DETERMINATION OF AN OPTIMAL TRANSPORTATION MODELS TO PRODUCTS DISTRIBUTION IN MANUFACTURING INDUSTRIES

A Case Study of

INTERNATIONAL TOBACCO COMPANY (ITC) LTD ILORIN

By

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CERTIFICATION

This is to certify that **MR. SAKA ADISA JAMIU** has successfully completed his practical project work in partial fulfillment of the requirement for the award of Post Graduate Diploma in Computer Science from the Department of Mathematics & Computer Science, Federal University of Technology (FUT) Minna.

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DEDICATION

This project is dedicated to the **ALMIGHTY ALLAH** for His protection on me against many accidents that would have made the programme unrealizable.

ACKNOWLEDGEMENT

I am indeed very grateful to the Almighty God for given me great opportunity to complete this program successfully, and those who in one way or the other might have contributed to the success of this program.

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At this juncture, I must never fail to express my profound gratitude to my beloved parents Alhaji Saka Aremu and Hajia Hajarat Saka for their moral and encouragement at all times.

May Almighty Allah reward you all abundantly (Amen)

ABSTRACT

This research was carried out to find ways of minimizing total ransportation cost so as to maximize the profit for the company.

The data was collected from ITC ltd. The products under consideration re various kinds of cigarettes in a homogenous park. There are three sources transporting firms connected at three different places in Ilorin) and five lestinations (KANO, KATSINA, ONITSHA, SAPELE and LAGOS).

Three methods of finding the initial feasible solutions were applied here, he North-west corner rule, the Least Cost Rule and Vogel's Approximation VAM). And MODI Algorithm was used to finds its optimality.

Meanwhile, this research was succeeded in minimizing the total ransportation cost by searching for the best allocation method which the company should use in order to maximize the profit.

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CHAPTER ONE

1.0 PRELIMINARIES

1.1 GENERAL INTRODUCTIONS ON TRANSPORTATION PROBLEMS

Production is the creation of goods and provision of services to satisfy human wants. The production of any particular commodity is incomplete until the product gets to the final consumer. The question to be asked at this stage is how do the finished products get to the final consumer? This question makes the business organisation, private individuals and government to be aware of the important tools used to solve problems of the above kind and this is the ANALYSIS OF TRANSPORTATION PROBLEMS.

More importantly, the cost of transportation goes a long way in influencing the cost of finished products, that is, the lower the transportation cost the cheaper the cost of finished products and vice versa. There is a popular opinion that AMERICA dominates the whole world today just because it has good communication and transportation net-work system. Now that everyone has realized the importance of transportation system in our everyday life, the fact that transportation problem does exist is indisputable.

Meanwhile, from the above discussion one can conveniently come to a conclusion that the progress of any manufacturing company is directly proportional to the efficiency of the TRANSPORTATION METHODS of the company.

At this point it is necessary to define transportation problems.

TRANSPORTATION PROBLEMS are generally concerned with the distribution of a certain product from several sources to numerous localities at a very minimum cost.

1.2 BRIEF HISTORICAL BACKGROUND OF INTERNATIONAL TOBACCO COMPANY (ITC) LIMITED.

The company was established in 1962 when it was first registered as KWARA TOBACCO LIMITED. The official opening ceremony took place on the 8th of May, 1964 by the then premier of Northern Nigeria His Excellency, the late Sir Ahmadu Bello (The Saudana of Sokoto). Both the United Africa Company and the Northern Nigeria Investments limited were the initial owners of the company.

However, in April 1967, Philips Morris Incorporated purchased a controlling share in the company after which the name of the company was changed to PHILIP MORRIS NIGERIA. Following the indigenization Decree, 40% of the shares of the company were sold to Nigerians including the employees of the company. Consequently, the company changed its name to INTERNATIONAL CIGARETTE COMPANY (ICC) LIMITED in 1980 trading under the name of Philip Morris Nigeria.

In 1986 the Khalil Brothers who have a controlling share in 7up Bottling Company in Nigeria acquired majority shares of the Philip Morris Incorporated holding and the company assumed its present name INTERNATIONAL TOBACCO COMPANY (ITC) LIMITED.

The following are the different kinds of cigarette produced by the company: TARGET, GREEN SPORT and LINK.

1.3 AIMS AND OBJECTIVES

The basic aim of this study is to determine the quantity of cigarettes to be transported along a given route at a very minimum cost in order to maximize profit.

1.4 SOURCES AND METHOD OF DATA COLLECTION

Data can be simply defined as a piece of information collected for a specific purpose. Data collection can be classified into primary and secondary sources of collection.

Basically, the data needed for transportation problem focuses on quantities and costs. One should note that all the data used for this study are basically secondary data obtained from the marketing, sales and shipping department of INTERNATIONAL TOBACCO COMPANY (ITC) Ilorin.

1.5 SCOPE OF THE STUDY

This research only focuses on three sources [i.e. three transporting firms connected at three different places in Ilorin] and five sets of customers or destinations [i.e. KANO, KATSINA, ONITSHA, SAPELE and LAGOS].

Chapter one generally deals with the introductory aspect of the study.

Chapter two deals with literature review and a full description of transportation problems.

Chapter three contains the statistical methodology and data presentation.

Chapter four deals with data analysis and evaluation.

On a final note, the summary, conclusion and recommendation make up chapter five.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 A DESCRIPTION OF TRANSPORTATION PROBLEMS.

Transportation problems are generally concerned with the distribution of a certain product from several sources to numerous localities at a minimum cost. Suppose there are m warehouses, where a commodity is stocked and n markets (localities) where it is needed and the supply available in the warehouses be S_1, S_2, S_3 ....Si, where i = 1,2..............................m and the demand at the market be

d_1, d_2, d_3.............................dj, where j = 1,2............................n. Let the unit cost of shipping from warehouse i to market j be =N=C_{ij}. This problem wants to find an optimal shipping schedule, which minimize the total cost of transportation from all warehouses to all the markets.

2.1.1 LINEAR PROGRAMMING FORMULATION

To formulate the transportation problems as a linear problem, we define X_{ij} as the quantity shipped from the warehouses i to mark j, i assumed values from 1 to m and j from 1 to n. The number of decision variables is given by the product of m and n i.e. nm.

The supply constraints guarantee that the total amounts shipped from any warehouse does not exceed its capacity. The demand constraints guarantee that the total shipped to market meet the minimum demand at the market.

Including the non-negative constraints, the total numbers of constraints is (m+n), the market demands can be met, if and only if the total supply of the warehouses is equal to the total demand at the markets where

$$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} d_j$$

Every available supply at warehouse will be shipped to meet the minimum demands at the markets. In this case, all the supply and the demand constraints would become strict equations and we shall have a standard transportation problem given by:

$$\text{Min } Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} X_{ij}$$

Subject to

$$\sum_{j=1}^{n} X_{ij} = S_i \,, \qquad i = 1, 2 \,\ldots\ldots\ldots\ldots\, m \text{ (supply)}$$

$$\sum_{i=1}^{m} X_{ij} = d_j \,, \qquad j = 1, 2 \,\ldots\ldots\ldots\ldots\, n \text{ (Demand)}$$

$$X_{ij} \geq 0 \qquad \text{for all i and j}$$

The above transportation problem can equally be expanded as follows:

$$\text{Min } Z = C_{11} X_{11} + C_{12} X_{12} + \ldots\ldots\ldots\ldots\ldots\ldots C_{1n} X_{1n} + C_{21} X_{21}$$
$$+ C_{22} X_{22} + \ldots\ldots\ldots\ldots\ldots\ldots C_{2n} X_{2n} + \ldots\ldots\ldots\ldots\ldots$$
$$\ldots\ldots\ldots\ldots\ldots + C_{m1} X_{m1} + C_{m2} X_{m2} + \ldots\ldots\ldots\ldots + C_{mn} X_{mn}$$

Subject to

$$X_{11} + X_{12} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{1n} = S_1$$

$$X_{21} + X_{22} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{2n} = S_2$$

" " " "

$$
\begin{array}{l}
\text{"} \quad \text{"} \qquad\qquad\qquad\qquad \text{"} \quad \text{"} \\
X_{m1} + X_{m2} + \ldots\ldots\ldots\ldots + X_{mn} = S_m \\
\\
X_{11} + X_{21} + \ldots\ldots\ldots\ldots + X_{m1} = d_1 \\
X_{12} + X_{22} + \ldots\ldots\ldots\ldots + X_{m2} = d_2 \\
\text{"} \quad \text{"} \qquad\qquad\qquad\qquad \text{"} \quad \text{"} \\
\text{"} \quad \text{"} \qquad\qquad\qquad\qquad \text{"} \quad \text{"} \\
X_{1n} + X_{2n} + \ldots\ldots\ldots\ldots + X_{mn} = d_n \\
S_i \geq 0 \\
d_j \geq 0, \qquad \text{for all } (i, j)
\end{array}
$$

2.1.2 THE TRANSPORTATION ARRAY

The transportation problem can be expressed in form of a table and the value of Si, dj and Cij of all the data co-efficients associated with the problems are displayed in the table. This shows an important feature of the standard transportation problem. The constraints and the objective function of the transportation model can be read off directly from the table.

The transportation table for m warehouses and n markets are shown below:

TABLEAU 2.1 TRANSPORTATION TABLEAU

	M_1	M_2	----------------	M_n	S_i
W_1	C_{11} X_{11}	C_{12} X_{12}	----------------	C_{1n} X_{1n}	S_1
W_2	C_{21} X_{21}	C_{22} X_{22}	----------------	C_{2n} X_{2n}	S_2
" " "	" " "	" " "	" " "	" " "	" " "
W_M	C_{m1} X_{m1}	C_{m2} X_{m2}	----------------	C_{mn} X_{mn}	S_m
d_J DEMAND	d_1	d_2	----------------	d_n	$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} d_j$

Where W_1, W_2...................................... Wm are the warehouses (sources)

M_1, M_2...................................... Mn are the markets (Destinations)

In this table, the supply constraints can be obtained by merely equating the sum of all variables in each column to the market demands. The above transportation tableau is for any STANDARD TRANSPORTATION PROBLEM.

Note that for any non-standard problem, where the demands and supplies do not balance, this must be converted to a standard transportation problem before it can be solved. This conversion can be achieved by the use of dummy warehouse or a dummy market.

2.2 ASSUMPTIONS AND DEFINITIONS

2.2.1 THE FOLLOWING ASSUMPTIONS ARE MADE;

(a) All goods must be homogenous, so that any origin is capable of supplying any destination.

(b) The total demand for the destinations must equal to the total that the sources is ready to supply to the market.

$$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} d_j$$

2.2.2 DEFINITIONS

(a) DUMMY WAREHOUSE OR DUMMY MARKET (DUMMY VARIABLE)

It helps in the conversion of non-standard transportation problem into standard transportation problem. The conversion can be achieved by the use of a dummy warehouse r a dummy market. Hence, this dummy variable will have zero unit cost (i.e. Zero Unit Cost will be assigned to each cell).

(b) BASIC FEASIBLE SOLUTION

A feasible solution is one in which assignments are made in such a way that all the supply and demand requirements are satisfied. In general, the number of non-zero (occupied) cells should equal to one less than the sum of the number of rows and the number of columns in a transportation table. In the case of m rows and n columns; the number of basic feasible variables is (m+n-1).

2.3 GENERAL REVIEW OF RELEVANT LITERATURE ON DISTRIBUTION (TRANSPORTATION SYSTEM)

The development of operations research as an integrated body of knowledge began during World War II. The first comprehensive operations research was made in Great Britain and it dealt with such military problem as the right depth at which to denote anti-submarine charges, the proper size of merchant ship convoys and the relationship between losses and the number of planes in a formation. Operations research immigrated to the United State in the early 1940's and was extensively used to solve tactical and strategic military problems. Successful applications by the military during and after the war gave expediency for the use of operations research techniques to study business problems.

Today, the impact of operations research can be felt in many areas. This is indicated by the number of academic institutions offering courses in this subject at all degree levels. Many management consulting firms are currently engaged in operations research activities. These activities have gone beyond military and business applications to include hospitals, financial institutions, libraries, city planning, TRANSPORTATION SYSTEMS, and even crime investigation studies.

However, the major aim of any management is to bring together all the available scarce resources such as money, labour, time and raw materials in order to maximize profit and to reduce the cost of operations. To attain this aim, TRANSPORTATION PROBLEMS have to be taken into consideration that is to device a strategic decision that involves a systematic selection of the transportation route so as to allocate the products to various destinations in the most efficient manner and at a total minimum cost.

At this point, we can now trace the origin of TRANSPORTATION SYSTEM to 1941 when F. L. Hitchcock presented a study entitled "The Distribution of the product from several sources to numerous localities". This presentation was published in the journal of Mathematical Physics, Vol. 20, 1941. It was considered to be the first important contribution to the solution of transportation problems.

Also in 1947, T. C. Koopman presented a study related to Hitchcook's called "Optimum Utilization of the Transportation system". These two contributions helped in the development of transportation methods, which involves a number of shipping sources and a number of destinations.

CHAPTER THREE

3.0 METHODOLOGY & DATA PRESENTATION

3.1 FINDING AN INITIAL FEASIBLE SOLUTION

A feasible solution is one in which assignments are made in such a way that all supply and demand requirement are satisfied. In general, the number of non-zero (occupied) cells should equal one less than the sum of the number of rows and the number of columns in a transportation tableau. In the case of m rows and n columns; the number of basic feasible variables is (m+n-1).

Simple method of linear program can be used to solve the problem but because of its special feature, an easier method is adopted and this makes use of the transportation tableau using different methods to generate initial feasible solution.

The methods to be considered in this project work in finding an initial feasible solution includes:

(i) North - West Corner Rule.

(ii) Least Cost Rule (An intuitive approach)

(iii) Vogel's Approximation method (VAM)

3.1.1 NORTH - WEST CORNER RULE METHOD

The North-west corner rule method is a systematic approach for developing an initial feasible solution through the following steps:

STEP I: Starting with the variable X_{11} at upper left hand cell (the North-west corner) of the table, allocate as many units as possible to the cell. This will be the minimum of the row supply and the column demand i.e. Min (Si, dj).

STEP II: Remain in a row or column until its supply or demand is completely exhausted or satisfied, allocating the minimum number of units to each cell in turn.

STEP III: Check to see that all row requirements has been satisfied.

3.1.2 LEAST COST RULE METHOD

This approach is also known as INTUITIVE APPROACH. It uses lowest cell cost as the basis for selecting routes. The steps below explain better:

STEP I: Identifying the cell that has the lowest unit cost. If there is a tie, select one arbitrarily. Allocate a quantity to this cell that is equal to the lower of the available supply for the row and demand for the columns.

STEP II: Cross out the cells in the row or column that has been exhausted (if both have been exhausted), adjust the remaining row or column total accordingly.

STEP III: Identifying the cell with the lowest cost from the remaining cells. Allocate a quantity to this cell that is equal to the lower of the available supply of the row and demand for the column.

STEP IV: Repeat steps 2 and 3 until all supply and demand have been allocated.

3.1.3 VOGEL APPROXIMATION METHOD (VAM) OR PENALTY METHOD

Vogel Approximation method has been a popular criterion for so many years and it is sometimes called penalty method It is used upon the concept of minimizing opportunity cost. The opportunity cost for a given supply row or demand column is defined as the difference between the lowest-cost and second -lowest-cost.

Moreover, (VAM) happens to be one of the best methods of finding the initial feasible solution. This is due to the fact that its initial associated transportation cost is normally close to the optimal solution of the first or second iteration.

The steps to the VAM are as follows:

STEP I: For each row and column, select the lowest-cost and second-lowest-cost alternatives from among those already not allocated. The difference between these two costs will be the opportunity cost for the row or column.

STEP II: Look for. these opportunity-cost figures and identify the row or column with the largest opportunity cost. If ties exist between two rows or columns, select one arbitrarily. Allocate as many units as possible to this row or column in the square with the least cost.

STEP III: Repeat step 1 and step 2 until the initial solution is feasible.

3.2 IMPROVEMENT ON INITIAL FEASIBLE SOLUTION

The methods like North-West corner rule, Least cost rule and Vogel Approximation for determining an initial feasible solution to transportation problem has already been discussed. Importantly, to improve on these methods let us look into some other methods which can give the best optimal solution and these are:

(i) Modified Distribution Algorithm

(ii) Stepping Stone Algorithm.

3.2.1 MODIFIED DISTRIBUTION (MODI) ALGORITHM

The MODI method is very similar to the stepping stone method except that it provides a more efficient means for comparing the improvement indices for the empty cell (unused squares). The major difference between these two methods concerns that steps in the problem solution at which the closed paths are traced.

In order to calculate the improvement indices for a particular solution; It was necessary in the stepping stone method to trace a closed path for each empty cell. The empty cell with the most improvement potential (the most negative value) was then selected to enter the solution.

In the MODI method, however, the improvement indices can be calculated without drawing the closed paths. The MODI, in fact requires tracing only one closed path. This path is drawn after the empty cell with the highest improvement index has been identified.

The steps are as follows:

STEP I: For each solution, compute the row R and column K values for the table using the formula $R_i + k_j = C_{ij}$; (the cost at the stone square ij) Row one is always set equal to zero i.e. $R_1 = 0$.

STEP II: Calculate the improvement indices for all empty cells squared using

Cij (Cost of empty cell) - Ri - Kj = Improvement index.

