# BIA 674 – Supply Chain Analytics
# FALL 2015 MID-TERM

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Please provide well-edited answer to all parts. This is an individual assignment and no cooperation is allowed. Send your answers to my Canvas email.

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# Super Grain Cereal Supply Chain

The SUPER GRAIN Cereal Company sells two products: Oat Cereal and Corn Cereal. They can buy their raw materials (Oat, Corn) from farm cooperatives (Suppliers) in Idaho, Maine and/or Iowa, where the first two cooperatives supply mainly oat and the last one supply mainly corn. The suppliers' data table that is provided at the end of this case summarizes the suppliers' respective cost per ton of oat or corn purchased. The same table also contains the minimum and maximum quantities that must be purchased, if a specific supplier is selected.

**Suppliers Data:**

|  | Suppliers Costs ($ per ton) | | Suppliers Upper bounds ('000 tons) | | Suppliers Lower bounds ('000 tons) | |
|---|---|---|---|---|---|---|
|  | Oat | Corn | Oat | Corn | Oat | Corn |
| IDAHO | 365 | 457 | 15 | 1 | 2.5 | 0 |
| MAINE | 352 | 458 | 17.5 | 3.4 | 4.2 | 0 |
| IOWA | 330 | 422 | 3.15 | 10.25 | 0 | 2.55 |

SUPER GRAIN has three Plants located in Peoria (PEO), Wichita (WIC), and Cincinnati (CIN) with food processing and packaging capabilities to make both products. While oat and corn cereals utilize different processing units, they make use of the same packaging line. In other words, if a particular plant operates, it can either produce exclusively oat or corn cereal, or make both oat and corn cereal. The products can be sold and distributed to customers via Distribution Centers (DC's) in five metropolitan market zones: Indianapolis (IND), Kansas (KAN), Memphis (MEM), Omaha (OMA) and St. Louis (STL). The Transportation Data tables summarize the distances in miles from suppliers to plants and from plants to DCs. It is also known that the unit freight cost per ton-mile from suppliers to plants is $0.272, and the unit freight cost per 100 case-mile from plants to DC's is $0.251.

**Transportation Data:**

a) Distances in miles from suppliers to plants

| Suppliers | PEO | WIC | CIN |
|---|---|---|---|
| IDAHO | 1,059 | 703 | 1,278 |
| MAINE | 1,188 | 1,465 | 923 |
| IOWA | 175 | 244 | 449 |

b) Distance in miles from plants to DC's

| Plants | IND | KAN | MEM | OMA | STL |
|---|---|---|---|---|---|
| PEO | 213 | 395 | 445 | 391 | 197 |
| WIC | 681 | 190 | 532 | 298 | 427 |
| CIN | 114 | 637 | 519 | 735 | 366 |

A schematic representation of SUPER GRAIN's supply chain is shown in Figure 1. Raw materials are delivered to the plants where they are processed in separate oat and corn processing units. The processed products (cereals) are then packaged in bags and the bags packaged in cases for shipment to the markets. There is one packaging line in each plant. Indeed, operation of the processing and packaging lines at each plant incurs fixed and variable costs, as shown in the Plants Data tables. Note that the plants in PEO and CIN are newer, larger and more efficient. The same table also provides information about the capacity of both lines.

**Plants Data:**

a) Processing Data:

| Plant | Fixed Processing Costs ('000$) | | Processing Capacity ('000 tons) | | Variable Processing Costs ($ per ton) | |
|---|---|---|---|---|---|---|
| | Oat | Corn | Oat | Corn | Oat | Corn |
| PEO | 53 | 64.4 | 25.5 | 14 | 42 | 57 |
| WIC | 94.5 | 101.5 | 19.25 | 11.25 | 54.5 | 71 |
| CIN | 61 | 78 | 26.4 | 16 | 37 | 58 |

b) Packaging Data:

| Plant | Fixed Packaging Costs ('000$) | Packaging Capacity (shifts) | Packaging Utilization (shifts per 100 cases) | | Variable Packaging Costs ($ per 100 cases) | |
|---|---|---|---|---|---|---|
| | | | OAT | CORN | OAT | CORN |
| PEO | 222 | 685 | .1313 | .1570 | 21.33 | 30.55 |
| WIC | 179.5 | 805 | .1791 | .2085 | 28.50 | 35.28 |
| CIN | 233 | 610 | .1275 | .1585 | 20.45 | 29.75 |

