LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY

A RATIONAL PROCEDURE FOR REORGANISING A COMMERCIAL DISTRIBUTION SYSTEM

(with special reference to the distribution of petroleum fuels in Ceylon)

-- PART 2 --

A supplement to a Thesis submitted for the degree of Doctor of Philosophy

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INTRODUCTION

During the course of the oral examination held on 28th. July, 1969, consequent to the submission of the main thesis on this subject, it was pointed out by the Examiners that certain aspects of this analysis had not received adequate attention from the author. The points that required further study were:-

a. the problem of constraints on the availability of capital for the development of the distribution system. A complete addition to the program was requested, together with a demonstration of its efficacy.

b. the likelihood of there being more than one central source in the system. A brief description was required of the problem involved and of the changes that would be necessary in the program to cope with it.

c. the need for a direct comparison between the new method described in the thesis and two other methods mentioned in the literature in order to demonstrate any qualitative or quantitative improvements in the former. This would the solution of the same problem by the three methods and a comparison of the results obtained therefrom.

This supplement, which has been cross-referenced with the main thesis, describes the work that has been carried out on the new aspects of the problem.

ACKNOWLEDGEMENTS

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My thanks are also due to the staff of the Computer Centre at Loughborough University for their help in processing the several computer programs required for this work.

CONTENTS

CONSTRAINTS ON CAPITAL

1. The limited availability of capital is a severe constraint on the structure of a distribution network, especially if it has to be constructed from scratch. As originally written, the optimisation program assumed that adequate capital would be made available for this project. It was also assumed that when the optimal structure was determined, a separate exercise in investment appraisal would evaluate whether the new depots would provide an acceptable rate of return on the capital expended on their construction. The program has now been modified to give due consideration to a situation of limited capital availability, and to optimise the network within this constraint.

1.1. Consideration of the constraint would logically take place after the optimal network has been identified. The only alteration required in the main program would be the inclusion of a subroutine which calculates the capital requirements at each stage of the optimisation. Once the main program has terminated, a comparison would be made between capital requirement and capital availability. If the former is greater, further study is required in order to amend the network, so that the restraint is met.

1.2. I have adopted the following principles before making amendments to the program:-

a. The availability of capital is not an absolute figure. There would be a certain leeway, one way or the other, and I have assumed that the usual ± 10% will be available. In this context, the program will operate on the median figure with the awareness that the final figure could be either a little more or a little less.

b. The program will first reach the unrestrained optimum. It will then take into account the limitation on capital and sub-optimise within this constraint. We will then have 2 solutions which provide management the information on which to decide whether to divert additional capital to the distribution system from elsewhere.

c. The program will also calculate the bond rate of return on the investment. When the cut-off is applied on capital, a corresponding cut-off will appear on bond rates. This will further assist management to decide whether to divert capital to this system from other investments.

d. The constraint on capital becomes relevant only when considering new depots. Each new depot will be considered as a new investment.

e. I have fixed a 20 year life for new depots, and no residual scrap value. It is very easy to alter either of these conditions.

1.3. Working on these assumptions, I have made the following additions/amendments to the program :-

1.3.1. Section 6.2.8. of the main thesis describes how fixed costs of new depots have been generated. From this we note that the capital required was

(P x .001 + 4000) x 185, where P is the monthly throughput.

I have already assigned the value of .001 to the variable AX, and the statement would then read

(P x AX + 4000) x 185

There will now be provision for AZ=4000 and LQ=185, and the capital required would then be obtained by

(P x AX + AZ) x LQ

1.3.2. I have also assigned the variable KQ to represent the availability of capital. In my example I have set KQ as equal to Rs. 3,000,000/-.

1.3.3. A new input to the main program would therefore be

```
     READ(1,299)AZ,KQ,LQ
 299 FORMAT(F5.0,I7,I3)
```

1.3.4. When the status quo has been summarised at the end of each iteration, an additional segment calculates the capital requirement of each new depot, and its bond rate of return.

i.e. within the DO 152 I=1,ID loop

```
 158 IF(I.LT.JC)GO TO 159                                   (1)
     E(I)=TT(I)*AX+AY                                       (2)
     CAP(I)=(TT(I)*AX+AZ)*LQ                                (3)
     CAPT=CAPT+CAP(I)                                       (4)
     ENT=0                                                  (5)
 300 PRV=0                                                  (6)
     II=1                                                   (7)
 301 PRV=PRV+(12*(RA(I)+(TT(I)*AX+AZ)))/((1+
                   ENT/100)**II)                            (8)
     II=II+1                                                (9)
     IF(II-20)301,302,302                                  (10)
 302 IF(PRV-CAP(I))303,303,304                             (11)
 304 ENT=ENT+.01                                           (12)
     GO TO 300                                             (13)
 303 DCF(I)=ENT                                            (14)
 159 F=F+E(I)                                              (15)
```

(1) ensures that only new depots are studied

(2) calculates monthly fixed cost of new depots using earlier relationship

(3) calculates capital requirement by relationship noted in section 1.3.1. earlier.

(4) to (13) are calculations prior to determining bond rate of return in (14). This is done by establishing the nett present value for different rates of return and selecting that rate

which makes NPV equal to or just less than the capital requirement. Statement (4) sums up the capital requirements of all new depots selected at this stage.

The last statement sums up the monthly fixed costs.

1.3.4.1. The print out at this stage includes a display of capital cost, monthly saving, and the annual bond rate of return of each new depot. The cumulative capital requirement is also displayed. Appendix "A" contains a specimen printout.

1.3.5. At the end of the main program a check is made to determine whether the total capital requirement exceeds availability. If it does not, the program continues with the sensitivity analysis. If it does, additional deliberations follow.

1.3.5.1. Initially all new depots are arranged in descending order of bond rates. Within the context of capital shortage, one attempts to maximise return on investment, and the bond rates of each of the new depots assist in making comparisons with other projects.

1.3.5.2. The subroutine which does so is :-

```
          IJ=0                                          (1)
          DO 313 I=1,ID                                 (2)
          TT(I),IS(I)=06                                (3)
          J=1                                           (4)
          IF(DCF(J)-DCF(J+1))314,315,315                (5)
      315 YC=DCF(J)                                     (6)
          II=J                                          (7)
          GO TO 316                                     (8)
      314 YC=DCF(J+1)                                   (9)
          II=J+1                                       (10)
      316 J=J+1                                        (11)
          IF(J-ID)317,317,318                          (12)
      317bIF(YC-DCF(J+1))314,316,316                   (13)
      318 TT(I)=DCF(II)                                (14)
          IS(I)=II                                     (15)
      313 DCF(II)=0                                    (16)
          WRITE(2,319)                                 (17)
      319 FORMAT(3X49HDEPOTS ARRANGED IN DESCENDING
                    ORDER OF BOND RATES//)             (18)
```

```
      WRITE(2,320)                                      (19)
  320 FORMAT(10X5HDEPOT6X9HBOND RATE//)                 (20)
      DO 321 I=1,ID                                     (21)
      IF(TT(I))321,321,322                              (22)
  322 WRITE(2,323)DP(IS(I)),TT(I),IS(I),CAP(IS(I))      (23)
  323 FORMAT(9XA8,4XF8.2,6XI3,6XF10.2)                  (24)
      IJ=IJ+1                                           (25)
  321 CONTINUE                                          (26)
```

(1) sets up a counter which indicates the number of new depots in the basis.

(2) to (16) arranges bond rates in descending order of magnitude. In doing so, it creates a new series of variables TT(i) which will denote the descending series of bond rates. The original notation of bond rates, the DCF(i) values are then set to zero. It also creates a new series of IS(i) values which represent the distinctive numbers of the depots whose bond rates are arranged in descending order in the TT(i) series.

(17) to (26) provide for a printout of the above information. The counter IJ (in statement 25) will count the number of new depots.

1.3.6. The next step is to select from the lists prepared in section 1.3.5. above, those depots which can be accomodated within the limited availability of capital. In doing so, those with the higher rates of bond return will be chosen in preference to those with lower rates, while ensuring all the time that the capital restraint is not broken. The subroutine ensures that as many depots as possible are accepted.

```
      I=1                                               (1)
      J=0                                               (2)
      TH=CAP(IS(I))                                     (3)
  324 IF(KQ-TH)325,325,326                              (4)
  326 J=J+1                                             (5)
      NE(J)=IS(I)                                       (6)
      IS(I)=0                                           (7)
  330 I=I+1                                             (8)
      IF(I-ID)327,327,328                               (9)
  327 IF(CAP(IS(I)))328,328,329                         (10)
  329 TH=TH+CAP(IS(I))                                  (11)
      GO TO 324                                         (12)
  325 TH=TH-CAP(IS(I))                                  (13)
      GO TO 330                                         (14)
  328 WRITE(2,17)                                       (15)
```

```
    WRITE(2,331)J                                           (16)
331 FORMAT(3X49HTHE CAPITAL LIMIT HAS BEEN REACHED
    AFTER OPENING I3,19H DEPOTS. THEY ARE:-/)               (17)
    DO 332 I=1,J                                            (18)
332 WRITE(2,333)DP(NE(I)),CAP(NE(I)),TT(I)                  (19)
333 FORMAT(35XA8,2(3XF10.2))                                (20)
```

(1) to (14) - the section which accepts as many depots as possible within the limit of capital availability. Preference is given to those with higher bond rates of return. There is the possibility that a depot with a high rate of return may be dropped in favour of one with a lower rate, but this will happen only if the inclusion of the former will break the capital restraint while the latter is still within acceptable limits.

This segment also identifies the depots that should remain in the basis by means of the NE(i) indicator (statement 6). At the same time the IS(i) value of all such depots is set to zero (statement 7).

1.3.6.1. The information obtained in the preceding sections together with the sensitivity analysis that follows will enable management to decide on whether an "unacceptable" depot should still be brought in.

1.3.7. We have now reached the stage where we know which of the selected depots should be retained and which should not. The only criterion which decides this is whether or not they fit into the pattern of capital availability. The next step is to divert the throughput assigned to the latter to the selected depots, so that the final solution becomes complete. In other words, we have 2 categories of depots in the final basis, the acceptable selecteds and the non-acceptable selecteds.The solution becomes complete when the locations assigned to the latter are diverted to the best alternative sources among the former.

1.3.7.1. Up to now, we have been looking only at the new depots. It will be clear that the former (acceptable selecteds) would be supplemented by all the existing depots, since these would not require any capital expenditure. We now proceed to identify them.

```
      DO 341 I=1,JB                                     (1)
      IF(KD(I)-1)341,390,341                            (2)
  390 IW=IW+1                                           (3)
      LZ(IW)=1                                          (4)
  341 CONTINUE                                          (5)
```

(1) JB is the number of existing depots which head the list of ID depots which are being conditionally considered.

(2) eliminates the central source from the list of depots.

(3) sets up a counter IW, which determines the number of existing depots remaining in the new basis.

(4) activates the indicator LZ(i) which identifies these depots.

1.3.7.1. We then have to identify, again using the LZ(i) indicator those new depots which have been found acceptable to remain in the basis. Wev know from section 1.3.6. above that there will be J such depots, identified by the NE(i) indicator (statement 6 in that section).

```
      DO 342 I=1,J                                      (1)
  342 LZ(IW+I)=NE(I)                                    (2)
```

We have thus ensured that all depots which are still feasible are identified by the LZ(i) indicator, and those that wre originally accepted but are now deemed infeasible will have a positive IS(i) value, as set in statement (15) of section 1.3.5.2. and not set to zero by statement (7) of section 1.3.6. above.

1.3.8. We are now faced with the task of reallocating those locations which were assigned to depots with a positive IS(i) value to those with a positive LZ(i) indicator, with minimum increase in cost.

1.3.8.1. Initially, we identify those depots which have a positive IS(i) value. We must them find out which locations have to be supplied from these depots, and then find the cheapest alternative route to these locations from the depots that are still retained in the basis - those which have positive NE(i) indicators.

```
      DO 348 I=1,IJ                                         (1)
      IF(IS(I))348,348,344                                  (2)
  344 DO 348 IK=1,IC                                        (3)
      IF(LA(IK)-IS(I))348,346,348                           (4)
  346 DO 347 IL=1,IW+J                                      (5)
  347 CALL UTD2(1,(LZ(IL)-1)*IC+IK,1,TT(IL))                (6)
      DO 348 IL=1,IW+J                                      (7)
      J1=1                                                  (8)
      IF(TT(J1)-TT(J1+1))349,349,350                        (9)
  349 YC=TT(J1)                                            (10)
      J2=LZ(J1)                                            (11)
      GO TO 351                                            (12)
  350 YC=TT(J1+1)                                          (13)
      J2=LZ(J1+1)                                          (14)
  351 J1=J1+1                                              (15)
      IF(J1-(IW+J))352,353,353                             (16)
  352 IF(YC-TT(J1+1))351,351,350                           (17)
  353 S(IK)=YC                                             (18)
      LA(IK)=J2                                            (19)
  348 CONTINUE                                             (20)
```

(1) ensures that only the IJ new depots are considered

(2) checks that new depots with positive values only are dealt with, i.e., those which have to be dropped

(3) and (4) determine which locations are being supplied by these depots, I.E., those locations which have LA(i) values equal to that depot number

(5) and (6)extract elements from the Transport Cost Data Grid relating to the above locations and the IW+J depots which are to be retained

(8) to (17) arrange these costs in increasing order of magnitude

(18) selects the smallest cost and (19) identifies the source which supplies each location at this smallest cost

The functions performed by the 4 DO loops are clear. The first considers only new depots; the second considers all locations; the third extracts all supply costs for all the feasible depots, and the fourth finds the lowest of these costs and

and identifies the cheapest alternative source.

