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Solving Transportation problem with LP: Biopharma Case study

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Abstract: *The BioPharma case study is a transportation problem that requires a problem-solving approach to help in making appropriate decisions. The mathematical model formulated from a linear programming (LP) is a powerful tool and was used to solve the transport problem. In this paper the mathematical model formulated has adopted the concept of the new capacitated transportation model because; the company's shipments are directly from a supply point to a demand point. This is a special transport problem model and is used to determine the optimal total cost from the feasible solution of the decision variables. The model requires input data on prices, demand, and plant capacity to solve for the optimal solution. By help of the Solver Tool, the optimal solution was computed and the new shipment plan was achieved and is illustrated by Figure 4 to portray the optimal network flow. The new shipment plan enables the company to cut down 12% of its cost.*
Keywords*: LP, transport model, network flow model.*

I. Introduction

1.0 Background

BioPharma, Inc. is a global company which is dedicated in manufacturing of bulk chemicals that are then used in the pharmaceutical industry.
The BioPharma Inc. holds patents on two chemicals which, are called *Highcal* and *Relax* internally. The six plants located at different places can supply products produced from six various regions.

1.1 Problem

From the information provided, we can learn that the BioPharma Inc. has experienced more than one problem and the serious ones are three:

1. a sharp decline in profits
2. very high costs at its plants in Germany and Japan
3. It has a surplus capacity in its global production network which overwhelm the company

The three problems above are co-dependent such that solution for problem 3 can make a solution for problem 2 and eventually for problem 1. So the problem in this company is only one – the shipment plan which will cost the company as minimum as possible.

1.2 Objective

Bearing in mind the problem statement in section 1.2, our objective for this work is naturally twofold:
1. to minimize the transportation costs of transporting goods from plants to customers, and,
2. to satisfy the company's customers

1.3 Assumptions

We assume that
- the demand for the company's sales for the two products will be stable for all parts of the world, except for Asia without Japan
- In the region of Asia without Japan, sales are expected to grow by 10% annually for five years consecutively before stabilizing
- the demand will remain unchanged for all parts of the world except for the region of Asia without Japan

1.4 Methodology

After a careful study of the company's information we find that, the products are transported directly from the plant to the market. Moreover, the other things unveiled in the information include: sales by region, capacity by plants, fixed and variable costs, transportation costs and import tariffs.

Therefore, the BioPharma problem befits the "transport problem model" which is about moving products at least cost from origins to destination.

There are 6 sources of supplies with respective supply capacity and there are 6 demand destinations as well. Therefore, there is transportation costs associated with such network flow and our objective is to minimize the transportation costs with respect to the supply quantity from origin to destination. We can do so by use of linear programming (LP) method. The linear programming (LP) is one of the powerful tools to determine the minimum cost network flow model. However, we can adopt Murthy's proposition (2007), where out of it, the LP problem (LPP) can be formulated as mathematical statement to translate our objective (section 1.3) and constraints of the problem into a set of mathematical model.

$$\text{Minimize } z = c_{11}x_1 + c_{12}x_2 + \ldots + c_{1n}x_n \qquad \text{Objective function}$$

Subject to restrictions

$$z = c_{11}x_1 + c_{12}x_2 + \ldots + c_{1n}x_n \geq b_1$$
$$z = c_{21}x_1 + c_{22}x_2 + \ldots + c_{2n}x_n \geq b_2$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$
$$z = c_{m1}x_1 + c_{m2}x_2 + \ldots + c_{mn}x_n \geq b_n$$

and all x_i are = 0 Nonnegativit

where $i = 0, 1, \ldots, n$

Structural

constraints

II. Description Of Data

A preliminary analysis on the actual data in Table 1 shed more light on the BioPharma problem. The company has six facilities, one in each of the six regions. This forms a system of logistic supply chain. The system can help in reduction of transport costs and avoidance of import duties on products if were to be imported from other regions. On the other hand it is associated with some disadvantage because; plants tend to be sized to meet local demand and do not aim to fully exploiting the economies of scale.

