**Mid-term Exam – Super Grain Cereals Supply Chain**

**Correct Answers**

**Part A**

Exponential Smoothing method with a = 0.05 and b = 0.1

Forecasts

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Corn Cereal Forecast | Oat Cereal Forecast |
| 2014 | I | 5,731 | 7,205 |
|  | II | 6,047 | 7,423 |
|  | Total | 11,778 | 14,628 |

**Part B**

Mathematical model notation

**Variables**

Χijp = quantities shipped from supplier i to plant j of product p

Zip = 1 supplier i is used to supply product p / 0, otherwise

Yjkp = quantities shipped from plant j to DC k of product p

Wjp = 1, if plant j processes product p / 0, otherwise

Vj = 1, if plant j does packaging / 0, otherwise

p : {1, 2} Products: 1= Oat, 2= Corn

i : {1, 2, 3} Suppliers: 1= IDA, 2= MAI, 3= IOW

j : {1, 2, 3} Plants: 1= WIC, 2= CIN, 3= PEO

k : {1, 2, 3, 4, 5} DCs: 1= IND, 2= KAN, 3= MEM, 4= OMA, 5= STL

**Objective Function**

+Revenues (Oat)

1,165(Y111+Y211+Y311) + 1,241(Y121+Y221+Y321) + 1,160(Y131+Y231+Y331+Y331) + +1,218(Y141+Y241+Y341+Y341) + + 1,245(Y151+Y251+Y351+Y351)

+Revenues (Corn)

1,548(Y112+Y212+Y312) + 1,629(Y122+Y222+Y322) + 1,625(Y132+Y232+Y332+Y332) + 1,646(Y142+Y242+Y342+Y342) + + 1,637(Y152+Y252+Y352+Y352)

-Suppliers variable cost (Oat)

365(X111+X121+X131) + 352(X211+X221+X231) + 330(X311+X321+X331)

-Suppliers variable cost (Corn)

457(X112+X122+X132) + 458(X212+X222+X232) + 422(X312+X322+X332)

-Transportation Cost from suppliers to plants (Oat)

0.272 (703X111+1,278X121+1,059X131 + … from supplier 1 to all plants

+ 1465X211+923X221 + 1,188X231 + … from supplier 2 to all plants

+ 244X311+449X321+175X331) … from supplier 3 to all plants

-Transportation Cost from suppliers to plants (Corn)

0.272 (703X112+1,278X122+1,059X132+ … from supplier 1 to all plants

+ 1465X212+923X222 + 1,188X232 + … from supplier 2 to all plants

+ 244X312+449X322+175X332) … from supplier 3 to all plants

-Variable Processing Cost (Oat, Corn)

54.5(X111+X211+X311)+37(X121+X221+X321)+42(X131+X231+X331) (Oat)

71(X112+X212+X312)+58(X122+X222+X322)+57(X132+X232+X332) (Corn)

-Fixed Processing Cost (Oat, Corn)

[94,500W11+61,000W21+53,000W31] (Oat)

[101500W12+78000W22+64400W32] (Corn)

-Transportation Cost from plants to DC (Oat)

0.251(681Y111+190Y121+532Y131+298Y141+427Y151+ … from plant 1 to all DCs

114Y211+637Y221+519Y231+735Y241+366Y251+ … from plant 2 to all DCs

213Y311+395Y321+445Y331+391Y341+197Y351) … from plant 3 to all DCs

-Transportation Cost from plants to DC (Corn)

0.251(681Y112+190Y122+532Y132+298Y142+427Y152+ … from plant 1 to all DCs

114Y212+637Y222+519Y232+735Y242+366Y252+ … from plant 2 to all DCs

213Y312+395Y322+445Y332+391Y342+197Y352) … from plant 3 to all DCs

-Fixed Packaging Cost

179,500V1+233,000V2+222,000V3

-Variable Packaging Cost (Oat)