1.3.9. We are now left with the final task of calculating the total cost of the second (sub-)optimal basis. We know which depots comprise this basis and which locations they supply. The transport costs are already available in the Transport Cost Data Grid.

```
      DO 379 I=1,ID                                              (1)
  379 TT(I),TX(I)=0                                              (2)
      V=0                                                        (3)
      DO 354 I=1,IC                                              (4)
      U=D(I)*S(I)                                                (5)
      KK=LA(I)                                                   (6)
      TT(KK)=TT(KK)+D(I)                                         (7)
      TX(KK)=TX(KK)+U                                            (8)
  354 V=V+U                                                      (9)
      CAPT,F,DA,VA=0                                            (10)
      WRITE(2,214)                                              (11)
      DO 355 I=1,IW+J                                           (12)
      IF(LZ(I).LT.JC)GO TO 374                                  (13)
      E(LZ(I))=TT(LZ(I))*AX+AY                                  (14)
      CAPT=CAPT+(TT(LZ(I))*AX+AZ)*LQO                           (15)
  374 WRITE(2,223)DP(LZ(I)),TT(LZ(I)),E(LZ(I)),
                                        TX(LZ(I))               (16)
      VA=VA+TX(LZ(I))                                           (17)
      DA=DA+TT(LZ(I))                                           (18)
      F=F+E(LZ(I))                                              (19)
  355 CONTINUE                                                  (20)
      F9=F+VA+T8                                                (21)
      IF(F1-DA)371,370,371                                      (22)
  371 F8=F1-DA                                                  (23)
      WRITE(2,372)F8,DA                                         (24)
  372 FORMAT(3X5HF8 = F11.2,3X5HDA = F11.2)                     (25)
  370 WRITE(2,373)VA                                            (26)
  373 FORMAT(//3X22HTOTAL VARIABLE COST = F10.2//)              (27)
      WRITE(2,377)F                                             (28)
  377 FORMAT(/3X19HTOTAL FIXED COST = F10.2//)                  (29)
      WRITE(2,25)T8                                             (30)
      WRITE(2,378)F9                                            (31)
  378 FORMAT(/3X21HTOTAL OVERALL COST = F10.2//)                (32)
      WRITE(2,380)CAPT                                          (33)
  380 FORMAT(//3X28HTOTAL CAPITAL REQUIREMENT =
                                        F10.2//)                (34)
```

(1) and (2) set all TT(i) and TX(i) values at zero, and (3) sets V at zero

(4) to (9) calculate and accumulate transport cost and demand

(10) to (20) calculates and accumulates the capital requirement and provides a print out of the position of each

depot.

(21) to (34) provides for a print out which summarises the costs and the total capital requirement of the final feasible basis.

1.4. The modifications described above have been incorporated into the computer program listed in the main thesis. The same problem has been tackled with an arbitrary limitation on capital of Rs. 3,000,000/-. The result, as shown in Appendix "A" indicate that 2 of the 5 new depots originally selected have to be dropped. The cut-off bond rate is 6.54% (the bond rates of the rejected depots being 3.95% and 3.34%). The total cost increases by Rs. 968.96, and the capital requirement is Rs. 2,547,286.81.

MULTIPLE REFINERIES

2. The presence of multiple refineries can cause drastic changes in a distribution system and the computer program has to be significantly modified to cope with their existence. The changes are consequent to the possibility that depots can be served from several main sources, at varying cost. Each depot will have a prime source, i.e., that refinery which can deliver product to it at the lowest cost. If there are no constraints on the pattern of refinery production, the program would allocate each depot to its prime source and will allocate the country8wide demand between the refineries, via the depots.

2.1. Having reached this allocation, we can then examine how total demand has been divided between the refineries. Is the allocated demand for each refinery compatible with its processing capacity? Will the allocation be less than, equal to or greater than its optimal capacity? What increases in marginal cost would result if the optimal capacity is exceeded? There would be a level of throughput which is so high that it would be clearly infeasible. It is assumed here that a suitable expression of the increased cost function is available and that it contains inbuilt provision to reflect excessive average marginal cost when the maximum throughput is approached. This expression of cost has been referred to as FUNCTN in the sample FORTRAN IV statements that I have used to illustrate my arguments.

2.1.1. Let there be i refineries, R_1, R_2.....R_i. Let their optimum throughputs be TPT_1, TPT_2.....TPT_i. (These values would have been suitably adjusted to make them compatible with the demand figures used in the distribution program.) Let the demand allocated to each refinery be DT_1, DT_2.....DT_i. The expression FUNCTN determines the extra average marginal cost that would be incurred at each refinery when DT_i exceeds TPT_i.

2.2. The following courses of action are available:-

2.2.1. Do nothing - absorb the increased costs and permit the refinery/ies to operate above optimum capacity.

2.2.2. Check whether any other refineries are operating below optimum levels. If so, check whether the extra cost of diverting supplies to a depot from the first refinery to the second is less then the cost of operating the first above its optimal throughput. In other words, divert supplies to a depot awat from its prime source and determine whether the additional expense of doing so would be less than the higher marginal cost of operating above optimal levels. If so, divert the dpots concerned and still operate at a cost lower than at 2.2.1. above.

2.2.3. It may be possible to import product from outside the system at a cost lower then the cost of production at a local refinery operating above its optimum level. In this case the throughput of the refinery (local) would be controlled by import parity.

2.3. It is intended that provision be made to deal with all three possibilities, and to select the best mix. Initially, an attempt will be made to divert depots from a refinery operating above optimum to one having spare capacity. Thereafter imports will be consisdered and refineries will be allowed to continue operating above optimum levels only as a last resort.

2.4. I will now go through the original program, describing the changes in its logic, and also suggesting with sample segemnts of FORTRAN IV, how the changes could be implemented.

2.4.1. The dimensions of the program will have to be changed. e.g., the trunking costs TT(i) will have to be replaced by a 2-dimensional variable TY(JD,ID), where JD is the number of refineries, and ID the number of depots. Similarly, the variable Y(i) which was the cost of direct supply (from the single refinery) to the IC destinations would also be 2-dimensional and read Y(JD,IC). Several new variables DT(JD) - refinery demand allocation; TPT(JD) - optimum throughput levels; EC(JD) - excess od DT(i) over TPT(i); CPT(JD) - the additional marginal cost incurred when operating with a positive EC(i) value (obtained by the use of the expression FUNCTN), and TIM(JD) - the import price of product originating from outside the system. Other new variables would include IND(JD) - the prime source of each depot, and RC(JD) indicating ex-refinery costs.

2.4.2. The inputs to the program will require alteration to reflect the above changes. e.g.,

```
      READ(4)(TT(J),J=1,ID)        would be replaced by
      DO 500 I=1,JD
  500 READ(1,501)(TY(I,J),J=1,ID)
  501 FORMAT(20F4.2)
```

2.4.3. A new subroutine would determine the prime source of each depot. e.g.,

```
      DO 614 I=JD+1,ID
      J=1
      IF((RC(J)+TY(J,I))-(RC(J+1)+TY(J+1,I)))610,610,611
  610 CLO=TY(J,I)
      IND(I)=J
      GO TO 612
  611 CLO=TY(J+1)
      IND(I)=J+1
  612 J=J+1
```

```
      IF(J-JD)613,614,614
  613 IF(CLO-TY(J+1,I))612,612,611
  614 CONTINUE
```

It is assumed that the refineries head the list of potential sources of supply, and that each refinery can make deliveries direct to customers.

This sequence creates a new variable IND(i) which denotes the prime source (refinery) of each depot.

2.4.4. The subroutine which calculates the elements of the Transport Cost Data Grid would be modified to retain 2-dimensional values of Y. e.g.,

```
IF(I.LT.JD+1)Y(I,J)=D(J)
```

2.4.5. At the initial stage of the program, when calculating the cost of supplying all centres of demand direct from the refineries, a subroutine similar to that in section 2.4.3. above determines which refinery is the lowest cost soyrce for each centre. The costs are the Y(JD,IC) values. e.g.,

```
      DO 620 I=1,IC
      J=1
      IF(Y(J,I)-Y(J+1,I))615,615,616
  615 S(I)=Y(J,I)
      LA(I)=J
      GO TO 617
  616 S(I)=Y(J+1,I)
      LA(I)=J+1
  617 J=J+1
      IF(J-JD)618,619,619
  618 IF(S(I)-Y(J+1,I))617,617,616
  619 V=V+D(I)*S(I)
  620 DT(LA(I))=DT(LA(I))+D(I)
```

This segment determines the lowest cost refinery, identifies it (LA(i)), and notes the actual cost (S(i)). It also calculates the total variable cost V, and the refinery allocations DT(i).

2.4.6. We now have to determine whether any refinery is operating above its optimum, and, if so, whether any other refinery has spare capacity. We must also calculate the increase in marginal cost as a result of exceeding optimum throughput.

```
      DO 630 I=1,JD
      IF(DT(I)-TPT(I))631,632,633
  631 EC(I)=DT(I)-TPT(I)
      ECI=-EC(I)
      WRITE(2,634)DP(I),ECI
  634 FORMAT(3XA8,32H REFINERY HAS SPARE CAPACITY OF
                                       F8.2/)
      CPT(I)=0
      GO TO 630
  632 WRITE(2,635)DP(I)
  635 FORMAT(3XA8,37H REFINERY IS OPERATING AT ITS
                                         OPTIMUM/)
      EC(I),CPT(I)=0
      GO TO 630
  633 EC(I)=DT(I)-TPT(I)
      CPT(I)=EC(I)*FUNCTN
      WRITE(2,636)DP(I),EC(I),CPT(I)
  636 FORMAT(3XA8,33H REFINERY EXCEEDS ITS OPTIMUM BY
          F8.2,29H AND INCURS AN EXTRA COST OF F8.2/)
  630 CONTINUE
```

EC(I) represents the difference between the allocated and optimum throughput for each refinery, while CPT(I) denotes the extra cost of operating a refinery above its optimum. The expression FUNCTN has been used to derive the latter.

We now know which refinery operates below, at or above its optimum throughput, and the quantum of extra cost incurred. It has been assumed in the above statements that no extra cost is incurred when a refinery operates below its optimum. If such a cost has to be included, another cost expression, say FUNLOW, can be incorporated.

2.4.7. We now examine the possibility of diverting supplies from one refinery to another if the additional cost of doing so is less than the extra marginal cost total of CPT(i). Diversions will take place only to those refineries that have spare capacity. e.g.,

```
      DO 699 I=1,JD
      DO 640 II=1,JD
      DO 640 J=1,IC
  640 Y1(II,J)=Y(II,J)
      IZ=1
      IF(EC(I))699,699,700
  700 DO 701 J=1,IC
      IF(LA(J)-I)698,702,698
  698 TB(I)=20000000+I
      GO TO 701
  702 II=1
```

```
      IF(I.EQ.1)GO TO 704
      IF(Y1(II,J)-Y1(II+1,J))703,703,704
  703 YC=Y1(II,J)
      IYC=II
      GO TO 705
  704 IF(II+1.EQ.I)GO TO 703
      YC=Y1(II+1,J)
      IYC=II+1
  705 II=II+1
      IF(II+1.EQ.I)GO TO 705
      IF(II-JD)706,707,707
  706 IF(YC-Y1(II+1,J))705,705,704
  707 IF(EC(IYC))708,709,709
  708 TB(J)=(YC-Y1(I,J))*D(J)
      GO TO 701
  709 Y1(IYC,J)=1000000
      TB(J)=20000000
      IZ=IZ+1
      IF(IZ-JD)702,641,641
  641 WRITE(2,642)I
  642 FORMAT(3X25HTHE EXCESS FROM REFINERY A8,39H CANNOT
                 BE DIVERTED TO ANOTHER REFINERY/)
  701 CONTINUE
```

Y1(JD,ID) is an intermediate variable.

Tanking only those refineries that are operating above optimum, the above segment locates the cheapest alternative source(refinery) for each depot supplied by this refinery. It then calculates the notional additional cost (TB(i)) of doing so. It calculates similar costs for supplies from all other refineries. Since we are interested in minimising costs we should rank these costs in ascending order of magnitude.

```
      DO 716 L=1,IC
      J=2
      IF(TB(J-1)-TB(J))717,717,718
  717 HL=TB(J-1)
      II=J-1
      GO TO 719
  718 HL=TB(J)
      II=J
  719 J=J+1
      IF(J-IC)719,719,718
  720 IF(HL-TB(J))719,719,718
  721 IS(L)=II
  716 TB(II)=20000000+L
```

We can now decide how many of these depots are to be diverted such that the total cost of doing so does not exceed CPT(i)

```
      J=1
      II=0
      TH=TB(IS(J))
  714 IF(CPT(I)-TH)710,716,716
  716 IYC=LA(IS(J))
      DT(IYC)=DT(IYC)+D(IS(J))
      DT(I)=DT(I)-D(IS(J))
      EC(IYC)=EC(IYC)+D(IS(J))
      EC(I)=EC(I)-D(IS(J))
      VP=VP+TB(IS(J))
      IF(EC(IYC))713,699,699
  713 J=J+1
  715 IF(J-IC)712,712,699
  712 TH=TH+TB(IS(J))
      GO TO 714
  710 TH=TH-TB(IS(J))
      GO TO 713
  699 CPT(I)=EC(I)*FUNCTN
```

The above segment would divery supply from an "over-burdened" refineryto the lowest cost refinery which would still have spare capacity, provided the extra cost of doing so does not exceed the additional cost incurred by the former. It also ensures that the latter does not go above its optimum level of throughput.