The capacity of six plants consolidated together equals 143,000 kilograms, while the total sales were 105,000 kilograms. This imply that the six plants together had extra capacity for more customers totaling to 143,000 – 105,000 = 38,000 kilograms.

Table 1 Sales by regions, 2005

	Highcal	Relax	Total	Capacity
Brazil - L. America	7.0	7.0	14.0	18
Germany - Europe	15.0	12.0	27.0	45
India - Asia(-Jpn)	5.0	3.0	8.0	18
Japan - Japan	7.0	8.0	15.0	10
Mexico - Mexico	3.0	3.0	6.0	30
US - US	18.0	17.0	35.0	22
Total Sales	55.0	50.0	105.0	143.0

Source: Author, 2010

Nevertheless, demand for chemicals in Japan and US appear to be greater than the plant capacities located in Japan and US. Theoretically it is possible for the unmet demand in the regions to be supplied by other sources but at a risk of a rise of total cost due to transportation and tariffs.

Table 1 also shows that; the four plants of Brazil, Germany, India and Mexico supply below their specific capacities. The trend is more serious at Mexico and India whose sales equal to 20% and 44% of their capacities consecutively. The actual data in Table 1 show that; the actual shipment plan of the company had a capacity utilization of more than 73% in 2005. The ratio may be encouraging, yet profitability depends more on the set up of the network flow system that can minimize the total transport costs. Thus the optimal network flow model is required to cut down cost in the company.

2.1 Costs :

Table 2 summarizes the BioPharma capacity and demand data along with production, transportation and inventory costs at different plants. Even so, the costs experienced by the company fall into two main classes: fixed and variable costs. A fixed cost is the portion of the total cost that does not depend on the production volume (William, 2000); this cost tends to remain the same no matter how much is produced. For the BioPharma plant, the total fixed cost alone is equal to US$ 151 million (Table 2).

Table 2 Fixed and Variable costs

Supply Regions	Highcal			Relax			Plant Fixed Cost	Production Cost ($/ kg)	
	Fixed Cost ($)	Raw Material	Capacity	Fixed Cost ($)	Raw Material	Capacity		Highcal	Relax
Brazil	5.00	3.60	11.00	5.00	4.60	7.00	20.00	5.10	6.60
Germany	13.00	3.90	15.00	14.00	5.00	0.00	45.00	7.00	8.50
India	4.00	3.60	10.00	4.00	4.50	8.00	18.00	4.50	6.00
Japan	6.00	3.90	2.00	6.00	5.10	0.00	17.00	7.50	9.00
Mexico	6.00	3.60	12.00	6.00	4.60	18.00	30.00	5.00	6.50
US	5.00	3.60	5.00	5.00	4.50	17.00	21.00	5.00	6.50
	Total plant fixed cost						151		

Source: Author, 2010

The variable cost, on the other hand, is the portion of the total cost that depends on and varies with the production volume (ibid, 2000). The variable costs which depend on the volume produced and shipped to the demand regions can be minimized by use of the linear programming (LP) method.

Table 2 shows that; cost of raw materials for the Relax plant was apparently higher than that of raw materials for the Highcal plant at all supply regions. However, fixed cost in Highcal and Relax plants appear to be more or less equal.

2.2 Transport Models and Network Configuration Models

(1) The Transportation Model

The transportation model deals with a special class of LP problem (LPP) in which the objective is to transport a homogeneous commodity from various origins or factories to different destinations or markets at a total minimum cost (Murthy, 2007). In general, as it is put by Winston (1998), a company produces products at location called supply points and transports the products to customer location called demand points. And, it is common for each supply point to have a limited amount that it can ship and each customer must receive a required quantity of the product (Bertsekas DP, 1998).