c) Product conversion:
1.16 ton of oat gives 100 cases of oat cereals
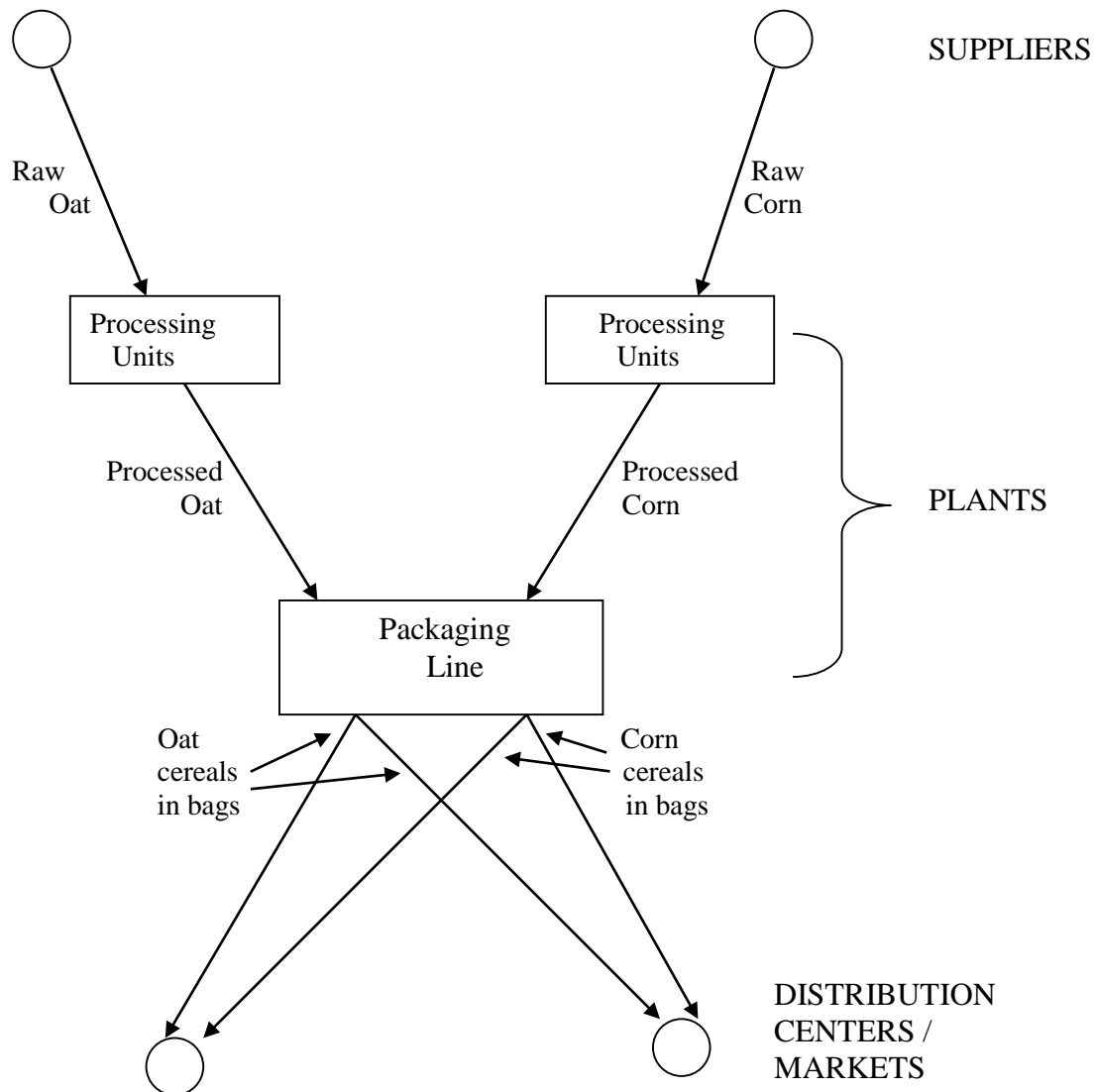1.23 ton of corn gives 100 cases of corn cereals

Figure 1: SUPER GRAIN CEREAL COMPANY SUPPLY CHAIN

Each DC has specific minimum and maximum sales requirements. As the Distributions Centers Data table indicates, the minimum sales requirements are the same for all DCs. The same table also summarizes the gross revenues obtained at each DC per 100-cases of cereals sold and the percentage of sales. On the other hand, the percentage of sales is shown to be almost constant over time, and it can be used to estimate the maximal sales of each DC. In particular, if we want to calculate the maximal sales of a product at a particular DC, we multiply the total sales (or total product demand) with the corresponding percentage of sales of the product.

**Distribution Centers Data:**

| DC | Percentage of sales | | Unit Gross Revenues ($ per 100 cases) | | Minimal Sales (100 cases) | |
|---|---|---|---|---|---|---|
| | Oat | Corn | Oat | Corn | Oat | Corn |
| IND | 23.64% | 14.92% | 1,165 | 1,548 | 600 | 400 |
| KAN | 18.86% | 19.29% | 1,241 | 1,629 | 600 | 400 |
| MEM | 16.05% | 24.52% | 1,160 | 1,625 | 600 | 400 |
| OMA | 20.34% | 19.37% | 1,218 | 1,646 | 600 | 400 |
| STL | 21.11% | 21.90% | 1,245 | 1,637 | 600 | 400 |

**Part A (25 points) – Forecast Sales for 2014**

SUPER GRAIN's CEO has asked you to provide an aggregate sales forecast (the potential total demand) of each product for the next year (2014). The data that you have available are provided in the Historical Aggregate Sales Data table below.

