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OPTIMIZING CEMENT DISTRIBUTION IN THE NIGERIAN CEMENT MANUFACTURING INDUSTRY: THE CASE OF CEMENT DISTRIBUTION FROM SELECTED FIRMS TO MARKETS IN EBONYI STATE

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ABSTRACT

This study sought to optimize cement distribution in the Nigerian cement manufacturing industry with special interest in cement distribution from three selected factories to four markets in Ebonyi state. Sources of distribution were identified as Gboko, Port-Harcourt and Calabar, while destinations or markets were identified as Abakaliki, Onueke, Oha-ozara and Afikpo with a view to determining the shortest route that minimized the cost of cement transportation from Gboko, Port-Harcourt and Calabar factories to Abakaliki, Onueke, Oha-ozara and Afikpo markets respectively. The literature reviewed showed that transportation model could improve the shipment route at minimal cost. The study employed Descriptive research design of which secondary data were collected from the randomly selected cement producing firms and the data collected were analyzed with Excel solver. It was found that these companies incur cost following the transportation of cement from factories to number of destinations which subsequently affect per unit **cost** of their product. Therefore, high cost of transporting products from factories to their respective markets to a large extent increases the price of the product and therefore concludes that transportation model is an indispensable tool that could improve the cost efficiency required in the distribution net-work. it is against this background that the study recommends that cement producing firms should adopt this model as a tool in order to minimize cost of transportation by identifying the most efficient route.

KEYWORDS: Optimization, Transportation Model, Linear Programming and Solver-In

INTRODUCTION

The dynamism of business environment, logistic and supply chain management plays a pertinent role in the management of an organization. Most manufacturing firms that supply their products from various factories to their respective destinations (warehouses) strive to evolve transportation model as a technique that would minimize the cost of transportation. This is because cost of shipment to an extent determine per unit price of the products.

Transportation model is a model for capacity planning and scheduling. As a tool, it borrows its design from Linear Programme (LP). Thus, the transportation problem is a specialized form of the linear programming problem. This problem can be visualized as a business concern having M factories, each of the factories having fixed production capacity. It has N warehouses or destinations each spatially separated from the factories (Abara, 2011). Moreover, each of the warehouses needs to receive a fixed amount of the product from each factory. Therefore, transportation model uses a distinctive approach in evaluating various shipment routes in attempt to improve on the transportation flow of the organization at a minimized cost. in the light of the aforementioned, Lee et al (1981) argue that transportation problem deals with the transportation of a product from a number of sources, with limited supplies, to a number of destinations, with a specified demands, at the minimum total transportation cost. Given the information regarding the total capacities of the origins, the total requirements of the destinations and the shipping cost per unit of goods for available shipping routes, the transportation model is used to determine the optimal shipping programmes that results in minimum total shipping cost. In addition, Lee et al (1981) observed that the constraints of the transportation problem are that demand at each warehouse must be met without exceeding productive capacity at each factory.

These companies however distribute quantity of cements from their factories to their respective markets (aggregate "distributors") in Ebonyi State . Due to the competitive nature of business environments, these firms ought to evolve transportation model as a strategy to reduce the cost of transportation. The cost involved in shipping the product plays a major role in price determination because consumers all over are sensitive to cost. Therefore, transportation model is a special class of linear programming problems of which the overriding objective is to transport product from different manufacturing plants to their respective warehouses or markets at minimum costs. This model is an indispensable tool that looks for the best route in attempt to improve transportation flow of the organization.

Statement of the Problem

Dangote, Ibeto, and United Cement (Unicem) organizations exert a considerable efforts in evaluating problems involving efficient transportation **routes** and it’s cost implications in an attempt to improve the transportation flow of the organization. These companies incur cost following the transportation of cement from factories to number of destinations which subsequently affect per unit **cost** of their product. Therefore, high cost of transporting products from factories to their respective markets to a large extent increases the price of the product hence posing great challenges to the organizations. Thus, it is imperative to evaluate the shipment concerns of these cement producing firms so as to determine the most efficient route to be used.

Therefore this paper sought to optimize cement distribution in the Nigerian cement manufacturing industry using the transportation model. Specifically, the objectives are:

- To determine the shortest route that minimizes the cost of cement transportation from Gboko, Port-Harcourt, and Calabar factories to Abakaliki, Onueke, Oha-ozara and Afikpo markets.
- To establish that unit cost minimization on scheduling maximizes unit profit from shipment from Gboko, Port-Harcourt, and Calabar factories to Abakaliki, Onueke, Oha-ozara and Afikpo markets.
- To determine the quantity (Xij) that minimizes the total cost of shipment (supply) from Gboko, Port-Harcourt, and Calabar factories while satisfying the demand restrictions in shipment of cement to Abakaliki, Onueke, Oha-ozara and Afikpo markets.