STEP III: If all the indices are greater than or equal to zero, the optimal solution is obtained i.e. $C_{ij} - R_i - K_j \geq 0$, otherwise select the empty cell with most negative index and proceed to step IV.

STEP IV: Beginning with the selected most negative empty cell, trace a close path (moving horizontally and vertically) from this empty cell via stone squares (used squares) back to the original empty cell. Only one closed path exists for each empty cell in a given solution. Although the path may skip over non-empty (stone) or empty cells and may cross over itself; corners of the closed path may occur only at the stone squares and the unused square (empty cell) being evaluated.

STEP V: Assign plus (+) and minus (-) signs alternatively at each corner

STEP V: Assign plus (+) and minus (-) signs alternatively at each corner square of the closed path, beginning with a clockwise or a anticlockwise direction. The positive and negative sings represent the addition or subtraction of one unit to a cell.

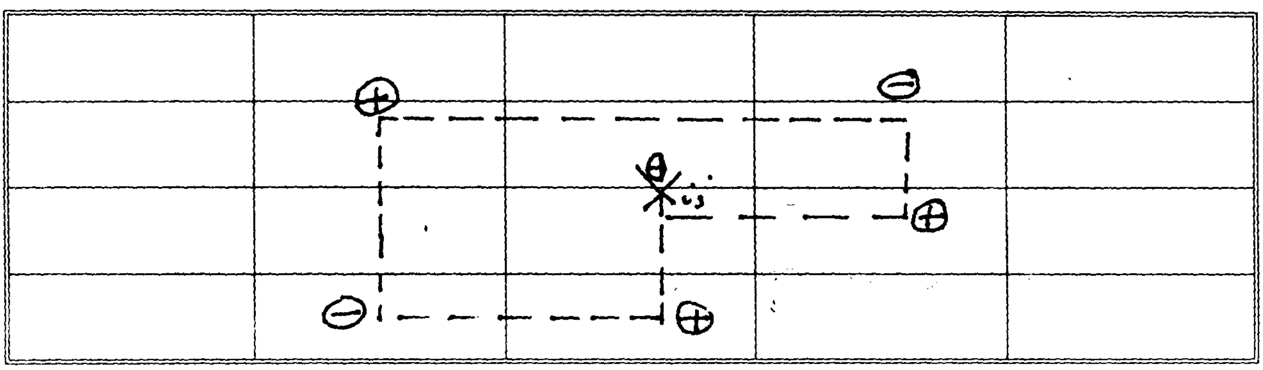
STEP VI: Determine the next change in costs as a result of the changes made in tracing the path. Summing the unit cost in each cell with a plus sign will give the addition to cost. The decrease in cost is obtained by summing the unit cost in each cell with a negative signs.

STEP VII: Develop a new solution and go to step 1. (To develop a new solution, we shift a smaller quantity of the stones that have negative figure to the most negative cell of the improvement index).

STEP VII: Repeat the above steps until the solution is optimal i.e. the improvement index is greater than or equal to zero, i.e.

$(C_{ij} - R_i - K_j \geq 0)$

ILLUSTRATION



3.3 DATA PRESENTATION

TABLEAU 3.1

DESTINATION	WEEKLY DEMAND (in cartons)
1. KANO	350
2. KATSINA	450
3. ONITSHA	270
4. SAPELE	180
5. LAGOS	250
TOTAL	1,500

For efficient distribution of her product, the management of INTERNATIONAL TOBACCO COMPANY (ITC) needs the services of transporting firms.

Hence three transporting firms were connected at three different locations in Ilorin and each gives bid per unit of carton on the quantity they are allocated to supply. The bids in Naira (=N=) are given below.

The first firm bids 100, 104, 101, 141 and 55 to KANO, KATSINA, ONITSHA, SAPELE, and LAGOS respectively and the firm is allocated 500 cartons to be supplied.

The second firm bids 90, 94, 91, 127, and, 49 to KANO, KATSINA. ONITSHA, SAPELE and LAGOS respectively and the firm is allocated 600 cartons to be supplied.

The third firm bids 105, 109, 106, 148 and 58 to KANO, KATSINA, ONITSHA, SAPELE, and LAGOS respectively and the firm is allocated 400 cartons to be supplied.

The following are the various bids of the transporting firms in matrix form.

TABLEAU 3.2

	KANO	KATSINA	ONITSHA	SAPELE	LAGOS	SUPPLY ALLOCATION
IRM1	100	104	101	141	55	500
)EMAND	350	450	270	180	250	

TABLEAU 3.3

	KANO	KATSINA	ONITSHA	SAPELE	LAGOS	SUPPLY ALLOCATION
FIRM2	90	94	91	127	49	600
DEMAND	350	450	270	180	250	

TABLEAU 3.4

	KANO	KATSINA	ONITSHA	SAPELE	LAGOS	SUPPLY ALLOCATION
FIRM3	105	109	106	148	58	400
DEMAND	350	450	270	180	250	

The table below shows the combined cost matrix called balanced transportation tableau since total supply equals to total demand.

TABLEAU 3.5 BALANCED TRANSPORTATION TABLEAU

	KANO	KATSINA	ONITSHA	SAPELE	LAGOS	SUPPLY ALLOCATION
M 1	100	104	101	141	55	500
M 2	90	94	91	127	49	600
M 3	105	109	106	148	58	400
MAND	350	450	270	180	250	1,500

For easy computation let:

FIRM 1 = SOURCE 1 = S_1
FIRM 2 = SOURSE 2 = S_2
FIRM 3 = SOURSE 3 = S_3

KANO = DEMAND 1 = d_1
KATSINA = DEMAND 2 = d_2
ONITSHA = DEMAND 3 = d_3
SAPELE = DEMAND 4 = d_4
LAGOS = DEMAND 5 = d_5

Where

DEMAND = d_j

SUPPLY ALLOCATION = S_i

Therefore tableau 3.5 now becomes

TABLEAU 3.6

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104	101	141	55	500
S_2	90	94	91	127	49	600
S_3	105	109	106	148	58	400
d_J	350	450	270	180	250	1,500

TABLEAU 3.7

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100 X_{11}	104 X_{12}	101 X_{13}	141 X_{14}	55 X_{15}	500
S_2	90 X_{21}	94 X_{22}	91 X_{23}	127 X_{24}	49 X_{25}	600
S_3	105 X_{31}	109 X_{32}	106 X_{33}	148 X_{34}	58 X_{35}	400
d_J	350	450	270	180	250	1,500

At this point, the tableau 3.6 and 3.7 are the required Standard Balanced Transportation Tableau that is needed in determining the INITIAL FEASIBLE SOLUTION through the analysis that will be carried out in chapter four.

CHAPTER FOUR

4.0 DATA ANALYSIS

TABLE 4.1 TRANSPORTATION TABLEAU

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100 X_{11}	104 X_{12}	101 X_{13}	141 X_{14}	55 X_{15}	500
S_2	90 X_{21}	94 X_{22}	91 X_{23}	127 X_{24}	49 X_{25}	600
S_3	105 X_{31}	109 X_{32}	106 X_{33}	148 X_{34}	58 X_{35}	400
d_j	350	450	270	180	250	1,500

The above information can be expressed as a Linear Programming Problem (LPP). This is shown below:

$$\text{Min } Z = 100X_{11} + 104X_{12} + 101X_{13} + 141X_{14} + 55X_{15}$$
$$+ 90X_{21} + 94X_{22} + 91X_{23} + 127X_{24} + 49X_{25}$$
$$+ 105X_{31} + 109X_{32} + 106X_{33} + 148X34 + 58X_{35}$$

Subject to :

$X_{11} + X_{12} + X_{13} + X_{14} + X_{15} = 500$

$X_{21} + X_{22} + X_{23} + X_{24} + X_{25} = 600$

$X_{31} + X_{32} + X_{33} + X_{34} + X_{35} = 400$

$X_{11} + X_{21} + X_{31} = 350$

$X_{12} + X_{22} + X_{23} = 450$

$X_{13} + X_{23} + X_{33} = 270$

$X_{14} + X_{24} + X_{34} = 180$

$X_{15} + X_{25} + X_{35} = 250$

$X_{ij} \geq 0$, for all pairs (i, j)

4.1 DETERMINATION OF INITIAL FEASIBLE SOLUTION

All the three methods of finding the initial feasible solution discussed in chapter three shall now be used to analyze the already presented data.

4.1.1 FINDING AN INITIAL FEASIBLE SOLUTION USING NORTH WEST CORNER RULE METHOD

Using the steps enumerated in chapter three on North-West corner rule for Tableau 3.6.

TABLEAU 4.2

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100 350	104 150	101	141	55	500
S_2	90	94 300	91 270	127 30	49	600
S_3	105	109	106	148 150	58 250	400
d_j	350	450	270	180	250	1,500.

The solution is feasible with

Total cost Z = 100(350) + 104(150) + 94(300) + 91(270)

+ 127(30) + 148(150) + 58(250)

= **=N=143,880**

4.1.2 FINDING AN INITIAL FEASIBLE SOLUTION USING LEAST COST RULE METHOD

Using the steps enumerated in chapter three on least cost rule for Tableau 3.6:

TABLEAU 4.3

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104	101	141	55	500
S_2	90	94	91	127	49 250	350
S_3	105	109	106	148	58	400
d_J	350	450	270	180	0	

TABLEAU 4.4

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104	101	141	55	500
S_2	90 350	94	91	127	49 250	0
S_3	105	109	106	148	58	400
d_J	0	450	270	180	0	

TABLEAU 4.5

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104	101 270	141	55	230
S_2	90 350	94	91	127	49 250	0
S_3	105	109	106	148	58	400
d_J	0	450	0	180	0	

TABLEAU 4.6

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104 230	101 270	141	55	0
S_2	90 350	94	91	127	49 250	0
S_3	105	109	106	148	58	400
d_J	0	220	0	180	0	

TABLEAU 4.7

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104 230	101 270	141	55	0
S_2	90 350	94	91	127	49 250	0
S_3	105	109 220	106	148	58	180
d_J	0	0	0	180	0	

TABLEAU 4.8

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104 230	101 270	141	55	0
S_2	90 350	94	91	127	49 250	0
S_3	105	109 220	106	148 180	58	0
d_j	0	0	0	0	0	

The solution is not feasible since (m+n-1) $\neq$ 7, but to restore the feasibility assign zero to any empty cell that has the most minimum cost.

TABLEAU 4.9

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104 230	101 270	141	55 0	0
S_2	90 350	94	91	127	49 250	0
S_3	105	109 220	106	148 180	58	0
d_j	0	0	0	0	0	

The solution is now feasible with

Total cost z = 104(230) + 101(270) + 55(0) + 90(350) + 49(250)

+ 109(220) + 148(180)

= **=N=145,560**

Remark that, the basic solution in table 4.9 include six positive variables and one zero variable. This means that the starting basic solution is DEGENERATE, that is, at least one basic variable equal zero. Degeneracy, however, presents no special problem in solving the problem, since the basic variable can be treated as any of the positive basic variables.

4.1.3 FINDING AN INITIAL FESIBLE SOLUTION USING VOGEL APPROXIMATION METHOD (VAM)

Using the steps enumerated in chapter three on VAM for Tableau 3.6

TABLEAU 4.10

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
S_1	100	104	101	141	55	500	45
S_2	90	94	91	127	49	600	41
S_3	105	109	106	148	58	400	47
d_j	350	450	270	180	250		
Column Penalty	10	10	10	14	6		

TABLEAU 4.11

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
S_1	100	104	101	141	55	500	1
S_2	90	94	91	127	49	600	1
S_3	105	109	106	148	58 250	150	1
d_j	350	450	270	180	0		
Column Penalty	10	10	10	14	*		

TABLEAU 4.12

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
S_1	100	104	101	141	55	500	1
S_2	90	94	91	127 180	49	420	1
S_3	105	109	106	148	58 250	150	1
d_j	350	450	270	0	0		
Column Penalty	10	10	10	*	*		

TABLEAU 4.13

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
S_1	100	104	101	141	55	500	3
S_2	90 350	94	91	127 180	49	70	3
S_3	105	109	106	148	58 250	150	3
d_j	0	450	270	0	0		
Column Penalty	*	10	10	*	*		

TABLEAU 4.14

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
S_1	100	104	101	141	55	500	3
S_2	90 350	94	91 70	127 180	49	0	*
S_3	105	109	106	148	58 250	150	3
d_j	0	450	200	0	0		
Column Penalty	*	5	5	*	*		

TABLEAU 4.15

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
	100	104	101 200	141	55	300	104
2	90 350	94	91 70	127 180	49	0	*
3	105	109	106	148	58 250	400	109
d_j	0	450	0	0	0		
Column Penalty	*	5	*	*	*		

TABLEAU 4.16

	d_1	d_2	d_3	d_4	d_5	S_i	Row Penalty
S_1	100	104 300	101 200	141	55		*
S_2	90 350	94	91 70	127 180	49	0	*
S_3	105	109 150	106	148	58 250	0	*
d_j	0	0	0	0	0		
Column Penalty	*	*	*	*	*		

The solution is feasible with

Total Cost Z = 104(300) + 101(200) + 90(350) + 91(70) + 127(180)

+ 109(150) + 58(250)

= **=N=142,980**

4.2 PROCESSING TO THE OPTIMAL FEASIBLE SOLUTION

It has been stated earlier in chapter three that the initial feasible solution is the solution which can still be improved on. At this point the MODIFIED DISTRIBUTION (MODI) ALGORITHM discussed in chapter three will be used for further improvement on initial feasible solutions.

4.2.1 IMPROVEMENT ON INITIAL FEASIBLE SOLUTION PROVIDED BY NORTH WEST CORNER RULE METHOD.

TABLEAU 4.17

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100 350	104 150	101	141	55	500
S_2	90	94 300	91 270	127 30	49	600
S_3	105	109	106	148 150	58 250	400
d_j	350	450	270	180	250	

FIRST ITERATION

Compute $R_i + K_j = C_{ij}$ to obtain table 4.18

$R_1 + K_1 = 100$ ....(1)

$R_1 + K_2 = 104$ ....(2)

$R_2 + K_2 = 94$ ....(3)

$R_2 + K_3 = 91$ ....(4)

$R_2 + K_4 = 127$ ....(5)

$R_3 + K_4 = 148$ ....(6)

$R_3 + K_5 = 58$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_1 = 100$

$k_1 = 100$ $\therefore k_1 = 100$

From eqt(2)

$R_1 + k_2 = 104$

$k_2 = 104$ $\therefore k_2 = 104$

From eqt(3)

$R_2 + k_2 = 94$

$R_2 + 104 = 94$

$R_2 = -10$ $\therefore R_2 = -10$

From eqt(4)

$R_2 + k_3 = 91$

$-10 + k_3 = 91$

$k_3 = 101$ $\therefore k_3 = 101$

From eqt(5)

$R_2 + k_4 = 127$

$-10 + k_4 = 127$

$k_4 = 137$ $\therefore k_4 = 137$

From eqt(6)

$R_3 + k_4 = 148$

$R_3 + 137 = 148$

$R_3 = 11$ $\therefore R_3 = 11$

From eqt(7)

$R_3 + k_5 = 58$

$11 + k_5 = 58$

$k_5 = 47$ $\therefore k_5 = 47$

The evaluations of the non-basic variables are thus given as follows by computing the improvement indices for the empty cells;

$$\text{i.e. } X_{ij} \Rightarrow C_{ij} - R_i - K_j = \geq \Delta_{ij}$$

Therefore

$X_{13} \Rightarrow C_{13} - R_1 - K_3 = 101 - 0 - 101 = 0$

$X_{14} \Rightarrow C_{14} - R_1 - K_4 = 141 - 0 - 137 = 4$

$X_{15} \Rightarrow C_{15} - R_1 - K_5 = 55 - 0 - 47 = 8$

$X_{21} \Rightarrow C_{21} - R_2 - K_1 = 90 - (-10) - 100 = 0$

$X_{25} \Rightarrow C_{25} - R_2 - K_5 = 49 - (-10) - 47 = 12$

$X_{31} \Rightarrow C_{31} - R_3 - K_1 = 105 - 11 - 100 = -6$

$X_{32} \Rightarrow C_{31} - R_3 - K_1 = 109 - 11 - 104 = -6$

$X_{33} \Rightarrow C_{33} - R_3 - K_3 = 106 - 11 - 101 = -6$

The solution is not optimal since $C_{ij} - R_i - k_j \geq 0$ (i.e Having negative value)

X_{31}, X_{32} and X_{33} are non-basic variables having the most negative values (-6). Since there is tie, pick one arbitrarily to be the entries variables. Assuming X_{31} is picked, this implies that X_{31} is the entering variable.