To summarise the several functions performed by the above segemnts:-

a. "Over-burdened" refineries have been identified.

b. The locations that they supply have been determined.

c. The lowest alternative cost of supplying these locations have been isolated.

d. If the refinery which can supply at this lowest cost has spare capacity, it calculates the cost of diverting supplies to this refinery.

e. It diverts sufficient depots such that the extra cost of doing so does not exceed the extra cost incurred by operating the "over-burdened" refinery above its optimum.

f. In doing so, it ensures that that the second refinery does not itself become "over-burdened".

g. It sums up the extra costs of diversions (which will be less than the cost referred to in e. above.

The total variable cost now becomes the sum of

i. the orihinal variable cost V,

ii. the cost, VP, of "filling up" refineries with spare capacity, and

iii. the cost penalties of refineries that still operate above their optimum.

2.4.8. The possibility of imports is now considered for any remaining "over-burdened" refineries. e.g.,

```
      DO 650 I=1,JD
      IF(EC(I))650,650,651
  651 ETPT=1
  654 IF((ETPT*(RC(I)+FUNCTN)-TIM(I)))652,652,653
  652 ETPT=ETPT+1
      IF(ETPT-EC(I))654,654,655
  655 WRITE(2,656)I
  656 FORMAT(3X20HIMPORTS TO REFINERY A8,46H ARE TOO
            COSTLY AT PRESENT LEVEL OF OPERATIONS/)
      GO TO 650
  653 DT(I)=TPT(I)+ETPT
      ETPT1=EC(I)-ETPT
      COSE=ETPT1*TIM(I)
      CPT(I)=(DT(I)-TPT(I))*FUNCTN
      WRITE(2,657)ETPT1,DP(I),COSE
  657 FORMAT(3X7HIMPORT F10.2,15H INTO REFINERY A8,14H AT
                                A COST OF F10.2/)
      WRITE(2,658)DP(I),DT(I),CPT(I)
  658 FORMAT(3X9HREFINERY A8,32H NOW OPERATES AT A
       THROUGHPUT OF F10.2,27H AND STILL INCURS A COST
                                         OF F10.2/)
  650 CONTINUE
```

The total cost now becomes the sum of

i. the original cost V,

ii. the cost VP,

iii. the import cost COSE, and

iv. the costs CPT(i).

2.4.9. The above procedure is rpeeated after the demand allocations are known at each iteration of the main program. The importatnt features that need emphasis are

a. the demand points are now the <u>depots</u>, and not individual centres of demand,

b. Depots are diverted, rather than customers,

c. the indicator IND(i) is additional to indicator LA(j),

and d. the costs that are compared are the trunking costs TY(i,j) rather than the direct supply costs Y(k,l).

2.4.10. Further small modifications are required to cope with the altered situation. They include

i. LA(II)=IND(LB) to replace LA(II)=1, and

S(II)=Y(IND(LB),II) to replace S(II)=Y(II), in the check stage of the main program when a depot is dropped as being "unprofitable", and the locations supplied by it are reverted to the central source; in this case they will be reverted to the refinery which is the prime source of the depot.

ii. The demand allocation for each refinery has to be built up. The statement

DT(IND(KK))=DT(IND(KK)+TT(KK), added to the sequence which adds up depot costs and throughputs will accomplish this.

iii. Changes similar to i. above will also be required in the sensitivity analysis.

iv. other small changes mainly in the legends in the print out will have to be made.

2.5. The above modifications are designed to cope with a system having any number of refineries. I have already adapted my main program to handle 2 refineries. This modified program was used as the principal algorithm in a problem which was tackled as a post-graduate project[1] at Loughborough

University. A hypothetical problem was created; the marketing area covering England and Wales, divided into 195 centres of demand. The 2 refineries were located at Loughborough and Avonmouth, and 33 possible locations for bulk depots were postulated. The program ran successfully and selected 20 bulk depots to serve the whole area. Very substantial savings were effected by their intorduction. An accurate estimate of savings could not be obtained because the students did not use a realistic mileage grid to calculate the Transport Cost Data Grid. They represented deliveries that were clearly infeasible by an arbitrary high distance of 999 miles and this introdueed errors into the calculation. They did not utilise the segments involved in the study of allocated against optimal refinery capacity, mainly due to lack of time in data praparation. This project report was accepted as being of satisfactory standard.

2.6. The bulk of the above extra effort dealt with the likelihood that there is an externally determined pattern of optimum production at each refinery, and that deviations from these levels would increase refining cost. Even though this is an exercise in distribution optimisation, provision must be made for its effect on other costs in the larger system to maintain the same total systems approach that has been adhered to throughout this study.

2.7. If each refinery is flexible enough to cope with any demand made on it, the inclusion of multiple refineries becomes a much simpler matter. All that need be determined is the prime source for each depot, and the total allocation of demand to each refinery. This assumption was made in the project report referred to earlier.

COMPARISON OF METHODS OF ANALYSIS

3. The main thesis contained a general description of the new method, and compared its features with published work on this subject. Sections 4.7. to 4.21. contained details of these methods and pointed out certain weaknesses in their structure. However a quantitative comparison was not made between the new and the old methods. I have been requested to carry out such a comparison with 2 existing methods, namely, that of Maranzana (section 4.13. of main thesis), and that of either Feldman, lehrer and Ray, or Smykay (section 4.21.), or Keuhn & Hamburger (section 4.18.). I have successfully made contact with Dr. Maranzana, and in a devious way, with the work of Feldman, Lehrer and Ray. Professor Smykay has declined his assistance, while Keuhn and Hamburger have yet to reply to my requests for help.

3.1. I shall compare my method with that of Maranzana, and that of Feldman, Lehrer and Ray (described in section 4.19. of main thesis). For this purpose I have developed a problem based upon that used by Maranzana.[2] It is set in Italy, where a certain product is distributed to 40 centres of consumption from a factory located in Milan. He has specified the demand at each of these centres and has shown their location on a diagrammatic map of Italy. I have used this map to establish the possible routes of supply and to determine the distances involved. The demand figures are given in Table 1.

3.2. Appendix "B" contains a listing of Maranzana's program. In accordance with his directions I have had to fix

TABLE 1

DISTRIBUTION OF DEMAND

LOCATION	QUANTITY
1. Milan	50000
2. Rome	50000
3. Naples	15000
4. Turin	30000
5. Genoa	25000
6. Parma	10000
7. Bologna	15000
8. Florence	15000
9. Venice	10000
10. Trieste	10000
11. Bari	5000
12. Palermo	5000
13. Verona	8000
14. Trento	3000
15. Padua	7000
16. Pavia	500
17. Sondrio	300
18. Novara	500
19. Biella	200
20. La Spezia	200
21. Pisa	100
22. Lucca	100
23. Fano	30
24. Savona	50
25. Pesaro	300
26. Perugia	300
27. Foggia	25
28. Avellino	2
29. Cagliari	5000
30. Sassari	15
31. Catania	8
32. Syracuse	4
33. Ferrara	40
34. Piacenza	6
35. Alesandra	6
36. Siena	30
37. Grosetto	15
38. Ancona	4000
39. Viterbo	2
40. Rieti	2

(arbitrarily) the number of depots that should together form the optimal basis. This is done by nominating the number and feeding that many depots into the program as an initial solution. I have made 4 different runs, one with 3 depots; two with 4 depots; and one with 15 depots (the maximum capacity of the program supplied to me).

3.2.1. As described in the main thesis, Maranzana's method does not take into account the fixed costs of the depots. He also assumes that unit transportation cost is derectly proportional to distance. In using his program, I too have excluded fixed costs, and by assuming that the unit transport cost per unit distance is 1, have used the distance matrix as the Transport Cost Matrix.

3.2.2. The results obtained in the printout are rather meagre. They only comprise the initial solution, the final solution, a listing of centres of demand and depot number, and a reproduction of the distance matrix dealt with originally by the program.

3.2.3. Extracts of the results of all 4 runs are reproduced below. (Appendix "B" contains the full results). I had two runs with 4 depots in order to investigate whether the final solution varies if the original depots selected to form the initial solution vary. The objective functions are expressed as the sum of the products of demand and transport cost. In this case, I have assumed that unit cost per unit distance is 1.

3.2.3.1. <u>Run No. 1</u>

```
INITIAL SOLUTIONS WERE =  23   6   12
FINAL SOLUTIONS ARE =    2   1   9
OBJ. F. = 0.9642E 07
```

3.2.3.2. <u>Run No. 2</u>

```
INITIAL SOLUTIONS WERE =   2   1   9   12
FINAL SOLUTIONS ARE =    2   1   9   12
OBJ. F. = 0.9091E 07
```

3.2.3.3. Run No. 3

```
INITIAL SOLUTIONS WERE =   4    9    23    30
FINAL SOLUTIONS ARE =    18    2    15    29
OBJ. F. = 0.7887E 07
```

3.2.3.4. Run No. 4

```
INITIAL SOLUTIONS WERE = 1  2  3  4  5  6  7  8  9
   10  11  12  13  14  15
FINAL SOLUTIONS ARE =  1  2  3  4  5  6  7  8  9  10
   11  12  13  14  15
OBJ. F. = 0.7026E  06
```

3.2.4. The 4 values of the objective function indicate an obvious trend - the greater the number of depots, the smaller the transportation cost. This is the case with any distribution cost analysis which is based solely on depot-to-customer transportation costs. But there are other costs in the system, namely, factory-to-depot costs, and the fixed costs of the depots. Both categories of costs would increase with number of depots. What is required of an effective method would be to find a minimum total of all costs. This method does not accomplish this. On the contrary, if one persists with this method, the lowest cost solution would be reached when there is a depot at every centre of demand!

3.2.5. An equally serious weakness of the method is shown up by the results of the second and third runs. Both these require 4 depots in the basis. The initial solutions were purposely different for the two runs, with no depot being common to both. The results indicate a rather curious situation. One of the runs (the third) selected 4 new depots and eliminated all 4 of the initial selections. The objective function was 0.7887×10^{7}. The second run retained all 4 of the initial selections as the final basis. One would thus believe that these 4 were in fact the optimum; but the objective function turned out to be 0.9091 x 10^7, which is over 15% higher than that of the third run.

3.2.6. These results indicate that this method would not be suitable for solving a realistic problem within a reasonable time. The only way of reaching the optimum would be by carrying out many (hundreds or even thousands) runs, calculating the other costs of the system, and adding them, before finally deciding on the best network of depots. Unless runs with all possible combinations of depots in the initial solution are carried out, one cannot be certain of reaching the optimum.

3.2.7. A small modification to this method could make it cope with non-linearity of transport costs. Instead of feeding in distances, one could feed in transport costs, which have been calculated externally, and which contain provision for non-linearity. This method has been described in section 6.3.4.4. of the main thesis. The cost element could also contain the operating cost of the depot, and the common operating cost of the central source.

3.2.8. Further comments on this method are incorporated in section 3.5. which makes a comparison of all three methods. However, in view of the serious weaknesses of this method, no further computation has been carried with it. Its reliability is so suspect that there would be little purpose ganied by its further use. However, the comments made above form an adequate basis for comparison with the other methods.

3.3. As described in section 4.19. of the main thesis, Feldman, Lehrer and Ray have developed a program which is an extension of the Keuhn and Hamburger algorithm (section 4.18. of the main thesis). They have introduced the concept of incremental operating costs for each depot, where unit variable cost would bear some describable relationship to throughput.

3.3.1. They tackle the warehouse location problem from two directions. The first, the ADD approach, starts from an existing basis, or from the best single location, takes the likely depot sites, one by one, and includes in the basis only those that contribute in reducing the total distribution cost. The second approach is the DROP method, which assumes that all likely depots are in the basis and drops those whose rejection would reduce total costs.

3.3.2. The ADD approach is recommended for the construction of a new system or for the developemnt of an existing one. The DROP approach was introduced to reduce the frequency of certain infeasible solutions which occured in some large scale problems. The ADD approach has been used in tackling the present problem.

3.3.3. The input to this program consists of certain control instructions interspersed by many series of data in predetermined formats representing the fixed costs, depot variable costs and transport costs.

3.3.3.1. When tackling the present 40 x 40 problem, it was assumed that there were three existing supply points in the system, namely, the factory/depot at Milan, and a depot each at Rome and Naples. These are the points selected for the3-depot basis by Maranzana's program (section 3.2.3.1.). The fixed costs at these points were assumed to be 15000, 6000 and 2500 respectively.