(2) Network Flow Models

A network design that can minimize the cost of meeting a global or regional demand is required. A network according to Kolman B. and Beck RE (1995) is an interconnection of several terminals by routes between certain pairs of these terminals. Each route has a capacity … and flow of material along these routes is our concern. Intuitively, A network is a schematic diagram or configuration, consisting of points ($S_1, S_2, ..., S_m$ and $D_1, D_2, ..., D_n$) which are connected by lines or arrows as shown in Figure 1. The points are referred to as nodes and the lines are called arcs. A flow may occur between two nodes, passing through an arc as shown in Figure 1. When the flow is restricted to one direction, then the arcs are pointed and the network is referred to as a directed network (Figure 2).

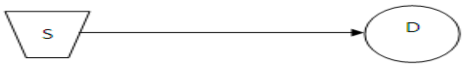

Figure 1. A flow between two nodes

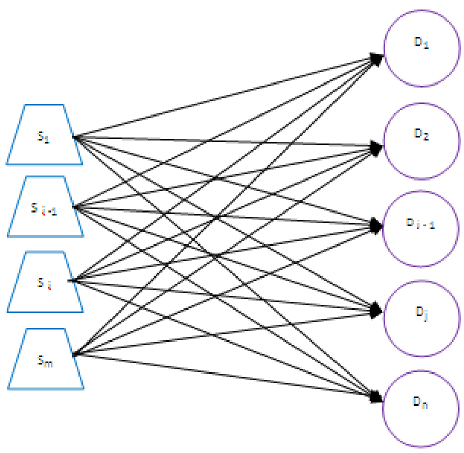

Figure 2. Supply and demand Network Model.

Network flow models are basically linear programming models and can be formulated and solved as such. Figure 2 point up a setting of a capacitated plant location model (Gen et al, 2008) which shows the shipment of goods from the plants (factories) to customers. The nodes of the network are the plants (S_i) and customers (D_j), while the arcs represent the possible routes over which the goods (x_{ij}) can be transported. The amounts of goods actually shipped, form the flows along the various arcs.

The plants or factories are considered as supply nodes. The flow (of goods) out of the various supply nodes must not exceed the amount of goods available (K_i). This is again a supply constraint. The customers are considered demand nodes (D_j). The flow into the demand must at least match the amount of goods required:

$$\sum_{j=1}^{n} x_{ij} = D_j .$$

Again, the demand constraint appears. Finally, the flows must be such that the costs of transportation are minimized.

(3) Mathematical Statement for the Supply and demand Network Model

Let us consider a directed network $G=(\beta,\alpha)$, which consists of a finite set of nodes $\beta=(1,2,...,n)$ and a set of directed $arcs\,\alpha=(i,j),(k,l),...,(s,t)$ which joins pairs of nodes in β (Korte B. & Vygen J., 2008). The links or edges have associated cost c_{ij} that could be based on their distance, capacity and quality of line (Gen et al, 2008).

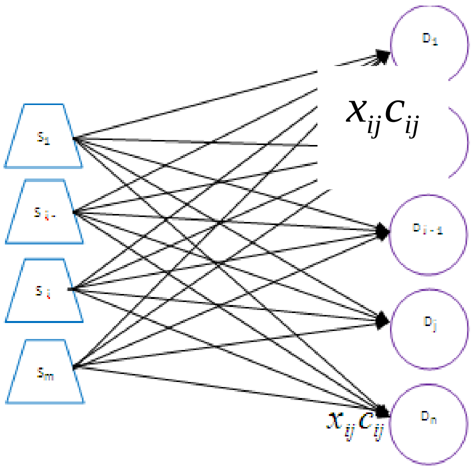

Figure 3. Bipartite Graph.

