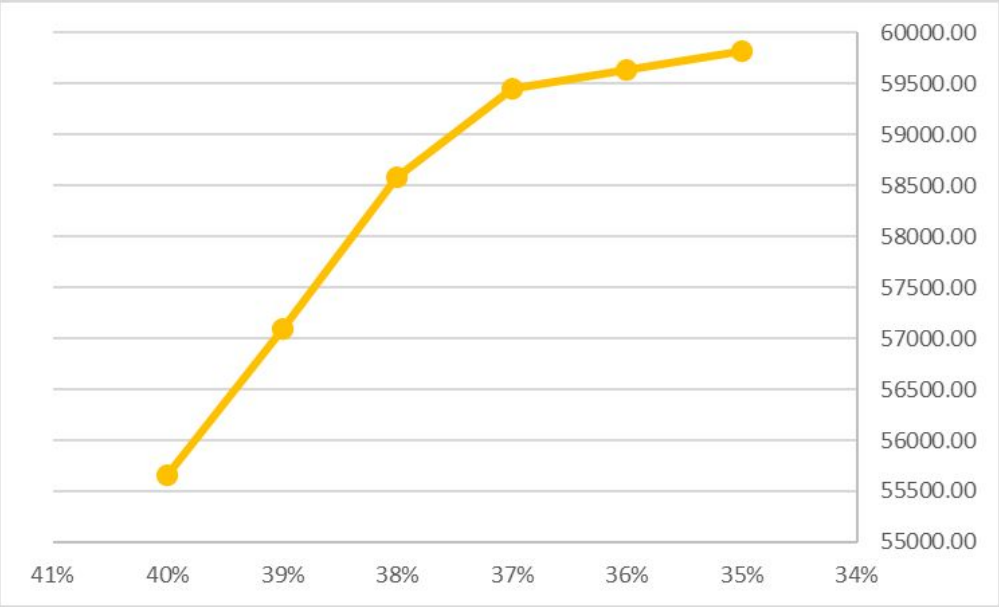


change	allowable bad critters	required good critters	Profit
original	7%	40%	55656.81
+1%	8%	40%	58900.00
+2%	9%	40%	58900.00
+3%	10%	40%	58900.00

Other Scenarios 2.2
Increasing the allowable bad critters

Decreasing the required good critters from 40% to 35%

Increase in profit of $4167.19



change	allowable bad critters	required good critters	Profit
original	7%	40%	55656.81
-1%	7%	39%	57089.17
-2%	7%	38%	58587.06
-3%	7%	37%	59454.40
-4%	7%	36%	59639.20
-5%	7%	35%	59824.00

Other Scenarios 3

Increasing the staff in the harvesting and baking departments

Production Allocation

(Gram)	Environment A	Environment B
Normal Time	11.11	988.89
Overtime	0	400.00
New Staff	216.16	0

Agent Work Allocation

(Gram)	Agent 1	Agent 2
FromA_Normal Time	0	0
FromA_Overtime	100	0
FromB_Normal Time	100	700
FromB_Overtime	200	0
FromA_New Staff	100	0
FromB_New Staff	200	0

Total gram after harvest: **1100** ↑

Total Revenue: **~$110000.00**

Total Cost: **~$ 52790.40** (included fixed cost for new hire)

Total Profit: **$ 57209.60** ↑

Adding new staffs to harvest Environment A and to apply Agent 1 in the baking process will lead to higher total yield in gram and more profit.

However, the feasibility can be subject to 1) the amount of budget available as cost also goes up and 2) management ability

Business Insights

Red Flags to Pay Attentions to

- If there are changes that impact the production or cost in environment A, the optimal production structure and work allocation can change dramatically

Variable Cost Reduction Potentials

- Hiring more agents or production work units that work in regular hours that reduces amount of additional overtime. But be careful about fixed cost increase

Revenue Increase Potentials

- Agent 2's skill in environment A would be improved for labor resources maximization
- Increase resource capacity that loosens the allowable harvest amount constraint
- Resources utilization efficiency (harvest ratio, agent quality output) would bring higher product output given existing production

Thank You

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