The fixed costs of the new depots were to be built up by the expression

Fixed Cost = 1000 + Throughput/10

The program, as originally written, envisages the inclusion of pre-calculated fixed costs as input data. However, to add some realism to the problem, the above expression has been included to ensure that fixed costs bear some relationship to throughput. It would be a simple matter to use a more suitable expression.

3.3.3.2. The transport cost data consists of Factory-to-Warehouse cotss (Factory cost plus transport cost), and Warehouse-to- Customer costs. The original Keuhn and Hamburger program assumes linear transportation costs, but I have altered the figures to represent realistic non-linear transportation costs. They have been built up in the manner described in section 6.3.4.4. of the main thesis, according to -

If distance is less than 30, unit rate = standard rate.

If less than 60 and greater than 29, unit rate = std. rate increased by 10%

If less than 110 and greater than 59, unit rate = std. rate increased by 22%

If less than 180 and greater than 109,unit rate = std. rate increased by 35%

If less than 260 and greater than 179,unit rate = std. rate increased by 55%

If less than 350 and greater than 259,unit rate = std. rate increased by 75%

If distance is greater than 349, unit rate is twice std. rate.

These same cost figures have been used in the new method as described later in section 3.4.

3.3.3.3. Appendix "C" contains more details of the computer program and the results of this problem.

3.4. The main thesis has adequately dealt with the details of the new method. This method has been applied to the same problem with certain assumptions; it has been assumed that there are 3 existing depots - Milan, Rome and Naples - depots 1, 2 and 9 as determined in section 3.2.3.1. by Maranzana's method - and the same initial basis as used in the second problem (section 3.3.). The fixed costs of these depots have again been taken as 15000, 6000 and 2500 respectively. The same expression

Fixed Cost = 1000 +Allocated throughput/10

has been used, as before, to calculate the fixed costs of any new depots. Similarly, non linearity in transport cost has been provided for as in Appendix "B" of the main thesis and in section 3.3.

3.4.1. Since this exercise is a comparison of the basic potentialities of 3 methods, I have not carried out a cost analysis as required by conditions of limited availability of capital, nor have I included provision for multiple factories. Neither of the earlier methods has provision for the former, but the second method can handle multiple factories. I have included the Sensitivity Analysis because it is a useful part of the technique which indicates whether a further inprovement in the solution is available.

3.4.1.2. Ihave not reduced the dimensions used for the original 86 x 613 problem solved in the main thesis, even though the present problem includes only a 40 x 40 matrix.

3.4.2. The results obtained indicate that the optimal basis consists of only 2 points of supply, the central factory/depot at Milan, and the existing depot at Rome.

3.4.3. The Sensitivity Analysis confirms that the above two points comprise the optimum basis. The retention of Naples, to preserve the existing basis, would incur a minimum additional cost of 1592 units, and losses would also arise if any other depots are forced into the basis.

3.4.4. Appendix "D" contains full details of the results.

3.5. This section compares the success of the three methods as used to solve the same problem. The preceding sections 3.2., 3.3. and 3.4. have covered the general features of the 3 methods and have shown that Maranzaza's method is clearly unsuitable for use in this type of problem. Be that as it may, coverage of this method is included in the following sub-sections which deal with specefic aspects of the methods used.

3.5.1. Overall Performance and Results

3.5.1.1. The first method (Maranzana's) has not been able to cope with the problem.

3.5.1.2. The second method (Feldman, Lehrer & Ray's) has reached an optimum. It indicates that the best warehouse pattern is the factory/depot at Milan, and one other depot at Rome. There is a saving of about 6.5% on the costs of the present 3-depot system.

3.5.1.3. The third method (the new one) has reached the same optimum.

We therefore have confirmation that these two methods are effective and have reached the optimum.

3.5.2. Computer Core Space Requirements

3.5.2.1. The first method required an average core space of 7100 for a 40 x 40 problem.

3.5.2.2. The second method required a core space of 22200 for the same 40 x 40 problem.

3.5.2.3. The thrid method required a core space of 23200 for a 85 x 613 problem. The diemnsions of the problem tackled in the main thesis were retained even for the 40 x 40 problem.

The striking economy of the third method is quite clear.

3.5.3. Computing Time

3.5.3.1. The first method required an average of 50 seconds for compilation and 95 seconds for execution.

3.5.3.2. The second method required 256 seconds for compilation and 231 seconds for execution with a restricted print out.The computer print out displayed in Appendix "C" shows an execution time only of over 15 minutes (907 seconds). This is due to the fact that this run had a full Trace. Removal of the Trace feature reduced the execution time very considerably.

3.5.3.3. The third method required 106 seconds for compilation and 157 seconds for execution (also with a restricted print out). Of this latter time, 129 seconds were for the main program and 28 seconds were for the Sensitivity Analysis.

3.5.3.4. The computer used for all the above runs was the ICT 1905 described in Appendix "A" of the main thesis.

The saving in time by the use of the third method is very significant.

3.5.4. Readability and Detail of Print out

3.5.4.1. The paucity of detail in results of the first method has already been mentioned and demonstrated (section 3.2.3. and Appendix "B"). It refers to warehouses by number, not by name, thus requiring further cross-referencing in order to interpret the results.

3.5.4.2. The print out obtained by the second method is restricted. The results are more easily read and understood, but in this case both warehouses and customers are referred to by number, again requiring cross-referencing before the results can be assimilated.

3.5.4.3. The third method too has been with a restricted print out, but the layout is more easily readable and contains much more information than that of the second method. This is particularly true of the sensitivity analysis which indicates the minimum increase in cost if a change is forced in the optimal basis. All depots and warehouses are referred to by name, thus eliminating the need for cross-referencing, and providing a <u>complete</u> answer to the problem.

3.5.5. <u>Preparation of Data</u>

3.5.5.1. All three methods are such that the preparation of data is a comparatively simple task.

3.5.6. <u>Flexibility of Algorithms</u>

3.5.6.1. The first method is quite restricted in its capabilities.

3.5.6.2. The second method can cope with many variations of the problem. The two basic methods of analysis, The ADD and DROP approaches have already been mentioned. This facility would be a self-checking mechanism, but there is no guarantee that the check would be effective as the two approaches have been designed to supplement rather than check each other. (The inability to guarantee reaching the basolute optimum is the feature common to <u>all three methods</u>, which are all heuristic.) There is also the EVALUATOR option, which carries out an accounting function, in that it verifies the costs, etc., of a preselected basis. This method can handle more than one factory, but only one product, (or a composite product). It cannot take capital constraints into consideration.

3.5.6.2.1. The ADD option does not have provision for calculating the cost of the existing basis, i.e., the Milan, Rome,Naples network. There is thus no control cost against which the performance of the algorithm can be judged. The only indication (by default) that the present basis has been considered is that Naples has been dropped. The EVALUATOR option has to be called to determine the cost of the existing network. This step would certainly increase computing time.

3.5.6.3. The third method has all the advantages of the second one. In addition, its logic is such that a counterpart of a DROP approach would be redundant; the sequence of steps ensures that <u>all solutions are feasible</u>. A built in segment determines the cost of any given basis, as it does in the sample problem, where the two systems evaluated are (a) the existing Milan,Rome,Naples network, and (b) supply from Milan only. The EVALUATOR function is also thus inherent in this method; it provides a bench mark against which future feasible solutions can be compared, and determines whether or not the exercise has been successful. The latest modifications to this program, as described in sections 1. and 2. of this supplement, provide for more than one central source and for conditions of restricted capital availability.

REFERENCES

1. Harington, G.C., and Bolbero, J.: Post-Graduate Project Report on Distribution Systems. Department of Chemical Engineering, Loughborough University of Technology, 1969.

2. Maranzaza, F.E.: "On the location of supply points to minimise transport costs". I.B.M. Systems Journal, 2. June 1963.

APPENDIX "A"

THE CAPITAL CONSTRAINTS PROGRAM

The following pages contain the full listing of the modified program which will cope with the problem of restricted capital availability. The full results are also presented. The problem that has been tackled is the same as that dealt with in the main thesis. The optimal result is there-fore the same.