28.5(Y111+Y121+Y131+Y141+Y151)+ … all packaging at plant 1

20.45(Y211+Y221+Y231+Y241+Y251)+ … all packaging at plant 2

21.33(Y311+Y321+Y331+Y341+Y351) … all packaging at plant 3

-Variable Packaging Cost (Corn)

35.28(Y111+Y121+Y131+Y141+Y151)+ … all packaging at plant 1

29.75(Y211+Y221+Y231+Y241+Y251)+ … all packaging at plant 2

30.55(Y311+Y321+Y331+Y341+Y351) … all packaging at plant 3

**Constraints**

Suppliers Bounds

2,500 Z11 ≤ X111+X121+X131≤ 15,000 Z11  (IDAHO - OAT)

0 ≤ X112+X122+X132 ≤ 1,000 Z12 (IDAHO - CORN)

4,200 Z21 ≤ X211+X221+X231 ≤ 17,500 Z21 (MAINE - OAT)

0 ≤ X212+X222+X232≤ 3,400 Z22 (MAINE - CORN)

0 ≤ X311+X321+X331 ≤ 3,150 Z31 (IOWA - OAT)

2,550 Z32 ≤ X312+X322+X332 ≤ 10,250 Z32 (IOWA - CORN)

Processing Capacity (Oat)

X111+X211+X311 ≤ 19,250 W11

X121+X221+X321 ≤ 26,400 W21

X131+X231+X331 ≤ 25,500 W31

Processing Capacity (Corn)

X112+X212+X312 ≤ 11,250 W12

X122+X222+X322 ≤ 16,000 W22

X132+X232+X332 ≤ 14,000 W32

Packaging

0.1791(Y111+Y121+Y131+Y141+Y151 ) + 0.2085(Y112+Y122+Y132+Y142+Y152 ) ≤ 805V1

0.1275(Y211+Y221+Y231+Y241+Y251) + 0.1585(Y212+Y222+Y232+Y242+Y252) ≤ 610V2

0.1313(Y311+Y321+Y331+Y341+Y351) + 0.157(Y312+Y322+Y332+Y342+Y352) ≤ 685V3

Revenue (Oat): Satisfy min & max sales constraints

600 ≤ Y111+Y211+Y311 ≤ 14,629 (0.2364)

600 ≤ Y121+Y221+Y321 ≤ 14,629 (0.1886)

600 ≤ Y131+Y231+Y331 ≤ 14,629 (0.1605)

600 ≤ Y141+Y241+Y341 ≤ 14,629 (0.2034)

600 ≤ Y151+Y251+Y351 ≤ 14,629 (0.2111)

Revenue (Corn): Satisfy min & max sales constraints

400 ≤ Y112+Y212+Y312 ≤ 11,778 (0.1492)

400 ≤ Y122+Y222+Y322 ≤ 11,778 (0.1929)

400 ≤ Y132+Y232+Y332 ≤ 11,778 (0.2452)

400 ≤ Y142+Y242+Y342 ≤ 11,778 (0.1937)

400 ≤ Y152+Y252+Y352 ≤ 11,778 (0.2190)

Product Conversion (Oat)

Χ111+Χ211+Χ311 ≥ 1.16 (Υ111+Υ121+Υ131+Υ141+Υ151)

Χ121+Χ221+Χ321 ≥ 1.16 (Υ211+Υ221+Υ231+Υ241+Υ251)

Χ131+Χ231+Χ331 ≥ 1.16 (Υ311+Υ321+Υ331+Υ341+Υ351)

Product Conversion (Corn)

Χ112+Χ212+Χ312 ≥ 1.23 (Υ112+Υ122+Υ132+Υ142+Υ152)

Χ122+Χ222+Χ322 ≥ 1.23 (Υ212+Υ222+Υ232+Υ242+Υ252)

Χ132+Χ232+Χ332 ≥ 1.23 (Υ312+Υ322+Υ332+Υ342+Υ352)

Logical (links between W and V)