Then construct a closed loop to make the necessary adjustment in the allocation. The new tableau becomes

TABLEAU 4.18

	$k_1 = 100$ d_1	$k_2 = 104$ d_2	$k_3 = 101$ d_3	$k_4 = 137$ d_4	$k_5 = 47$ d_5	S_i
$R_1 = 0$ S_1	100 (−) 350	104 (+) 150	101	141	55	500
$R_2 = -10$ S_2	90	94 (−) 300	91 270	127 (+) 30	49	600
$R_3 = 11$ S_3	105 (+) X_{13}	109	106	148 (−) 150	58 250	400
d_j	350	450	270	180	250	

Adjusting according to the associated signs, X_{34} is chosen as the leaving variable and the new solution is shown in the tableau 4.19

TABLEAU 4.19

	$k_1 = 100$ d_1	$k_2 = 104$ d_2	$k_3 = 101$ d_3	$k_4 = 137$ d_4	$k_5 = 47$ d_5	S_i
$R_1 = 0$ S_1	100 200	104 300	101	141	55	500
$R_2 = -6$ S_2	90	94 150	91 270	127 180	49	600
$R_3 = 5$ S_3	105 150	109	106	148	58 250	400
d_j	350	450	270	180	250	

SECOND ITERATION

Also compute $R_i + k_j = C_{ij}$

Therefore

$R_1 + k_1 = 100$ ....(1)

$R_1 + k_2 = 104$ ....(2)

$R_2 + k_2 = 94$ ....(3)

$R_2 + k_3 = 91$ ....(4)

$R_2 + k_4 = 127$ ....(5)

$R_3 + k_1 = 105$ ....(6)

$R_3 + k_5 = 58$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$$R_1 + k_1 = 100$$

$$k_1 = 100 \qquad \therefore k_1 = 100$$

From eqt(2)

$$R_1 + k_2 = 104$$

$$k_2 = 104 \qquad \therefore k_2 = 104$$

From eqt(3)

$$R_2 + k_2 = 94$$

$$R_2 + 104 = 94$$

$$R_2 = -10 \qquad \therefore R_2 = -10$$

From eqt(4)

$$R_2 + k_3 = 91$$

$$-10 + k_3 = 91$$

$$k_3 = 101 \qquad \therefore k_3 = 101$$

From eqt(5)

$$R_2 + k_4 = 127$$

$$-10 + k_4 = 127$$

$$k_4 = 137 \qquad \therefore k_4 = 137$$

From eqt(6)

$$R_3 + k_1 = 105$$

$$R_3 + 100 = 105$$

$R_3 = 5 \quad \therefore R_3 = 5$

From eqt(7)

$R_3 + k_5 = 58$

$5 + k_5 = 58$

$k_5 = 53 \quad \therefore k_5 = 53$

The evaluation of the non-basic variables are thus given as follows by the computing the improvement indices for the empty cells;

Then

$X_{13} \Rightarrow C_{13} - R_1 - K_3 = 101 - 0 - 101 = 0$

$X_{14} \Rightarrow C_{14} - R_1 - K_4 = 141 - 0 - 137 = 4$

$X_{15} \Rightarrow C_{15} - R_1 - K_4 = 55 - 0 - 53 = 2$

$X_{21} \Rightarrow C_{21} - R_2 - K_1 = 90 -(-10) - 100 = 0$

$X_{25} \Rightarrow C_{25} - R_2 - K_5 = 49 -(-10) - 53 = 6$

$X_{32} \Rightarrow C_{32} - R_3 - K_2 = 109 - 5 - 104 = 0$

$X_{33} \Rightarrow C_{33} - R_3 - K_3 = 106 - 5 - 101 = 0$

$X_{34} \Rightarrow C_{34} - R_3 - K_4 = 148 - 5 - 137 = 6$

From above, it shows that the solution in Table 4.19 is optimal since

$C_{ij} - R_i - k_j \quad 0$ for all i and j. Hence table 4.19 is the final optimal basic feasible solution with

Total Cost Z = 100(200) + 104(300) + 94(150) + 91(270) + 127(180) + 105(150) + 58(250)

= **=N=142,980**

4.2.2 IMPROVEMENT ON INTITIAL FEASIBLE SOLUTION PROVIDED BY LEAST COST RULE METHOD

TABLEAU 4.20

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104 230	101 270	141	55 0	500
S_2	90 350	94	91	127	49 250	600
S_3	105	109 220	106	148 180	58	400
d_j	350	450	270	180	250	

FIRST ITERATION

Compute $R_i + K_j = C_{ij}$

Therefore

$R_1 + k_2 = 104$ ....(1)

$R_1 + k_3 = 101$ ....(2)

$R_1 + k_5 = 55$ ....(3)

$R_2 + k_1 = 90$ ....(4)

$R_2 + k_5 = 49$ ....(5)

$R_3 + k_2 = 109$ ....(6)

$R_3 + k_4 = 148$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_2 = 104$

$k_2 = 104$ $\therefore k_2 = 104$

From eqt(2)

$R_1 + k_3 = 101$

$k_3 = 101$ $\therefore k_3 = 101$

From eqt(3)

$R_1 + k_5 = 55$

$k_5 = 55$ $\therefore k_5 = 55$

From eqt(4)

$R_2 + k_1 = 90$

$-6 + k_1 = 90$

$k_1 = 96$ $\therefore k_1 = 96$

From eqt(5)

$R_2 + k_5 = 49$

$R_2 + 55 = 49$

$R2 = -6$ $\therefore R_2 = -6$

From eqt(6)

$R_3 + k_2 = 109$

$R_3 + 104 = 109$

$R_3 = 5 \qquad \therefore R_3 = 5$

From eqt(7)

$R_3 + k_4 = 148$

$5 + k_4 = 148$

$k_4 = 143 \qquad \therefore k_4 = 143$

The evaluations of the non-basic variables are thus given as follows:

$X_{11} \Rightarrow C_{11} - R_1 - K_1 = 100 - 0 - 96 = 4$

$X_{14} \Rightarrow C_{14} - R_1 - K_4 = 141 - 0 - 143 = -2$

$X_{22} \Rightarrow C_{22} - R_2 - K_2 = 94 - (-96) - 104 = -4$

$X_{23} \Rightarrow C_{23} - R_2 - K_3 = 91 - (-6) - 101 = -4$

$X_{24} \Rightarrow C_{24} - R_2 - K_4 = 127 - (-6) - 143 = -10$

$X_{31} \Rightarrow C_{31} - R_3 - K_1 = 105 - 5 - 96 = 4$

$X_{33} \Rightarrow C_{33} - R_3 - K_3 = 106 - 5 - 101 = 0$

$X_{35} \Rightarrow C_{35} - R_3 - K_5 = 58 - 5 - 55 = -2$

The solution is not optimal.

Then X_{24} enters the basis been the most negative of all the non-basic variables.

Construct a closed loop to make the necessary adjustment in the allocation. The new table becomes.

TABLEAU 4.21

	$k_1 = 96$ d_1	$k_2 = 104$ d_2	$k_3 = 101$ d_3	$k_4 = 143$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	[100]	[104] 230 (−)	[101] 270	[141]	[55] 0 (+)	500
$R_2 = -6$ S_2	[90] 350	[94]	[91]	[127] X_{24} (+)	[49] 250 (−)	600
$R_3 = 5$ S_3	[105]	[109] 220 (+)	[106]	[148] 180 (−)	[58]	400
d_j	350	450	270	180	250	

Adjusting according to the associated signs X_{34} is chosen as the leaving variable and the new solution is shown in the table 4.22

TABLEAU 4.22

	$k_1 = 96$ d_1	$k_2 = 104$ d_2	$k_3 = 101$ d_3	$k_4 = 143$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	[100]	[104] 50	[101] 270	[141]	[55] 180	500
$R_2 = -6$ S_2	[90] 350	[94]	[91]	[127] 180	[49] 70	600
$R_3 = 5$ S_3	[105]	[109] 400	[106]	[148]	[58]	400
d_j	350	450	270	180	250	

SECOND ITERATION

Also compute $R_i + K_j = C_{ij}$

Therefore

$R_1 + k_2 = 104$ ....(1)

$R_1 + k_3 = 101$ ....(2)

$R_1 + k_5 = 55$ ....(3)

$R_2 + k_1 = 90$ ....(4)

$R_2 + k_4 = 127$ ....(5)

$R_2 + k_5 = 49$ ....(6)

$R_3 + k_2 = 109$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_2 = 104$

$k_2 = 104$ $\therefore k_2 = 104$

From eqt(2)

$R_1 + k_3 = 101$

$k_3 = 101$ $\therefore k_3 = 101$

From eqt(3)

$R_1 + k_5 = 55$

$k_5 = 55$ $\therefore k_5 = 55$

From eqt(4)

$R_2 + k_1 = 90$

$-6 + k_1 = 90$

$k_1 = 96$ $\therefore k_1 = 96$

From eqt(5)

$$R_2 + k_4 = 127$$

$$-6 + k_4 = 127$$

$$k_4 = 133 \qquad \therefore k_4 = 133$$

From eqt(6)

$$R_2 + k_5 = 49$$

$$R_2 + 55 = 49$$

$$R_2 = -6 \qquad \therefore R_2 = -6$$

From eqt(7)

$$R_3 + k_2 = 109$$

$$R_3 + 104 = 109$$

$$R_3 = 5 \qquad \therefore R_3 = 5$$

The evaluations of the non-basic variables are thus given as follows:

X_{11}	=>	$C_{11} - R_1 - K_1$	$= 100 - 0 - 96$	$= 4$
X_{14}	=>	$C_{14} - R_1 - K_4$	$= 141 - 0 - 133$	$= 8$
X_{22}	=>	$C_{22} - R_2 - K_2$	$= 94 -(-96)-104$	$=-4$
X_{23}	=>	$C_{23} - R_2 - K_3$	$= 91 -(-6) - 101$	$=-4$
X_{31}	=>	$C_{31} - R_3 - K_1$	$= 105 - 5 - 96-$	$= 4$
X_{33}	=>	$C_{33} - R_3 - K_3$	$= 106 - 5 - 101$	$= 0$
X_{34}	=>	$C_{34} - R_3 - K_4$	$= 148 - 5 - 133$	$= 10$
X_{35}	=>	$C_{35} - R_3 - K_5$	$= 58 - 5 - 55$	$= -2$

The solution is not optimal.

The X_{22} enters the basis been the most negative value of all the non-basic variables.

Construct a closed loop to make the necessary adjustments in the allocation then the new table becomes.

TABLEAU 4.23

	$k_1 = 96$ d_1	$k_2 = 104$ d_2	$k_3 = 101$ d_3	$k_4 = 133$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	100	104 ⊖ 50	101 270	141	55 ⊕ 180	500
$R_2 = -6$ S_2	90 350	94 ⊕ X_{22}	91	127 180	49 ⊖ 70	600
$R_3 = 5$ S_3	105	109 400	106	148	58	400
d_j	350	450	270	180	250	

Adjusting according to the associated signs, X_{12} is chosen as the leaving variable and the new solution is shown in the table 4.24

TABLEAU 4.24

	$k_1 = 96$ d_1	$k_2 = 104$ d_2	$k_3 = 101$ d_3	$k_4 = 133$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	100	104	101 270	141	55 230	500
$R_2 = -6$ S_2	90 350	94 50	91	127 180	49 20	600
$R_3 = 5$ S_3	105	109 400	106	148	58	400
d_j	350	450	270	180	250	

THIRD ITERATION

Also compute $R_i + K_j = C_{ij}$

Therefore

$R_1 + k_3 = 101$ ....(1)

$R_1 + k_5 = 55$ ....(2)

$R_2 + k_1 = 90$ ....(3)

$R_2 + k_2 = 94$ ....(4)

$R_2 + k_4 = 127$ ....(5)

$R_2 + k_5 = 49$ ....(6)

$R_3 + k_2 = 109$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_3 = 101$

$k_3 = 101$ $\therefore k_3 = 101$

From eqt(2)

$R_1 + k_5 = 55$

$k_5 = 55$ $\therefore k_5 = 55$

From eqt(3)

$R_2 + k_1 = 90$

$-6 + k_1 = 90$

$k_1 = 96$ $\therefore k_1 = 96$

From eqt(4)

$R_2 + k_2 = 94$

$-6 + k_2 = 94$

$k_2 = 100$ $\therefore k_2 = 100$

From eqt(5)

$R_2 + k_4 = 127$

$-6 + k_4 = 127$

$k_4 = 133$ $\therefore k_4 = 133$

From eqt(6)

$R_2 + k_5 = 49$

$R_2 + 55 = 49$

$R_2 = -6$ $\therefore R_2 = -6$

From eqt(7)

$R_3 + k_2 = 109$

$R_3 + 100 = 109$

$R_3 = 9 \qquad \therefore R_3 = 9$

The evaluations of the non-basic variables are thus given as follows:

$X_{11} \Rightarrow C_{11} - R_1 - K_1 = 100 - 0 - 96 = 4$

$X_{12} \Rightarrow C_{12} - R_1 - K_2 = 104 - 0 - 100 = 4$

$X_{14} \Rightarrow C_{14} - R_1 - K_4 = 141 - 0 - 133 = 8$

$X_{23} \Rightarrow C_{23} - R_2 - K_3 = 91 -(-6) - 101 = -4$

$X_{31} \Rightarrow C_{31} - R_3 - K_1 = 105 - 9 - 96 = 0$

$X_{33} \Rightarrow C_{33} - R_3 - K_3 = 106 - 9 - 101 = -4$

$X_{34} \Rightarrow C_{34} - R_3 - K_4 = 148 - 9 - 133 = 6$

$X_{35} \Rightarrow C_{35} - R_3 - K_5 = 58 - 9 - 55 = -6$

The solution is not optimal.

The X_{35} enters the basis been the most negative value of all the non-basic variables.

Construct a closed loop to make the necessary adjustments in the allocation then the new table becomes.

TABLEAU 4.25

	$k_1 = 96$ d_1	$k_2 = 100$ d_2	$k_3 = 101$ d_3	$k_4 = 133$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	100	104	101 270	141	55 230	500
$R_2 = -6$ S_2	90 350	94 (+) 50	91	127 180	49 (−) 20	600
$R_3 = 9$ S_3	105	109 (−) 400	106	148	58 (+) X_{35}	400
d_j	350	450	270	180	250	

Adjusting according to the associated signs, X_{25} is chosen as the leaving variable and the new solution is shown in the table 4.26

TABLEAU 4.26

	$k_1 = 96$ d_1	$k_2 = 100$ d_2	$k_3 = 101$ d_3	$k_4 = 133$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	100	104	101 270	141	55 230	500
$R_2 = -6$ S_2	90 350	94 70	91	127 180	49	600
$R_3 = 9$ S_3	105	109 380	106	148	58 20	400
d_j	350	450	270	180	250	

FOURTH ITERATION

Compute $R_i + K_j = C_{ij}$

Therefore

$R_1 + k_3$	=	101	..............................(1)
$R_1 + k_5$	=	55	..............................(2)
$R_2 + k_1$	=	90	..............................(3)
$R_2 + k_2$	=	94	..............................(4)
$R_2 + k_4$	=	127	..............................(5)
$R_3 + k_2$	=	109	..............................(6)
$R_3 + k_5$	=	58	..............................(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_3 = 101$

$k_3 = 101$ $\therefore k_3 = 101$

From eqt(2)

$R_1 + k_5 = 55$

$k_5 = 55$ $\therefore k_5 = 55$

From eqt(3)

$R_3 + k_1 = 90$

$-12 + k_1 = 90$

$k_1 = 102$ $\therefore k_1 = 102$

From eqt(4)

$R_2 + k_2 = 94$

$R_2 + 106 = 94$

$R_2 = -12$ $\therefore R_2 = -12$

From eqt(5)

$R_2 + k_4 = 127$

$-12 + k_4 = 127$

$k_4 = 139 \qquad \therefore k_4 = 139$

From eqt(6)

$R_2 + k_5 = 109$

$3 + K_2 = 109$

$K_2 = 106 \qquad \therefore K_2 = 106$

From eqt(7)

$R_3 + k_5 = 58$

$R_3 + 55 = 58$

$R_3 = 3 \qquad \therefore R_3 = 3$

The evaluations of the non-basic variables are thus given as follows:

$X_{11} \Rightarrow C_{11} - R_1 - K_1 = 100 - 0 - 102 = -2$

$X_{12} \Rightarrow C_{12} - R_1 - K_2 = 104 - 0 - 106 = -2$

$X_{14} \Rightarrow C_{14} - R_1 - K_4 = 141 - 0 - 139 = 2$

$X_{23} \Rightarrow C_{23} - R_2 - K_3 = 91 -(-12) - 101 = 2$

$X_{25} \Rightarrow C_{25} - R_2 - K_5 = 49 -(-12) - 55 = 6$

$X_{31} \Rightarrow C_{31} - R_3 - K_1 = 105 - 3 - 102 = 0$

$X_{33} \Rightarrow C_{33} - R_3 - K_3 = 106 - 3 - 101 = 2$

$X_{34} \Rightarrow C_{34} - R_3 - K_4 = 148 - 3 - 139 = 6$

The solution is not optimal.

The X_{11} enters the basis been the most negative value of all the non-basic variables.

Construct a closed loop to make the necessary adjustments in the allocation then the new table becomes.

