**Brad Schommer and Josh Gildea Anadolu Efes Case Report**

**Executive Summary**

Anadolu Efes is a company that produces and distributes beer within Turkey. Currently, the company operates two malt centers (plus importing), two breweries, and six different distribution centers within five different countries. Anadolu Efes has the goal of diversifying business and international presence while maintaining the dominating market share that they currently hold. To achieve this goal, they have come up with plans, but they still need analysis done to be sure that their plans will be successful and optimize them where possible.

Through our analysis, we were able to determine that the current shipment plan that Anadolu Efes uses is not as optimal and as cost-effective as it could be. A more optimal plan lowers the total cost from $11.25 million to $11.14 million per year by not importing malts in the first year. The current Istanbul-Antalya and Ankara-Bursa relationships are also not optimal, and while they may be some unspoken agreement as to why this is currently in effect, removing this relationship can reduce costs even further. In our report, we show what the most optimal shipping plan would be for the first year. We also looked into the next 3 years and analyzed what the best capacity expansion plan would be for Anadolu Efes since expected demand will increase past what the breweries are currently able to handle. This was all done while considering effects of capacity expansion, determined optimal distributions, and location.

In this report, we share our results of our analysis. This report contains the optimal solutions for both expansion and transportation as those are the two most prominent issues faced by the company. This report also contains recommendations which can help Anadolu Efes create a plan that maximizes capacity for the lowest overall costs.

**Summary of Analysis**

Our analysis brings to light the issue that Anadolu Efes faces and that they need help optimizing their current distribution systems. This analysis takes into consideration the cost of new brewery(s) and what their current transportation system costs. The goal of this analysis was to determine what the most optimal and cost efficient system could be while still being able to meet customer demand and providing maximum profit. To achieve this, we ran linear programming formulations, regression analyses, sensitivity analyses, and formed distribution models.

Malt Plants

| Name | Abbreviation |
|------|--------------|
| Afyon | 1 |
| Konya | 2 |
| Import | 3 |

Breweries

| Name | Abbreviation |
|---|---|
| Istanbul Brewery | 4 |
| Ankara Brewery | 5 |
| Izmir Brewery | 6 |
| Sakarya | 7 |
| Adana | 8 |

Distribution Centers

| Name | Abbreviation |
|---|---|
| Istanbul Dist. | 9 |
| Izmir Dist. | 10 |
| Antalya | 11 |
| Bursa | 12 |
| Kayseri | 13 |
| Export | 14 |

Binary Variables (Y)

| Name | Abbreviation |
|---|---|
| Year 1 | 1 |
| Year 2 | 2 |
| Year 3 | 3 |
| Open Izmir | 4 |
| Open Sakarya | 5 |
| Open Adana | 6 |
| Expand Izmir | 7 |
| Expand Sakarya | 8 |
| Expand Adana | 9 |

Malt Plant Supply Constraint

| Plant | Left Hand | Sign | Right Hand |
|---|---|---|---|
| Afyon | X14 + X15 + X16 + X17 + X18 | <= | 30 |
| Konya | X24 + X25 + X26 + X27 + X28 | <= | 68 |
| Import | X34 + X35 + X36 + X37 + X38 | <= | 20 |

Brewery Capacity Constraint

| Brewery | Left Hand | Sign | Right Hand |
|---|---|---|---|

| Istanbul Brewery | X49 + X410 + X411 + X412 + X413 + X414 | <= | 220 |
|---|---|---|---|
| Ankara | X59 + X510 + X511 + X512 + X513 + X514 | <= | 200 |
| Izmir Brewery | X69 + X610 + X611 + X612 + X613 + X614 | <= | Y14 * 70 + Y24 *70 +Y27*50 + Y37 *50 |
| Sakarya | X79 + X710 + X711 + X712 + X713 + X714 | <= | Y15 * 70 + Y25 *70 +Y28*50 + Y38 *50 |
| Adana | X89 + X810 + X811 + X812 + X813 + X814 | <= | Y16 * 70 + Y26 *70 +Y29*50 + Y39 *50 |