W11 + W12 ≥ V1

If a plant processes either product 1 or 2, then it also does packaging

W21 + W22 ≥ V2

W31 + W32 ≥ V3

W11 ≤ V1

W12 ≤ V1

If no packaging is done at a plant, there there is also no processing done

W21 ≤ V2

W22 ≤ V2

W31 ≤ V3

W32 ≤ V3

Logical (links between Z’s and corresponding Supply flows)

Z11 ≤ X111+X121+X131

Z21 ≤ X211+X221+X231

Z31 ≤ X311+X321+X331

If supplier i does not ship to any plant any quantity of product p, then Zip = 0

Z12 ≤ X112+X122+X132

Z22 ≤ X212+X222+X232

Z32 ≤ X312+X322+X332

**Question a:**

The optimal solution of the supply chain model has a Max Revenue $**8,241,686.88**.

**Optimal Supply Chain Structure**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OAT | | |  | | |  | | |  | | |
| **Xij1** | | | Plants | | |  | | |  | | |
| Suppliers | | | WIC | | | CIN | | | PEO | | |
| IDAHO | | | 2,500 | | | 0 | | | 0 | | |
| MAINE | | | 0 | | | 0 | | | 0 | | |
| IOWA | | | 0 | | | 2,722 | | | 0 | | |
| CORN |  | | |  | | |  | | |
| **Xij2** | Plants | | |  | | |  | | |
| Suppliers | WIC | | | CIN | | | PEO | | |
| IDAHO | 0 | | | 0 | | | 0 | | |
| MAINE | 0 | | | 0 | | | 0 | | |
| IOWA | 2,472 | | | 2,412 | | | 5,367 | | |
| OAT | |  | | |  | | |  | | |  | |  |
| **Yji1** | | DC | | |  | | |  | | |  | |  |
| Plants | | IND | | | KAN | | | MEM | | | OMA | | STL |
| WIC | | 0 | | | 1,555 | | | 0 | | | 600 | | 0 |
| CIN | | 600 | | | 0 | | | 600 | | | 0 | | 1,147 |
| PEO | | 0 | | | 0 | | | 0 | | | 0 | | 0 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CORN |  |  |  |  |  |
| **Yji2** | DC |  |  |  |  |
| Plants | IND | KAN | MEM | OMA | STL |
| WIC | 0 | 2,010 | 0 | 0 | 0 |
| CIN | 1,561 | 0 | 400 | 0 | 0 |
| PEO | 0 | 0 | 0 | 1,784 | 2,579 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Plants** | Wj1 | Wj2 | Vj |
| WIC | 1 | 1 | 1 |
| CIN | 1 | 1 | 1 |
| PEO | 0 | 1 | 1 |

|  |  |  |
| --- | --- | --- |
| Suppliers | Zi1 | Zi2 |
| IDAHO | 1 | 0 |
| MAINE | 0 | 0 |
| IOWA | 1 | 1 |

Note: a) No supply from MAINE, b) all plants are operational: WIC and CIN produce both Oat and Corn, PEO only Corn, c) the maximum packaging capacity has been reached (bottleneck) for all plants.

|  |  |  |  |
| --- | --- | --- | --- |
| Packaging Capacity Used |  | Packaging Capacity Available | Packaging Capacity Utilization |
| 805.00 | <= | 805.00 | 100% |
| 610.00 | <= | 610.00 | 100% |
| 685.00 | <= | 685.00 | 100% |

On the other hand, there is significant margin in the processing capacity.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Processing Capacity Used |  | Processing Capacity Available | Processing Capacity Utilization |  |
| 2,500.00 | <= | 19,250.00 | 12.98% | Processing Capacity (Oat) |
| 2,722.48 | <= | 26,400.00 | 10.31% |
| 0.00 | <= | 0.00 |  |
| 2,471.85 | <= | 11,250.00 | 21.96% | Processing Capacity (Corn) |
| 2,411.59 | <= | 16,000.00 | 15.06% |
| 5,366.56 | <= | 14,000.00 | 38.32% |

**Question b (15% reduction in maximal sales):**

We solve again the previous formulation with the maximum sales (right hand side) reduced by 15%. The max revenue now becomes **$8,213,193.38.** The difference with the previous question is relatively small. The bottleneck is still the packaging capacity; however, we managed to reach the maximum sales in more markets and we lost part of our share in some of the premium markets for corn cereals.