TABLEAU 4.27

	$k_1 = 102$ d_1	$k_2 = 106$ d_2	$k_3 = 101$ d_3	$k_4 = 139$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	100 (+) X_{11}	104	101 270	141	55 (−) 230	500
$R_2 = -12$ S_2	90 (−) 350	94 (+) 70	91	127 180	49	600
$R_3 = 3$ S_3	105	109 (−) 380	106	148	58 20 (+)	400
d_j	350	450	270	180	250	

Adjusting according to the associated signs, X_{15} is chosen as the leaving variable and the new solution is shown in the table 4.28

TABLEAU 4.28

	$k_1 = 102$ d_1	$k_2 = 106$ d_2	$k_3 = 101$ d_3	$k_4 = 139$ d_4	$k_5 = 55$ d_5	S_i
$R_1 = 0$ S_1	100 / 230	104	101 / 270	141	55	500
$R_2 = -12$ S_2	90 / 120	94 / 300	91	127 / 180	49	600
$R_3 = 3$ S_3	105	109 / 150	106	148	58 / 250	400
d_j	350	450	270	180	250	

FIFTH ITERATION

Compute $R_i + K_j = C_{ij}$

Therefore

$R_1 + k_1 = 100$ ....(1)

$R_1 + k_3 = 101$ ....(2)

$R_2 + k_1 = 90$ ....(3)

$R_2 + k_2 = 94$ ....(4)

$R_2 + k_4 = 127$ ....(5)

$R_3 + k_2 = 109$ ....(6)

$R_3 + k_5 = 58$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_1 = 100$

$k_1 = 100$ $\quad\therefore k_1 = 101$

From eqt(2)

$R_1 + k_3 = 101$

$k_3 = 101$ $\quad\therefore k_3 = 101$

From eqt(3)

$R_2 + k_1 = 90$

$R_2 + 100 = 90$

$R_2 = -10$ $\quad\therefore R_2 = -10$

From eqt(4)

$R_2 + k_2 = 94$

$-10 + k_2 = 94$

$k_2 = 104$ $\quad\therefore k_2 = 104$

From eqt(5)

$R_2 + k_4 = 127$

$-10 + k_4 = 127$

$k_4 = 137$ $\quad\therefore k_4 = 137$

From eqt(6)

$R_3 + k_5 = 109$

$R_3 + 104 = 109$

$R_3 = 5$ $\quad\therefore R_3 = 5$

From eqt(7)

$R_3 + k_5 = 58$

$5 + K_5 = 58$

$k_5 = 53$ $\therefore k_5 = 53$

The evaluations of the non-basic variables are thus given as follows:

X_{12}	=>	$C_{12} - R_1 - K_2$	= 104 - 0 - 104	= 0
X_{14}	=>	$C_{14} - R_1 - K_4$	= 141 - 0 - 137	= 4
X_{15}	=>	$C_{15} - R_1 - K_5$	= 55 - 0 - 53	= 2
X_{23}	=>	$C_{23} - R_2 - K_3$	= 91 -(-10) - 101	=0
X_{25}	=>	$C_{25} - R_2 - K_5$	= 49 -(-10) = 53	=6
X_{31}	=>	$C_{31} - R_3 - K_1$	= 105 - 5 - 100	= 0
X_{33}	=>	$C_{33} - R_3 - K_3$	= 106 - 5 - 101	= 0
X_{34}	=>	$C_{34} - R_3 - K_4$	= 148 - 5 - 137	= 6

From the above, it shows that the solution in table 4.28 is optimal since $C_{ij} - R_i - K_j$ _ 0, for all i and j. Hence table 4.28 is the final optimal basic feasible solution with.

Total Cost Z = 100(230) + 101(270) + 90(120) + 94(300) + 127(180)

+ 109(150) + 58(250)

= **=N=142,980**

IMPROVEMENT ON INITIAL FEASIBLE SOLUTION PROVIDED BY VOGEL APPROXIMATION METHOD (VAM)

TABLEAU 4.29

	d_1	d_2	d_3	d_4	d_5	S_i
S_1	100	104 300	101 200	141	55	500
S_2	90 350	94	91 70	127 180	49	600
S_3	105	109 150	106	148	58 250	400
d_j	350	450	270	180	250	

Compute $R_i + K_j = C_{ij}$

Therefore

$R_1 + k_2 = 104$ ....(1)

$R_1 + k_3 = 101$ ....(2)

$R_2 + k_1 = 90$ ....(3)

$R_2 + k_3 = 91$ ....(4)

$R_2 + k_4 = 127$ ....(5)

$R_3 + k_2 = 109$ ....(6)

$R_3 + k_5 = 58$ ....(7)

Setting $R_1 = 0$

From eqt(1)

$R_1 + k_2 = 104$

$k_2 = 104$ $\therefore k_2 = 104$

From eqt(2)

$R_1 + k_3 = 101$

$k_3 = 101$ $\therefore k_3 = 101$

From eqt(3)

$R_2 + k_1 = 90$

$-10 + k_1 = 90$

$k_1 = 100$ $\therefore k_1 = 100$

From eqt(4)

$R_2 + k_3 = 91$

$R_2 + 101 = 91$

$R_2 = -10$ $\therefore R_2 = -10$

From eqt(5)

$R_2 + k_4 = 127$

$-10 + k_4 = 127$

$k_4 = 137$ $\therefore k_4 = 137$

From eqt(6)

$R_3 + k_2 = 109$

$R_3 + 104 = 109$

$R_3 = 5$ $\therefore R_3 = 5$

From eqt(7)

$R_3 + k_5 = 58$

$5 + K_5 = 58$

$k_5 = 53$ $\therefore k_5 = 53$

The evaluations of the non-basic variables are thus givens follows:

$X_{11} \Rightarrow C_{11} - R_1 - K_2 = 100 - 0 - 100 = 0$

$X_{14} \Rightarrow C_{14} - R_1 - K_4 = 141 - 0 - 137 = 4$

$X_{15} \Rightarrow C_{15} - R_1 - K_5 = 55 - 0 - 53 = 2$

$X_{22} \Rightarrow C_{23} - R_2 - K_2 = 94 - (-10) - 104 = 0$

$X_{25} \Rightarrow C_{25} - R_2 - K_5 = 49 - (-10) - 53 = 6$

$X_{31} \Rightarrow C_{31} - R_3 - K_1 = 105 - 5 - 100 = 0$

$X_{33} \Rightarrow C_{33} - R_3 - K_3 = 106 - 5 - 101 = 0$

$X_{34} \Rightarrow C_{34} - R_3 - K_4 = 148 - 5 - 137 = 6$

From the above, it shows that the solution in table 4.29 is optimal since Cij - Ri - Kj _ 0, for all i and j. Hence table 4.29 is the final optimal basic feasible solution with.

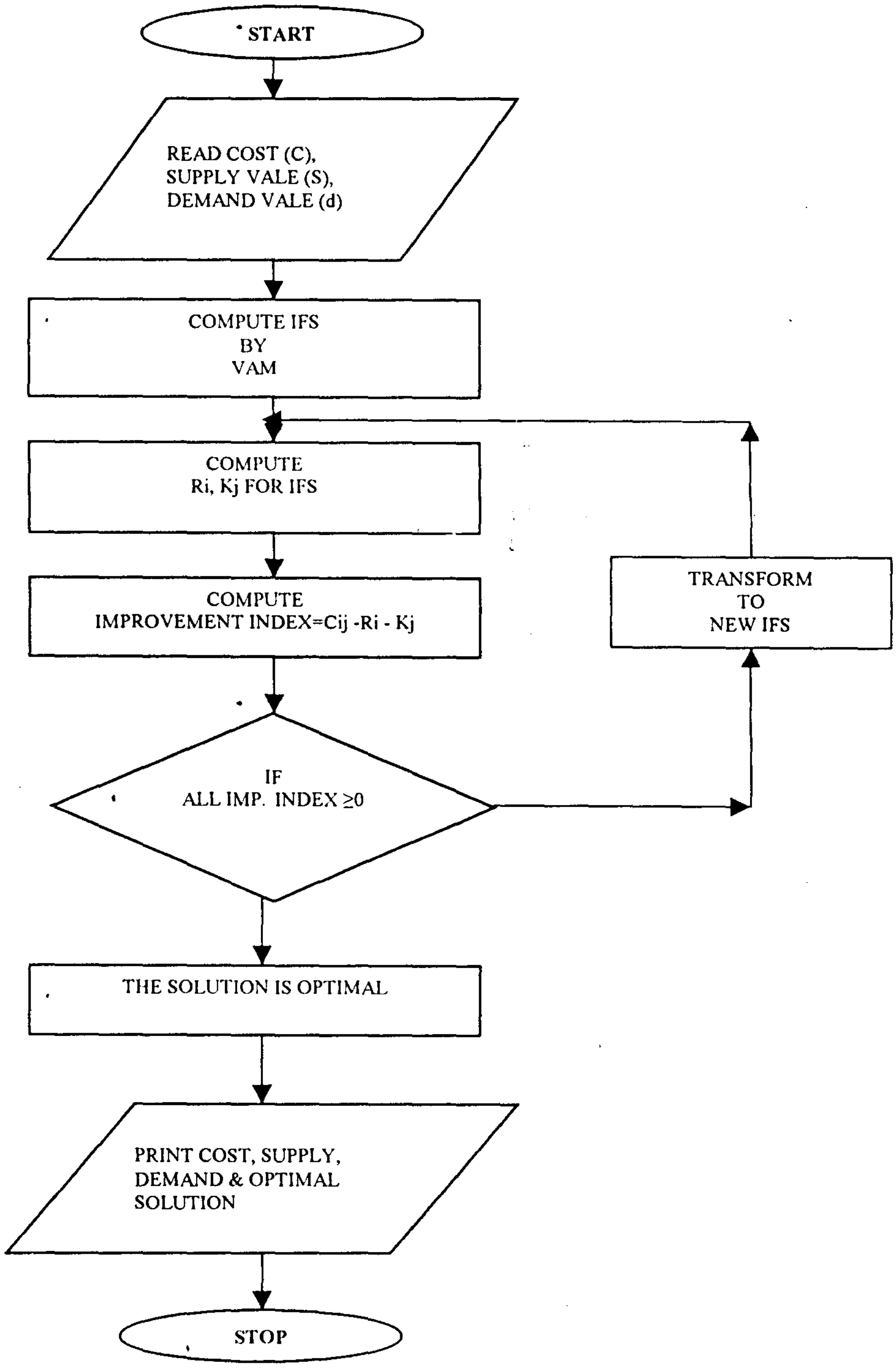
Total Cost Z = 104(300) + 101(200) + 90(350) + 91(70) + 127(180)

+ 109(150) + 58(250)

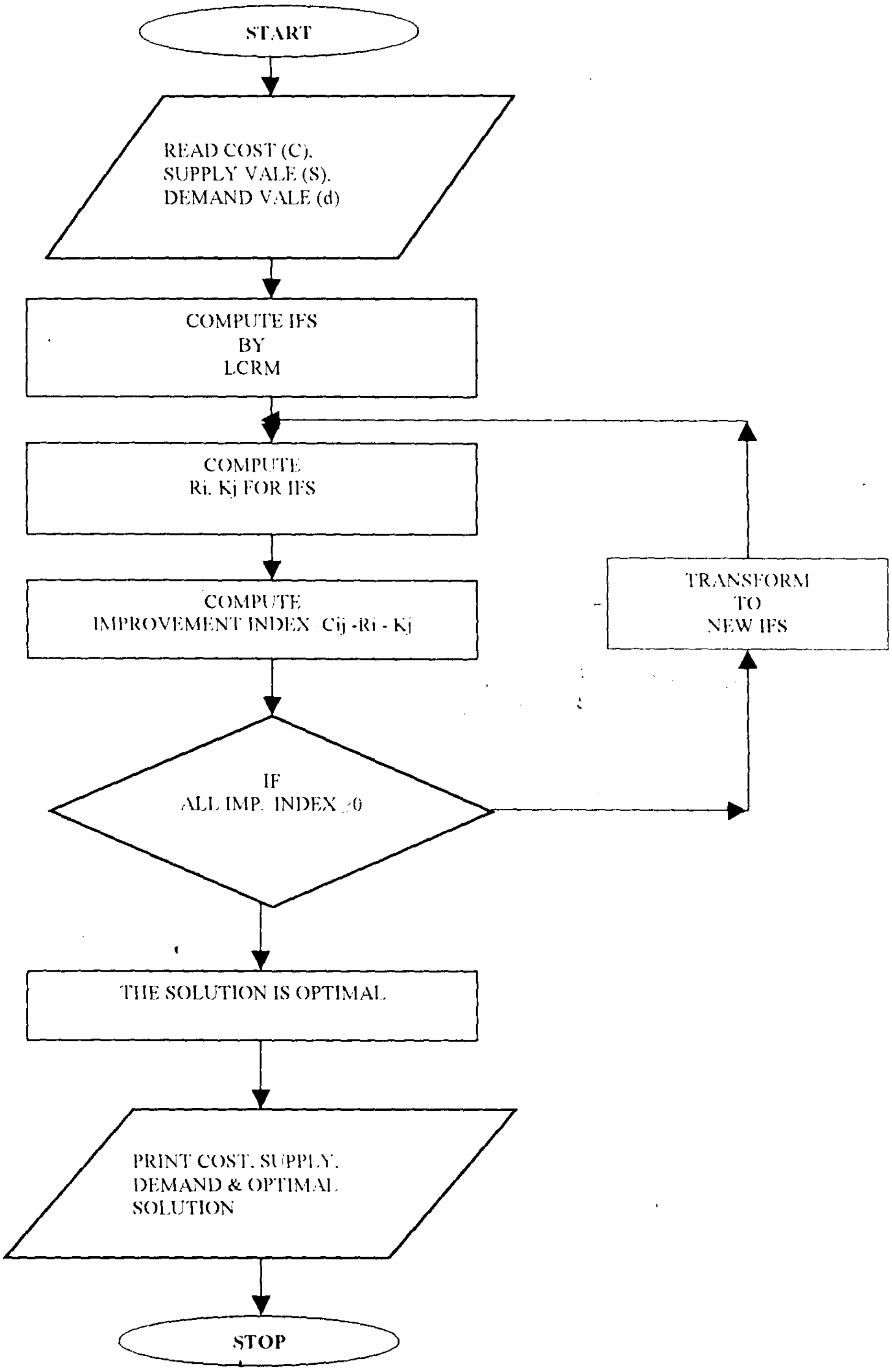
=N=142,980

4.3 FLOW CHART

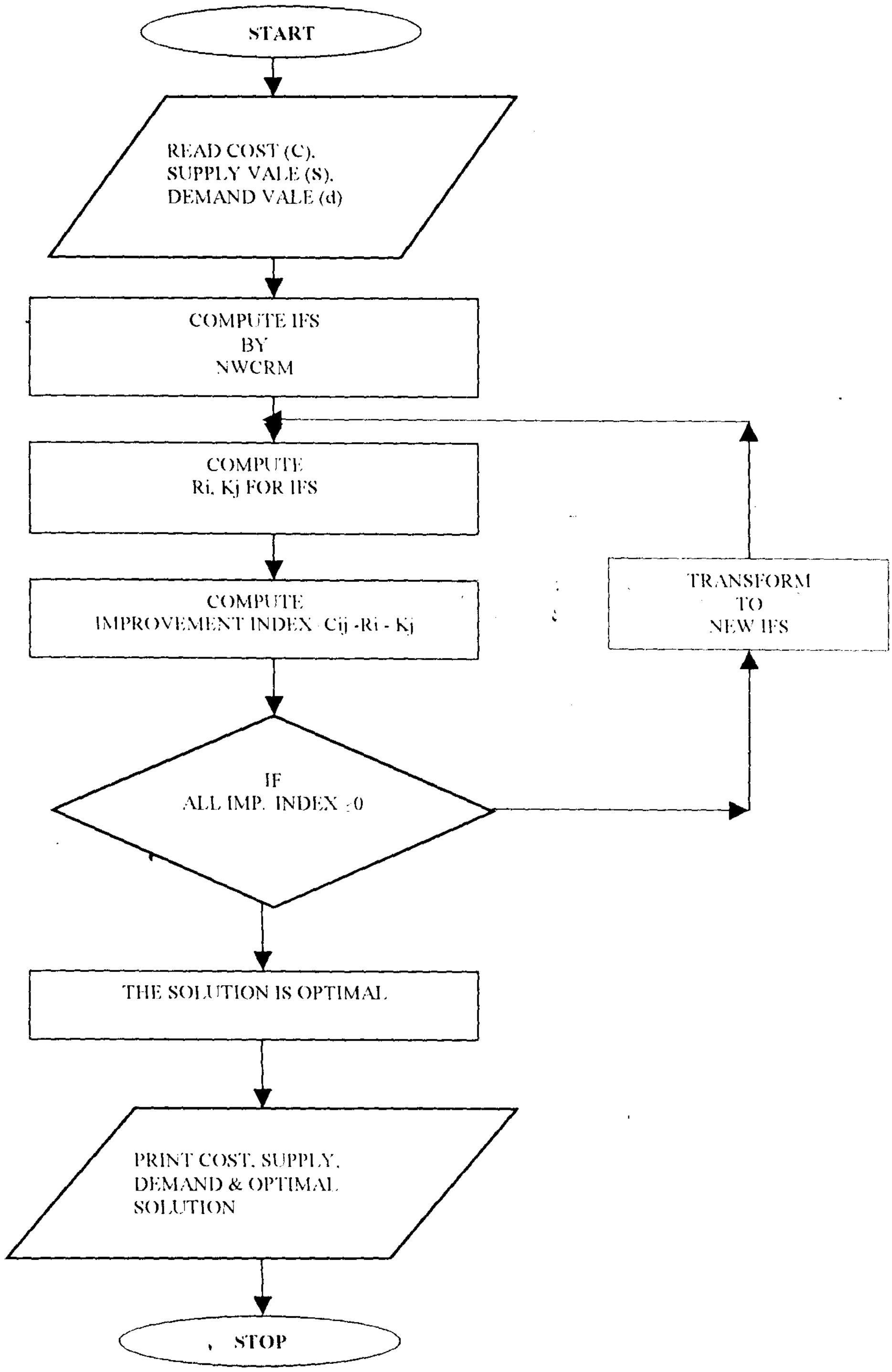
A FLOW CHART FOR TRANSPORTATION ALGORITHM FOR VOGEL APPROXIMATION METHOD (VAM)



A FLOW CHART FOR TRANSPORTATIONM ALGORITHM FOR LEAST COST RULE METHOD (LCRM)



A FLOW CHART FOR TRANSPORTATION ALGORITHM FOR NORTH – WEST CORNER RULE METHOD (NWCR).