Flow In = Flow Out Constraint for Distribution Centers

| Brewery | Left Hand | Sign | Right Hand |
|---|---|---|---|
| Istanbul Brewery | (X49 + X410 + X411 + X412 + X413 + X414) - ((8.333*(X14 +X24)) +(9.091* X34)) | = | 0 |
| Ankara | (X59 + X510 + X511 + X512 + X513 + X514) - ((8.333*(X15 +X25)) +(9.091* X35)) | = | 0 |
| Izmir Brewery | (X69 + X610 + X611 + X612 + X613 + X614)- ((8.333*(X16 +X26)) +(9.091* X36)) | = | 0 |
| Sakarya | (X79 + X710 + X711 + X712 + X713 + X714) - ((8.333*(X17 +X27)) +(9.091* X37)) | = | 0 |
| Adana | (X89 + X810 + X811 + X812 + X813 + X814) - ((8.333*(X18 +X28)) +(9.091* X38)) | = | 0 |

Distribution Demand Constraint (From Year One to Year Three)

| Distribution Center | Left Hand | Sign | Right Hand (Y1) | Right Hand (Y2) | Right Hand (Y3) |
|---|---|---|---|---|---|
| Istanbul Dist. | X49 + X59 + X69 + X79 + X89 | = | 103 | 110 | 125 |
| Izmir Dist. | X410 + X510 + X610 + X710 + X810 | = | 74 | 80 | 90 |
| Antalya | X411 + X511 + X611 + X711 + X811 | = | 50 | 53 | 60 |
| Bursa | X412 + X512 + X612 + X712 + X812 | = | 60 | 75 | 85 |
| Kayseri | X413+ X513 + X613 + X713+ X813 | = | 102 | 110 | 125 |
| Export | X414+ X514 + X614 + X714+ X814 | = | 13 | 13 | 15 |

## Part 1 Analysis

**Question 1**: Verify that the current shipment plan does not minimize the total shipment costs and show the improved plan under the current marketing considerations.

The current shipping plan has a cost of $11.25 million, but also maximizes the amount of imported malts that they can ship. Importing malt in the first year is not cost effective, as it is cheaper to produce and ship malt domestically than it is to import it. So by producing malt in Afyon and shipping that to the Istanbul brewery instead of importing brings the total cost down from $11.25 million to $11.14 million.

With importing:

**Transshipment Problem**

| Arc | | | Units |
|---|---|---|---|
| Start Node | End Node | Cost | Shipped |
| Afyon | Instanbul brew | 0.026 | 0 |
| Afyon | Ankara | 0.017 | 24 |
| Konya | Istanbul brew | 0.037 | 2.42 |
| Konya | Ankara | 0.017 | 0 |
| Import | Istanbul brew | 0.032 | 20 |
| Import | Ankara | 0.033 | 0 |
| Istanbul brew | Istanbul dist | 0 | 103 |
| Instabul brew | Izmir | 0.04 | 49 |
| Instabul brew | Antalya | 0.052 | 50 |
| Instanbul brew | Bursa | 0.041 | 0 |
| Instabul brew | Kayseri | 0.055 | 0 |
| Instabul brew | Export | 0.042 | 0 |
| Ankara | Istanbul dist | 0.032 | 0 |
| Ankara | Izmir | 0.041 | 25 |
| Ankara | Bursa | 0.027 | 0 |
| Ankara | Bursa | 0.027 | 60 |
| Ankara | Kayseri | 0.023 | 102 |
| Ankara | Export | 0.043 | 13 |
| | | | |
| Total Cost | 11.24754 | | |

Without importing:

**Transshipment Problem**

| Arc | | | Units |
|---|---|---|---|
| Start Node | End Node | Cost | Shipped |
| Afyon | Instanbul brew | 0.026 | 24.241 |
| Afyon | Ankara | 0.017 | 5.759 |
| Konya | Istanbul brew | 0.037 | 0 |
| Konya | Ankara | 0.017 | 18.242 |
| Import | Istanbul brew | 0.032 | 0 |
| Import | Ankara | 0.033 | 0 |
| Istanbul brew | Istanbul dist | 0 | 103 |
| Instabul brew | Izmir | 0.04 | 49 |
| Instabul brew | Antalya | 0.052 | 50 |
| | | | 0 |
| Instabul brew | Kayseri | 0.055 | 0 |
| Instabul brew | Export | 0.042 | 0 |
| Ankara | Istanbul dist | 0.032 | 0 |
| Ankara | Izmir | 0.041 | 25 |
| | | | 0 |
| Ankara | Bursa | 0.027 | 60 |
| Ankara | Kayseri | 0.023 | 102 |
| Ankara | Export | 0.043 | 13 |
| | | | |
| Total Cost | 11.14828153 | | |

**Question 2:** How much savings are possible with a distribution plan that ignores the established relationships between Istanbul-Antalya and Ankara-Bursa? Show the improved plan.

The optimized plan had a cost of $11.15 million. When removing the constraints or the relationships between Istanbul-Antalya and Ankara-Bursa, the total amount of savings possible is $532,000. Removing the relationships does not affect the amount of beer shipped from Ankara-Bursa. However, it significantly reduces the amount of beer shipped from Istanbul-Antalya since that is the more expensive option.

Improved plan pictured on next page.

## Transshipment Problem

| Arc | | | Units |
|---|---|---|---|
| Start Node | End Node | Cost | Shipped |
| Afyon | Instanbul brew | 0.026 | 24.241 |
| Afyon | Ankara | 0.017 | 5.759 |
| Konya | Istanbul brew | 0.037 | 0 |
| Konya | Ankara | 0.017 | 18.242 |
| Import | Istanbul brew | 0.032 | 0 |
| Import | Ankara | 0.033 | 0 |
| Istanbul brew | Istanbul dist | 0 | 103 |
| Instabul brew | Izmir | 0.04 | 74 |
| Instabul brew | Antalya | 0.052 | 12 |
| Instabul brew | Bursa | 0.041 | 0 |
| Instabul brew | Kayseri | 0.055 | 0 |
| Instabul brew | Export | 0.042 | 13 |
| Ankara | Istanbul dist | 0.032 | 0 |
| Ankara | Izmir | 0.041 | 0 |
| Ankara | Antalya | 0.039 | 38 |
| Ankara | Bursa | 0.027 | 60 |
| Ankara | Kayseri | 0.023 | 102 |
| Ankara | Export | 0.043 | 0 |
| | | | |
| Total Cost | 10.61628153 | | |

**Question 3:** What should be the annual cost of shipping 1 million liters of beer from the Istanbul brewery to the Antalya distribution center, and from the Ankara brewery to the Bursa distribution center so that it becomes optimal for Efes to send beer between these pairs?

Shipping one million liters of beer from Istanbul-Antalya would cost $52,000. On the other hand, shipping one million liters of beer from Ankara-Bursa would cost $27,000. The total cost of shipping 2 million liters of beer from these two locations is $79,000.

**Question 4:** Is it cost-effective for Efes to import malt in the first year? If not, under what input parameter changes would importing malt possibly become a viable option?

It is not cost-effective for Efes to import in the first year because the purchasing price of malt is greater than the selling price of beer. If the demand at the Izmir or Exporting distribution centers increases or if the cost of importing malt decreases, importing the malt would become feasible in the first year.

**Question 5:** The linear programming model uses the demand forecast for the next year to optimize the distribution plan, although demand is subject to variation over the years. Discuss the effects of beer demand variation on transportation costs using the information in the sensitivity report.