**Optimal Supply Chain Structure**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OAT | | |  | | |  | | |  | | |
| **Xij1** | | | Plants | | |  | | |  | | |
| Suppliers | | | WIC | | | CIN | | | PEO | | |
| IDAHO | | | 2,500 | | | 0 | | | 0 | | |
| MAINE | | | 0 | | | 0 | | | 0 | | |
| IOWA | | | 0 | | | 2,722 | | | 0 | | |
| CORN |  | | |  | | |  | | |
| **Xij2** | Plants | | |  | | |  | | |
| Suppliers | WIC | | | CIN | | | PEO | | |
| IDAHO | 0 | | | 0 | | | 0 | | |
| MAINE | 0 | | | 0 | | | 0 | | |
| IOWA | 2,472 | | | 2,412 | | | 5,367 | | |
| OAT | |  | | |  | | |  | | |  | |  |
| **Yji1** | | DC | | |  | | |  | | |  | |  |
| Plants | | IND | | | KAN | | | MEM | | | OMA | | STL |
| WIC | | 0 | | | 1,555 | | | 0 | | | 600 | | 0 |
| CIN | | 600 | | | 0 | | | 600 | | | 0 | | 1,147 |
| PEO | | 0 | | | 0 | | | 0 | | | 0 | | 0 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CORN |  |  |  |  |  |
| **Yji2** | DC |  |  |  |  |
| Plants | IND | KAN | MEM | OMA | STL |
| WIC | 0 | 1,931 | 0 | 79 | 0 |
| CIN | 1,494 | 0 | 467 | 0 | 0 |
| PEO | 0 | 0 | 309 | 1,861 | 2,192 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Plants** | Wj1 | Wj2 | Vj |
| WIC | 1 | 1 | 1 |
| CIN | 1 | 1 | 1 |
| PEO | 0 | 1 | 1 |

|  |  |  |
| --- | --- | --- |
| **Suppliers** | Zi1 | Zi2 |
| IDAHO | 1 | 0 |
| MAINE | 0 | 0 |
| IOWA | 1 | 1 |

**Question c (2-day delivery policy):**

To reflect the 2-day policy we need to ignore some of the connections between the plants and the DC that exceed the 500 miles threshold. In particular, we need to fix to 0 the following continuous variables:

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

Y111 = Y112 = 0

Y131 = Y132 = 0

Y221 = Y222 = 0

Y231 = Y232 = 0

Y241 = Y242 = 0

The max revenue now with this policy is $**8,159,955.96**, and it has been reduced by only 0.99% (compared to 8,241,686.88). This probably means that this policy makes sense to implement if it helps the brand of the company. The optimal supply chain structure is the following. Observe that the main difference is that all plants are producing all products now.