4.4 CHOICE OF PROGRAMMING LANGUAGE USED

After the flow chart must have been drawn. One has to decide on the programming language to be used for coding. For this reason VISUAL BASIC is chosen because of the following feature it possessed.

(i) It has structural programming facilities.

(ii) It has optimization techniques to make the application faster and smaller.

(iii) It has in–build database that allows user to sort, change, delete, display or print data from the database without lost of generality.

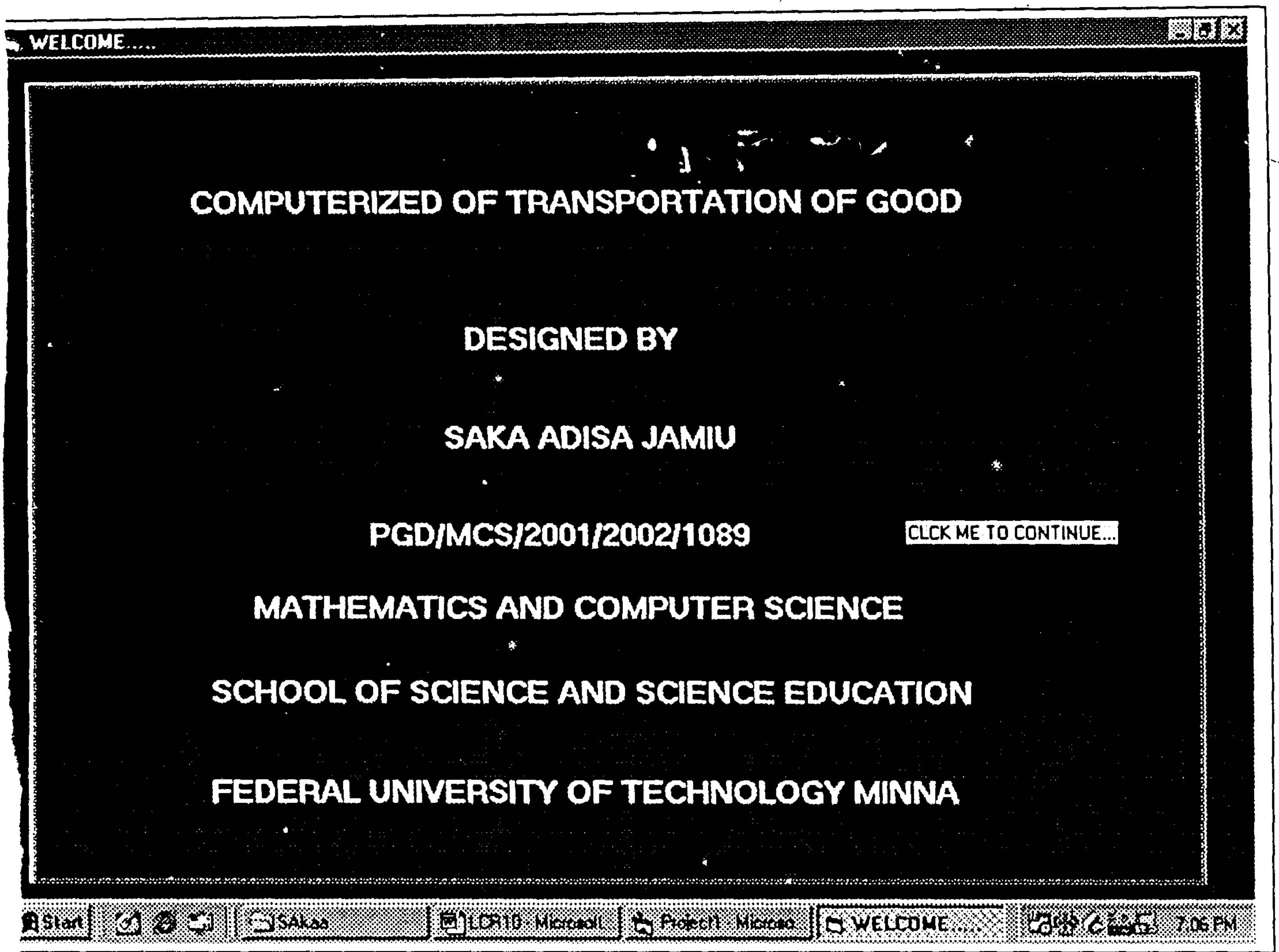
(iv) It is very flexible and easy to use.

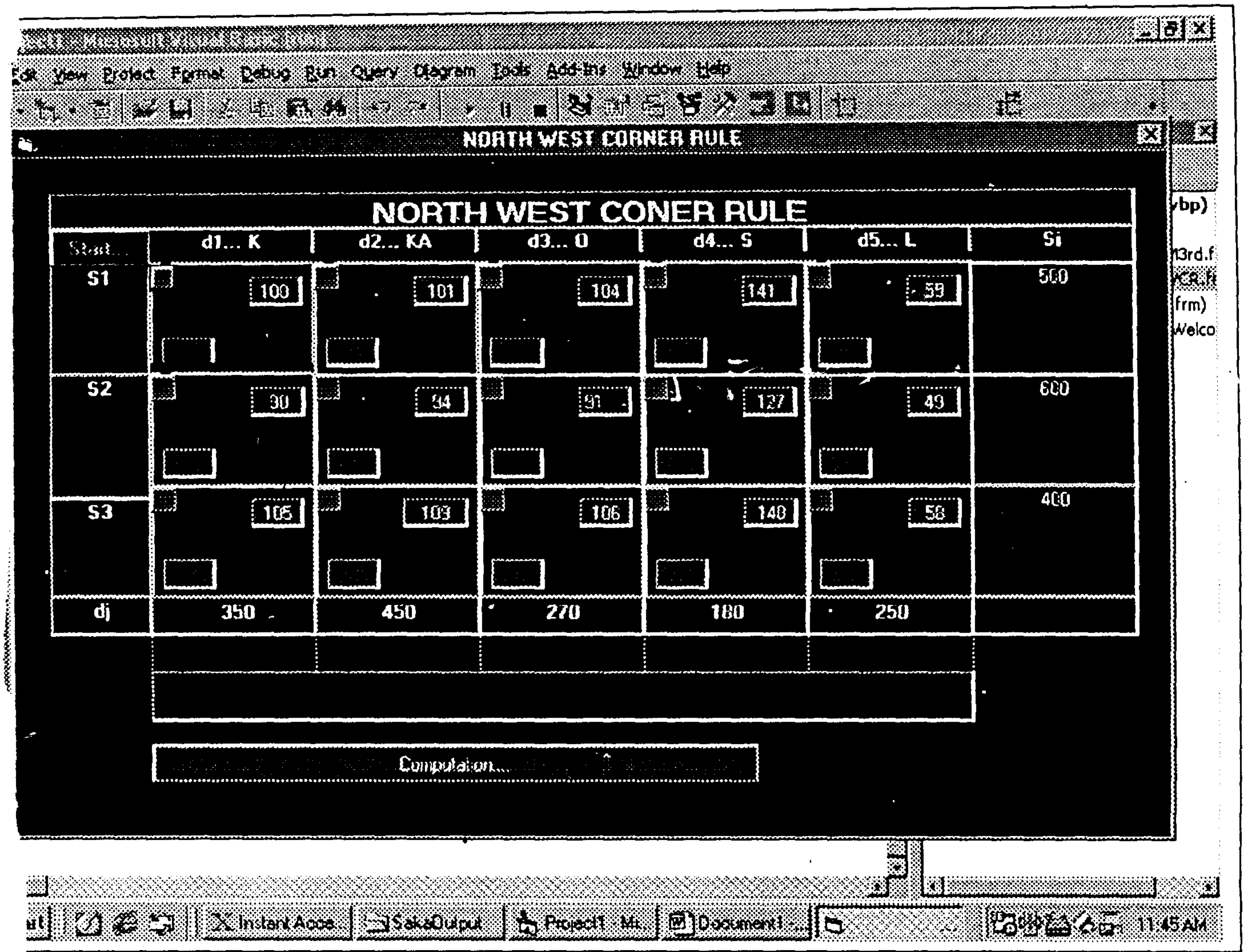
(v) It has Graphical user's interface (GUI) which makes it easy for user to explore the capabilities of the package.

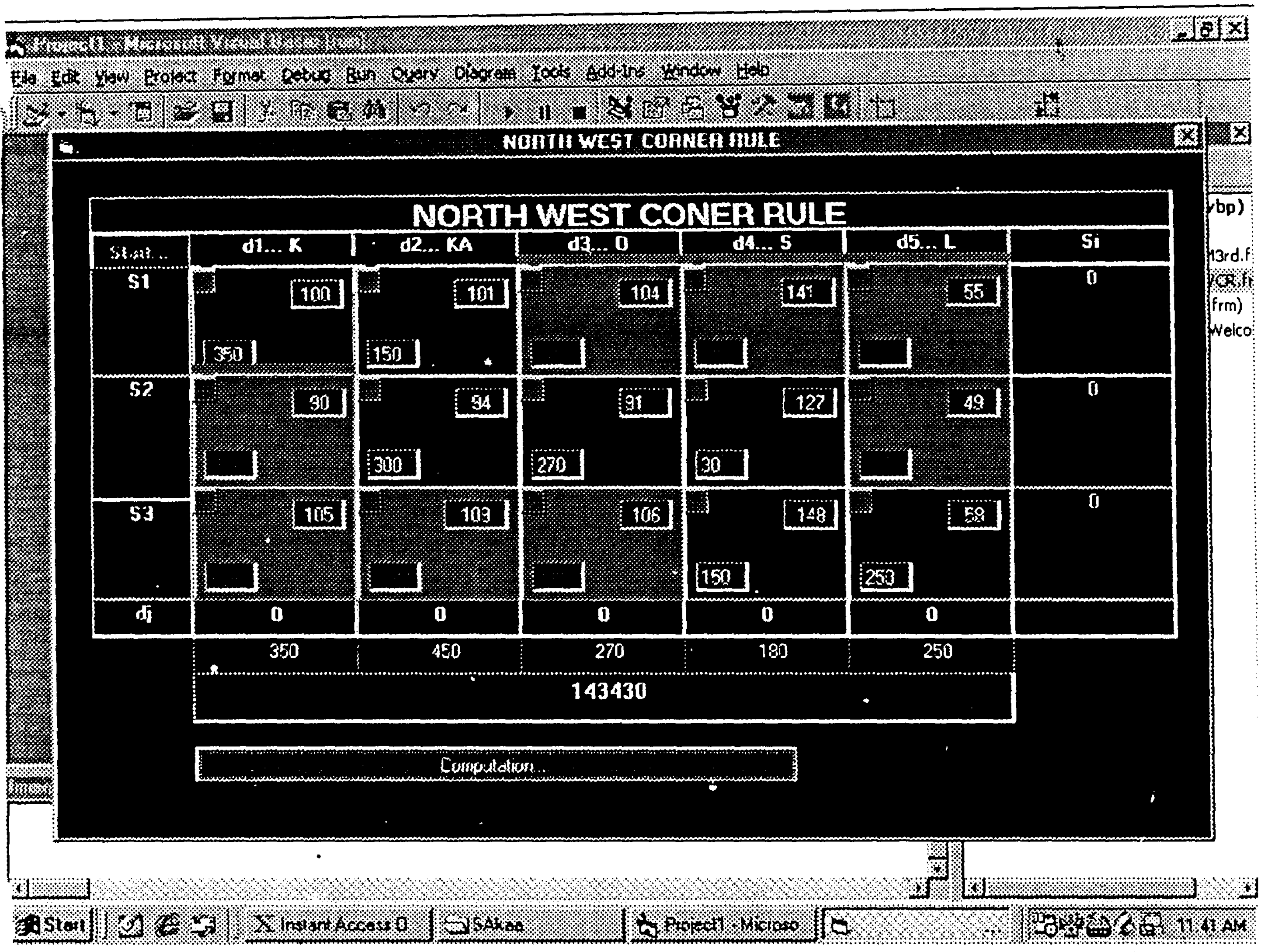
(vi) It makes use of sequence selection and iteration method which are the fundamentals of any structured program.

(vii) Code optimization is also one of the most important features of visual Basic.