The core space requirement of 22720 for the 86 x 613 problem noted in page 56.

```
      MASTER DISTRIBUTION COST ANALYSIS
      DIMENSION DP(86),E(86),KD(86),TT(86),TX(86),LX(86),RA(86),P(86),RT
     1(86),D(613),DN(613),LA(613),S(613),X(613),TB(613),IS(613),Y(613),S
     2I(613),ND(613),I0(3),I1(3),I2(3),I3(3),I4(3),I5(3),I6(5),I7(5),I8(
     35),LZ(613),SZ(613),NE(86),CAP(86),DCF(86)
      DATA I4(1)/12H   INITIAL  /,I5(1)/12H ADDITIONAL /,I1(1)/12H  INCL
     1USION /,I2(1)/12H  RETENTION /,I7(1)/20HENTER THE BASIS     /,I8(1
     2)/20HREMAIN IN THE BASIS /
      CALL TIME(T)
      WRITE(2,1)T
    1 FORMAT(/1X13HSTART TIME = A8/)
      CALL UTD1(110000)
      READ(1,2)AX,AY,AZ,LQ,KQ
    2 FORMAT(F5.3,F6.1,F5.0,I3,I7)
      JQ=10
      READ(4)IC,ID,JB,IG,OK,RR
      DO 3 I=1,ID
      READ(4)(D(J),J=1,IC)
    3 CALL UTD2(2,IC*(I-1)+1,IC,D(1))
      DO 4 I=1,IC
    4 READ(4)DN(I),S(I),SI(I),X(I),TB(I)
      READ(4)(DP(I),I=1,ID)
      READ(4)(E(I),I=1,JB)
      READ(4)(TT(I),I=1,ID)
      READ(4)(TX(I),I=1,ID)
      READ(4)(Y(I),I=1,IC)
      READ(4)(LX(I),I=1,ID)
      READ(4)(IS(I),I=1,IC)
      REWIND 4
      DO 5 I=1,JB
    5 CT=CT+E(I)
      WRITE(2,6)
    6 FORMAT(/3X38HSUMMARY OF COUNTRY WIDE DEMAND PATTERN//)
      WRITE(2,7)
    7 FORMAT(3X5HDESTN4X5HDEPOT2X6HDEL EX1X6HCOL EX1X6HDEL EX1X6HCOL EX,
     12(2X5HTOTAL3X5HTOTAL))
      WRITE(2,8)
    8 FORMAT(19X5HDEPOT3X5HDEPOT3X3HKOL4X3HKOL3X3HDEL3X3HCOL2X6HDEMAND4X
     14HCOST//)
      DO 9 I=1,IC
      IF(S(I))10,10,11
   11 CALL UTD2(1,IC*(IS(I)-1)+I,1,PX)
      GO TO 12
   10 S(I)=0
   12 IF(X(I))13,13,14
   14 CALL UTD2(1,I,1,0)
      GO TO 15
   13 X(I)=0
```

```
   15 T2=S(I)*PX
      T3=SI(I)*(OK+TT(IS(I))+TX(IS(I)))
      T4=X(I)*Q
      T5=TB(I)*OK
      T6=T6+T3
      T7=T7+T5
      W=T2+T3+T4+T5
      C1=C1+W
      WW=WW+T2+T4
      D(I)=S(I)+X(I)
      T1=SI(I)+TB(I)
      F1=F1+D(I)
      F2=F2+T1
      V=D(I)+T1
      J0=S(I)
      J1=SI(I)
      J2=X(I)
      J3=TB(I)
      J4=D(I)
      J5=T1
      J6=V
   16 FORMAT(2(1XA8),1XI6,1XI5,1XI7,1XI6,1XI7,1XI6,1XI7,1XF7.0)
    9 CONTINUE
      WRITE(2,17)
   17 FORMAT(//)
      WRITE(2,18)F1
   18 FORMAT(3X19HTOTAL DELIVERIES = F11.2/)
      WRITE(2,19)F2
   19 FORMAT(3X20HTOTAL COLLECTIONS = F10.2/)
      F3=F1+F2
      WRITE(2,20)F3
   20 FORMAT(/3X39HTOTAL DEMAND THROUGHOUT THE COUNTRY IS F12.2//)
      WRITE(2,21)CT
   21 FORMAT(//3X33HFIXED COST OF EXISTING NETWORK = F11.2/)
      WRITE(2,22)WW
   22 FORMAT(//3X36HDELIVERY COST OF EXISTING NETWORK = F11.2/)
      CT=CT+C1
      T8=T6+T7
      WRITE(2,23)T6
   23 FORMAT(/3X34HCOST OF COLLECTIONS FROM DEPOTS = F10.2)
      WRITE(2,24)T7
   24 FORMAT(3X42HCOST OF COLLECTIONS FROM CENTRAL SOURCE = F10.2)
      WRITE(2,25)T8
   25 FORMAT(/3X32HTOTAL COST OF ALL COLLECTIONS = F11.2//)
      WRITE(2,26)C1
   26 FORMAT(//3X36HVARIABLE COST OF EXISTING NETWORK = F11.2/)
      WRITE(2,27)CT
   27 FORMAT(///3X33HTOTAL COST OF EXISTING NETWORK = F13.2///)
```

```
      JC=ID-1
      JB=JB-1
      WRITE(2,28)DP(1),JC,JB
   28 FORMAT(//2X50HTHIS PROGRAM WILL ARRANGE SUPPLY FROM THE CENTRAL SO
     1URCE - A8/17H AND SOME OF THE I3,52H LIKELY DEPOT LOCATIONS TO RED
     2UCE TOTAL DISTRIBUTION/27H COST. OF THESE, THE FIRST I3,42H DEPOTS
     3 COMPRISE THE EXISTING DISTRIBUTIVE/8H NETWORK)
      JB=JB+1
      WRITE(2,29)JC
   29 FORMAT(3X4HTHE I3,29H LIKELY DEPOT LOCATIONS ARE:-//)
      WRITE(2,30)
   30 FORMAT(3X5HDEPOT3X14HOPERATING COST3X11HSUPPLY COST3X11HSOURCE COS
     1T3X19HTOTAL COST EX DEPOT0)
      WRITE(2,31)
   31 FORMAT(25X26HRUPEES PER IMPERIAL GALLON/)
      DO 32 I=2,ID
      TZ=TX(I)+TT(I)+OK
   32 WRITE(2,33)DP(I),TX(I),TT(I),OK,TZ
   33 FORMAT(1XA8,7XF6.4,9XF6.4,8XF6.4,11XF6.4)
      WRITE(2,17)
      JC=JB+1
      WRITE(2,34)DP(1)
   34 FORMAT(3X56HINITIAL DISTRIBUTION PATTERN - ALL DESTINATIONS SUPPLI
     1ED/26H FROM THE CENTRAL SOURCE (A8,1H)/)
      CALL UTD2(1,1,IC,S(1))
      V,W=0
      DO 35 I=1,IC
      W=S(I)*D(I)
      LA(I)=1
   35 V=V+W
      C=E(1)+V+T8
      WRITE(2,36)DP(1),E(1)
   36 FORMAT(/3X14HFIXED COST OF A8,4H IS F10.2)
      WRITE(2,37)DP(1),V
   37 FORMAT(3X49HVARIABLE COST OF SUPPLYING ALL DESTINATIONS FROM A8,4H
     1 IS F13.2/)
      WRITE(2,25)T8
      WRITE(2,38)C
   38 FORMAT(3X23HINITIAL OVERALL COST = F13.2//)
      C2=CT-C
      WRITE(2,39)C2
   39 FORMAT(3X42HIMPROVEMENT OVER COST OF PRESENT SYSTEM = F12.2/)
      C3=(100*C2)/CT
      WRITE(2,40)C3
   40 FORMAT(5X25HPERCENTAGE IMPROVEMENT = F7.2///)
      WRITE(2,41)
   41 FORMAT(1X53H-----------------------------------------------------)
      C4=C
```

```
      KD(1)=1
      KD(12),KD(26),KD(40),KD(43)=5
   42 K=1
      IR=0
   43 K=K+1
      IF(K.GT.ID)GO TO 44
      IF(KD(K).GT.4)GO TO 43
      IF(KD(K).EQ.1)GO TO 45
      BK,RK,NG=0
      CALL COPY(12,I0(1),1,I1(1),1)
      CALL COPY(12,I3(1),1,I4(1),1)
      CALL COPY(20,I6(1),1,I7(1),1)
      GO TO 46
   45 NG=1
      RK=RA(K)
      BK=AY
      CALL COPY(12,I0(1),1,I2(1),1)
      CALL COPY(12,I3(1),1,I5(1),1)
      CALL COPY(20,I6(1),1,I8(1),1)
   46 KD(K)=1
      CALL UTD2(1,(K-1)*IC+1,IC,X(1))
      M=-2
      IA=IC
      MD=0
   47 IF(M)48,48,49
   48 DO 50 J=1,ID
   50 RT(J)=RA(J)
      GO TO 51
   49 WRITE(2,52)DP(K),I6
   52 FORMAT(/3XA8,12H DEPOT WILL 5A4)
      WRITE(2,53)
   53 FORMAT(//3X23HIMPROVED SUPPLY PATTERN/)
   54 FORMAT(1X11HDESTINATION2X10HTHROUGHPUT2X6HSOURCE2X15HCOST PER GALL
     1ON2X14HTRANSPORT COST/)
      DO 55 J=1,ID
   55 TT(J),TX(J),CAP(J),DCF(J)=0
      GO TO 56
   51 MM=0
   56 V,Q,F,R,A=0
      DO 57 I=1,IA
      IF(MD)58,58,59
   58 IB=I
      GO TO 60
   59 IB=ND(I)
   60 TB(IB)=0
      IF(MM)61,62,61
   62 SI(IB)=S(IB)
   61 SX=SI(IB)-X(IB)
```

```
      IF(SX)63,63,64
   64 IF(M)65,66,65
   66 LB=LA(IB)
      IF(LB-1)67,65,67
   67 IF(LX(LB).GT.0.AND.KD(LB).EQ.1)LX(LB)=LX(LB)+D(IB)
      IF(LB-JC)68,69,69
   68 DI=0
      GO TO 70
   69 DI=D(IB)
   70 CALL UTD2(1,IG+(LB-1)*IC+IB,1,BT)
      RT(LB)=RT(LB)-BT+DI*AX
   71 IF(RT(LB))72,72,65
   72 RT(LB)=RA(LB)
      DO 73 II=1,IC
      IF(LB-LA(II))73,74,73
   74 IF(LB-JC)75,76,76
   75 DI=0
      GO TO 77
   76 DI=D(II)
   77 CALL UTD2(1,IG+(LB-1)*IC+II,1,BT)
      RT(LB)=RT(LB)-BT+DI*AX
      KD(LB)=3
      IR=IR+1
      LA(II)=1
      S(II)=V(II)
   73 CONTINUE
      WRITE(2,78)DP(LB),DP(1)
   78 FORMAT(/2XA8.60H DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATION
     1S ASSIGNED/22H TO IT WILL REVERT TO A8,18H FOR RE-ALLOCATION/)
      MM=1
      GO TO 56
   65 W=D(IB)*X(IB)
      TB(IB)=D(IB)*SX
      V=V+W
      R=R+TB(IB)
      A=A+D(IB)
      IF(M)57,57,79
   79 S(IB)=X(IB)
      LA(IB)=K
   80 FORMAT(68X5HSAVE F10.2,14H BY SUPPLYING A8,6H FROM A8)
      U=W
      GO TO 81
   63 U=D(IB)*S(IB)
      Q=Q+U
      IF(M)57,57,81
   81 KK=LA(IB)
      TT(KK)=TT(KK)+D(IB)
      TX(KK)=TX(KK)+U
```

```
 82 FORMAT(1XA8,3XF11.2,2XA8,5XF6.4,8XF10.2)
 57 CONTINUE
    IF(MD)83,83,84
 83 IF(M)85,85,86
 86 IF(KY.EQ.0)CALL UTD2(2,IG+(K-1)*IC+1,IC,TB(1))
    DO 87 I=1,ID
 87 RA(I)=RT(I)
 85 IF(A)88,88,89
 89 IF(K.LT.JC)GO TO 90
    E(K)=A*AX+AY-BK
 90 IF(NG)91,91,92
 91 RA(K)=R-E(K)
    GO TO 93
 92 IF(K-JC)94,94,95
 94 RA(K)=R+RK
    GO TO 93
 95 RA(K)=R-E(K)+RK
 93 IF(RA(K))96,96,97
 88 IF(NG.EQ.1)GO TO 43
 96 KD(K)=4
    GO TO 43
 97 IF(M.EQ.-1)GO TO 98
    IF(LX(K))99,100,101
101 IF(LX(K)-A)102,100,100
102 EX=A-LX(K)
    WRITE(2,103)A,DP(K),LX(K),EX
103 FORMAT(2X28HTHE GENERATED THROUGHPUT OF F10.2,4H AT A8,30H EXCEEDS
   1 ITS MAXIMUM VALUE OF 71XI10,4H BY F10.2)
    DO 104 L=1,IC
    J=2
    IF(TB(J-1)-TB(J))105,105,106
106 HI=TB(J-1)
    II=J-1
    GO TO 107
105 HI=TB(J)
    II=J
107 J=J+1
    IF(J-IC)108,108,109
108 IF(HI-TB(J))105,107,107
109 IS(L)=II
104 TB(II)=L-IC
    GO TO 110
100 M=M+1
110 IF(M.GT.1)GO TO 111
    M=M+1
    GO TO 47
 98 I=1
    J=0
```

```
      TH=D(IS(I))
  112 IF(LX(K)-TH)113,114,114
  114 J=J+1
      ND(J)=IS(I)
      IS(I)=0
  115 I=I+1
      IF(I-IC)116,116,117
  116 IF(D(IS(I)))117,117,118
  118 TH=TH+D(IS(I))
      GO TO 112
  113 TH=TH-D(IS(I))
      GO TO 115
   99 WRITE(2,119)K,DP(K)
  119 FORMAT(//8X39HERROR IN CALCULATIONS FOR DEPOT NUMBER I3,1H(A8,2H).
     1//)
      GO TO 43
  117 IF(J)120,120,121
  121 WRITE(2,122)DP(K),J
  122 FORMAT(3X26HTHE MAXIMUM THROUGHPUT OF A8,30H DEPOT HAS BEEN REACHE
     1D AFTER I3,13H DESTINATIONS/62H (ARRANGED IN DECREASING ORDER OF S
     2AVINGS)ARE SUPPLIED FROM IT/)
      M=M+1
      IA=J
      MD=1
      GO TO 47
   84 IF(M)123,123,124
  124 DO 125 I=1,IC
      IF(IS(I))125,125,126
  126 IB=IS(I)
      TB(IB)=0
      U=D(IB)*S(IB)
      Q=Q+U
      KK=LA(IB)
      TT(KK)=TT(KK)+D(IB)
      TX(KK)=TX(KK)+U
  125 CONTINUE
      IF(KY.EQ.0)CALL UTD2(2,IG+(K-1)*IC+1,IC,TB(1))
      DO 127 II=1,ID
  127 RA(II)=RT(II)
  123 IF(A)120,120,128
  128 IF(K.LT.JC)GO TO 129
      E(K)=A*AX+AY-BK
  129 IF(NG)130,130,131
  130 RA(K)=R-E(K)
      GO TO 132
  131 IF(K-JC)133,134,134
  133 RA(K)=R+RK
      GO TO 132
```

```
  134 RA(K)=R-E(K)+RK
  132 IF(RA(K))135,135,136
  120 IF(NG.EQ.1)GO TO 43
  135 KD(K)=4
      IF(KY)137,137,43
  137 WRITE(2,138)A,DP(K)
  138 FORMAT(3X30HTHE CONSTRAINED THROUHHPUT OF F10.2,31H IS INSUFFICIEN
     1T TO JUSTIFY THE/14H INCLUSION OF A8,13H IN THE BASIS///)
      WRITE(2,17)
      GO TO 43
  136 IF(M)139,139,140
  139 M=M+1
      GO TO 47
  140 LX(K)=LX(K)-A
  111 WRITE(2,141)T3,DP(K),A
  141 FORMAT(/3X3A4,14HTHROUGHPUT AT A8,4H IS F11.2/)
      IF(K-JB)142,142,143
  142 WRITE(2,144)DP(K),E(K)
  144 FORMAT(5X14HFIXED COST OF A8,4H IS F9.2)
      GO TO 145
  143 WRITE(2,146)T3,DP(K),E(K)
  146 FORMAT(5X11HCALCULATED 3A4,14HFIXED COST OF A8,4H IS F8.2)
  145 WRITE(2,147)T3,DP(K),V
  147 FORMAT(3X3A4,17HVARIABLE COST OF A8,4H IS F11.2/)
      WRITE(2,148)T3,T0,DP(K),R
  148 FORMAT(3X3A4,16HGROSS SAVING BY 3A4,3HOF A8,17H IN THE BASIS IS F1
     11.2)
      WRITE(2,149)T0,DP(K),RA(K)
  149 FORMAT(5X31HCONTRIBUTION TO NETT SAVING BY 3A4,3HOF A8,4H IS F9.2/
     1/)
      WRITE(2,150)
  150 FORMAT(3X15HDEPOTS IN BASIS//)
      WRITE(2,151)
  151 FORMAT(4X5HDEPOT3X18HPRESENT THROUGHPUT1X10HFIXED COST4X13HVARIABL
     1E COST6X7HCAPITAL4X9HBOND RATE//)
      CAPT,NY=0
      DO 152 I=1,ID
      J=1
      IF(KD(I)-1)153,154,153
  154 IF(I-LA(J))155,156,155
  156 IF(TT(I))157,157,158
  155 J=J+1
      IF(J-IC)154,154,153
  158 IF(I.LT.JC)GO TO 159
      E(I)=TT(I)*AX+AY
      CAP(I)=(TT(I)*AX+AZ)*LQ
      CAPT=CAPT+CAP(I)
      ENT=0
```

```
  300 PRV=0
      II=1
  301 PRV=PRV+(12*(RA(I)+(TT(I)*AX+AZ)))/((1+ENT/100)**II)
      II=II+1
      IF(II-20)301,301,302
  302 IF(PRV-CAP(I))303,303,304
  304 ENT=ENT+.01
      GO TO 300
  303 DCF(I)=ENT
  159 F=F+E(I)
      WRITE(2,160)DP(I),TT(I),E(I),TX(I),CAP(I),DCF(I)
  160 FORMAT(3XA8,3XF11.2,7XF9.2,5XF10.2,2(3XF10.2))
      GO TO 152
  157 KD(I)=2
  153 IF(I.GT.(JC-1))E(I)=0
  152 CONTINUE
      DO 161 I=1,ID
      IF(KD(I).EQ.2.OR.KD(I).EQ.3)GO TO 162
      GO TO 161
  162 WRITE(2,163)DP(I)
  163 FORMAT(/3XA8,35H DEPOT HAS DROPPED OUT OF THE BASIS)
      NY=NY+1
      KD(I)=4
  161 CONTINUE
      WRITE(2,17)
      WRITE(2,375)CAPT
  375 FORMAT(3X33HCUMULATIVE CAPITAL REQUIREMENT = F10.2/)
      IF(K-1)164,164,165