|  |  |  |  |
| --- | --- | --- | --- |
| OAT |  |  |  |
| **Xij1** | Plants |  |  |
| Suppliers | WIC | CIN | PEO |
| IDAHO | 2,500 | 0 | 0 |
| MAINE | 0 | 0 | 0 |
| IOWA | 0 | 1,999 | 696 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CORN |  | |  | |  | |
| **Xij2** | Plants | |  | |  | |
| Suppliers | WIC | | CIN | | PEO | |
| IDAHO | 0 | | 0 | | 0 | |
| MAINE | 0 | | 0 | | 0 | |
| IOWA | 2,472 | | 3,029 | | 4,749 | |
| OAT | |  | |  | |  | |  |  |
| **Yji1** | | DC | |  | |  | |  |  |
| Plants | | IND | | KAN | | MEM | | OMA | STL |
| WIC | | 0 | | 1,555 | | 0 | | 600 | 0 |
| CIN | | 600 | | 0 | | 0 | | 0 | 1,123 |
| PEO | | 0 | | 0 | | 600 | | 0 | 0 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CORN |  |  |  |  |  |
| **Yji2** | DC |  |  |  |  |
| Plants | IND | KAN | MEM | OMA | STL |
| WIC | 0 | 2,010 | 0 | 0 | 0 |
| CIN | 1,757 | 0 | 0 | 0 | 705 |
| PEO | 0 | 0 | 400 | 1,587 | 1,874 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Plants** | Wj1 | Wj2 | Vj |
| WIC | 1 | 1 | 1 |
| CIN | 1 | 1 | 1 |
| PEO | 1 | 1 | 1 |

|  |  |  |
| --- | --- | --- |
| **Suppliers** | Zi1 | Zi2 |
| IDAHO | 1 | 0 |
| MAINE | 0 | 0 |
| IOWA | 1 | 1 |

**Part C**

The CHIQUITO option becomes available. The mathematical model will change (see highlighted part with yellow color) as follows:

**Variables**

Χijp = quantities shipped from supplier i to plant j of product p

Zip = 1 supplier i is used to supply product p / 0, otherwise

Yjkp = quantities shipped from plant j to DC k of product p

Wjp = 1, if plant j processes product p / 0, otherwise

Vj = 1, if plant j does packaging / 0, otherwise

p : {1, 2} Products: 1= Oat, 2= Corn

i : {1, 2, 3} Suppliers: 1= IDA, 2= MAI, 3= IOW

j : {1, 2, 3, 4} Plants: 1= WIC, 2= CIN, 3= PEO, 4= STL

k : {1, 2, 3, 4, 5} DCs: 1= IND, 2= KAN, 3= MEM, 4= OMA, 5= STL

**Objective Function**

+Revenues (Oat)

1,165(Y111+Y211+Y311+Y411) + 1,241(Y121+Y221+Y321+Y421) + 1,160(Y131+Y231+Y331+Y331+Y431) + +1,218(Y141+Y241+Y341+Y341+Y441) + 1,245(Y151+Y251+Y351+Y351+Y451)

+Revenues (Corn)

1,548(Y112+Y212+Y312+Y412) + 1,629(Y122+Y222+Y322+Y422) + 1,625(Y132+Y232+Y332+Y332+Y432) + +1,646(Y142+Y242+Y342+Y342+Y442) + 1,637(Y152+Y252+Y352+Y352+Y452)

-Suppliers variable cost (Oat)

365(X111+X121+X131+X141)+352(X211+X221+X231+X241)+330(X311+X321+X331+X341)

-Suppliers variable cost (Corn)

457(X112+X122+X132+X142)+458(X212+X222+X232+X242)+422(X312+X322+X332+X342)

-Transportation Cost from suppliers to plants (Oat)

0.272 (703X111+1,278X121+1,059X131+1,177X141 + … from supplier 1 to all plants

+ 1465X211+923X221 + 1,188X231+1,310X241 + … from supplier 2 to all plants

+ 244X311+449X321+175X331+283X341) … from supplier 3 to all plants

-Transportation Cost from suppliers to plants (Corn)

0.272 (703X112+1,278X122+1,059X132+1,177X142 + … from supplier 1 to all plants

+ 1465X212+923X222 + 1,188X232+1,310X242 + … from supplier 2 to all plants

+ 244X312+449X322+175X332+283X342) … from supplier 3 to all plants

-Variable Processing Cost (Oat, Corn)

54.5(X111+X211+X311)+37(X121+X221+X321)+42(X131+X231+X331) +53(X141+X241+X341) (Oat)

71(X112+X212+X312)+58(X122+X222+X322)+57(X132+X232+X332) +65(X142+X242+X342) (Corn)