Variable Cells

| Cell | Name | Final Value | Reduced Cost | Objective Coefficient | Allowable Increase | Allowable Decrease |
|---|---|---|---|---|---|---|
| $D$5 | Instanbul brew Shipped | 24.24096964 | 0 | 0.026 | 0.003331867 | 0.000667 |
| $D$6 | Ankara Shipped | 5.759030361 | 0 | 0.017 | 0 | 0.003331867 |
| $D$7 | Istanbul brew Shipped | 0 | 0.011 | 0.037 | 1E+30 | 0.011 |
| $D$8 | Ankara Shipped | 18.24192968 | 0 | 0.017 | 0.003331867 | 0 |
| $D$9 | Istanbul brew Shipped | 0 | 0.003634945 | 0.032 | 1E+30 | 0.003634945 |
| $D$10 | Ankara Shipped | 0 | 0.014453618 | 0.033 | 1E+30 | 0.014453618 |
| $D$11 | Istanbul dist Shipped | 103 | 0 | 0 | 0.031 | 1E+30 |
| $D$12 | Izmir Shipped | 49 | 0 | 0.04 | 0 | 8.00432E-05 |
| $D$13 | Antalya Shipped | 50 | 0 | 0.052 | 1E+30 | 1E+30 |
| $D$14 | Shipped | 0 | 0 | 0 | 1E+30 | 0 |
| $D$15 | Kayseri Shipped | 0 | 0.033 | 0.055 | 1E+30 | 0.033 |
| $D$16 | Export Shipped | 0 | 0 | 0.042 | 1E+30 | 0 |
| $D$17 | Istanbul dist Shipped | 0 | 0.031 | 0.032 | 1E+30 | 0.031 |
| $D$18 | Izmir Shipped | 25 | 0 | 0.041 | 8.00432E-05 | 0 |
| $D$19 | Shipped | 0 | 8.00432E-05 | 0 | 1E+30 | 8.00432E-05 |
| $D$20 | Bursa Shipped | 60 | 0 | 0.027 | 1E+30 | 1E+30 |
| $D$21 | Kayseri Shipped | 102 | 0 | 0.023 | 0.033 | 1E+30 |
| $D$22 | Export Shipped | 13 | 0 | 0.043 | 0 | 1E+30 |

Constraints

| Cell | Name | Final Value | Shadow Price | Constraint R.H. Side | Allowable Increase | Allowable Decrease |
|---|---|---|---|---|---|---|
| $I$10 | Istanbul Brew Shipments | 0 | -0.003120125 | 0 | 152.01 | 47.99 |
| $I$11 | Ankara Shipments | 0 | -0.002040082 | 0 | 152.01 | 414.634 |
| $I$12 | Istanbul Dist Shipments | 103 | 0.003120125 | 103 | 18 | 103 |
| $I$13 | Izmir Shipments | 74 | 0.043120125 | 74 | 18 | 49 |
| $I$14 | Antalya Shipments | 50 | 0.055120125 | 50 | 18 | 50 |
| $I$15 | Bursa Shipments | 60 | 0.029120125 | 60 | 18 | 49 |
| $I$16 | Kayseri Shipments | 102 | 0.025120125 | 102 | 18 | 49 |
| $I$17 | Export Shipments | 13 | 0.045120125 | 13 | 18 | 13 |
| $I$18 | Instabul Brew c Shipments | 202 | 0 | 220 | 1E+30 | 18 |
| $I$19 | Ankara C Shipments | 200 | -8.00432E-05 | 200 | 49 | 18 |
| $I$7 | Afyon Shipments | 30 | 0 | 30 | 18.24192968 | 5.759030361 |
| $I$8 | Konya Shipments | 18.24192968 | 0 | 68 | 1E+30 | 49.75807032 |
| $I$9 | Import Shipments | 0 | 0 | 20 | 1E+30 | 20 |

The current demand for each distribution location is:

- Istanbul Dist = 103
- Izmir = 74
- Antalya = 50
- Bursa = 60
- Kayseri = 102
- Exports = 13

According to the sensitivity report, the allowable increase and/or decrease for demand is:

- Istanbul Dist.
  - Decrease –103
  - Increase + 18
  - Reduced Cost 0.003
- Izmir
  - Decrease -49
  - Increase = +18
  - Reduced Cost 0.04
- Antalya
  - Decrease –50
  - Increase + 18
  - Reduced Cost 0.055
- Bursa
  - Decrease –49
  - Increase + 18
  - Reduced Cost 0.029
- Kayseri
  - Decrease –49
  - Increase + 18
  - Reduced Cost 0.025
- Export
  - Decrease -13
  - Increase +18
  - Reduced Cost 0.045

If the demand for transporting beer from a beer distributor increases or decreases outside the allowable range, then the transportation costs increase by the reduced cost per unit beyond the range for each location. If the change in demand falls within the allowable increase/decrease, then the total cost will not be impacted. Demand that changes within the bounds given on the sensitivity report will cause minimal predictable changes in the transportation costs.

## Part 2 Analysis

**Question 6:** What are the effects of the planning horizon on the capacity expansion model? Specifically, discuss the time period over which the brewery opening and expansion may take place, the costs that should be considered in the objective function and the number of years these costs should be accounted for in the model.

During the first year, there is enough capacity at the original two breweries to meet total demand from the distribution centers. However, in year two, there is no longer enough capacity at the existing breweries since the original capacity of 420 million liters a year and there is demand for 441 million liters. Therefore, it is necessary to open a new brewery in year two and it is wise to open the new brewery at the Adana location as this has the lowest fixed cost to open which is $68 million and it will give us a total capacity of 490 million liters. During year three, the demand rises to 500 million liters, which can no longer be fulfilled. Therefore, it is advisable to expand the Adana location for an additional $25 million which would bring total capacity to 540 million liters/year. The total cost of $93 million that is spent on opening and expanding this location over the three years should be spread out between fifteen to twenty years as this is what the company has modeled the spread of the cost on in the past.

**Annual demand at distribution centers**

(Million liters/year)

| Dist. Centers | Year 1 | Year 2 | Year 3 |
|---|---|---|---|
| Istanbul | 103 | 110 | 125 |
| Izmir | 74 | 80 | 90 |
| Antalya | 50 | 53 | 60 |
| Bursa | 60 | 75 | 85 |
| Kayseri | 102 | 110 | 125 |
| Export(Izmir) | 13 | 13 | 15 |
| Total | 402 | 441 | 500 |

**FIXED COSTS:**

(Million $)

| Potential Brewery Sites | Open | Expand |
|---|---|---|
| Izmir | 75 | 30 |
| Sakarya | 70 | 27 |
| Adana | 68 | 25 |

**Annual capacity of breweries**

(Million liters/year)

| Existing Breweries | Current | |
|---|---|---|
| Istanbul | 220 | |
| Ankara | 200 | |

| Potential Breweries | New | Expansion |
|---|---|---|
| Izmir | 70 | 50 |
| Sakarya | 70 | 50 |
| Adana | 70 | 50 |

**Question 7:** Determine the optimal distribution, location, and capacity expansion decisions.

Y1: Do not Construct Any Breweries. Demand is able to be met by the current Breweries so there is not need to add additional cost onto the supply chain. Istanbul Brewery is able to meet the demand utilizing 202 out of 220 million liters/beer per year capacity and Ankara is utilizing 200/200 million liters of beer per year capacity, which meets demand. Therefore, there is no reason to open a new brewery within the first year.

| | | | | | |
|---|---|---|---|---|---|
| Afyon | | 30 | 30 | <= | 30 |
| Konya | | 18.242 | 18.242 | <= | 68 |
| Import | | 0 | 0 | <= | 20 |
| Istanbul Brew | 202 | 202 | 0 | = | 0 |
| Ankara brew | 200 | 200 | 0 | = | 0 |
| Izmir Brew | 0 | 0 | 0 | = | 0 |
| Sakarya Brew | 0 | 0 | 0 | = | 0 |
| Adana | 0 | 0 | 0 | = | 0 |
| Istanbul Dist | 103 | | 103 | = | 103 |
| Adana | 74 | | 74 | = | 74 |
| Antalya | 50 | | 50 | = | 50 |
| Bursa | 60 | | 60 | = | 60 |
| Kayseri | 102 | | 102 | = | 102 |
| Export | 13 | | 13 | = | 13 |
| Istanbul Brew | | 202 | 202 | <= | 220 |
| Ankara | | 200 | 200 | <= | 200 |
| Izmir Brew | | 0 | 0 | <= | 0 |
| Sakarya Brew | | 0 | 0 | <= | 0 |
| Adana | | 0 | 0 | <= | 0 |