  164 N=K
      GO TO 166
  165 N=N+1-NY-NG
  166 WRITE(2,167)N,F
  167 FORMAT(3X33HFIXED COST OF CENTRAL SOURCE AND I3,12H DEPOT/S IS F10
     1.2)
      VA=V+Q
      C=F+VA+T8
      WRITE(2,168)N,VA
  168 FORMAT(3X36HVARIABLE COST OF CENTRAL SOURCE AND I3,12H DEPOT/S IS
     1F10.2)
      WRITE(2,25)T8
      WRITE(2,169)C
  169 FORMAT(3X23HREDUCED OVERALL COST = F12.2//)
      C5=C4-C
      WRITE(2,170)I3,I0,DP(K),C5
  170 FORMAT(3X3A4,15HNETT SAVING BY 3A4,3HOF A8,17H IN THE BASIS IS F11
     1.2/)
      C2=CT-C
      C3=(100*C2)/CT
```

```
      WRITE(2,39)C2
      WRITE(2,40)C3
      IF(K-JB)308,308,309
  309 WRITE(2,307)DP(K),CAP(K),DCF(K)
  307 FORMAT(1X8HDEPOT - A8,2X15HCAPITAL COST = F9.2,2X12HBOND RATE = F7
     1.2//)
  308 WRITE(2,41)
      IF(KY)171,171,43
  171 C4=C
      GO TO 43
   44 IF(IR)172,172,173
  173 WRITE(2,174)IR
  174 FORMAT(/3X5HIR = I3/)
      GO TO 42
  172 TO,TF,TS=0
      IF(KY)175,175,176
  175 WRITE(2,177)
  177 FORMAT(//3X17HEND OF ITERATIONS//)
      WRITE(2,178)
  178 FORMAT(3X28HOPTIMAL DISTRIBUTION PATTERN///)
      WRITE(2,54)
      GO TO 179
  176 WRITE(2,180)
  180 FORMAT(3X30HRESULTANT DISTRIBUTION PATTERN//)
  179 DO 181 I=1,IC
      X(I)=S(I)*D(I)
  181 TS=TS+X(I)
      IF(KY)182,182,183
  182 WRITE(2,184)TS
  184 FORMAT(/3X45HSUM OF VARIABLE COSTS TO ALL DESTINATIONS IS F11.2/)
      WRITE(2,185)
  185 FORMAT(/3X37HALLOCATION OF DESTINATIONS TO SOURCES//)
      WRITE(2,186)
  186 FORMAT(///3X6HSOURCE8X11HDESTINATION4X10HTHROUGHPUT3X15HCOST PER G
     1ALLON3X14HTRANSPORT COST)
  183 DO 187 J=JC,ID
  187 E(J)=0
      DO 188 J=1,ID
      W,TX(J)=0
      DO 189 I=1,IC
      IF(J-LA(I))189,190,189
  190 W=W+D(I)
      IF(KY)191,191,192
  191 CONTINUE
  193 FORMAT(1XA8,7XA8,8XF11.2,10XF6.4,8XF11.2)
  192 TX(J)=TX(J)+X(I)
  189 CONTINUE
      IF(W)188,188,194
```

```
  194 IF(KY)195,195,196
  195 WRITE(2,197)DP(J),W
  197 FORMAT(5X20HFINAL THROUGHPUT AT A8,4H IS F11.2)
  196 IF(J-JB)198,198,199
  198 IF(KY)200,200,201
  200 WRITE(2,144)DP(J),E(J)
      GO TO 201
  199 E(J)=TT(J)*AX+AY
      IF(KY)202,202,203
  202 WRITE(2,204)DP(J),E(J)
  204 FORMAT(5X22HREVISED FIXED COST OF A8,4H IS F9.2)
  201 IF(KY)205,205,203
  205 WRITE(2,206)DP(J),TX(J)
  206 FORMAT(5X17HVARIABLE COST OF A8,4H IS F10.2/)
  203 TF=TF+E(J)
  188 CONTINUE
      TO=TF+TS+T8
      C2=CT-TO
      C3=(100*C2)/CT
      IF(KY)207,207,208
  207 WRITE(2,209)TF
  209 FORMAT(//3X58HTOTAL FIXED COST OF CENTRAL SOURCE AND SELECTED DEPO
     1TS IS F11.2)
      WRITE(2,210)TS
  210 FORMAT(3X42HTOTAL VARIABLE COST OF OPTIMAL PATTERN IS F11.2)
      WRITE(2,25)T8
      WRITE(2,211)TO
  211 FORMAT(///3X41HTOTAL OVERALL COST OF OPTIMAL PATTERN IS F11.2/)
      WRITE(2,39)C2
      WRITE(2,40)C3
      WRITE(2,380)CAPT
      WRITE(2,212)
  212 FORMAT(//3X46HFINAL THROUGHPUTS AND COSTS OF SELECTED DEPOTS/)
      WRITE(2,213)
  213 FORMAT(3X52H(ZERO THROUGHPUT INDICATES NON-UTILISATION OF DEPOT)/)
      WRITE(2,214)
  214 FORMAT(//1X5HDEPOT3X16HFINAL THROUGHPUT3X10HFIXED COST3X13HVARIABL
     1E COST/)
      DO 215 K=1,ID
      IF(E(K))216,216,217
  217 IF(TT(K))218,218,219
  218 WRITE(2,220)DP(K),TT(K),E(K),TX(K)
  220 FORMAT(1XA8,3(2XF11.2),1X36HTHIS EXISTING DEPOT WILL NOT BE USED)
      GO TO 215
  219 IF(K-JB)216,216,221
  221 WRITE(2,222)DP(K),TT(K),E(K),TX(K)
  222 FORMAT(1XA8,3(2XF11.2),1X18HNEW DEPOT LOCATION)
      GO TO 215
```

```
  216 WRITE(2,223)DP(K),TT(K),E(K),TX(K)
  223 FORMAT(1XA8,3(2XF11.2))
  215 CONTINUE
      NP=N-1
      TZ=TO
      GO TO 224
  208 WRITE(2,225)TF
  225 FORMAT(/3X19HTOTAL FIXED COST = F10.2)
      WRITE(2,226)TS
  226 FORMAT(3X22HTOTAL VARIABLE COST = F10.2)
      WRITE(2,25)TB
      WRITE(2,227)TO
  227 FORMAT(3X21HTOTAL OVERALL COST = F10.2)
      TQ=TO-TZ
      WRITE(2,228)TQ
  228 FORMAT(/3X22HMINIMUM EXTRA COST IS F10.2//)
      IF(TQ)229,229,230
  229 WRITE(2,231)DP(IZ),IZ
  231 FORMAT(3X39HTHE PROGRAM SHOULD BE RE-RUN EXCLUDING A8,17H DEPOT BY
     1 SETTING/4H KD(I3,12H) EQUAL TO 5///)
      GO TO 230
  224 IF(IQ)232,232,233
  233 DO 234 I=1,IC
  234 D(I)=D(I)*INCRSE
      CONTINUE
      GO TO 42
  232 IF(KQ)334,334,335
  335 IF(KQ-CAPT)310,334,334
  310 CAPTS=CAPT-KQ
      WRITE(2,17)
      WRITE(2,311)CAPT,KQ,CAPTS
  311 FORMAT(3X33HTHE TOTAL CAPITAL REQUIREMENT OF F10.2,20H EXCEEDS THE
     1 MAXIMUM/17H AVAILABILITY OF I7,4H BY F10.2//)
      DO 313 I=1,ID
      IS(I),TT(I)=0
      J=1
      IF(DCF(J)-DCF(J+1))314,315,315
  315 YC=DCF(J)
      II=J
      GO TO 316
  314 YC=DCF(J+1)
      II=J+1
  316 J=J+1
      IF(J-ID)317,318,318
  317 IF(YC-DCF(J+1))314,316,316
  318 TT(I)=DCF(II)
      IS(I)=II
  313 DCF(II)=0
```

```
      WRITE(2,319)
  319 FORMAT(3X49HDEPOTS ARRANGED IN DESCENDING ORDER OF BOND RATES//)
      WRITE(2,320)
  320 FORMAT(10X5HDEPOT6X9HBOND RATE//)
      IJ=0
      DO 321 I=1,ID
      IF(TT(I))321,321,322
  322 WRITE(2,323)DP(IS(I)),TT(I),IS(I),CAP(IS(I))
      IJ=IJ+1
  323 FORMAT(9XA8,4XF8.2,6XI3,6XF10.2)
  321 CONTINUE
      I=1
      J=0
      TH=CAP(IS(I))
  324 IF(KQ-TH)325,325,326
  326 J=J+1
      NE(J)=IS(I)
      IS(I)=0
  330 I=I+1
      IF(I-ID)327,327,328
  327 IF(CAP(IS(I)))328,328,329
  329 TH=TH+CAP(IS(I))
      GO TO 324
  325 TH=TH-CAP(IS(I))
      GO TO 330
  328 WRITE(2,17)
      WRITE(2,331)J
  331 FORMAT(3X49HTHE CAPITAL LIMIT HAS BEEN REACHED AFTER OPENING I3,19
     1H DEPOTS. THEY ARE:-/)
      DO 332 I=1,J
  332 WRITE(2,333)DP(NE(I)),CAP(NE(I)),TT(I)
  333 FORMAT(35XA8,2(3XF10.2))
      DO 343 I=1,ID
  343 TT(I),TX(I)=0
      DO 341 I=1,JB
      IF(KD(I)-1)341,390,341
  390 IW=IW+1
      LZ(IW)=I
  341 CONTINUE
      DO 342 I=1,J
  342 LZ(IW+I)=NE(I)
      DO 348 I=1,IJ
      IF(IS(I))348,348,344
  344 DO 348 IK=1,IC
      IF(LA(IK)-IS(I))348,346,348
  346 DO 347 IL=1,IW+J
  347 CALL UTD2(1,(LZ(IL)-1)*IC+IK,1,TT(IL))
      DO 348 IL=1,IW+J
```

```
      J1=1
      IF(TT(J1)-TT(J1+1))349,349,350
  349 YC=TT(J1)
      J2=LZ(J1)
      GO TO 351
  350 YC=TT(J1+1)
      J2=LZ(J1+1)
  351 J1=J1+1
      IF(J1-(IW+J))352,353,353
  352 IF(YC-TT(J1+1))351,351,350
  353 S(IK)=YC
      LA(IK)=J2
  348 CONTINUE
      DO 379 I=1,ID
  379 TT(I),TX(I)=0
      V=0
      DO 354 I=1,IC
      U=D(I)*S(I)
      KK=LA(I)
      TT(KK)=TT(KK)+D(I)
      TX(KK)=TX(KK)+U
  354 V=V+U
      CAPT,F,DA,VA=0
      WRITE(2,214)
      DO 355 I=1,IW+J
      IF(LZ(I).LT.JC)GO TO 374
      E(LZ(I))=TT(LZ(I))*AX+AY
      CAPT=CAPT+(TT(LZ(I))*AX+AZ)*LQ
  374 WRITE(2,223)DP(LZ(I)),TT(LZ(I)),E(LZ(I)),TX(LZ(I))
      VA=VA+TX(LZ(I))
      DA=DA+TT(LZ(I))
      F=F+E(LZ(I))
  355 CONTINUE
      F9=F+VA+T8
      IF(F1-DA)371,370,371
  371 F8=F1-DA
      WRITE(2,372)F8,DA
  372 FORMAT(3X5HF8 = F11.2,3X5HDA = F11.2)
  370 WRITE(2,373)VA
  373 FORMAT(//3X22HTOTAL VARIABLE COST = F10.2//)
      WRITE(2,377)F
  377 FORMAT(/3X19HTOTAL FIXED COST = F10.2//)
      WRITE(2,25)T8
      WRITE(2,378)F9
  378 FORMAT(/3X21HTOTAL OVERALL COST = F10.2//)
      WRITE(2,380)CAPT
  380 FORMAT(//3X28HTOTAL CAPITAL REQUIREMENT = F10.2//)
  334 IF(JQ)235,235,236
```

```
  235 WRITE(2,237)
  237 FORMAT(///3X20HSENSITIVITY ANALYSIS//)
      CALL TIME(T)
      WRITE(2,238)T
  238 FORMAT(3X7HTIME = A8/)
      KY=1
      DO 340 I=1,ID
      NE(I)=KD(I)
  340 P(I)=RA(I)
      DO 239 I=1,IC
      SZ(I)=S(I)
  239 LZ(I)=LA(I)
      DO 230 IZ=2,ID
      WRITE(2,41)
      WRITE(2,41)
      IF(NE(IZ).EQ.1)GO TO 240
      CALL UTD2(1,(IZ-1)*IC+1,IC,X(1))
      K,DJ,TB(IZ),TT(IZ)=0
      WRITE(2,242)DP(IZ)
  242 FORMAT(//3XA8,66H DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CE
     1NTRES OF DEMAND:-)
      DO 243 J=1,IC
      S(J)=SZ(J)
      SX=S(J)-X(J)
      IF(SX)243,243,244
  244 TB(IZ)=TB(IZ)+(SX*D(J))
      K=K+1
      TT(IZ)=TT(IZ)+D(J)
      WRITE(2,245)DN(J),D(J)
  245 FORMAT(55XA8,5XF10.2)
      IF(LA(J)-JB)246,246,247
  246 DI=0
      GO TO 248
  247 DI=D(J)
  248 DJ=DJ+DI
  243 CONTINUE
      IF(K)249,249,250
  249 WRITE(2,251)
  251 FORMAT(55X4HNONE)
  250 WRITE(2,252)TB(IZ)
  252 FORMAT(3X30HTHE TOTAL POTENTIAL SAVING IS F10.2)
      IF(IZ.LT.JC)GO TO 253
      E(IZ)=TT(IZ)+AX+AY
  253 RA(IZ)=E(IZ)-TB(IZ)-DJ*AX
      WRITE(2,254)RA(IZ)
  254 FORMAT(/3X51HMINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS F1
     10.2//)
      GO TO 230
```

```
  240 WRITE(2,255)DP(IZ)
  255 FORMAT(//3X19HEFFECT OF DROPPING A8,27H DEPOT FROM THE FINAL BASIS
     1/)
      N=NP
      DO 256 I=1,ID
      RA(I)=P(I)
  256 KD(I)=NE(I)
      KD(IZ)=5
      DO 257 I=1,IC
      IF(LZ(I).EQ.IZ)GO TO 258
      LA(I)=LZ(I)
      S(I)=SZ(I)
  258 S(I)=Y(I)
      LA(I)=1
      GO TO 257
  257 CONTINUE
      GO TO 42
  230 CONTINUE
  236 CALL TIME(T)
      WRITE(2,259)T
  259 FORMAT(/1X18HCOMPLETION TIME = A8/)
      WRITE(2,260)
  260 FORMAT(//3X10HEND OF JOB)
      STOP
      END

 END OF SEGMENT, LENGTH  3840, NAME  DISTRIBUTIONCOSTANALYSIS
```

```
CONSOLIDATED BY XPCL 5B      DATE   25/08/69   TIME 07/29/05

PROGRAM GP03
COMPACT DATA (15AM)      . . .
COMPACT PROGRAM (DRM)
CORE             22720   ....... Note:  Core space requirement for 86 x 613 problem.

LW    *00000120     80
LV    *00000122     82
R3    *00000411    265
LP    *00000433    283
LT    *00001562    882
RR    *00001605    901
UP    *00015336   6878
R8    *00040356   8430
UV    *00040606   8582
RW    *00054204  22660

SEG   *00001605    901   %%%F
CUP   *00040356   8430   %FIOINF
CLP   *00001353    747   %FIOLIST
SEG   *00014021   6161   %FIOCARD
SEG   *00014134   6236   %FIOLPDB
SEG   *00014442   6434   %FIOMT
CUP   *00040406   8454   %FIOBUF
SEG   *00011674   5052   %FERL
SEG   *00001605    901   DISTRIBUTIONCOSTANALYSIS
SEG   *00011377   4863   %FAP4
ENT   *00011741   5089   %FPM
SEG   *00015274   6844   TIME
SEG   *00014070   5176   %FINOUT
SEG   *00011205   4741   UTD1
SEG   *00011674   5052   %FPP
SEG   *00011251   4777   UTD2
SEG   *00015301   6849   COPY
SEG   *00014372   6394   %FIOTA
SEG   *00011776   5118   %FSTOP
ENT   *00011773   5115   %FERND
CLV   *00000411    265   %LIB
CLV   *00000421    273   %FMC
CLP   *00001362    754   %F1
ENT   *00011743   5091   %FER
ENT   *00011735   5085   %FRL
CLP   *00001364    756   %AA4K
CLP   *00001464    820   %FITER
ENT   *00011674   5052   %FPRO2
ENT   *00011775   5117   %FMN4
ENT   *00014070   5176   %FIOAUX
CLP   *00001465    821   %FEB
CLP   *00001500    832   %FDIS
CLP   *00001502    834   %ACLOS
CLP   *00001503    835   %FPNO
CLP   *00001504    836   %FDMK
SEG   *00013756   6126   %FINF
CLV   *00000424    276   %FIOLEN
CLV   *00000426    278   %FMTP
```

```
ENT *00013151 5737 %FIOA
ENT *00013357 5871 %FIOC
ENT *00013426 5910 %FIOG
ENT *00013550 5992 %FIOD
CLV *00000431  281 %FIOPER
ENT *00014314 6348 %FIOND
ENT *00014535 6365 %FOTR
SEG *00014305 6341 %FINIL
CLV *00000432  282 %FDA
CLP *00001517  847 %FIOWKB
CLP *00001532  858 %FMTCOM
CLP *00001542  866 %FDCOM1
ENT *00015006 6662 %FMTND
ENT *00015036 6686 %FIORWD
ENT *00015253 6827 %FIOREL
ENT *00015017 6671 %FIOALLO
ENT *00015026 6673 %FIOREN
SEG *00014604 6532 %FINMT
ENT *00015137 6751 %FIRD
ENT *00015152 6762 %FIWT
ENT *00015166 6774 %FIOBKSP
ENT *00015065 6709 %FIOENDF
CLP *00001547  871 %FOPF
ENT *00015001 6657 %FIOCHT
ENT *00015127 6743 %FBUFZ
```