Conceptual Framework

Transportation model is a special class of linear programming that involves the shipment of products from point of origin to various destinations Abara,(2011) noted that

Transportation model is a model for capacity planning and scheduling. As a tool, it borrows its design from Linear Programme (LP). Thus, the transportation problem is a specialized form of the linear programming problem. Transportation problem can be visualized as a business concern having M factories, each of the factories having fixed production capacity. It has N warehouses or destinations each spatially separated from the factories

This model however is concern with the outcome on the effectiveness function regarding the shipment concern of manufacturing firms having various number of plants (sources) and respective destinations (markets). Thus, transportation model explore the available route in attempt to improve on the transportation flow of the organization at a minimized cost

In another development. Abara (2011) argued that problems that conspicuously deal with "transportation" when such problems relatively involves efficient transportation ROUTES require the application of a special solution procedure known as the transportation method of solving a linear programming (LP) version to solving transportation problems. Abara (2011) further stressed that the application of this sol ution procedure requires modification of the traditional linear programming model and such modification into particular model arises in decision regarding routing, scheduling, assignment and locating new plant (product/marketing) facilities where transportation factors are of much relevance.

From the aforementioned, the various cement producing plants are: Dangote group (Benue State), Ibeto group (Rivers State) and Unicem (Cross River) respectively are the three supply units i(i=1,2,3...m) while Abakaliki, Afikpo, Onueke, and oha-ozara are the number of destinations (markets) which are represe nted as: j(j=1,2, 3…,n). Cij represents the unit transportation cost for transporting the units from sources to their respective destinations. The overall goal is to determine the number of units to be converged destination so that the total transportation cost is minimized. On the other hand, Sharma (2011) argue that the structure of transportation problem involves a large number of shipping routes with several supply origins to several demand destinations. This should be done within the limited quantity of products available at each supply.

As with every mathematical model, the transportation model is vital to the extent it satisfies these assumptions. The following assumptions were outlined by Sharma (2011).

The shipment of product from plants (source) to destinations (markets) could be done comfortably, although this assumption according to Sharma (2011) is not realistic and could be modified in cases where the equality condition does not hold, the shipment cost per unit of item from plants to destinations is known (deterministic), and the shipment cost on a particular route is supposedly presumed to be proportional to quantity transported on that route.

Mathematical Formulation of the Transportation Model

Assume that there are three companies producing cement:

Dangote group (Benue State) represented as = A_1

Ibeto Group (Rivers State) represented as = A_2

Unicen (Cross River) represented as = A_3

The aforementioned are various facility locations where cement is produced and supplied to their markets in Ebonyi State. Let the markets in Ebonyi State be represented as follows:

Abakaliki which is represented as = B_1

Afikpo which is represented as = B_2

Onueke which is represented as = B_3

Oha-ozara which is represented as = B_4

Let the quantity of cement produced at A_1, A_2, and A_3 be a_1, a_2 and a_3, respectively, and the demand at their deports be b_1, b_2, b_3 and b_4. We assume this condition under balanced transportation problem. Where:

$a_1 + a_2 + a_3 = b_1 + b_2 + b_3 + b_4$

The distribution network of the transportation model is shown in figure 1

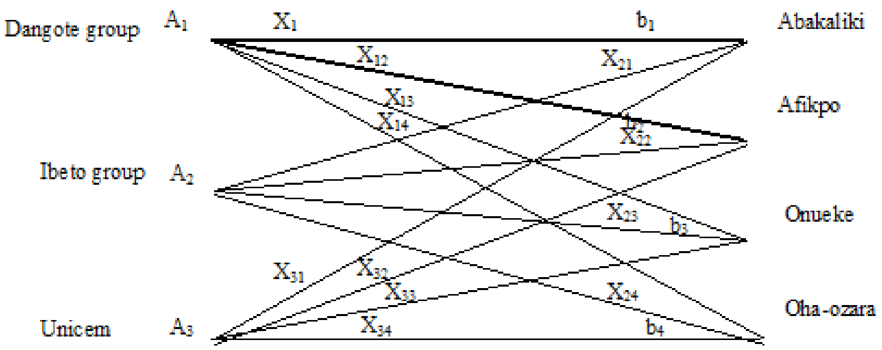

Figure 1: A Network of the Transportation Model

The quantity of cement to be transported from a_1 to all destinations i.e. b_1, b_2, b_3 and b_4 must be equal to

$X_{11} + X_{12} + X_{13} + X_{14} = a_1$

Similarly from a_2 and a_3 the cement transported is equal to a2 and a3 respectively.