-Fixed Processing Cost (Oat, Corn)

[94,500W11+61,000W21+53,000W31+60,000W41] (Oat)

[101500W12+78000W22+64400W32+70,000W42] (Corn)

-Transportation Cost from plants to DC (Oat)

0.251(681Y111+190Y121+532Y131+298Y141+427Y151+

114Y211+637Y221+519Y231+735Y241+366Y251+

213Y311+395Y321+445Y331+391Y341+197Y351+ 305Y411+305Y421+310Y431+480Y441+140Y451)

-Transportation Cost from plants to DC (Corn)

0.251(681Y112+190Y122+532Y132+298Y142+427Y152+

114Y212+637Y222+519Y232+735Y242+366Y252+

213Y312+395Y322+445Y332+391Y342+197Y352+ 305Y412+305Y422+310Y432+480Y442+140Y452)

-Fixed Packaging Cost

179,500V1+233,000V2+222,000V3+190,000V4

-Variable Packaging Cost (Oat)

28.5(Y111+Y121+Y131+Y141+Y151)+

20.45(Y211+Y221+Y231+Y241+Y251)+

21.33(Y311+Y321+Y331+Y341+Y351)

24(Y411+Y421+Y431+Y441+Y451)

-Variable Packaging Cost (Corn)

35.28(Y111+Y121+Y131+Y141+Y151)+

29.75(Y211+Y221+Y231+Y241+Y251)+

30.55(Y311+Y321+Y331+Y341+Y351)

28(Y411+Y421+Y431+Y441+Y451)

**Constraints**

Suppliers Bounds

2,500 Z11 ≤ X111+X121+X131+X141 ≤ 15,000 Z11 (IDAHO - OAT)

0 ≤ X112+X122+X132+X142 ≤ 1,000 Z12 (IDAHO - CORN)

4,200 Z21 ≤ X211+X221+X231+X241 ≤ 17,500 Z21 (MAINE - OAT)

0 ≤ X212+X222+X232+X242 ≤ 3,400 Z22 (MAINE - CORN)

0 ≤ X311+X321+X331+X341 ≤ 3,150 Z31 (IOWA - OAT)

2,550 Z32 ≤ X312+X322+X332+X342 ≤ 10,250 Z32 (IOWA - CORN)

Processing Capacity (Oat)

X111+X211+X311 ≤ 19,250 W11

X121+X221+X321 ≤ 26,400 W21

X131+X231+X331 ≤ 25,500 W31

X141+X241+X341 ≤ 20,000 W41

Processing Capacity (Corn)

X112+X212+X312 ≤ 11,250 W12

X122+X222+X322 ≤ 16,000 W22

X132+X232+X332 ≤ 14,000 W32

X142+X242+X342 ≤ 16,000 W42

Packaging

0.1791(Y111+Y121+Y131+Y141+Y151 ) + 0.2085(Y112+Y122+Y132+Y142+Y152 ) ≤ 805V1

0.1275(Y211+Y221+Y231+Y241+Y251) + 0.1585(Y212+Y222+Y232+Y242+Y252) ≤ 610V2

0.1313(Y311+Y321+Y331+Y341+Y351) + 0.157(Y312+Y322+Y332+Y342+Y352) ≤ 685V3

0.155(Y411+Y421+Y431+Y441+Y451) + 0.1865(Y412+Y422+Y432+Y442+Y452) ≤ 750V4

Revenue (Oat): Satisfy min & max sales constraints – increased by 20%

600 ≤ Y111+Y211+Y311+Y411 ≤ 14,629 (0.2364)(1.20)

600 ≤ Y121+Y221+Y321+Y421 ≤ 14,629 (0.1886)(1.20)

600 ≤ Y131+Y231+Y331+Y431 ≤ 14,629 (0.1605)(1.20)

600 ≤ Y141+Y241+Y341+Y441 ≤ 14,629 (0.2034)(1.20)