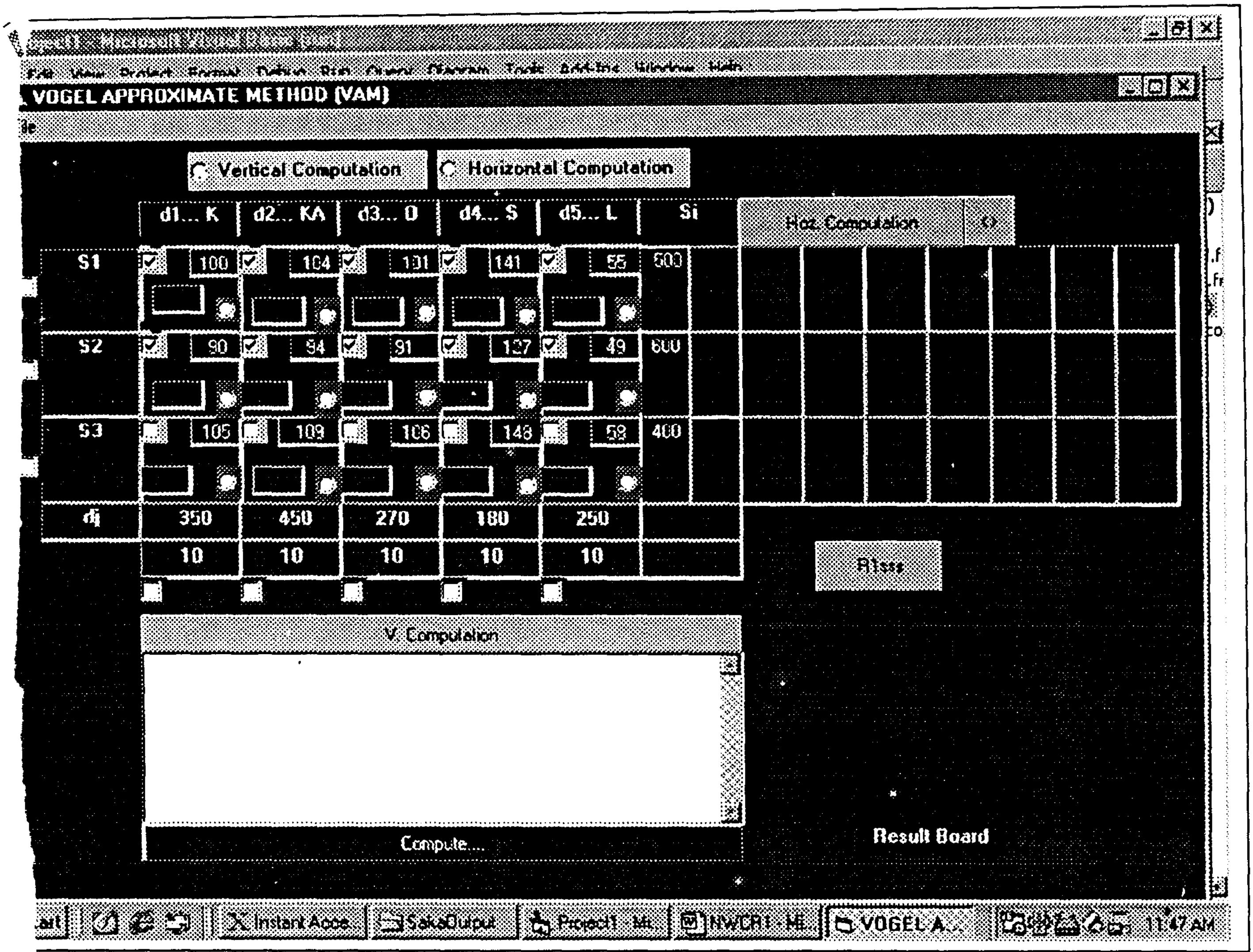
4.4 COMPUTER OUTPUT

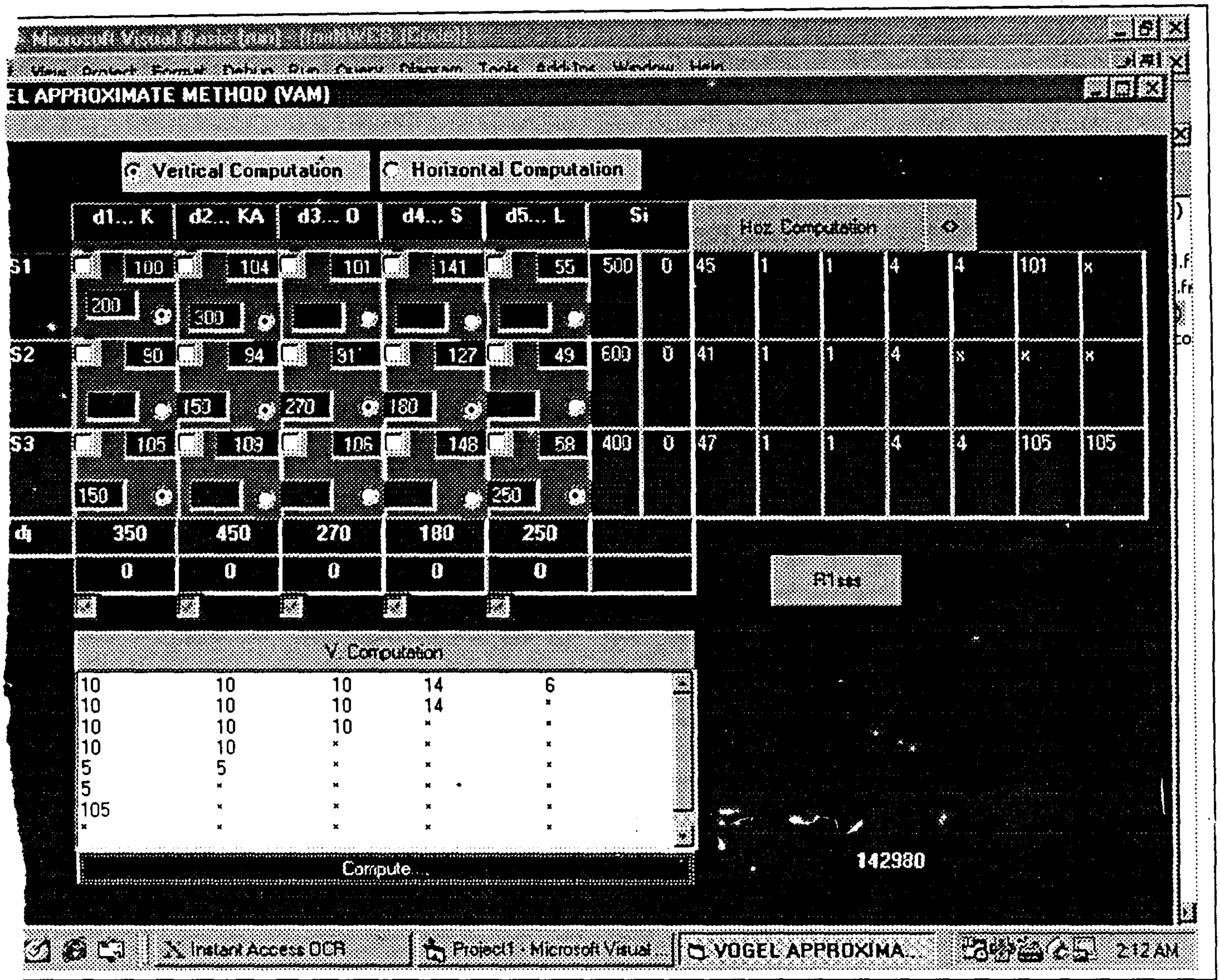


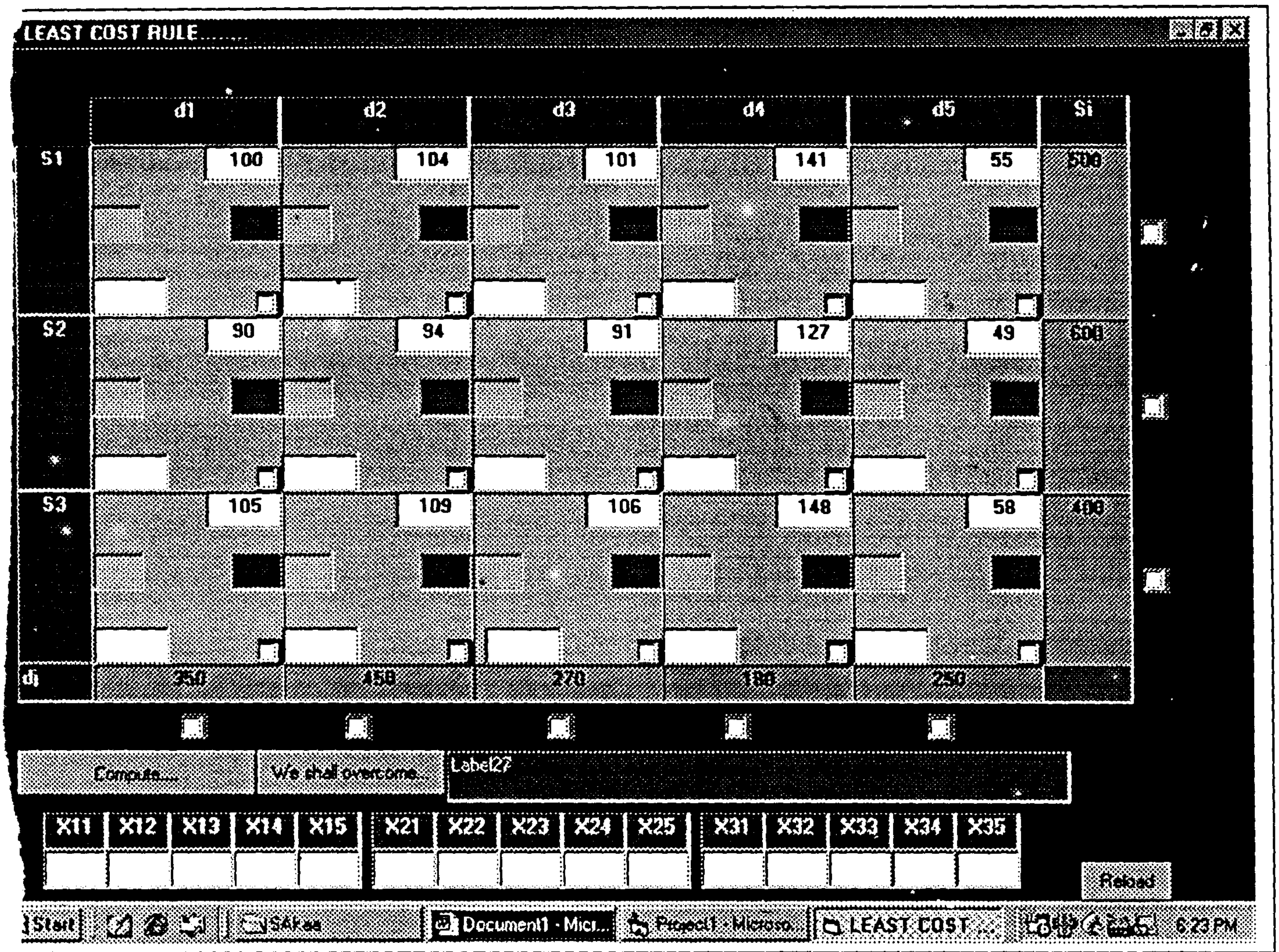

Edit View Project Format Debug Run Query Diagram Tools Add-Ins Window Help
NORTH WEST CORNER RULE
NORTH WEST CONER RULE
d1... K
d2... KA
d3... O
d4... S
d5... L
Si
S1
100
101
104
141
59
500
S2
30
34
91
127
49
600
S3
105
103
106
140
58
400
dj
350
450
270
180
250
Computation...
Instant Acce
SakaOutput
Project1 - Mi
Document1 -
11:45 AM

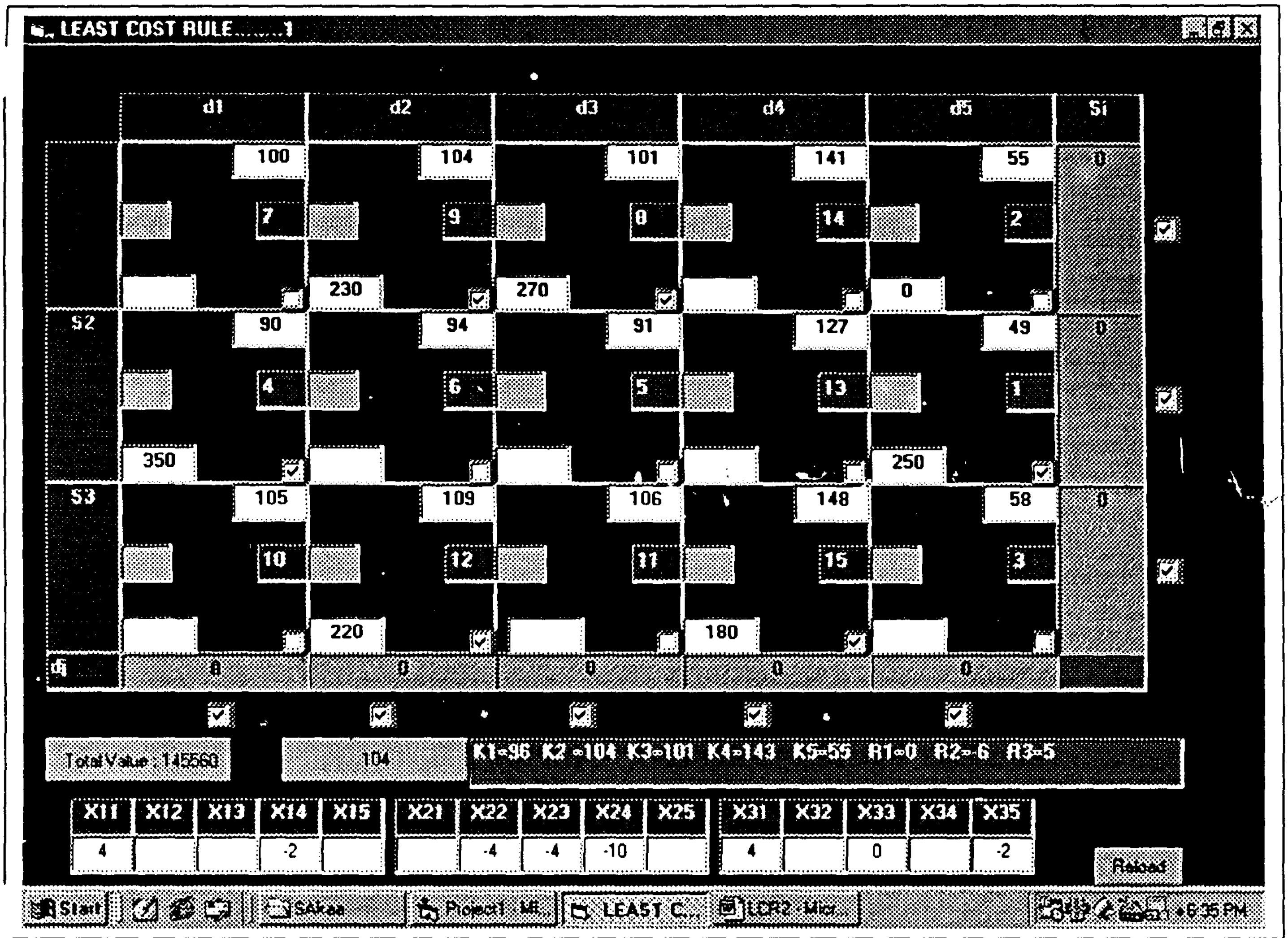


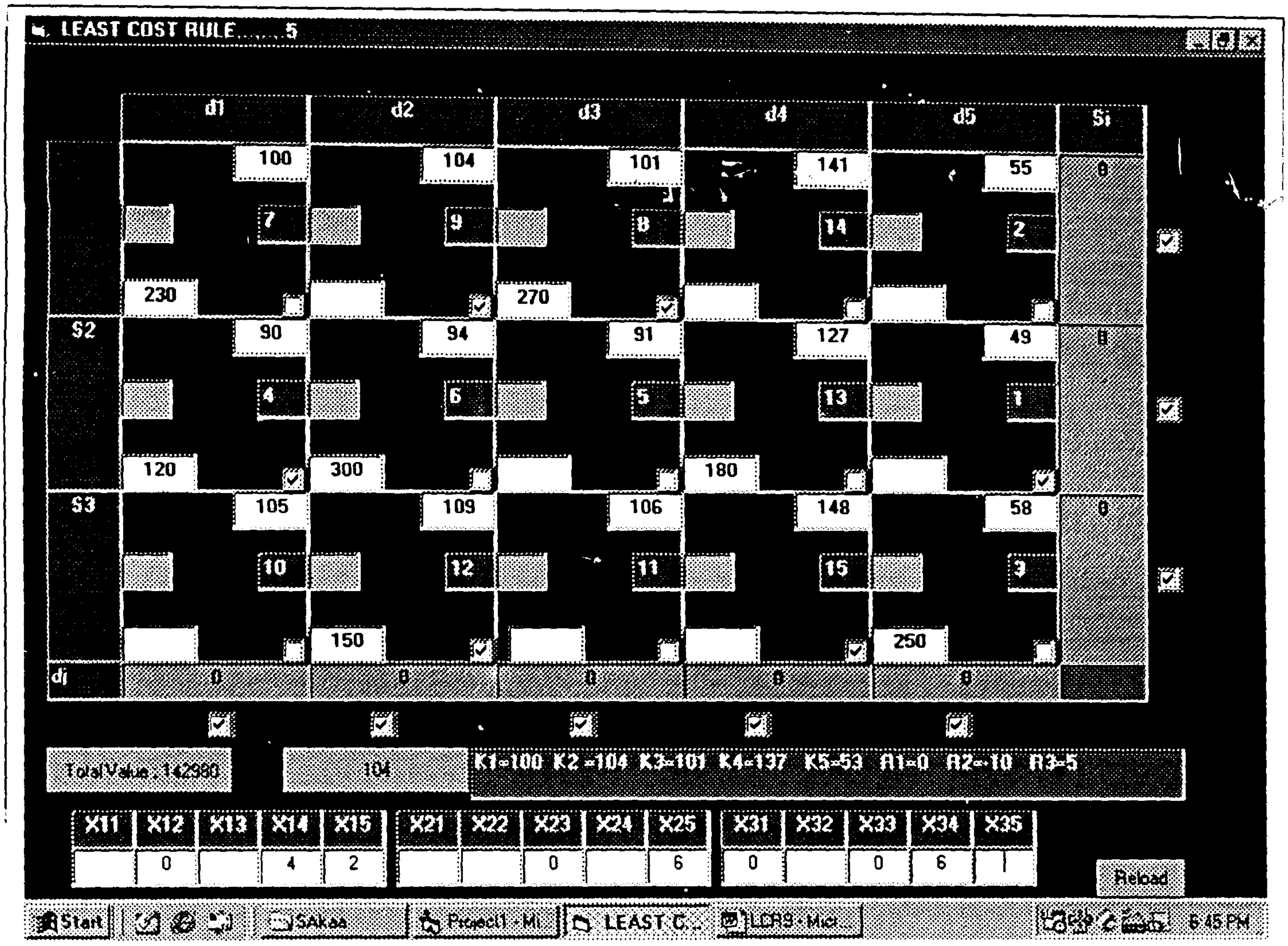
NORTH WEST CORNER RULE
NORTH WEST CONER RULE
Stat...	d1... K	d2... KA	d3... O	d4... S	d5... L	Si
S1	100 / 350	101 / 150	104	141	55	0
S2	90	94 / 300	91 / 270	127 / 30	49	0
S3	105	103	106	148 / 150	58 / 250	0
dj	0	0	0	0	0	
	350	450	270	180	250	
143430
Computation...


VOGEL APPROXIMATE METHOD (VAM)
Vertical Computation
Horizontal Computation
d1... K
d2... KA
d3... O
d4... S
d5... L
Si
Hoz. Computation
S1
100
104
101
141
55
500
S2
90
94
91
127
49
600
S3
105
109
106
148
58
400
dj
350
450
270
180
250
10
10
10
10
10
V. Computation
Compute...
Result Board
Instant Acce...
SakaOutput
Project1 - Mi...
NWCR1 - Mi...
VOGEL A...
11:47 AM


EL APPROXIMATE METHOD (VAM)
Vertical Computation
Horizontal Computation
d1... K
d2... KA
d3... O
d4... S
d5... L
Si
Hoz Computation
S1
S2
S3
dj
V. Computation
Compute...
142980
Instant Access OCR
Project1 - Microsoft Visual ...
VOGEL APPROXIMA...
2:12 AM


LEAST COST RULE.......
d1
d2
d3
d4
d5
Si
S1
100
104
101
141
55
S2
90
94
91
127
49
S3
105
109
106
148
58
dj
Compute....
We shall overcome....
Label27
X11
X12
X13
X14
X15
X21
X22
X23
X24
X25
X31
X32
X33
X34
X35
Reload
Start
Document1 - Micr...
Project1 - Microso...
LEAST COST
6:23 PM


LEAST COST RULE.......1
d1 d2 d3 d4 d5 Si
S2
S3
dj
Total Value : 145560
104
K1=96 K2=104 K3=101 K4=143 K5=55 R1=0 R2=-6 R3=5
X11 X12 X13 X14 X15 X21 X22 X23 X24 X25 X31 X32 X33 X34 X35
Reload
Start


LEAST COST RULE......5
d1
d2
d3
d4
d5
Si
S2
S3
dj
Total Value : 142980
104
K1=100 K2 =104 K3=101 K4=137 K5=53 R1=0 R2=-10 R3=5
X11 X12 X13 X14 X15 X21 X22 X23 X24 X25 X31 X32 X33 X34 X35
Reload
Start
LEAST C...
6:45 PM

CHAPTER FIVE

5.0 ANALYSIS OF RESULT

5.1 DISCUSSION OF RESULT/FINDINGS

Having critically studied the analysis in chapter four, we discovered that the total cost (=N=142,980) provided by initial feasible solution using Vogel Approximation Method (VAM) never changed at all even after an improvement has been made on it. That is the total cost still remains at =N=142,980.