$X_{21} + X_{22} + X_{23} + X_{24} = a_2$

$X_{31} + X_{32} + X_{33} + X_{34} = a_3$

On the other hand, the total quantity of cement delivered to b_1 from a_1, a_2 and a_3 are equal to b_1, b_2, b_3 and b_4 e.g.

$X_{11} + X_{21} + X_{31} = b_1$

$X_{12} + X_{22} + X_{23} = b_2$

$X_{13} + X_{23} + X_{33} = b_3$

$X_{14} + X_{24} + X_{34} = b_4$

With the aforementioned, we construct the following table.

Table 1: Represents a Balanced Transportation Model

	B_1	B_2	B_3	B_4	Supply
A_1	X_{11}	X_{12}	X_{13}	X_{14}	a_1
A_2	X_{21}	X_{22}	X_{23}	X_{24}	a_2
A_3	X_{31}∑	X_{32}	X_{33}	X_{34}	a_3
Demand	B_1	B_2	B_3	B	∑ai =∑ bj i=1 j=1

In table 1, the as and Bs, Xijs, as and Cijs are parameters and variables used to a transportation problem in matrix (tableau) form without loss of meaning. The variables and parameters are defined as follows:

Cij = unit of cost of shipping from factory a_1 to their distributors bj. (e.g., C_{23} is the unit cost of shipping from factory A_2 to their major distributor $B_{3)}$

Xij = the physical amount shipped from factory i to their distributor j. (e.g. X_{23} is the amount Shipped from factory A_2 to their distributor B_3)

ai = total capacity (supply) of factory i

bj = total amount required (demand) by warehouse j.

The matrix depicts three cement factories and four markets in Ebonyi State. Each cell in the matrix represents a variable, and a route from a particular factory to a particular destination. There are M x N (3x4) or 12 routes in this problem. Also listed on the right hand –side of the matrix are the amounts available at each factory. The quantity required at each distributor's are listed on the bottom of the matrix. In addition, these required quantities must be supplied from one or more factories. The lower edge of the matrix shows that the total quantities of the products available at all factories (supply) just equal the total quantities required by their distributors (demand).

The objective of the transportation problem therefore is to find the shipping routes from factories to their distributors which will minimize the total cost of transportation. In cell matrix the unit cost of shipping one unit through the cell or routes is shown. The total cost of transportation is then the sum of the amounts shipped through each cell multiplied by the unit cost shipping through that cell.

- **Market Constraints**

Where the number above the diagonal of each cell is the cost per unit (Cij) shipped through the cell, Xij is the amount shipped through the cell, bi is the total amount required by the market j, and m is the number of markets. This simply means that the number of units shipped into a demand point is equal to the amount required.

thus, we have, $\sum_{i=1}^{m} Xij=bj$ 1

- **Supply Constraints**

Where ai = total amount available at warehouse i. we assume here that the total amount shipped to all the markets equal the amount available at each warehouse. Summation is across all columns (j=1) for each row i, we sum over all markets j for each warehouse i.

This constraint may be stated as $\sum_{j=i} Xij=ai$ 2

- **Non-Negativity Constraints**

This is the condition, that only non-negative quantities can be shipped. It suggests that the amount shipped be non-negative. This constraint may be stated as:

$Xij \geq 0$ …………………………………………………………………… … ……..3

- **Objective Function**

The objective is to minimize the total cost of transportation. To formulate the objectives function, we let Cij represent the cost of shipping one unit from warehouse I to markets j. Multiplying these unit costs by the total transportation cost C.

Thus we have: $C = \sum_{i=1}^{m} \sum_{j=1}^{n} Cij\ Xij = ai$ ………… ………………… …4

The mathematical problem then is to minimize the shipping cost given by Equation 4 above subject to restrictions on Equations1, 2 and 3. The following conditions also apply:

- **Number of Variables:** the number of variables in transportation model equals the number of factors (plants), m, multiplied by the number of warehouses (n). thus, NV=NM ……………………………………………………. .5

  Equation (5) defines the objective function variables and number of routes.