Y2: Constructed Adana Brewery to keep up with demand. With this new brewery, we started to import malt due to the location proximity of Adana. Istanbul Brewery will use its total capacity, shipping 220 million liters of beer per year. The total capacity of Adana is also used in Year Two because it is cheaper to ship from compared to Ankara. With the opening of Adana, Ankara no longer uses the total capacity of 200.

| | | | | | |
|---|---|---|---|---|---|
| Afyon | | 30 | 30 | <= | 30 |
| Konya | | 1.1028 | 1.1028 | <= | 68 |
| Import | | 20 | 20 | <= | 20 |
| Istanbul Brew | 220 | 220 | 0 | = | 0 |
| Ankara brew | 151 | 151 | 0 | = | 0 |
| Izmir Brew | 0 | 0 | 0 | = | 0 |
| Sakarya Brew | 0 | 0 | 0 | = | 0 |
| Adana | 70 | 70 | 0 | = | 0 |
| Istanbul Dist | 110 | | 110 | = | 110 |
| Adana | 80 | | 80 | = | 80 |
| Antalya | 53 | | 53 | = | 53 |
| Bursa | 75 | | 75 | = | 75 |
| Kayseri | 110 | | 110 | = | 110 |
| Export | 13 | | 13 | = | 13 |
| Istanbul Brew | | 220 | 220 | <= | 220 |
| Ankara | | 151 | 151 | <= | 200 |
| Izmir Brew | | 0 | 0 | <= | 0 |
| Sakarya Brew | | 0 | 0 | <= | 0 |
| Adana | | 70 | 70 | <= | 70 |

Y3: Expanded Adana Brewery. Adana Brewery was expanded in order to keep up with growing demand. In Year Three, the total capacity of Istanbul and Ankara reaches its limit, and the extra capacity gained from expanding Adana is cheaper relative to opening an additional brewery. In Year Three, no importing occurs after Adana is expanded.

| | | | | | |
|---|---|---|---|---|---|
| Afyon | | 30 | 30 | <= | 30 |
| Konya | | 30.002 | 30.002 | <= | 68 |
| Import | | 0 | 0 | <= | 20 |
| Istanbul Brew | 220 | 220 | 0 | = | 0 |
| Ankara brew | 200 | 200 | 0 | = | 0 |
| Izmir Brew | 0 | 0 | 0 | = | 0 |
| Sakarya Brew | 0 | 0 | 0 | = | 0 |
| Adana | 80 | 80 | 0 | = | 0 |
| Istanbul Dist | 125 | | 125 | = | 125 |
| Adana | 90 | | 90 | = | 90 |
| Antalya | 60 | | 60 | = | 60 |
| Bursa | 85 | | 85 | = | 85 |
| Kayseri | 125 | | 125 | = | 125 |
| Export | 15 | | 15 | = | 15 |
| Istanbul Brew | | 220 | 220 | <= | 220 |
| Ankara | | 200 | 200 | <= | 200 |
| Izmir Brew | | 0 | 0 | <= | 0 |
| Sakarya Brew | | 0 | 0 | <= | 0 |
| Adana | | 80 | 80 | <= | 120 |

**Question 8:** What parts of the model are most prone to uncertainty? How sensitive is the solution to changes in beer demand of different distributors? If extra efforts could be made to estimate some portion of the data more accurately, which of the data should these efforts be spent on?

