Computer Project #2

Calcutta Paper Procurement

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**EXECUTIVE SUMMARY**

**Problem Description**

Ari Patel is the procurement manager at the Calcutta Container Company that produces a variety of corrugated containers from various grades of paper. Ari has identified three suppliers that can provide the required grades of paper to two plants. Monthly demands have been forecast in six grade categories for each of the two plants. The objective is to decide how much of each grade to buy from each supplier and the shipping instructions to give to each supplier by creating a least cost procurement (minimization) plan that considers both paper cost and shipping cost.

**List of Methodologies/Tools Used**

Ari compiled the preliminary data tables (Exhibit A) required for the analysis which include: demand, supply, price per ton, and shipping cost dollars per ton respective to plant distance. These tables were the foundations to construct the linear programming problem statement (Exhibit B). Ari was able to leverage a linear programming software tool, Microsoft Excel and the Solver Add-In to analyze the variables and constraints and derive an optimal solution. The built in Sensitivity and Answer reports enabled Ari to determine the low cost leader by supplier and grade. Ari added additional constraints to analyze what benefit his company could realize if they were to choose to participate in the quantity discount program his suppliers offered.

**Principal Results**

The optimal solution for this linear programming minimization problem is detailed in the spreadsheet attachment section of this paper. In summary: total paper cost came to $574,620.00; shipping cost to both plants totaled $64,139.63 for a total procurement cost of $638,759.63. Per the sensitivity report results the following table was created to display supplier and paper grade combinations that yield the greatest benefit from increased quantities.

|  |  |  |  |
| --- | --- | --- | --- |
| Supplier | Grade | Shadow Price | Objective Coefficient |
| S1 | 6 | -639 | $74.69 |
| S2 | 4 | -455 | $47.03 |
| S3 | 1 | -318 | $43.65 |

After additional analysis and applying the additional conditions for the quantity discounts, Supplier 2 was the low cost leader if Calcutta Container Company decides to participate in the program. The table below displays the results of the analysis.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Tons | Rebate |  | MIN COST |  |
| S1 | 450 | 2.25% |  | $ 635,605.54 | |
| S2 | 600 | 3.00% |  | $ 631,279.45 | |
| S3 | 500 | 2.50% |  | $ 631,279.45 | |

The following marginal cost table was constructed to display the potential impact to the objective function subject to additional demand less than or equal to the allowable increase quantity.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Marginal** | **Allowable** | **Maximum** | **Objective Function** |
| **Plant** | **Name** | **Cost** | **Increase** | **Impact** | **Impact** |
| Plant 1 | G1 | $ 361.70 | 50 | $ 18,085.00 | $ 656,844.63 |
| Plant 1 | G2 | $ 391.92 | 30 | $ 11,757.75 | $ 650,517.37 |
| Plant 1 | G3 | $ 424.65 | 30 | $ 12,739.50 | $ 651,499.13 |
| Plant 1 | G4 | $ 481.65 | 25 | $ 12,041.25 | $ 650,800.87 |
| Plant 1 | G5 | $ 521.02 | 20 | $ 10,420.50 | $ 649,180.12 |
| Plant 1 | G6 | $ 705.03 | 45 | $ 31,726.13 | $ 670,485.75 |
| Plant 2 | G1 | $ 344.82 | 50 | $ 17,241.25 | $ 656,000.87 |
| Plant 2 | G2 | $ 383.82 | 30 | $ 11,514.75 | $ 650,274.37 |
| Plant 2 | G3 | $ 450.08 | 30 | $ 13,502.25 | $ 652,261.88 |
| Plant 2 | G4 | $ 493.83 | 20 | $ 9,876.50 | $ 648,636.13 |
| Plant 2 | G5 | $ 512.92 | 20 | $ 10,258.50 | $ 649,018.12 |
| Plant 2 | G6 | $ 696.92 | 45 | $ 31,361.62 | $ 670,121.25 |

**Exhibit A: Data Tables**

***Demand Forecast Table***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand (tons)** | **G1** | **G2** | **G3** | **G4** | **G5** | **G6** |
| Demand at **P1** | 100 | 120 | 140 | 130 | 110 | 80 |
| Demand at **P2** | 80 | 110 | 130 | 140 | 120 | 100 |

***Available Supply***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Supply(Tons)** | **G1** | **G2** | **G3** | **G4** | **G5** | **G6** |
| **S1** | 155 | 35 | 75 | 160 | 45 |  |
| **S2** | 75 | 155 | 55 |  | 165 | 155 |
| **S3** |  | 70 | 170 | 155 | 40 | 70 |

***Paper Cost by Grade, Supplier***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Prices in $/ton** | **G1** | **G2** | **G3** | **G4** | **G5** | **G6** |
| **S1** | 287 | 326 | 358 | 436 | 454 |  |
| **S2** | 305 | 343 | 389 |  | 474 | 658 |
| **S3** |  | 318 | 381 | 438 | 461 | 643 |

***Shipping Cost by Supplier, Plant***

|  |  |  |
| --- | --- | --- |
| **Shipping**  **$/Ton** | **P1** | **P2** |
| **S1** | $74.70 | $57.83 |
| **S2** | $47.03 | $38.93 |
| **S3** | $43.65 | $69.08 |

|  |  |  |
| --- | --- | --- |
| **Discount for each supplier** | **Threshold (tons)** | **Rebate (% of $)** |
| **S1** | 450 | 2.25% |
| **S2** | 600 | 3% |
| **S3** | 500 | 2.50% |

**Exhibit B: Linear Programming Formulation Table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Variable | Qualitative Value | Function | Possible Values |  |
| Base Variable | k | Paper grade | For: | (1,2,3,4,5,6) |  |
| j | Plant | For: | (1,2) |  |
| i | Supply | For: | (1,2,3) |  |
| Transportation Coefficients | c | Shipping | ij |  | Shipping cost $/ton from i supplier to j plant |
| x | Quantity | ijk |  | Tons of grade k paper supplied by i supplier for plant j |
| xij |  | x1k+x2k |  |  |
| xik |  | xij1+xij2+…xij6 |  |  |
| p | Paper cost | ik |  | $/ton paper cost for grade k from supplier i |
| s | Paper supply | ik |  | Tons of grade paper k @ supply i constraints |
| Constraints |  | Supply | xik<sik |  | For all i,k |
|  | Demand | ∑x1jk+ x2jk+ x3jk |  | For all j,k |
|  |  |  |  | For j=1 |
|  |  |  |  | For j=2 |
|  | Quantity | xijk>0 |  | For all j,k |
| Objective Function |  |  | ∑pikxik=∑cijxij |  | Subject to i,k |

**Exhibit C: Network Diagram**

**Plant**