START TIME = 07/30/10

SUMMARY OF COUNTRY WIDE DEMAND PATTERN

DESTN	DEPOT	DEL EX DEPOT	COL EX DEPOT	DEL EX KOL	COL EX KOL	TOTAL DEL	TOTAL COL	TOTAL DEMAND	TOTAL COST

TOTAL DELIVERIES = 21182769.96

TOTAL COLLECTIONS = 3325496.07

TOTAL DEMAND THROUGHOUT THE COUNTRY IS 24508266.03

FIXED COST OF EXISTING NETWORK = 516850.00

DELIVERY COST OF EXISTING NETWORK = 2124485.88

COST OF COLLECTIONS FROM DEPOTS = 36607.19
COST OF COLLECTIONS FROM CENTRAL SOURCE = 43527.19

TOTAL COST OF ALL COLLECTIONS = 80134.38

TOTAL COST OF EXISTING NETWORK = 2721470.26

THIS PROGRAM WILL ARRANGE SUPPLY FROM THE CENTRAL SOURCE - KOLONAWA
AND SOME OF THE 85 LIKELY DEPOT LOCATIONS TO REDUCE TOTAL DISTRIBUTION
COST. OF THESE, THE FIRST 13 DEPOTS COMPRISE THE EXISTING DISTRIBUTIVE
NETWORK
THE 85 LIKELY DEPOT LOCATIONS ARE:-

DEPOT	OPERATING COST	SUPPLY COST	SOURCE COST	TOTAL COST EX DEPOT
	RUPEES PER IMPERIAL GALLON			
MATARA	0.0186	0.0983	0.0141	0.1310
KOTAGALA	0.0107	0.1300	0.0141	0.1548
HAPUTALE	0.0164	0.1690	0.0141	0.1995
PERDNIYA	0.0083	0.0793	0.0141	0.1017
BATICALO	0.0163	0.2078	0.0141	0.2382
KURNGALA	0.0125	0.0613	0.0141	0.0879
ANURPURA	0.0106	0.1242	0.0141	0.1489
JAFFNA	0.0124	0.2341	0.0141	0.2606
RATNPURA	0.0231	0.0652	0.0141	0.1024
GALLE	0.0101	0.0738	0.0141	0.0980
KILINCHI	0.0237	0.1965	0.0141	0.2343
NEWPERAD	0.0188	0.0801	0.0141	0.1130
CHINABAY	0.0200	0.0499	0.0141	0.0840
MORATUWA	0.0080	0.0195	0.0141	0.0416
PANADURA	0.0080	0.0234	0.0141	0.0455
WADDUWA	0.0080	0.0269	0.0141	0.0490
KALUTARA	0.0080	0.0324	0.0141	0.0545
ALUTGAMA	0.0080	0.0427	0.0141	0.0648
AMBLGODA	0.0080	0.0570	0.0141	0.0791
HIKADUWA	0.0080	0.0630	0.0141	0.0851
HABRDUWA	0.0080	0.0797	0.0141	0.1018
WELIGAMA	0.0080	0.0908	0.0141	0.1129
JA-ELA	0.0080	0.0196	0.0141	0.0417
NEGOMBO	0.0080	0.0286	0.0141	0.0507
LUNUWILA	0.0080	0.0377	0.0141	0.0598
MADAMPE	0.0080	0.0479	0.0141	0.0700
CHILAW	0.0080	0.0539	0.0141	0.0760
BATLUOYA	0.0080	0.0648	0.0141	0.0869
PUTTALAM	0.0080	0.0836	0.0141	0.1057
RAGAMA	0.0080	0.0163	0.0141	0.0384
GAMPAHA	0.0080	0.0227	0.0141	0.0448
VEYNGODA	0.0080	0.0278	0.0141	0.0499
MIRIGAMA	0.0080	0.0352	0.0141	0.0573
ALAWWA	0.0080	0.0443	0.0141	0.0664
PULGHWLA	0.0080	0.0491	0.0141	0.0712
MAHO	0.0080	0.0861	0.0141	0.1082
GALGMUWA	0.0080	0.0985	0.0141	0.1206
MADWCHYA	0.0080	0.1391	0.0141	0.1612
VAVUNIYA	0.0080	0.1527	0.0141	0.1748
MANKULAM	0.0080	0.1787	0.0141	0.2008
EL. PASS	0.0080	0.2054	0.0141	0.2275
PALLAI	0.0080	0.2119	0.0141	0.2340

GALOYA	0.0080	0.1368	0.0141	0.1589
KANTALAI	0.0080	0.1536	0.0141	0.1757
TRINCMLI	0.0080	0.1768	0.0141	0.1989
HINGRKGD	0.0080	0.1465	0.0141	0.1686
POLNRUWA	0.0080	0.1563	0.0141	0.1784
WELIKNDA	0.0080	0.1712	0.0141	0.1933
VALACHNI	0.0080	0.1904	0.0141	0.2125
ERAVUR	0.0080	0.2005	0.0141	0.2226
MADHU RD	0.0080	0.1638	0.0141	0.1859
MURUNKAN	0.0080	0.1712	0.0141	0.1933
MANNAR	0.0080	0.1844	0.0141	0.2065
TALMANAR	0.0080	0.1985	0.0141	0.2206
KANDY	0.0080	0.0841	0.0141	0.1062
KATGSTTA	0.0080	0.0879	0.0141	0.1100
WATEGAMA	0.0080	0.0929	0.0141	0.1150
MATALE	0.0080	0.1038	0.0141	0.1259
RAMBKANA	0.0080	0.0554	0.0141	0.0775
KADGNAWA	0.0080	0.0710	0.0141	0.0931
GAMPOLA	0.0080	0.0885	0.0141	0.1106
NAWLPTYA	0.0080	0.0985	0.0141	0.1206
WATAWALA	0.0080	0.1150	0.0141	0.1371
HATTON	0.0080	0.1260	0.0141	0.1481
TALWKELE	0.0080	0.1355	0.0141	0.1576
WATAGODA	0.0080	0.1406	0.0141	0.1627
NANU OYA	0.0080	0.1488	0.0141	0.1709
AMBAWELA	0.0080	0.1570	0.0141	0.1791
BANDRWLA	0.0080	0.1724	0.0141	0.1945
DEMODARA	0.0080	0.1757	0.0141	0.1978
HALI ELA	0.0080	0.1803	0.0141	0.2024
BADULLA	0.0080	0.1879	0.0141	0.2100
PANITPYA	0.0080	0.0163	0.0141	0.0384
HOMAGAMA	0.0080	0.0217	0.0141	0.0438
PADUKKA	0.0080	0.0259	0.0141	0.0480
AVISWELA	0.0080	0.0399	0.0141	0.0620
EHELYGDA	0.0080	0.0552	0.0141	0.0773
KURUWITA	0.0080	0.0621	0.0141	0.0842
KAHAWATA	0.0080	0.0810	0.0141	0.1031
OPANAIKE	0.0080	0.0848	0.0141	0.1069

INITIAL DISTRIBUTION PATTERN - ALL DESTINATIONS SUPPLIED
FROM THE CENTRAL SOURCE (KOLONAWA)

FIXED COST OF KOLONAWA IS 411000.00
VARIABLE COST OF SUPPLYING ALL DESTINATIONS FROM KOLONAWA IS 3038759.70

TOTAL COST OF ALL COLLECTIONS = 80134.38

INITIAL OVERALL COST = 3529894.08

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -808423.82

PERCENTAGE IMPROVEMENT = -29.71

MATARA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT MATARA IS 1107024.51