5.2 CONCLUSION

Importantly, however, this is a pointer to the fact that VAM seems to be the best method of distributing the cigarette to the different customers' destinations when compared to other two methods.

5.3 RECOMMENDATION

The ultimate, aim of this study as stated earlier is to determine the quantity of cigarettes to be transported along a given rout at a very minimum cost in order to maximize profit for ITC Ltd.

If the management of ITC Ltd; actually wanted to achieve their aim, the following allocations schedules should be followed.

Transporting firm I (Source 1) should be allocated to supply **300** cartons of cigarette to **KATSINA** at the rate of =N=**104** per carton and **200** cartons of cigarette to **ONITSHA** at the rate of =N=**101** per carton.

Transporting firm 2 (Source 2) should be allocated to supply **350** cartons of cigarette to **KANO** at the rate of =N=**90** per carton, **70** cartons of cigarette to

ONITSHA at the rate of =N=**91** per carton and **180** cartons of cigarette to **SAPELE** at the rate of =N=**127** per carton.

Transporting firm 3 (source 3) should be allocated to supply **150** cartons of cigarette to **KATSINA** at the rate of =N=**109** per carton and **250** cartons of cigarette to **LAGOS** at the rate of =N=**58** per carton.

At this juncture, we wish to state that if the distribution methods recommended above are properly followed, ITC will definitely minimize the total transportation cost and indirectly maximize it profit.