600 ≤ Y151+Y251+Y351+Y451 ≤ 14,629 (0.2111)(1.20)

Revenue (Corn): Satisfy min & max sales constraints – increased by 20%

400 ≤ Y112+Y212+Y312+Y412 ≤ 11,778 (0.1492)(1.20)

400 ≤ Y122+Y222+Y322+Y422 ≤ 11,778 (0.1929)(1.20)

400 ≤ Y132+Y232+Y332+Y432 ≤ 11,778 (0.2452)(1.20)

400 ≤ Y142+Y242+Y342+Y442 ≤ 11,778 (0.1937)(1.20)

400 ≤ Y152+Y252+Y352+Y452 ≤ 11,778 (0.2190)(1.20)

Product Conversion (Oat)

Χ111+Χ211+Χ311 ≥ 1.16 (Υ111+Υ121+Υ131+Υ141+Υ151)

Χ121+Χ221+Χ321 ≥ 1.16 (Υ211+Υ221+Υ231+Υ241+Υ251)

Χ131+Χ231+Χ331 ≥ 1.16 (Υ311+Υ321+Υ331+Υ341+Υ351)

Product Conversion (Corn)

Χ112+Χ212+Χ312 ≥ 1.23 (Υ112+Υ122+Υ132+Υ142+Υ152)

Χ122+Χ222+Χ322 ≥ 1.23 (Υ212+Υ222+Υ232+Υ242+Υ252)

Χ132+Χ232+Χ332 ≥ 1.23 (Υ312+Υ322+Υ332+Υ342+Υ352)

Logical (links between W and V)

W11 + W12 ≥ V1

W21 + W22 ≥ V2

W31 + W32 ≥ V3

W41 + W42 ≥ V4

W11 ≤ V1

W12 ≤ V1

W21 ≤ V2

W22 ≤ V2

W31 ≤ V3

W32 ≤ V3

W41 ≤ V4

W42 ≤ V4

Logical (links between Z and Supply flows)

Z11 ≤ X111+X121+X131+X141

Z21 ≤ X211+X221+X231+X241

Z31 ≤ X311+X321+X331+X341

Z12 ≤ X112+X122+X132+X142

Z22 ≤ X212+X222+X232+X242

Z32 ≤ X312+X322+X332+X342

We solve the above problem twice: a) without the availability of CHIQUITO plant, and b) with the availability of the CHIQUITO plant. The max revenue with the new plant is $10,534,291.38, whereas without the plant it is $8,262,163.89. Therefore, a net increase in revenue equal to the difference of $2,272,127.49 is attributed to the acquisition and operation of the CHIQUITO plant.

|  |  |  |  |
| --- | --- | --- | --- |
| Expected sales increase in 2015 vs. 2014 | Profit within 2015 with CHIQUITO plant | Profit within 2015 without CHIQUITO plant | Difference in profit (DIFF) |
| 20% | $10,534,291 | $8,262,164 | $2,272,127 |

Evaluation of the acquisition pricing given an annual 18% Return on Investment (ROI)

The above means that there will be 21 months from purchase date of the Chiquito plant, until the returns from the new plant’s operation are realized. This includes 9 months of plant conversion and 12 months of operation. Therefore, the required ROI should be calculated for 21 months. The required ROI is (1+0.18)\*(1+9\*0.18/12) = 1.34 or 34%.

9-month conversion 12 months of operation

To calculate the Acquisition Price (AP) to be proposed, we think as follows:

In order to satisfy the requirements of the BoD, the following inequality should hold:

DIFF ≥ 0.34\*Acquisition Cost = 0.34\*(Purchase Price + Conversion Cost), or:

DIFF ≥ 0.34\*(AP + 650,000)

AP ≤ (DIFF/0.34) – 650,000

Given that DIFF = 2,272,127 it follows that

AP ≤ 2,272,127/0.34 – 650,000 = $6,032,728

Thus, the purchase price for CHIQUITO should be less than $**6,032,728** to satisfy the BoD.