- **Number of Constraints:** the number of constraints equals the sun of the number of plants (M) and the number of warehouses (n). then NC is the number of constraints, then,

  NC = m + n …….……………………………… …………………… …..6

METHODOLOGY

The research design used for this study is descriptive research method and secondary data was obtained from the selected three cements producing firms consisting of Dangote Group (Benue State), Ibeto Group (Rivers State) and Unicen Cement Company (Cross River State) as well as their respective markets in Ebonyi State. These companies produce cements and transport them to their major distributors in Abakaliki, Afikpo, Onueke and Oha-ozara. In attempt to achieve the stated objective the researcher obtained detailed information with respects to a number of trailer load of cements transported to their distributors with its associated unit cost within the month of August 2012. Below are the data: Dangote group (Benue state) supplied 300 trailer loads of cements at full capacity of 800 bags each, Ibeto Group (River State) supplied 80 trailer loads of cement at full capacity of 700 bags each, and Unicem (Cross River) supplied 150 trailer loads of cement at full capacity of 700 bags each.

- Dangote Group = 800 bags x 300 trailer loads = 240,000 bags
- Ibeto Group = 700 bags x 80 trailer loads = 56,000 bags
- Unicen Cement = 700 bags x 150 trailer loads = 105,000 bags

Table 2: Initial Tableau with North-West Corner Rule (NWCR)

From To	Abakaliki	Afikpo	Onueke	Ohaozara	Supply
Dangote (Benue State)	100 220,000	110 20,000	110	120 110	240,000
Ibeto (Rivers State)	140 120	130 56,000	130 120	120 + 130	56,000
Unicen (Cross River)	60 50	60 24,000 +	50 38,000	60 43,000	105,000
Demand	220,000	100,000	38,000	43,000	401,000

From the table above we have:

Min. X = 100x1 +110x2 + 110x3 + 120x4 + 140x5 + 130x6 + 130x7 +120x8 +60x9 + 60x10 + 50x11 + 60x12

Subject to:

$$X_1 + X_2 + X_3 + X_4 = 240{,}000$$
$$X_5 + X_6 + X_7 + X_8 = 56{,}000$$
$$X_9 + X_{10} + X_{11} + X_{12} = 105{,}000$$
$$X_1 \quad X_5 \quad X_9 = 220{,}000$$
$$X_2 \quad X_6 \quad X_{10} = 100{,}000$$
$$X_3 \quad X_7 \quad X_{11} = 38{,}000$$
$$X_4 \quad X_8 \quad X_{12} = 43{,}000$$

Xij ≥ 0 (i = 1, 2, 3, J = 1, 2, 3, 4)

Solving the above linear programming problem using Microsoft Excel.

Table 3: Transportation Model

Var Name		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12		Value
Var Value		1640	0	345.4545	316.6667	400	0	0	0	0	1666.667	0	83.33333		401000
OBJECTIVE FUNCTION															
ST			RHS												
CONSTRAINT 1		240000	240000												
CONSTRAINT 2		56000	56000												
CONSTRAINT 3		105000	105000												
CONSTRAINT 4		220000	220000												
CONSTRAINT 5		100000	100000												
CONSTRAINT 6		38000	38000												
CONSTRAINT 7		43000	43000												
CONSTRAINT 8		1640	0												
CONSTRAINT 9		0	0												
CONSTRAINT 10		345.4545	0												
CONSTRAINT 11		316.6667	0												
CONSTRAINT 12		400	0												
CONSTRAINT 13		0	0												
CONSTRAINT 14		0	0												
CONSTRAINT 15		0	0												
CONSTRAINT 16		0	0												
CONSTRAINT 17		1666.667	0												
CONSTRAINT 18		0	0												
CONSTRAINT 19		83.33333	0												