APPENDIX (PROGRAMMING)

```
Dim K As Integer
Dim R1 As Integer
Dim R2 As Integer
Dim R3 As Integer
Dim I As Integer
Dim Kon As Integer
'
Dim K1 As Integer, K2 As Integer, K3 As Integer
Dim K4 As Integer, K5 As Integer
'
Dim Ite As Integer
Dim PN As Boolean

Private Sub c1_Click()
 K = K + 1
 c1.Text = K

End Sub

Private Sub c10_Click()
 K = K + 1
 c10.Text = K
End Sub

Private Sub c11_Click()
K = K + 1
 c11.Text = K
End Sub

Private Sub c12_Click()
 K = K + 1
 c12.Text = K
End Sub


Private Sub c13_Click()
 K = K + 1
 c13.Text = K
End Sub

Private Sub c14_Click()
 K = K + 1
 c14.Text = K
End Sub

Private Sub c15_Click()
 K = K + 1
 c15.Text = K
End Sub
```

```
 If Tx2 < Tx5 Then
  tt15.Text = Tx2
  Text2.Text = 0
  Text5.Text = Tx5 - Tx2
 End If
 '
 If Tx2 = Tx5 Then
  tt15.Text = Tx2
   Text5.Text = 0
   Text2.Text = 0
 End If

End Sub

Private Sub Check10_Click()

 Dim Tx8 As Integer
 Dim Tx7 As Integer
 Tx8 = Val(Text8.Text)
 Tx7 = Val(Text7.Text)

  If Tx8 > Tx7 Then
   tt6.Text = Tx7
   Text7.Text = 0
   Text8.Text = Tx8 - Tx7
 End If
 '
  If Tx8 < Tx7 Then
   tt6.Text = Tx8
   Text8.Text = 0
   Text7.Text = Tx7 - Tx8
 End If
 '
 If Tx8 = Tx7 Then
   tt6.Text = Tx8
    Text8.Text = 0
    Text7.Text = 0
  End If
End Sub

Private Sub Check11_Click()

 Dim Tx1 As Integer
 Dim Tx3 As Integer
 Tx1 = Val(Text1.Text)
 Tx3 = Val(Text3.Text)

  If Tx1 > Tx3 Then
   tt2.Text = Tx3
   Text3.Text = 0
```

```
  Text1.Text = Tx1 - Tx3
End If
'
 If Tx1 < Tx3 Then
  tt2.Text = Tx1
  Text1.Text = 0
  Text3.Text = Tx3 - Tx1
End If
'
If Tx1 = Tx3 Then
  tt2.Text = Tx3
   Text3.Text = 0
   Text1.Text = 0
 End If

End Sub

Private Sub Check12_Click()

 Dim Tx1 As Integer
 Dim Tx7 As Integer
 Tx1 = Val(Text1.Text)
 Tx7 = Val(Text7.Text)

  If Tx1 > Tx7 Then
   tt1.Text = Tx7
   Text7.Text = 0
   Text1.Text = Tx1 - Tx7
 End If
 '
  If Tx1 < Tx7 Then
   tt1.Text = Tx1
   Text1.Text = 0
   Text7.Text = Tx7 - Tx1
 End If
 '
 If Tx1 = Tx7 Then
   tt1.Text = Tx1
    Text7.Text = 0
    Text1.Text = 0
  End If
End Sub

Private Sub Check13_Click()

 Dim Tx2 As Integer
 Dim Tx4 As Integer
 Tx2 = Val(Text2.Text)
 Tx4 = Val(Text4.Text)

  If Tx2 > Tx4 Then
```

```
  tt13.Text = Tx4
  Text4.Text = 0
  Text2.Text = Tx2 - Tx4
End If
'
 If Tx2 < Tx4 Then
  tt13.Text = Tx2
  Text2.Text = 0
  Text4.Text = Tx4 - Tx2
End If
'
If Tx2 = Tx4 Then
  tt13.Text = Tx2
   Text2.Text = 0
   Text4.Text = 0
 End If

End Sub

Private Sub Check14_Click()
 Dim Tx2 As Integer
 Dim Tx6 As Integer
 Tx2 = Val(Text2.Text)
 Tx6 = Val(Text6.Text)

 If Tx2 > Tx6 Then
  tt14.Text = Tx6
  Text6.Text = 0
  Text2.Text = Tx2 - Tx6
 End If
 '
  If Tx2 < Tx6 Then
  tt14.Text = Tx2
  Text2.Text = 0
  Text6.Text = Tx6 - Tx2
 End If
 '
 If Tx2 = Tx6 Then
  tt14.Text = Tx2
   Text6.Text = 0
   Text2.Text = 0
  End If
End Sub

Private Sub Check15_Click()
 Dim Tx8 As Integer
 Dim Tx5 As Integer
 Tx8 = Val(Text8.Text)
 Tx5 = Val(Text5.Text)

  If Tx8 > Tx5 Then
```

```
  tt10.Text = Tx5
  Text5.Text = 0
  Text8.Text = Tx8 - Tx5
 End If
 '
 If Tx8 < Tx5 Then
  tt10.Text = Tx8
  Text8.Text = 0
  Text5.Text = Tx5 - Tx8
 End If
 '
 If Tx8 = Tx5 Then
  tt10.Text = Tx5
   Text5.Text = 0
   Text8.Text = 0
 End If

End Sub

Private Sub Check17_Click()
 Label5.BackColor = vbBlack
 Label6.BackColor = vbBlack
 Label7.BackColor = vbBlack
End Sub

Private Sub Check18_Click()
 Label2.BackColor = vbBlack
 Label3.BackColor = vbBlack
 Label4.BackColor = vbBlack
End Sub

Private Sub Check19_Click()
 Label4.BackColor = vbBlack
 Label7.BackColor = vbBlack
 Label13.BackColor = vbBlack
 Label14.BackColor = vbBlack
 Label1.BackColor = vbBlack


End Sub

Private Sub Check2_Click()

 Dim Tx8 As Integer
 Dim Tx6 As Integer
 Tx8 = Val(Text8.Text)
 Tx6 = Val(Text6.Text)

 If Tx8 > Tx6 Then
  tt9.Text = Tx6
  Text6.Text = 0
```

```
    Text8.Text = Tx8 - Tx6
  End If
  '
   If Tx8 < Tx6 Then
    tt9.Text = Tx8
    Text8.Text = 0
    Text6.Text = Tx6 - Tx8
  End If
  '
  If Tx8 = Tx6 Then
    tt9.Text = Tx6
     Text8.Text = 0
     Text6.Text = 0
   End If
End Sub

Private Sub Check20_Click()
 Label3.BackColor = vbBlack
 Label6.BackColor = vbBlack
 Label16.BackColor = vbBlack
 Label11.BackColor = vbBlack
 Label12.BackColor = vbBlack


End Sub

Private Sub Check21_Click()
 Label5.BackColor = vbBlack
 Label2.BackColor = vbBlack
 Label10.BackColor = vbBlack
 Label8.BackColor = vbBlack
 Label15.BackColor = vbBlack
End Sub

Private Sub Check22_Click()
 Label8.BackColor = vbBlack
 Label12.BackColor = vbBlack
 Label13.BackColor = vbBlack
End Sub

Private Sub Check23_Click()
 Label14.BackColor = vbBlack
 Label11.BackColor = vbBlack
 Label10.BackColor = vbBlack
End Sub

Private Sub Check24_Click()
 Label15.BackColor = vbBlack
 Label16.BackColor = vbBlack
 Label1.BackColor = vbBlack
```

```
End Sub

Private Sub Check3_Click()
 Dim Tx1 As Integer
 Dim Tx5 As Integer
 Tx1 = Val(Text1.Text)
 Tx5 = Val(Text5.Text)

  If Tx1 > Tx5 Then
   tt5.Text = Tx5
   Text5.Text = 0
   Text1.Text = Tx1 - Tx5
 End If
 '
  If Tx1 < Tx5 Then
   tt5.Text = Tx1
   Text1.Text = 0
   Text5.Text = Tx5 - Tx1
 End If
 '
  If Tx1 = Tx5 Then
   tt5.Text = Tx5
    Text5.Text = 0
    Text1.Text = 0
  End If



End Sub

Private Sub Check4_Click()

 Dim Tx1 As Integer
 Dim Tx6 As Integer
 Tx1 = Val(Text1.Text)
 Tx6 = Val(Text6.Text)

  If Tx1 > Tx6 Then
   tt4.Text = Tx6
   Text6.Text = 0
   Text1.Text = Tx1 - Tx6
 End If
 '
  If Tx1 < Tx6 Then
   tt4.Text = Tx1
   Text1.Text = 0
   Text6.Text = Tx6 - Tx1
 End If
 '
 If Tx1 = Tx6 Then
```

```
  tt4.Text = Tx1
   Text6.Text = 0
   Text1.Text = 0
 End If

End Sub

Private Sub Check5_Click()

 Dim Tx2 As Integer
 Dim Tx7 As Integer
 Tx2 = Val(Text2.Text)
 Tx7 = Val(Text7.Text)

  If Tx2 > Tx7 Then
   tt11.Text = Tx7
   Text7.Text = 0
   Text2.Text = Tx2 - Tx7
 End If
 '
  If Tx2 < Tx7 Then
   tt11.Text = Tx2
   Text2.Text = 0
   Text7.Text = Tx7 - Tx2
 End If
 '
 If Tx2 = Tx7 Then
   tt11.Text = Tx2
    Text2.Text = 0
    Text7.Text = 0
  End If
End Sub

Private Sub Check6_Click()

 Dim Tx2 As Integer
 Dim Tx3 As Integer
 Tx2 = Val(Text2.Text)
 Tx3 = Val(Text3.Text)

  If Tx2 > Tx3 Then
   tt12.Text = Tx3
   Text3.Text = 0
   Text2.Text = Tx2 - Tx3
 End If
 '
  If Tx2 < Tx3 Then
   tt12.Text = Tx2
   Text2.Text = 0
   Text3.Text = Tx3 - Tx2
 End If
```

```
'
If Tx2 = Tx3 Then
  tt12.Text = Tx2
   Text2.Text = 0
   Text3.Text = 0
 End If

End Sub

Private Sub Check7_Click()

 Dim Tx8 As Integer
 Dim Tx4 As Integer
 Tx8 = Val(Text8.Text)
 Tx4 = Val(Text4.Text)

  If Tx8 > Tx4 Then
   tt8.Text = Tx4
   Text4.Text = 0
   Text8.Text = Tx8 - Tx4
 End If
  '
   If Tx8 < Tx4 Then
   tt8.Text = Tx8
   Text8.Text = 0
   Text4.Text = Tx4 - Tx8
 End If
 '
 If Tx8 = Tx4 Then
   tt8.Text = Tx4
    Text4.Text = 0
    Text8.Text = 0
  End If

End Sub

Private Sub Check8_Click()

 Dim Tx1 As Integer
 Dim Tx4 As Integer
 Tx1 = Val(Text1.Text)
 Tx4 = Val(Text4.Text)

  If Tx1 > Tx4 Then
   tt3.Text = Tx4
   Text4.Text = 0
   Text1.Text = Tx1 - Tx4
 End If
  '
   If Tx1 < Tx4 Then
   tt3.Text = Tx1
```

```
  Text1.Text = 0
  Text4.Text = Tx4 - Tx1
 End If
'
If Tx1 = Tx4 Then
  tt3.Text = Tx5
   Text4.Text = 0
   Text1.Text = 0
 End If
End Sub

Private Sub Check9_Click()

 Dim Tx8 As Integer
 Dim Tx3 As Integer
 Tx8 = Val(Text8.Text)
 Tx3 = Val(Text3.Text)

  If Tx8 > Tx3 Then
   tt7.Text = Tx3
   Text3.Text = 0
   Text8.Text = Tx8 - Tx3
 End If
  '
   If Tx8 < Tx3 Then
   tt7.Text = Tx8
   Text8.Text = 0
   Text3.Text = Tx3 - Tx8
 End If
 '
 If Tx8 = Tx3 Then
   tt7.Text = Tx3
    Text8.Text = 0
    Text3.Text = 0
  End If

End Sub

Private Sub cmdComp_Click()
 Dim R1 As Single
 Dim R2 As Single
 Dim R3 As Single, Tota As Single
 '
 R1 = (Val(tt1) * Val(t1)) + (Val(tt2) * Val(t2)) + (Val(tt3) * Val(t3)) + (Val(tt4) *
Val(t4)) + (Val(tt5) * Val(t5))
 R2 = (Val(tt6) * Val(t6)) + (Val(tt7) * Val(t7)) + (Val(tt8) * Val(t8)) + (Val(tt9) *
Val(t9)) + (Val(tt10) * Val(t10))
 R3 = (Val(tt11) * Val(t11)) + (Val(tt12) * Val(t12)) + (Val(tt13) * Val(t13)) + (Val(tt14)
* Val(t14)) + (Val(tt15) * Val(t15))
 Tota = R1 + R2 + R3
 cmdComp.Caption = " Total Value : " & Tota
```

```
End Sub

Private Sub cmdRel_Click()
 K = 0
 Unload frmLCRM
  Load frmLCRM
  frmLCRM.Show

End Sub


Private Sub cmdWork_Click()
X11.Text = ""
X12.Text = ""
X13.Text = ""
X14.Text = ""
X15.Text = ""
'
X21.Text = ""
X22.Text = ""
X23.Text = ""
X24.Text = ""
X25.Text = ""
'
X31.Text = ""
X32.Text = ""
X33.Text = ""
X34.Text = ""
X35.Text = ""
'



 K1 = 0: K2 = 0: K3 = 0: K4 = 0: K5 = 0
   R1 = 0: R2 = 0: R3 = 0: I = 0
   PN = True
   Label1.Caption = ""
   Label2.Caption = ""
   Label3.Caption = ""
   Label4.Caption = ""
   Label5.Caption = ""
   Label6.Caption = ""
   Label7.Caption = ""
   Label8.Caption = ""
   Label9.Caption = ""
   Label10.Caption = ""
   Label11.Caption = ""
   Label12.Caption = ""
   Label13.Caption = ""
   Label14.Caption = ""
```

```
   Label15.Caption = ""
   Label16.Caption = ""


Ite = Ite + 1

R1 = 0

'
'
If Len(Trim(tt1.Text)) <> 0 Then
   K1 = Val(t1.Text)
End If
'
If Len(Trim(tt2.Text)) <> 0 Then
   K2 = Val(t2.Text)
End If
'
If Len(Trim(tt3.Text)) <> 0 Then
   K3 = Val(t3.Text)
End If
'
If Len(Trim(tt4.Text)) <> 0 Then
   K4 = Val(t4.Text)
End If
'

If Len(Trim(tt5.Text)) <> 0 Then
   K5 = Val(t5.Text)
End If
'
'

'
'end of row 1 computation...
'
'beginning of k1
'cmdWork.Caption = K1
'Exit Sub

kunmi:

   If Len(Trim(tt6.Text)) <> 0 Then
         If K1 <> 0 Then
            R2 = Val(t6) - K1
            If K2 = 0 And Len(Trim(tt7)) <> 0 Then
               K2 = Val(t7) - R2

            End If
            If K4 = 0 And Len(Trim(tt9)) <> 0 Then
```

```
        K4 = Val(t9) - R2
      End If
    End If
    cmdWork.Caption = K2
If K1 = 0 Then


    If Len(Trim(tt7.Text)) <> 0 Then
      If K2 <> 0 Then
        R2 = Val(t7) - K2
        K1 = Val(t6.Text) - R2


      If Len(Trim(tt8)) <> 0 Then
          If K3 = 0 Then
            K3 = Val(t8) - R2
          End If
        End If
        '
        If Len(Trim(tt9)) <> 0 Then
          If K4 = 0 Then
            K4 = Val(t9) - R2

            End If
        End If

        '
        If Val(Trim(tt10)) <> 0 Then
          If K5 = 0 Then
            K5 = Len(Trim(t10)) - R2
          End If
        End If

        ''' GoTo unk
        '
      End If
      '
  End If
'


  If Len(Trim(tt8.Text)) <> 0 Then
    If K3 <> 0 Then
      R2 = Val(t8) - K3
      K1 = Val(t6) - R2
      '
      If K2 = 0 Then
        K2 = Val(t7) - R2

      End If
      '
```

```
        If K4 = 0 Then
          K4 = Val(t9) - R2

        End If
        '
        If K5 = 0 Then
          K5 = Val(t10) - R2
        End If
        '
       ''' GoTo unk

    End If
End If

'
If Len(Trim(tt9.Text)) <> 0 Then
    If K4 <> 0 Then
        R2 = Val(t9) - K4

        K1 = Val(t6) - R2
        '
        If K2 = 0 Then
          K2 = Val(t7) - R2

        End If
        '
        If K3 = 0 Then
          K3 = Val(t8) - R2
        End If
        '
        If K5 = 0 Then
          K5 = Val(t10) - R2
        End If

        ''''''
        '''GoTo unk
    End If
End If
'
If Len(Trim(tt10.Text)) <> 0 Then
    If K5 <> 0 Then
        R2 = Val(t10) - K5
        ''''''
        K1 = Val(t6) - R2
        '
        If K2 = 0 And Len(Trim(tt7)) <> 0 Then
          K2 = Val(t7) - R2

        End If
        '
        If K3 = 0 And Len(Trim(tt8)) <> 0 Then
```

```
            K3 = Val(t8) - R2
          End If
          '
          If K4 = 0 And Len(Trim(tt9)) <> 0 Then
            K4 = Val(t9) - R2

          End If

          '''GoTo unk
        End If
      End If
    '
    End If
  End If
  'end of k1
  '
  'Label27.Caption = "K1=" & K1 & "  K2 =" & K2 & "  K3=" & K3 & "  K4=" & K4 &
"  K5=" & K5 & "  R1=" & R1 & "  R2=" & R2 & "  R3=" & R3

  'Beginning of
  '
  'last row....
  If Len(Trim(tt11)) <> 0 Then
    If K1 <> 0 Then
      R3 = Val(t11) - K1
      '
        If K2 = 0 And Len(Trim(tt12)) <> 0 Then
          K2 = Val(t12) - R3

        End If
        '

        If K3 = 0 And Len(Trim(tt13)) <> 0 Then
          K3 = Val(t13) - R3
        End If
        '
        If K4 = 0 And Len(Trim(tt14)) <> 0 Then
          K4 = Val(t14) - R3
        End If
        '
        If K5 = 0 And Len(Trim(tt15)) <> 0 Then
          K5 = Val(t15) - R3
        End If
        '
    End If
  End If


  ' Label27.Caption = "K1=" & K1 & "  K2 =" & K2 & "  K3=" & K3 & "  K4=" & K4
& "  K5=" & K5 & "  R1=" & R1 & "  R2=" & R2 & "  R3=" & R3
```

```
'
'
If Len(Trim(tt12)) <> 0 Then
   If K2 <> 0 Then
      R3 = Val(t12) - K2
         If K1 = 0 And Len(Trim(tt11)) <> 0 Then
            K1 = Val(t11,) - R3
         End If
         '
         If K3 = 0 And Len(Trim(tt13)) <> 0 Then
            K3 = Val(t13) - R3
         End If
         '
         If K4 = 0 And Len(Trim(tt14)) <> 0 Then
            K4 = Val(t14) - R3
         End If
         '
         If K5 = 0 And Len(Trim(tt15)) <> 0 Then
            K5 = Val(t15) - R3
         End If
         '

      End If
   End If
   '
   '
   'cmdWork.Caption = R3
'Exit Sub
'

   If Len(Trim(tt13)) <> 0 Then
   If K3 <> 0 Then
      R3 = Val(t13) - K3
         If K2 = 0 And Len(Trim(tt12)) <> 0 Then
            K2 = Val(t12) - R3

         End If
         '
         If K1 = 0 And Len(Trim(tt11)) <> 0 Then
            K1 = Val(t11) - R3
         End If
         '
         If K4 = 0 And Len(Trim(tt14)) <> 0 Then
            K4 = Val(t14) - R3
         End If
         '
         If K5 = 0 And Len(Trim(tt15)) <> 0 Then
            K5 = Val(t15) - R3
         End If
         '
```

```
      End If
   End If
   '
   '
   If Len(Trim(tt14)) <> 0 Then
   If K4 <> 0 Then
     R3 = Val(t14) - K4
       If K2 = 0 And Len(Trim(tt12)) <> 0 Then
         K2 = Val(t12) - R3

       End If
       '
       If K3 = 0 And Len(Trim(tt13)) <> 0 Then
         K3 = Val(t13) - R3
       End If
       '
       If K1 = 0 And Len(Trim(tt11)) <> 0 Then
         K1 = Val(t11) - R3
       End If
       '
       If K5 = 0 And Len(Trim(tt15)) <> 0 Then
         K5 = Val(t15) - R3
       End If
       '
      End If
   End If
   '
   '
   If Len(Trim(tt15)) <> 0 Then
   If K5 <> 0 Then
     R3 = Val(t15) - K5
       If K2 = 0 And Len(Trim(tt12)) <> 0 Then
         K2 = Val(t12) - R3
     '         cmdWork.Caption = R2
' Exit Sub
       End If
       '
       If K3 = 0 And Len(Trim(tt13)) <> 0 Then
         K3 = Val(t13) - R3
       End If
       '
       If K4 = 0 And Len(Trim(tt14)) <> 0 Then
         K4 = Val(t14) - R3
       End If
       '
       If K1 = 0 And Len(Trim(tt11)) <> 0 Then
         K1 = Val(t11) - R3
       End If
       '
      End If
   End If
```

```
Private Sub c2_Click()
K = K + 1
 c2.Text = K
End Sub

Private Sub c3_Click()
 K = K + 1
 c3.Text = K
End Sub
Private Sub c4_Click()
 K = K + 1
 c4.Text = K
End Sub

Private Sub c5_Click()
 K = K + 1
 c5.Text = K
End Sub

Private Sub c6_Click()
 K = K + 1
 c6.Text = K
End Sub

Private Sub c7_Click()
 K = K + 1
 c7.Text = K
End Sub

Private Sub c8_Click()
 K = K + 1
 c8.Text = K
End Sub

Private Sub c9_Click()
 K = K + 1
 c9.Text = K
End Sub

Private Sub Check1_Click()
 Dim Tx2 As Integer
 Dim Tx5 As Integer
 Tx2 = Val(Text2.Text)
 Tx5 = Val(Text5.Text)

  If Tx2 > Tx5 Then
   tt15.Text = Tx5
   Text5.Text = 0
   Text2.Text = Tx2 - Tx5
 End If
```

```
    '''
    ' Label27.Caption = "k2 " & K2 & "   k1    " & K1 & "   k4    " & K4 & "   r2    " &
R2
    ' Exit Sub

     If K1 = 0 Then GoTo kunmi
     If K4 = 0 Then GoTo kunmi
     If R2 = 0 Then GoTo kunmi


     'If K4 = 0 Then GoTo kunmi


     '''


  Label27.Caption = "K1=" & K1 & "  K2 =" & K2 & "  K3=" & K3 & "  K4=" & K4 &
"  K5=" & K5 & "   R1=" & R1 & "   R2=" & R2 & "   R3=" & R3
   frmLCRM.Caption = " LEAST COST RULE........" & Ite
 '  K1 = 0: K2 = 0: K3 = 0: K4 = 0: K5 = 0
 '  R1 = 0: R2 = 0: R3 = 0



End Sub




Private Sub Form_Load()
PN = True

End Sub


Private Sub PN1_Click()
  I = I + 1
  '
  If I = 1 Then
     Kon = Val(tt1)
  End If
  '
  If PN = True Then
     Label1.Caption = "-"
```

```
        tt1.Text = Val(tt1) - Kon
        If tt1 = 0 Then
          tt1 = Trim("")
        End If
        PN = False
    ElseIf PN = False Then
        Label1.Caption = "+"
        tt1.Text = Val(tt1) + Kon
        PN = True
    End If




End Sub

Private Sub PN10_Click()
  I = I + 1
   '
   If I = 1 Then
      Kon = Val(tt10)
   End If
   '
   If PN = True Then
      Label3.Caption = "-"
      tt10.Text = Val(tt10) - Kon
      If tt10 = 0 Then
        tt10 = Trim("")
      End If
      PN = False
   ElseIf PN = False Then
      Label3.Caption = "+"
      tt10.Text = Val(tt10) + Kon
      PN = True
   End If

End Sub




Private Sub PN11_Click()
 I = I + 1
   '
   If I = 1 Then
      Kon = Val(tt11)
   End If
   '
```

```
If PN = True Then
   Label15.Caption = "-"
   tt11.Text = Val(tt11) - Kon
   If tt11 = 0 Then
      tt11 = Trim("")
   End If
   PN = False
ElseIf PN = False Then
   Label15.Caption = "+"
   tt11.Text = Val(tt11) + Kon
   PN = True
End If

End Sub

Private Sub PN12_Click()
  I = I + 1
  '
  If I = 1 Then
     Kon = Val(tt12)
  End If
  '
  '
  If PN = True Then
     Label10.Caption = "-"
     tt12.Text = Val(tt12) - Kon
     If tt12 = 0 Then
        tt12 = Trim("")
     End If
     PN = False
  ElseIf PN = False Then
     Label10.Caption = "+"
     tt12.Text = Val(tt12) + Kon
     PN = True
  End If
  '

End Sub

Private Sub PN13_Click()
  I = I + 1
  '
  If I = 1 Then
     Kon = Val(tt8)
  End If
```

```
'
'
If PN = True Then
   Label8.Caption = "-"
   tt13.Text = Val(tt13) - Kon
   If tt13 = 0 Then
      tt13 = Trim("")
   End If
   PN = False
ElseIf PN = False Then
   Label8.Caption = "+"
   tt13.Text = Val(tt13) + Kon
   PN = True
End If
'


End Sub

Private Sub PN14_Click()
 I = I + 1
 '
  If I = 1 Then
     Kon = Val(tt14)
  End If
  '
  If PN = True Then
     Label5.Caption = "-"
     tt14.Text = Val(tt14) - Kon
     If tt14 = 0 Then
        tt14 = Trim("")
     End If

     PN = False
  ElseIf PN = False Then
     Label5.Caption = "+"
     tt14.Text = Val(tt14) + Kon
     PN = True
  End If




End Sub

Private Sub PN15_Click()
   I = I + 1
   '
   If I = 1 Then
      Kon = Val(tt15)
   End If
```

```
'
'
If PN = True Then
    Label2.Caption = "-"
    tt15.Text = Val(tt15) - Kon
    If tt15 = 0 Then
      tt15 = Trim("")
    End If
    PN = False
  ElseIf PN = False Then
    Label2.Caption = "+"
    tt15.Text = Val(tt15) + Kon
    PN = True
  End If

End Sub


Private Sub PN2_Click()
I = I + 1
  '
  If I = 1 Then
    Kon = Val(tt2)
  End If
  '
  If PN = True Then
    Label14.Caption = "-"
    tt2.Text = Val(tt2) - Kon
    If tt2 = 0 Then
      tt2 = Trim("")
    End If
    PN = False
  ElseIf PN = False Then
    Label14.Caption = "+"
    tt2.Text = Val(tt2) + Kon
    PN = True
  End If

End Sub


Private Sub PN3_Click()
I = I + 1
  '
  If I = 1 Then
    Kon = Val(tt3)
  End If
```

```
    '
    '
    If PN = True Then
       Label13.Caption = "-"
       tt3.Text = tt3 - Kon
       If tt3 = 0 Then
          tt3 = Trim("")
       End If
       PN = False
    ElseIf PN = False Then
       Label13.Caption = "+"
       tt3.Text = tt3 + Kon
       PN = True
    End If


End Sub

Private Sub PN4_Click()
 I = I + 1
    '
    If I = 1 Then
       Kon = Val(tt4)
    End If
    '
    If PN = True Then
       Label7.Caption = "-"
       tt4.Text = Val(tt4) - Kon
       If tt4 = 0 Then
          tt4 = Trim("")
       End If
       PN = False
    ElseIf PN = False Then
       Label7.Caption = "+"
       tt4.Text = Val(tt4) + Kon
       PN = True
    End If


End Sub

Private Sub PN5_Click()
 I = I + 1
    '
    If I = 1 Then
       Kon = Val(tt5)
    End If
    '
    If PN = True Then
       Label4.Caption = "-"
       tt5.Text = Val(tt5) - Kon
```

```
      If tt5 = 0 Then
         tt5 = Trim("")
      End If
      PN = False
   ElseIf PN = False Then
      Label4.Caption = "+"
      tt5.Text = Val(tt5) + Kon
      PN = True
   End If


End Sub



Private Sub PN6_Click()
 I = I + 1
   '
   If I = 1 Then
      Kon = Val(tt6)
   End If
   '
   If PN = True Then
      Label16.Caption = "-"
      tt6.Text = Val(tt6) - Kon
      If tt6 = 0 Then
         tt6 = Trim("")
      End If
      PN = False
   ElseIf PN = False Then
      Label16.Caption = "+"
      tt6.Text = Val(tt6) + Kon
      PN = True
   End If



End Sub

Private Sub PN7_Click()
 I = I + 1
   '
   If I = 1 Then
      Kon = Val(tt7)
   End If
   '
   If PN = True Then
      Label11.Caption = "-"
```

```
    tt7.Text = Val(tt7) - Kon
    If tt7 = 0 Then
      tt7 = Trim("")
    End If
    PN = False
  ElseIf PN = False Then
    Label11.Caption = "+"
    tt7.Text = Val(tt7) + Kon
    PN = True
  End If

End Sub


Private Sub PN8_Click()

  I = I + 1
  '
  If I = 1 Then
    Kon = Val(tt8)
  End If
  '
  '
  If PN = True Then
    Label12.Caption = "-"
    tt8.Text = Val(tt8) - Kon
    If tt8 = 0 Then
      tt8 = Trim("")
    End If
    PN = False
  ElseIf PN = False Then
    Label12.Caption = "+"
    tt8.Text = Val(tt8) + Kon
    PN = True
  End If
  '


End Sub

Private Sub PN9_Click()
 I = I + 1
  '
  If I = 1 Then
    Kon = Val(tt9)
  End If
  '
  If PN = True Then
```

```
    Label6.Caption = "-"
    tt9.Text = Val(tt9) - Kon
    If tt9 = 0 Then
       tt9 = Trim("")
    End If
    PN = False
  ElseIf PN = False Then
    Label6.Caption = "+"
    tt9.Text = Val(tt9) + Kon
    PN = True
  End If


End Sub

Private Sub tt1_Click()
 tt1.Text = 0
End Sub




Private Sub tt5_Click()
 tt5.Text = 0
End Sub

Private Sub tt6_Click()
 tt6.Text = 0
End Sub


Private Sub X11_Click()
   If Len(Trim(tt1)) = 0 Then
      X11 = Val(t1) - R1 - K1
   End If


End Sub


Private Sub X12_Click()
  If Len(Trim(tt2)) = 0 Then
      X12 = Val(t2) - R1 - K2
   End If

End Sub
```

```
Private Sub X13_Click()
 If Len(Trim(tt3)) = 0 Then
     X13 = Val(t3) - R1 - K3
   End If
End Sub


Private Sub X14_Click()
 If Len(Trim(tt4)) = 0 Then
     X14 = Val(t4) - R1 - K4
   End If
End Sub


Private Sub X15_Click()
 If Len(Trim(tt5)) = 0 Then
     X15 = Val(t5) - R1 - K5
 End If
End Sub


Private Sub X21_Click()
If Len(Trim(tt6)) = 0 Then
     X21 = Val(t6) - R2 - K1
 End If
End Sub


Private Sub X22_Click()
If Len(Trim(tt7)) = 0 Then
     X22 = Val(t7) - R2 - K2
 End If
End Sub


Private Sub X23_Click()
If Len(Trim(tt8)) = 0 Then
     X23 = Val(t8) - R2 - K3
 End If
End Sub


Private Sub X24_Click()
 If Len(Trim(tt9)) = 0 Then
```

```
    X24 = Val(t9) - R2 - K4
 End If
End Sub

Private Sub X25_Click()
If Len(Trim(tt10)) = 0 Then
    X25 = Val(t10) - R2 - K5
 End If
End Sub


Private Sub X31_Click()
 If Len(Trim(tt11)) = 0 Then
    X31 = Val(t11) - R3 - K1
 End If
End Sub


Private Sub X32_Click()
 If Len(Trim(tt12)) = 0 Then
    X32 = Val(t12) - R3 - K2
 End If
End Sub


Private Sub X33_Click()
 If Len(Trim(tt13)) = 0 Then
    X33 = Val(t13) - R3 - K3
 End If
End Sub

Private Sub X34_Click()
 If Len(Trim(tt14)) = 0 Then
    X34 = Val(t14) - R3 - K4
 End If
End Sub

Private Sub X35_Click()
 If Len(Trim(tt15)) = 0 Then
    X35 = Val(t15) - R3 - K5
 End If
End Sub
```