The network model (or linear logistics model or transportation model) contain two main sets of constrains: one set of i constraints associated with the source nodes denoted as S and one set of j constraints associated with the destination nodes denoted as D. There are ij variables in the problem, each corresponding to an arc from source node to a destination node. Therefore, the underlying graph is a directed graph and it is characterized as a bipartite graph (Gen, Cheng, & Lin, 2008), that is, the nodes of this network model can be partitioned into two sets S and D. this is graphically illustrated in Fig. 3.

The network optimizations require the following conditions/constraints be fulfilled:

1. The amount of goods shipped (x_{ij}) from the plant must be less than or equal to the supply at that plant.
2. The amount of goods shipped to customers must meet their demand (D_j).

The supply and demand Network Model requires the following inputs:

n = number of markets or demand points

m = number of potential plant locations/capacity

c_{ij} = cost of producing and shipping one unit from plant i to market j

$D_j =$ demand from market j

$x_{ij} =$ the unknown quantity transported from the plant i to market j

$f_i =$ fixed cost of keeping plant i open

$K_i =$ potential capacity of plant i

The mathematical transport model seeks to attain the minimal cost pattern of shipment from plants to market. This is, according to William SN (2000) and Chopra et al (2004) an optimization model of (m, n) = (origin, destination) and is formulated as:

$$Minimize \sum_{i=1}^{m} f_i y_i + \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} x_{ij}$$ The total transport cost

Subject to:

1. $\sum_{i=1}^{m} x_{ij} \le K_i \quad (i = 1, 2, ..., m)$ — The supply capacity cannot be exceeded (here $S_i \le K_i$)
2. $\sum_{j=1}^{n} x_{ij} = D_j \quad (j = 1, 2, ..., m)$ — The demand must be met
3. $x_{ij} \ge 0 \quad (i = 1, 2, ..., m, \& \ j = 1, 2, ..., n)$ — The non-negativity constraints

The total cost (fixed and variable) of setting up and operating the network can be minimized by the objective function in conjunction with the constraints. Additional constraints for a plant can be added as follows;

- the closed plant: $y_i = 0$ and $y_i K_i = 0$, and
- the open plant: $y_i = 1$ and $y_i K_i = K_i$

The solution achieved from the mathematical model will identify the plants that are to be kept open, their capacity, and the allocation of regional demand to these plants.

III. Results for 2005

3.1 Current configuration

The current company's configuration is not optimal and the associated operating total cost is approximately US$ 394 million. In Table 3 below we use the actual data to test the model if it agrees with company's account.

Table 3 Sales and Production Quantities at Highcal and Relax in 2005

Supply Regions	Demand Region - Production Allocation (Million Units)						Highcal Plants (1=Open)	Relax Plants (1=Open)
	L. America	Europe	Asia w/o Japan	Japan	Mexico	US		
Brazil	14.00	1.00	0.00	3.00	0.00	0.00	1.00	1.00
Germany	0.00	15.00	0.00	0.00	0.00	0.00	1.00	1.00
India	0.00	0.00	8.00	10.00	0.00	0.00	1.00	1.00
Japan	0.00	0.00	0.00	2.00	0.00	0.00	1.00	1.00
Mexico	0.00	11.00	0.00	0.00	6.00	13.00	1.00	1.00
US	0.00	0.00	0.00	0.00	0.00	22.00	1.00	1.00
Total	14.00	27.00	8.00	15.00	6.00	35.00		

Source: Author, 2010

In the table above it is shown that, each market is supplied by at least one plant which is capable of producing two types of chemical products. The decision variables given in the table are basically transport volumes and production allocation of the supply chain network. Using the optimal function and by help of a Solver, the total production and transport cost can be computed.

The table shows that all the Highcal and Relax plants are open and by use of the Solver, the total transportation cost alone is equal to US$ 24.7 million. This amount represents about 6.27% of the total cost. So, the total fixed and variable cost of operating the supply chain network is US$ 393.97 million. This cost, together with production cost, raw material cost, need to be minimized.