Historical Aggregate Sales Data (half year total sales of all DCs per product)**:**

| Half-year terms | Corn Cereals (100 cases) | Oat Cereals (100 cases) |
|---|---|---|
| 2008 I | 1,902 | 4,610 |
| 2008 II | 2,210 | 4,813 |
| 2009 I | 2,608 | 5,071 |
| 2009 II | 2,860 | 5,245 |
| 2010 I | 3,030 | 5,458 |
| 2010 II | 3,501 | 5,648 |
| 2011 I | 4,004 | 5,824 |
| 2011 II | 4,310 | 6,050 |
| 2012 I | 4,604 | 6,364 |
| 2012 II | 4,832 | 6,576 |
| 2013 I | 5,080 | 6,787 |
| 2013 II | 5,178 | 7,034 |

Estimate the sales for the next two periods (year 2014 – terms I and II) using the exponential smoothing with trend adjustment (Holt's Model) with a = 0.05 and b = 0.1. Use a simple linear regression of the observed demand over time to estimate the initial (at period 0) level and the trend. Evaluate also the MAD, MAPE and MSE.

**PART B (50 points) – Optimize the Supply Chain**

Based on the total demand forecast for the next year (2014) calculated earlier in Part A[1], SUPER GRAIN's CEO has asked you to develop a model of the company's purchasing, manufacturing, transportation, and sales activities. He is concerned that the total delivered cost of the company's products could be significantly reduced, and net revenues significantly increased, if the company would pursue an integrated planning approach to its supply chain. He is also interested in evaluating options for next year relating to sourcing, manufacturing and customer service.

You are asked to develop a supply chain optimization model for maximizing SUPER GRAIN's net revenues for next year (2014). Answer the following questions in a clear and concise manner, trying to explain and analyse:

(a) Develop and optimize the model using Excel and prepare a brief report on SUPER GRAIN's optimal strategy for 2014.

(b) The CEO believes that the 2014 maximal sales forecasts may be overly optimistic. He asks you to re-run the model (a) with an across the board 15% decrease in maximal sales of both products. Optimize the model with this new data and briefly compare the strategy with the one obtained with the optimistic sales forecast.

(c) For 2014, the VP for Marketing is considering a new customer service policy of 2-day delivery from all plants to all DC's. This translates into a maximal distance allowed of 500 miles for travel between a plant and a DC. Re-run the model to measure the impact of this policy. Do you believe it is worth implementing?

**PART C (25 points) – Evaluate Acquisition Option**

For several months, SUPER GRAIN has been negotiating with the CHIQUITO Company to acquire their tortilla chip processing and packaging plant just outside of St. Louis. An engineering study has determined that this plant could be converted to make SUPER GRAIN's cereals for $650,000. The conversion would take 6 to 9 months. The CEO is interested in pursuing the acquisition for two reasons:

- The CHIQUITO plant is well situated relative to SUPER GRAIN's market areas;

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[1] If no answer is provided for Part A, then assume that the total demand for year 2014 is 11,772 for corn cereals and 14,621 for oat cereals.

- Marketing projections indicate a significant increase in demand for SUPER GRAIN's products in year 2015 and beyond. Since SUPER GRAIN's current production capabilities will be strained by 2014 demand, acquisition of the CHIQUITO plant at an acceptable price would permit SUPER GRAIN to exploit the increased demand and add significantly to the company's profits starting in year 2015.

The CEO asks you to use the supply chain optimization model you developed to study this strategic acquisition option. The following are the data relevant to your analysis:

a) Distances to/from the CHIQUITO plant:

Miles to St Louis from suppliers:
| IDAHO | 1,177 |
| MAINE | 1,310 |
| IOWA | 283 |

Miles from St Louis to Distribution Centers:

| IND | 305 |
| KAN | 305 |
| MEM | 310 |
| OMA | 480 |
| STL | 140 |

b) Production data of the CHIQUITO Plant:

- Fixed Costs for Processing Oat = $60,000
- Fixed Costs for Processing Corn = $70,000
- Capacity for Processing Oat = 20,000 tons
- Capacity for Processing Corn = 16,000 tons
- Variable Oat Processing Cost = $53/ton
- Variable Corn Processing Cost = $65/ton
- Fixed Packaging Costs = $190,000
- Packaging Capacity = 750 shifts
- Oat cereals packaging utilisation = 0.1550 shifts per 100 cases
- Corn cereals packaging utilisation = 0.1865 shifts per 100 cases
- Variable Oat Cereals Packaging Costs = $24 per 100 cases
- Variable Corn Cereals Packaging Costs = $28 per 100 cases

The Marketing and Sales Department has forecasted that potential sales for year 2015 will be:

2015 QMAX = 1.20 x 2014 QMAX (calculated in part A)

The CEO asks you to run and use results from the supply chain optimization model to evaluate the acquisition option for CHIQUITO's St. Louis plant. SUPER GRAIN'S Board of Directors requires an annual return of 18% on major capital investments.