488 Lab 3

Fred Kaesmann

March 24, 2020

Ray,

We looked over your production arrangements as requested and we are reasonably certain we have found some significant improvements to your current production model.

From the outset we would like you to know that we understand the realities of your current situation, resource management has become a top priority in the industry given the recent shuttering of bars and restaurants throughout the tri state area. Other breweries we have worked with have seen their revenue take a 40% to 50% hit, forcing them to furlough employees and cut pay for those remaining. Then on top of it are the difficult discussions with investors.

We believe that given your existing output, a small batch brewery like yourself could be well positioned to withstand a market downturn, assuming you are willing to make some tough decisions.

The Numbers

By the information you provided we have your current production at 100 gallons of Ale, 400 gallons of Lager and 200 gallons of Stout, from which your current monthly profit is $17,734. This can be improved dramatically, though we must note this will come at the cost of some difficult business decisions.

Our proprietary model has developed an improved production plan relative to the monthly profit by house beer. [1] The implementation of this plan will require some changes not only to production but will also require changes at the brand level, so should you decide to pursue this to fruition, we highly recommend including a representative from marketing and sales to discuss the impact on the brand image, in addition to the bottom line.

Our model has developed a production plan which will, by our calculations, improve your montly profit by approximately 20% to $21,507. We stress again that this is not a "free lunch," though this represents a marked improvements in the bottom line, this assumes you cease production of your Copy Cat "We Swear it's not a Repackaged Guinness" stout, on more than just copyright infringement grounds. We again stress the need to include marketing and sales in on this decision before moving forward, as our model has not looked into market sentiment surrounding each of your products. [2]

Our model maximizes your profit with 337 gallons of your "Haughty Nurse Ale" and 524 gallons of your "Sam Clemens Style Lager."

The New Deal

We also looked into your questions about the profitablility of entering into a strategic partnership with the Two Dog Brewery down the road. Our model shows this being a very green new deal, as this will increase your monthly profits, on top of what the model has already shown above. Should you enter into the agreement with Two Dog we find that would increase profits an additional 10% to $23463.

As always it was a pleasure working with you gentlemen, and if you have any further questions feel free to contact us

Fred Kaesmann

President and CEO

Brewing by the Numbers

[1] Though we need to stress that our model does not take into account the time required for brewing, nor the labor required for each beer, as the information was not provided. We would be more than happy to have our model account for this if you would like to provide that information.

[2] We feel now is the appropriate time to mention that this is another one of the many forms of analysis we can provide upon request.

Appendix I

Methods and Calculations

We approached this as a simple exercise in linear programming.

Given the initial revenue function

$$\text{Monthly Revenue } = \$38 \text{ per gallon of Ale} + \$26 \text{ per gallon of Lager} + \$40.50 \text{ per gallon of Stout}$$

the ingredient requirements

	Ale	Lager	Stout
Water (gals)	1.250	1.100	1.300
Malted Barley (lbs)	2.250	1.222	3.233
Hops (lbs)	0.045	0.011	0.022
Brewer's Yeast (pkgs)	0.157	0.185	0.172

as well as the associated costs

	Material Costs
Water (gals)	0.45
Malted Barley (lbs)	2.50
Hops (lbs)	3.75
Brewer's Yeast (pkgs)	6.00

we were able to combine the cost vector and the ingredient matrix to develop a cost matrix.

	Ale	Lager	Stout
Water (gals)	0.56250	0.49500	0.5850
Malted Barley (lbs)	5.62500	3.05500	8.0825
Hops (lbs)	0.16875	0.04125	0.0825
Brewer's Yeast (pkgs)	0.94200	1.11000	1.0320

This cost matrix yields our cost per style of beer,

$$\text{Monthly Cost } = \$7.30 \text{ per gallon of Ale} + \$4.70 \text{ per gallon of Lager} + \$9.78 \text{ per gallon of Stout}$$

which, when subtracted from the above revenue equation, gives us the montly profit for the brewery.

$$\text{Monthly Profit } = \$30.70 \text{ per gallon of Ale} + \$21.30 \text{ per gallon of Lager} + \$30.72 \text{ per gallon of Stout}$$

Our given system constrains we were,

	Availability
Water (gals)	2000
Malted Barley (lbs)	1400
Hops (lbs)	50
Brewer's Yeast (pkgs)	150

and when combined with the cost per resource gives us the budgetary impact of our resource constraints.