3.2 The 2005 Optimal

Once a production volume is established, the optimal function model can be used to compute the optimal total cost by help of the Solver Tool in Excel.

Table 4 summarizes the optimal production volume and the volume to be supplied to each market.

Table 4 Optimal Sales and Production Quantities at Highcal and Relax in 2005

Supply Regions	Demand Region - Production Allocation (Million Units)						Highcal Plants (1=Open)	Relax Plants (1=Open)
	L. America	Europe	Asia w/o Japan	Japan	Mexico	US		
Brazil	**14.00**	**1.00**	0.00	**3.00**	0.00	0.00	1.00	1.00
Germany	0.00	**15.00**	0.00	0.00	0.00	0.00	1.00	0.00
India	0.00	0.00	**8.00**	**10.00**	0.00	0.00	1.00	1.00
Japan	0.00	0.00	0.00	**2.00**	0.00	0.00	1.00	0.00
Mexico	0.00	**11.00**	0.00	0.00	**6.00**	**13.00**	1.00	1.00
US	0.00	0.00	0.00	0.00	0.00	**22.00**	1.00	1.00
Total	**14.00**	**27.00**	**8.00**	**15.00**	**6.00**	**35.00**		

Source: Author, 2010

The optimal shipment plan is also illustrated graphically in Figure 4 for the sake of clarity. A minimum cost of US$ 346.37 million is required to operate such a shipment plan. Only ten routes are used in this network model.

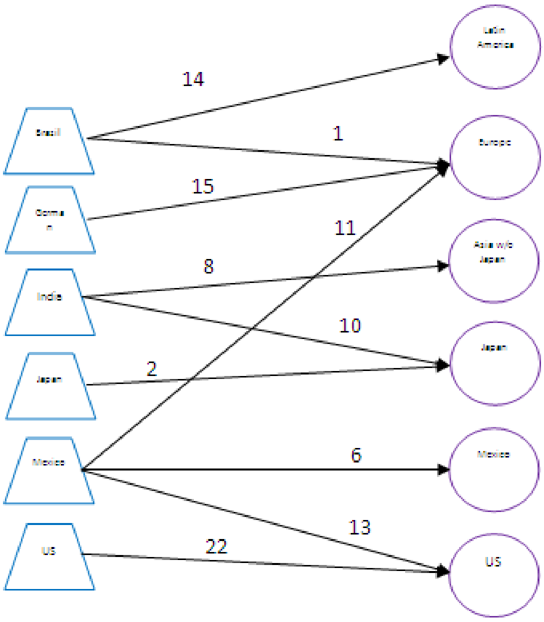

Figure 4. Optimal shipment for BioPharma Case.

The networks on Figure 4 divulge that, the European market does not solely depend on the Germany plant, but combines supply from Brazil and Mexico. Actually, it is cheaper to supply about 48% of the chemical products from Brazil and Mexico than to rely on the Germany plant in full.

Further, it is feasible for the Highcal plants in all the six regions to be set open for production. On the other hand, it is for the best interest of the BioPharma to close the Relax plants in Germany and Japan while keeping the other plants open (ref Table 4).

The total monthly cost of this network and operation is US$ 28.9 million. This cost represents savings of about UD$ 3.97 million per month compared to the situation when Germany and Japan Relax plants are open. This reduction is equivalent to 12% of the total cost of operating the network with all plants open.

3.2 Optimal Schedule versus Actual Schedule

A comparison of the account for the company with the optimal account thereof (ref. Table 5) reveal a key difference in the shipment plan. The differences appear to be a sheer rearrangement of distribution network in response to the demand. This is supported by two facts:

1. the number of negative as well as positive differences given in Table 5, are equal
2. the consolidated shipment volumes for the actual account of the company and the optimized account are also equal

Table 5 Difference of the company's account and the computed, 2005

Supply Regions	The Company's account	The Computed Account	Differences
Brazil	**14**	**18**	**-4**
Germany	**27**	**15**	**12**
India	**8**	**18**	**-10**
Japan	**15**	**2**	**13**
Mexico	**6**	**30**	**-24**
US	**35**	**22**	**13**
Grand Total	**105**	**105**	**0**

Source: Author, 2010

Conclusively it can be said that, the main reason for the high cost problem in the BioPharma Inc. was contributed by the unfeasible network flow pattern. The company's former network flow impacted on performance by affecting the total production, inventory and transportation costs incurred by the supply chain to satisfy the customer demand.