| Year | Demand | Growth | TC | NPV |
|---|---|---|---|---|
| 1 | 402 | 0.044936 | 10.61628 | $148.42 |
| 2 | 441 | -0.17248 | 82.14999 | |
| 3 | 500 | 0.161258 | 38.13565 | |
| 4 | 580.6288 | 0.253359 | 38.13565 | |
| 5 | 727.7362 | 0.272694 | 38.13565 | |
| 6 | 926.1855 | 0.096787 | 38.13565 | |
| 7 | 1015.829 | 0.039469 | 38.13565 | |
| 8 | 1055.923 | 0.241454 | 38.13565 | |
| 9 | 1310.879 | -0.04254 | 38.13565 | |
| 10 | 1255.119 | -0.05717 | 38.13565 | |
| 11 | 1183.366 | 0.091287 | 38.13565 | |
| 12 | 1291.391 | -0.13345 | 38.13565 | |
| 13 | 1119.053 | 0.088113 | 38.13565 | |
| 14 | 1217.656 | 0.247631 | 38.13565 | |
| 15 | 1519.185 | 0.147662 | 38.13565 | |
| 16 | 1743.511 | -0.04235 | 38.13565 | |
| 17 | 1669.676 | 0.029093 | 38.13565 | |
| 18 | 1718.252 | 0.028674 | 38.13565 | |
| 19 | 1767.522 | 0.003782 | 38.13565 | |
| 20 | 1774.206 | 0.034322 | 38.13565 | |

| Year | Demand | Growth | TC | NPV |
|---|---|---|---|---|
| 1 | 402 | -0.0624 | 10.61628 | $319.39 |
| 2 | 441 | 0.144173 | 82.14999 | |
| 3 | 500 | -0.0761 | 38.13565 | |
| 4 | 461.9518 | -0.05364 | 38.13565 | |
| 5 | 437.1737 | -0.05277 | 38.13565 | |
| 6 | 414.1039 | 0.05282 | 38.13565 | |
| 7 | 435.977 | 0.09367 | 38.13565 | |
| 8 | 476.8151 | 0.166681 | 38.13565 | |
| 9 | 556.2913 | 0.051153 | 38.13565 | |
| 10 | 584.7474 | 0.115129 | 38.13565 | |
| 11 | 652.0689 | 0.272918 | 38.13565 | |
| 12 | 830.0303 | 0.11406 | 38.13565 | |
| 13 | 924.7036 | 0.060374 | 38.13565 | |
| 14 | 980.5317 | 0.108038 | 38.13565 | |
| 15 | 1086.467 | 0.106587 | 38.13565 | |
| 16 | 1202.27 | 0.14515 | 38.13565 | |
| 17 | 1376.779 | 0.143003 | 38.13565 | |
| 18 | 1573.663 | 0.091697 | 38.13565 | |
| 19 | 1717.964 | 0.240798 | 38.13565 | |
| 20 | 2131.646 | 0.140372 | 38.13565 | |

The part of the model that is most prone to uncertainty is the demand of beer per year. Based on the two models that were shared above, demand has a significant impact on the supply necessary from different distributors. When using our linear programming model to determine new brewery openings/expansions from year 1-3, demand alone has the most significant impact on the decision. If demand forecasts are not accurately estimated, locations can be opened unnecessarily, which would lead to higher costs for the supply chain overall. Analogously, if demand forecasts are not accurately estimated, locations may not be opened or expanded when necessary, causing the firm to lose out on sales.

## Conclusions and Recommendations

Andalou Efes should not import any malt in the first year because it is not cost effective. Not importing malt in the first year saves the company 0.8 million. The firm should also not construct any breweries until Year Two because the capacity of their breweries can fulfill demand in the first year. In Year Two, Andalou Efes should build the Adana Brewery in order to keep up with demand and to minimize costs. With this increase in demand and new brewery, the firm imports 20 tons of malt which is the full capacity of the plant. In Year Three, the company should expand the Adana Brewery in order to fulfil rising demand for beer. By utilizing these recommendations, Anadalou Efes can position itself for success in the next three years.