	Availablility (Dollars)
Water (gals)	900.0
Malted Barley (lbs)	3500.0
Hops (lbs)	187.5
Brewer's Yeast (pkgs)	900.0

Taking all these factors into account, our model finds that profit is maximized at $21,507 when Copy Cat makes 337 gallons of Ale, 524 gallons of Lager. Our model also returns shadow prices of $4.16 for Malted Barley and $7.28 for yeast packages, meaning for each additional pound of Malted Barley and each additional yeast package the brewery can expect to see increases in monthly profit by $4.16 and $7.28 respectively.

The New Deal

After the deal offered by Two Dog, we readjust our resource availability, recognizing the increased availability of Malted Barley and additional yeast packages.

	New Availability
Water (gals)	2000
Malted Barley (lbs)	2000
Hops (lbs)	50
Brewer's Yeast (pkgs)	155

We solve as before using the new resource constraints, and find that even after the new deal, we see increases in profits by an additional 10% to $23463.

We are left with new shadow prices for Malted Barley and Yeast Packages, $10.41 and $46.37 respectively.

Appendix II

```r
##### Chunk Options ####
library(knitr)                    # chunk options and kable() for fancy display
opts_chunk$set(echo = TRUE,
               message = FALSE,
               warning = FALSE)

##### Names Vector ####
# This will be used multiple times below
namesVec <-
    c("Water (gals)",
      "Malted Barley (lbs)",
      "Hops (lbs)",
      "Brewer's Yeast (pkgs)")

##### Create Ingredient Matrix ####
ingredientMatrix <- matrix(
             c(1.250, 1.100, 1.300,
               2.250, 1.222, 3.233,
               0.045, 0.011, 0.022,
               0.157, 0.185, 0.172),
             byrow = TRUE,
  nrow = 4,
  dimnames = list(
    # Row Names
    namesVec,
    # Column Names
    c("Ale", "Lager", "Stout"))
)
kable(ingredientMatrix)


##### Cost Vector ####
costVector <- matrix(
             c(0.45,
               2.50,
               3.75,
               6.00),
             nrow = 4,
             byrow = TRUE,
             dimnames = list(
               namesVec,
               "Material Costs"
             ))
kable(costVector)

costMatrix <- ingredientMatrix * costVector[, 1]
kable(costMatrix)

##### Profit ####
# Objective function
# Profit = Revenue - Cost
```

```r
profit <- c(38 - sum(costMatrix[, 1]), # Ale
            26 - sum(costMatrix[, 2]), # Lager
         40.50 - sum(costMatrix[, 3])) # Stout

##### Constraint Directionals ####
directionals <- c("<=",
                  "<=",
                  "<=",
                  "<=")

##### Availablility Vector ####
availablilityVector <- matrix(c(
    2000,
    1400,
    50,
    150),
    byrow = TRUE,
    dimnames = list(
      namesVec,
      "Availability"
    )
)
# Nice display
kable(availablilityVector)

##### Spending Limits ####
costConstraint <- availablilityVector * costVector
colnames(costConstraint) <- "Availablility (Dollars)"
kable(costConstraint)

##### Solve with lp() ####
solutions <- lpSolve::lp("max",
                profit,
                costMatrix,
                directionals,
                costConstraint,
                compute.sens = TRUE)

##### Explore Solutions Object ####
cat("Our x,y,z values are:\n", solutions$solution)

cat("\nThe profit is:\n", solutions$objval)

cat("\nThe Shadow Prices are:\n", solutions$duals)

##### New Availability Vector ####
new_availability <- matrix(
  c(
    2000,
    2000,
    50,
    155),
  nrow = 4,
```

```
  dimnames = list(
    namesVec,
    "New Availability"
  )
)
# Nice display
kable(new_availability)

##### New Solutions ####
new_solutions <- lpSolve::lp("max",
                profit,
                ingredientMatrix,
                directionals,
                new_availability,
                compute.sens = TRUE)

##### Explore Solutions Object ####
cat("Our producction levels of Ale, Lagger, and Stout (repsectively) are:\n",
    new_solutions$solution)

cat("\nThe Profit after the deal is:\n",
    new_solutions$objval - 600 * 7.5)


cat("\nThe Shadow Prices are:\n",
    new_solutions$duals)
```