3.3 Results for reconfigured network

3.3.1 The Optimal Solution from a Modified Network

The test for flexibility was done by closing down one plant whose performance is far below its allocated capacity. The two candidates for this scenario were the plants at Japan and Germany. The results for this were recorded as follows:

3.3.2 Japan:

Total transport cost = US$ 328.97 mil + 20% = 394.764 mill
Excess capacity = 2mil kg was required at the Japan plant

3.3.3 Germany :

Total transport cost = US$ 322.47 mil+ 20% = 386.964 mil
Excess capacity = 15 was required from the Germany plant
By setting $K_i = 0$ for either the Japan or Germany plants, then run the Solver tool, no optimal solutions was obtained. However, by setting $y_i = 0$ of the above plants the total costs recalculated to give the above solutions. However, the solutions computed are far too higher than the optimal solution attained on section 3.0.2. so, the test for flexibility did not work out constructively.

IV. Sensitivity Analysis

4.1 Sensitivity report

Solving an LPP is just one part of mathematically modeling a situation. After the problem is solved, one must ask whether the solution makes sense in the actual situation. Frequently, according to Kolman B and Beck RE (1995) the numbers that are given to the task force are estimates of the true numbers and many times they will not be very good estimate. Apparently, the solution depends on the values that are specified for the model, and because these are subject to variation, it is important to know how the solution will vary with the variation in the input data. That is a reason why we want to run a **sensitivity analysis**. Sensitivity report helps us to know the range of feasibility, range of optimality and shadow prices which are vital in decision making.

Unfortunately in this work, the Solver failed to give out the sensitivity report and instead it gave out the following message:

"Sensitivity report and limits report are not meaningful for problems with integer constraints".

So there is no sensitivity report for the optimal solution and for the flexibility testing. But the Solver was able to produce the answer report which we have appended with this report on page 16.

4.2 Test results by increasing demand by 10% for all regions

Another test was conducted by increasing the demand by 10% for all regions caused more problems to the plan. The outcome was that; first, the solver required excess capacity of 10.50 mil kg from the Brazilian plant and the total transport cost was high (about US$ 365.93) and after many trials the Solver kept on producing different values. Likewise, when we let the demand at Asia w/o Japan to increase by 10% and the rest of the regions unchanged, there was no optimal solution still.

V. Conclusion

The report has outlined a transportation model and the mathematical model thereof that can be applied to minimize transportation total cost for the BioPharma Compan. The mathematical model is just a linear programming formulated to solve a transport problem.

We have calculated the minimized total transportation cost for the company and about 12% of the cost can be avoided. This is a big saving for the company and about UD$ 3.97 million per month will accumulate in the company's bank account.

The optimal shipment plan given in Table 4 provides a reduction of the company's burden by 12% by rearranging the network flow. Likewise, the optimal network flow agrees with the original plan by closing down the two Relax plants at Germany and Japan. This is mainly to avoid high running costs of the plants due to their relatively higher cost raw materials.