Table 4

Microsoft Excel 11.0 Answer Report					
Worksheet: [Book1.xls]Sheet1					
Report Created: 2/28/2013 9:37:36 AM					
Target Cell (Min)					
Cell	**Name**	**Original Value**	**Final Value**		
$P$4	Var Value Value	0	401000		
Adjustable Cells					
Cell	**Name**	**Original Value**	**Final Value**		
$C$4	Var Value X1	0	1640		
$D$4	Var Value X2	0	0		
$E$4	Var Value X3	0	345.4545455		
$F$4	Var Value X4	0	316.6666667		
$G$4	Var Value X5	0	400		
$H$4	Var Value X6	0	0		
$I$4	Var Value X7	0	0		
$J$4	Var Value X8	0	0		
$K$4	Var Value X9	0	0		
$L$4	Var Value X10	0	1666.666667		
$M$4	Var Value X11	0	0		
$N$4	Var Value X12	0	83.33333333		
Constraints					
Cell	**Name**	**Cell Value**	**Formula**	**Status**	**Slack**
$C$7	CONSTRAINT 1 X1	240000	$C$7<=$D$7	Binding	0
$C$8	CONSTRAINT 2 X1	56000	$C$8<=$D$8	Binding	0
$C$9	CONSTRAINT 3 X1	105000	$C$9<=$D$9	Binding	0
$C$10	CONSTRAINT 4 X1	220000	$C$10=$D$10	Not Binding	0
$C$11	CONSTRAINT 5 X1	100000	$C$11=$D$11	Not Binding	0
$C$12	CONSTRAINT 6 X1	38000	$C$12=$D$12	Not Binding	0
$C$13	CONSTRAINT 7 X1	43000	$C$13=$D$13	Not Binding	0

$C$14	CONSTRAINT 8 X1	1640	$C$14>=$D$14	Not Binding	1640
$C$15	CONSTRAINT 9 X1	0	$C$15>=$D$15	Binding	0
$C$16	CONSTRAINT 10 X1	345.4545455	$C$16>=$D$16	Not Binding	345.4545455
$C$17	CONSTRAINT 11 X1	316.6666667	$C$17>=$D$17	Not Binding	316.6666667
$C$18	CONSTRAINT 12 X1	400	$C$18>=$D$18	Not Binding	400
$C$19	CONSTRAINT 13 X1	0	$C$19>=$D$19	Binding	0
$C$20	CONSTRAINT 14 X1	0	$C$20>=$D$20	Binding	0
$C$21	CONSTRAINT 15 X1	0	$C$21>=$D$21	Binding	0
$C$22	CONSTRAINT 16 X1	0	$C$22>=$D$22	Binding	0
$C$23	CONSTRAINT 17 X1	1666.666667	$C$23>=$D$23	Not Binding	1666.666667
$C$24	CONSTRAINT 18 X1	0	$C$24>=$D$24	Binding	0
$C$25	CONSTRAINT 19 X1	83.33333333	$C$25>=$D$25	Not Binding	83.33333333

Table 5

Microsoft Excel 11.0 Sensitivity Report						
Worksheet: [Book1.xls]Sheet1						
Report Created: 2/28/2013 9:37:37 AM						
Adjustable Cells						
		Final	Reduced	Objective	Allowable	Allowable
Cell	Name	Value	Cost	Coefficient	Increase	Decrease
Table 5: Contd.,						
$C$4	Var Value X1	1640	0	100	0	0
$D$4	Var Value X2	0	0	110	1E+30	0
$E$4	Var Value X3	345.4545455	0	110	0	1E+30
$F$4	Var Value X4	316.6666667	0	120	0	0
$G$4	Var Value X5	400	0	140	0	1E+30
$H$4	Var Value X6	0	0	130	1E+30	0
$I$4	Var Value X7	0	0	130	1E+30	0
$J$4	Var Value X8	0	0	120	1E+30	0
$K$4	Var Value X9	0	0	60	1E+30	0
$L$4	Var Value X10	1666.666667	0	60	0	1E+30
$M$4	Var Value X11	0	0	50	1E+30	0
$N$4	Var Value X12	83.33333333	0	60	0	0
Constraints						
		Final	Shadow	Constraint	Allowable	Allowable
Cell	Name	Value	Price	R.H. Side	Increase	Decrease
$C$7	CONSTRAINT 1 X1	240000	0	240000	5000	0
$C$8	CONSTRAINT 2 X1	56000	0	56000	5000	0
$C$9	CONSTRAINT 3 X1	105000	0	105000	1E+30	0
$C$10	CONSTRAINT 4 X1	220000	1	220000	0	5000
$C$11	CONSTRAINT 5 X1	100000	1	100000	0	100000
$C$12	CONSTRAINT 6 X1	38000	1	38000	0	5000
$C$13	CONSTRAINT 7 X1	43000	1	43000	0	5000
$C$14	CONSTRAINT 8 X1	1640	0	0	1640	1E+30
$C$15	CONSTRAINT 9 X1	0	0	0	0	45.45454545
$C$16	CONSTRAINT 10 X1	345.4545455	0	0	345.4545455	1E+30
$C$17	CONSTRAINT 11 X1	316.6666667	0	0	316.6666667	1E+30
$C$18	CONSTRAINT 12 X1	400	0	0	400	1E+30
$C$19	CONSTRAINT 13 X1	0	0	0	292.3076923	0