Further work is needed to establish the reasons why the Solver failed to give a sensitivity report. Sensitivity report could save a lot of effort for flexibility tests for closing plants or increasing demands

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Appendix

Microsoft Excel 12.0 Answer Report						
Worksheet: [Case 2 New Approach.xls]Modell O						
Report Created: 8/10/2010 4:02:53 PM						
Target Cell (Min)						
	Cell	**Name**	**Original Value**	**Final Value**		
	C39	Cost = L. America	$ 331.67	$ 331.67		
Adjustable Cells						
	Cell	**Name**	**Original Value**	**Final Value**		
	C19	Brazil L. America	14.00	14.00		
	D19	Brazil Europe	3.00	3.00		
	E19	Brazil Asia(-Jpn)	0.00	0.00		
	F19	Brazil Japan	0.00	0.00		
	G19	Brazil Mexico	0.00	0.00		
	H19	Brazil US	0.00	0.00		
	I19	Brazil Highcal Plants (1=Open)	1.00	1.00		
	J19	Brazil Relax Plants (1=Open)	1.00	1.00		
	C20	Germany L. America	0.00	0.00		
	D20	Germany Europe	15.00	15.00		
	E20	Germany Asia(-Jpn)	0.00	0.00		
	F20	Germany Japan	0.00	0.00		
	G20	Germany Mexico	0.00	0.00		
	H20	Germany US	0.00	0.00		
	I20	Germany Highcal Plants (1=Open)	1.00	1.00		
	J20	Germany Relax Plants (1=Open)	0.00	0.00		
	C21	India L. America	0.00	0.00		
	D21	India Europe	3.00	3.00		
	E21	India Asia(-Jpn)	8.00	8.00		
	F21	India Japan	7.00	7.00		
	G21	India Mexico	0.00	0.00		
	H21	India US	0.00	0.00		
	I21	India Highcal Plants (1=Open)	1.00	1.00		
	J21	India Relax Plants (1=Open)	1.00	1.00		
	C22	Japan L. America	0.00	0.00		
	D22	Japan Europe	0.00	0.00		
	E22	Japan Asia(-Jpn)	0.00	0.00		
	F22	Japan Japan	8.00	8.00		
	G22	Japan Mexico	0.00	0.00		