$C$20	CONSTRAINT 14 X1	0	0	0	292.3076923	0
$C$21	CONSTRAINT 15 X1	0	0	0	316.6666667	1366.666667
$C$22	CONSTRAINT 16 X1	0	0	0	83.33333333	633.3333333
$C$23	CONSTRAINT 17 X1	1666.666667	0	0	1666.666667	1E+30
$C$24	CONSTRAINT 18 X1	0	0	0	100	0
$C$25	CONSTRAINT 19 X1	83.33333333	0	0	83.33333333	1E+30

The data in the Excel result shown above are from the Answer report and Sensitivity report when solving this problem. These types of report are available whenever Excel solves a Linear Programming Problem, even if that problem is not a blending problem as we have here.

From the aforementioned analysis, the optimal solution to the linear programming problem (transportation problem) has the value of N401, 000.00. The variables value X1, X2, X3………… and X12 represent the twelve routes (cell) with associated final value indicating quantity of cements that were transported through the route. Each constraint has a corresponding shadow price which is a marginal value that indicates the amount by which the value of the objective function would change, if there were one unit change in the Right Hand side constraint.

In addition, the shadow price for each constraint, it's RHS value and the allowable increase and allowable decrease determine the range of feasibility for the constraint.

CONCLUSIONS

Transportation model is an indispensable tool that improves the transportation flow of manufacturing firms in order to minimize the cost on transportation by finding an optimum solution for transportation routes from different factories (sources) to different warehouses.

The study is considered worthwhile as it plays a pertinent role in cost minimization and optimization of the transportation process in attempts to improve the company's position on the market and increase the profitability of the organization. This model is used is different sort of business arrears with many suppliers, buyers and different quantities.

RECOMMENDATIONS

From the findings and conclusion drawn from this study, the researcher made the following recommendations:

- The recommended routes that minimized the cost of transportation from Answer report of the solver-in analysis are as follows:

  X_1 C_1 = Benue State to Abakaliki

  X_1 C_3 = Benue State to Onueke

  X_1 C_4 = Benue State to Ohaozara

  X_2 C_1 = Rivers state =Abakaliki

  X_3 C_2 = Cross River = Afikpo

  X_3 C_4 = Cross River to Ohaozara

- On the other hand, government should provide a conducive environment for the distribution of products across the regions by developing cost saving and faster means of transportation system such as Rail.

- Considering the onerous nature of transportation system in Nigeria, government should rehabilitate most routes to ease transportation flow which to a large extent reduce the rate of road accidents in Nigeria.

Cement producing firms should adopt transportation model as a tool to improve on the transportation routes/flow of the organization in order to minimize the cost of transportation.

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APPENDICES

Table 6

Microsoft Excel 11.0 Limits Report									
Worksheet: [Book1.xls]Limits Report 1									
Report Created: 2/28/2013 9:37:37 AM									
Target									
	Cell	**Name**	**Value**						
	$P$4	Var Value Value	401000						
		Adjustable			**Lower**	**Target**		**Upper**	**Target**
	Cell	**Name**	**Value**		**Limit**	**Result**		**Limit**	**Result**
	$C$4	Var Value X1	1640		1640	401000		1640	401000
	$D$4	Var Value X2	0		0	401000		0	401000
	$E$4	Var Value X3	345.4545455		345.4545455	401000		345.4545455	401000
	$F$4	Var Value X4	316.6666667		316.6666667	401000		316.6666667	401000
	$G$4	Var Value X5	400		400	401000		400	401000
	$H$4	Var Value X6	0		0	401000		0	401000
	$I$4	Var Value X7	0		-5.59689E-14	401000		-5.59689E-14	401000
	$J$4	Var Value X8	0		6.0633E-14	401000		6.0633E-14	401000
	$K$4	Var Value X9	0		0	401000		0	401000
Table 6: Contd.,									
	$L$4	Var Value X10	1666.666667		1666.666667	401000		1666.666667	401000
	$M$4	Var Value X11	0		-1.45519E-13	401000		-1.45519E-13	401000
	$N$4	Var Value X12	83.33333333		83.33333333	401000		83.33333333	401000