	H22	Japan US	0.00	0.00		
	I22	Japan Highcal Plants (1=Open)	1.00	1.00		
	J22	Japan Relax Plants (1=Open)	0.00	0.00		
	C23	Mexico L. America	0.00	0.00		
	D23	Mexico Europe	6.00	6.00		
	E23	Mexico Asia(-Jpn)	0.00	0.00		
	F23	Mexico Japan	0.00	0.00		
	G23	Mexico Mexico	6.00	6.00		
	H23	Mexico US	18.00	18.00		
	I23	Mexico Highcal Plants (1=Open)	1.00	1.00		
	J23	Mexico Relax Plants (1=Open)	1.00	1.00		
	C24	US L. America	0.00	0.00		
	D24	US Europe	0.00	0.00		
	E24	US Asia(-Jpn)	0.00	0.00		
	F24	US Japan	0.00	0.00		
	G24	US Mexico	0.00	0.00		
	H24	US US	17.00	17.00		
	I24	US Highcal Plants (1=Open)	0.00	0.00		
	J24	US Relax Plants (1=Open)	1.00	1.00		
Constraints						
	Cell	**Name**	**Cell Value**	**Formula**	**Status**	**Slack**
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	C30	Germany Excess Capacity	0.00	C30>=0	Binding	0.00
	C31	India Excess Capacity	0.00	C31>=0	Binding	0.00
	C32	Japan Excess Capacity	0.00	C32>=0	Binding	0.00
	C33	Mexico Excess Capacity	0.00	C33>=0	Binding	0.00
	C34	US Excess Capacity	0.00	C34>=0	Binding	0.00
	C36	L. America	0	C36=0	Not Binding	0
	D36	Europe	0	D36=0	Not Binding	0
	E36	Asia(-Jpn)	0	E36=0	Not Binding	0
	F36	Japan	0	F36=0	Not Binding	0
	G36	Mexico	0	G36=0	Not Binding	0
	H36	US	0	H36=0	Not Binding	0
	C19	Brazil L. America	14.00	C19>=0	Not Binding	14.00
	D19	Brazil Europe	3.00	D19>=0	Not Binding	3.00
	E19	Brazil Asia(-Jpn)	0.00	E19>=0	Binding	0.00
	F19	Brazil Japan	0.00	F19>=0	Binding	0.00
	G19	Brazil Mexico	0.00	G19>=0	Binding	0.00
	H19	Brazil US	0.00	H19>=0	Binding	0.00
	C20	Germany L. America	0.00	C20>=0	Binding	0.00
	D20	Germany Europe	15.00	D20>=0	Not Binding	15.00
	E20	Germany Asia(-Jpn)	0.00	E20>=0	Binding	0.00
	F20	Germany Japan	0.00	F20>=0	Binding	0.00
	G20	Germany Mexico	0.00	G20>=0	Binding	0.00
	H20	Germany US	0.00	H20>=0	Binding	0.00
	C21	India L. America	0.00	C21>=0	Binding	0.00
	D21	India Europe	3.00	D21>=0	Not Binding	3.00
	E21	India Asia(-Jpn)	8.00	E21>=0	Not Binding	8.00
	F21	India Japan	7.00	F21>=0	Not Binding	7.00
	G21	India Mexico	0.00	G21>=0	Binding	0.00
	H21	India US	0.00	H21>=0	Binding	0.00
	C22	Japan L. America	0.00	C22>=0	Binding	0.00
	D22	Japan Europe	0.00	D22>=0	Binding	0.00
	E22	Japan Asia(-Jpn)	0.00	E22>=0	Binding	0.00
	F22	Japan Japan	8.00	F22>=0	Not Binding	8.00
	G22	Japan Mexico	0.00	G22>=0	Binding	0.00
	H22	Japan US	0.00	H22>=0	Binding	0.00
	C23	Mexico L. America	0.00	C23>=0	Binding	0.00
	D23	Mexico Europe	6.00	D23>=0	Not Binding	6.00
	E23	Mexico Asia(-Jpn)	0.00	E23>=0	Binding	0.00
	F23	Mexico Japan	0.00	F23>=0	Binding	0.00
	G23	Mexico Mexico	6.00	G23>=0	Not Binding	6.00
	H23	Mexico US	18.00	H23>=0	Not Binding	18.00
	C24	US L. America	0.00	C24>=0	Binding	0.00
	D24	US Europe	0.00	D24>=0	Binding	0.00
	E24	US Asia(-Jpn)	0.00	E24>=0	Binding	0.00
	F24	US Japan	0.00	F24>=0	Binding	0.00
	G24	US Mexico	0.00	G24>=0	Binding	0.00
	H24	US US	17.00	H24>=0	Not Binding	17.00
	I19	Brazil Highcal Plants (1=Open)	1.00	I19=binary	Binding	0.00

	J19	Brazil Relax Plants (1=Open)	1.00	J19=binary	Binding	0.00
	I20	Germany Highcal Plants (1=Open)	1.00	I20=binary	Binding	0.00
	J20	Germany Relax Plants (1=Open)	0.00	J20=binary	Binding	0.00
	I21	India Highcal Plants (1=Open)	1.00	I21=binary	Binding	0.00
	J21	India Relax Plants (1=Open)	1.00	J21=binary	Binding	0.00
	I22	Japan Highcal Plants (1=Open)	1.00	I22=binary	Binding	0.00
	J22	Japan Relax Plants (1=Open)	0.00	J22=binary	Binding	0.00
	I23	Mexico Highcal Plants (1=Open)	1.00	I23=binary	Binding	0.00
	J23	Mexico Relax Plants (1=Open)	1.00	J23=binary	Binding	0.00
	I24	US Highcal Plants (1=Open)	0.00	I24=binary	Binding	0.00
	J24	US Relax Plants (1=Open)	1.00	J24=binary	Binding	0.00