FIXED COST OF MATARA IS 7200.00
INITIAL VARIABLE COST OF MATARA IS 249617.47

INITIAL GROSS SAVING BY INCLUSION OF MATARA IN THE BASIS IS 70136.81
CONTRIBUTION TO NETT SAVING BY INCLUSION OF MATARA IS 62936.81

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	20075745.45	411000.00	2719005.42	0.00	0.00
MATARA	1107024.51	7200.00	249617.47	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 1 DEPOT/S IS 418200.00
VARIABLE COST OF CENTRAL SOURCE AND 1 DEPOT/S IS 2968622.89

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3466957.27

INITIAL NETT SAVING BY INCLUSION OF MATARA IN THE BASIS IS 62936.81

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -745487.01

PERCENTAGE IMPROVEMENT = -27.39

KOTAGALA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KOTAGALA IS 1187688.32

FIXED COST OF KOTAGALA IS 13000.00
INITIAL VARIABLE COST OF KOTAGALA IS 319932.61

INITIAL GROSS SAVING BY INCLUSION OF KOTAGALA IN THE BASIS IS 40646.09
CONTRIBUTION TO NETT SAVING BY INCLUSION OF KOTAGALA IS 27646.09

KOLONAWA	19048827.09	411000.00	2456387.39	0.00	0.00
MATARA	946254.55	7200.00	151656.79	0.00	0.00
KOTAGALA	1187688.32	13000.00	319932.61	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 2 DEPOT/S IS 431200.00
VARIABLE COST OF CENTRAL SOURCE AND 2 DEPOT/S IS 2927976.80

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3439311.18

INITIAL NETT SAVING BY INCLUSION OF KOTAGALA IN THE BASIS IS 27646.09

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -717840.91

PERCENTAGE IMPROVEMENT = -26.38

KOTAGALA DEPOT WILL DROP OUT OF THE BASIS, ALL DESTINATIONS ASSIGNED
TO IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

HAPUTALE DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT HAPUTALE IS 986638.60

FIXED COST OF HAPUTALE IS 6500.00
INITIAL VARIABLE COST OF HAPUTALE IS 301377.36

INITIAL GROSS SAVING BY INCLUSION OF HAPUTALE IN THE BASIS IS 39740.06
CONTRIBUTION TO NETT SAVING BY INCLUSION OF HAPUTALE IS 33240.06

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	19249876.81	411000.00	2444976.87	0.00	0.00
MATARA	946254.55	7200.00	151656.79	0.00	0.00
HAPUTALE	986638.60	6500.00	301377.36	0.00	0.00

KOTAGALA DEPOT HAS DROPPED OUT OF THE BASIS

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3402845.40

INITIAL NETT SAVING BY INCLUSION OF HAPUTALE IN THE BASIS IS 36465.78

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -681375.14

PERCENTAGE IMPROVEMENT = -25.04

PERDNIYA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT PERDNIYA IS 4497880.41

FIXED COST OF PERDNIYA IS 15200.00
INITIAL VARIABLE COST OF PERDNIYA IS 1331642.09

INITIAL GROSS SAVING BY INCLUSION OF PERDNIYA IN THE BASIS IS 240065.13
CONTRIBUTION TO NETT SAVING BY INCLUSION OF PERDNIYA IS 224865.13

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	15053456.18	411000.00	985997.67	0.00	0.00
MATARA	946254.55	7200.00	151656.79	0.00	0.00
HAPUTALE	685178.82	6500.00	188649.35	0.00	0.00
PERDNIYA	4497880.41	15200.00	1331642.09	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 3 DEPOT/S IS 439900.00
VARIABLE COST OF CENTRAL SOURCE AND 3 DEPOT/S IS 2657945.89

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3177980.27

INITIAL NETT SAVING BY INCLUSION OF PERDNIYA IN THE BASIS IS 224865.13

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -456510.01

BATICALO DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT BATICALO IS 385059.02

FIXED COST OF BATICALO IS 7000.00
INITIAL VARIABLE COST OF BATICALO IS 106827.05

INITIAL GROSS SAVING BY INCLUSION OF BATICALO IN THE BASIS IS 43999.15
CONTRIBUTION TO NETT SAVING BY INCLUSION OF BATICALO IS 36999.15

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	15053456.18	411000.00	985997.67	0.00	0.00
MATARA	946254.55	7200.00	151656.79	0.00	0.00
HAPUTALE	524653.92	6500.00	119881.46	0.00	0.00
PERDNIYA	4273346.29	15200.00	1249583.77	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 4 DEPOT/S IS 446900.00
VARIABLE COST OF CENTRAL SOURCE AND 4 DEPOT/S IS 2613946.74

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3140981.12

INITIAL NETT SAVING BY INCLUSION OF BATICALO IN THE BASIS IS 36999.15

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -419510.86

PERCENTAGE IMPROVEMENT = -15.41

KURNGALA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KURNGALA IS 2791521.51

FIXED COST OF KURNGALA IS 9850.00
INITIAL VARIABLE COST OF KURNGALA IS 951893.90

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	14148061.69	411000.00	836937.03	0.00	0.00
MATARA	946256.55	7200.00	151656.79	0.00	0.00
HAPUTALE	524653.92	6500.00	119881.46	0.00	0.00
PERDNIYA	2387219.27	15200.00	329088.36	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	2791521.51	9850.00	951893.90	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 5 DEPOT/S IS 456750.00
VARIABLE COST OF CENTRAL SOURCE AND 5 DEPOT/S IS 2496284.59

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3033168.97

INITIAL NETT SAVING BY INCLUSION OF KURNGALA IN THE BASIS IS 107812.15

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -311698.71

PERCENTAGE IMPROVEMENT = -11.45

ANURPURA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT ANURPURA IS 1774556.52

FIXED COST OF ANURPURA IS 6000.00
INITIAL VARIABLE COST OF ANURPURA IS 576921.25

INITIAL GROSS SAVING BY INCLUSION OF ANURPURA IN THE BASIS IS 230196.52
CONTRIBUTION TO NETT SAVING BY INCLUSION OF ANURPURA IS 224196.52

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	14148061.69	411000.00	836937.03	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 6 DEPOT/S IS 462750.00
VARIABLE COST OF CENTRAL SOURCE AND 6 DEPOT/S IS 2266088.07

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2808972.45

INITIAL NETT SAVING BY INCLUSION OF ANURPURA IN THE BASIS IS 224196.52

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -87502.18

PERCENTAGE IMPROVEMENT = -3.22

JAFFNA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT JAFFNA IS 1081888.76

FIXED COST OF JAFFNA IS 9350.00
INITIAL VARIABLE COST OF JAFFNA IS 299824.18

INITIAL GROSS SAVING BY INCLUSION OF JAFFNA IN THE BASIS IS 125741.04
CONTRIBUTION TO NETT SAVING BY INCLUSION OF JAFFNA IS 116391.04

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	14148061.69	411000.00	836937.03	0.00	0.00
MATARA	946254.55	7200.00	151656.79	0.00	0.00
HAPUTALE	524653.92	6500.00	119881.46	0.00	0.00
PERDNIYA	2387219.27	15200.00	329088.36	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	1016964.99	9850.00	144776.13	0.00	0.00
ANURPURA	692667.76	6000.00	151356.04	0.00	0.00
JAFFNA	1081888.76	9350.00	299824.18	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 7 DEPOT/S IS 472100.00
VARIABLE COST OF CENTRAL SOURCE AND 7 DEPOT/S IS 2140347.02

TOTAL COST OF ALL COLLECTIONS = 80134.38

INITIAL NETT SAVING BY INCLUSION OF JAFFNA IN THE BASIS IS 116391.04

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 28888.86

PERCENTAGE IMPROVEMENT = 1.06

RATNPURA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 776732.82

FIXED COST OF RATNPURA IS 3000.00
INITIAL VARIABLE COST OF RATNPURA IS 109497.06

INITIAL GROSS SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 7479.63
CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 4479.63

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	13517805.46	411000.00	750484.09	0.00	0.00
MATARA	946254.55	7200.00	151656.79	0.00	0.00
HAPUTALE	378177.33	6500.00	89357.71	0.00	0.00
PERDNIYA	2387219.27	15200.00	329088.36	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	1016964.99	9850.00	144776.13	0.00	0.00
ANURPURA	692667.76	6000.00	151356.04	0.00	0.00
JAFFNA	1081888.76	9350.00	299824.18	0.00	0.00
RATNPURA	776732.82	3000.00	109497.06	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 8 DEPOT/S IS 475100.00
VARIABLE COST OF CENTRAL SOURCE AND 8 DEPOT/S IS 2132867.40

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2688101.78

INITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 4479.63

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 33368.48

PERCENTAGE IMPROVEMENT = 1.23

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT GALLE IS 1076991.91

FIXED COST OF GALLE IS 8850.00
INITIAL VARIABLE COST OF GALLE IS 126549.21

INITIAL GROSS SAVING BY INCLUSION OF GALLE IN THE BASIS IS 39561 75
CONTRIBUTION TO NETT SAVING BY INCLUSION OF GALLE IS 30711.75

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	12746074.99	411000.00	634979.36	0.00	0.00
MATARA	640993.11	7200.00	101050.57	0.00	0.00
HAPUTALE	378177.33	6500.00	89357.71	0.00	0.00
PERDNIYA	2387219.27	15200.00	329088.36	0.00	0.00
BATICALO	385959.02	7000.00	106827.05	0.00	0.00
KURNGALA	1016964.99	9850.00	144776.13	0.00	0.00
ANURPURA	692667.76	6000.00	151356.04	0.00	0.00
JAFFNA	1081868.76	9350.00	299824.18	0.00	0.00
RATNPURA	776732.82	3000.00	109497.06	0.00	0.00
GALLE	1076991.91	8850.00	126549.21	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 9 DEPOT/S IS 483950.00
VARIABLE COST OF CENTRAL SOURCE AND 9 DEPOT/S IS 2093305.65

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2657390.03

INITIAL NETT SAVING BY INCLUSION OF GALLE IN THE BASIS IS 30711.75

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 64080.23

PERCENTAGE IMPROVEMENT = 2.35

CHINABAY DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT CHINABAY IS 365903.61

INITIAL GROSS SAVING BY INCLUSION OF CHINABAY IN THE BASIS IS 39066.48
CONTRIBUTION TO NETT SAVING BY INCLUSION OF CHINABAY IS 27566.48

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	12746074.99	411000.00	634979.36	0.00	0.00
MATARA	640993.11	7200.00	101050.57	0.00	0.00
HAPUTALE	378177.33	6500.00	89357.71	0.00	0.00
PERDNIYA	2387219.27	15200.00	329088.36	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	392510.70	9850.00	116127.25	0.00	0.00
ANURPURA	451218.44	6000.00	90007.57	0.00	0.00
JAFFNA	1081888.76	9350.00	299824.18	0.00	0.00
RATNPURA	776732.82	3000.00	109497.06	0.00	0.00
GALLE	1076991.91	8850.00	126549.21	0.00	0.00
CHINABAY	365903.61	11500.00	50930.86	0.00	0.00

CUMULATIVE CAPITAL REQUIREMENT = 0.00

FIXED COST OF CENTRAL SOURCE AND 10 DEPOT/S IS 495450.00
VARIABLE COST OF CENTRAL SOURCE AND 10 DEPOT/S IS 2054239.17

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2629823.55

INITIAL NETT SAVING BY INCLUSION OF CHINABAY IN THE BASIS IS 27566.48

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 91646.71

PERCENTAGE IMPROVEMENT = 3.37

AMBLGODA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT AMBLGODA IS 341810.64

CALCULATED INITIAL FIXED COST OF AMBLGODA IS 7341.81
INITIAL VARIABLE COST OF AMBLGODA IS 32125.27

INITIAL GROSS SAVING BY INCLUSION OF AMBLGODA IN THE BASIS IS 7641.43
CONTRIBUTION TO NETT SAVING BY INCLUSION OF AMBLGODA IS 299.62

KOLONAWA	12511970.95	411000.00	607903.02	0.00	0.00
MATARA	640993.11	7200.00	101050.57	0.00	0.00
HAPUTALE	378177.33	6500.00	89357.71	0.00	0.00
PERDNIYA	2387219.77	15200.00	329088.36	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	892510.70	9850.00	116127.25	0.00	0.00
ANURPURA	451218.44	6000.00	90007.57	0.00	0.00
JAFFNA	1081888.76	9350.00	299824.18	0.00	0.00
RATNPURA	776732.82	3000.00	109497.06	0.00	0.00
GALLE	969285.31	8850.00	113858.85	0.00	0.00
CHINABAY	365903.61	11500.00	50930.86	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34

CUMULATIVE CAPITAL REQUIREMENT = 803234.97

FIXED COST OF CENTRAL SOURCE AND 11 DEPOT/S IS 502791.81
VARIABLE COST OF CENTRAL SOURCE AND 11 DEPOT/S IS 2046597.73

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2629523.93

INITIAL NETT SAVING BY INCLUSION OF AMBLGODA IN THE BASIS IS 299.62

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 91946.34

PERCENTAGE IMPROVEMENT = 3.38

DEPOT - AMBLGODA CAPITAL COST = 803234.97 BOND RATE = 3.34

MADAMPE DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT MADAMPE IS 538937.87

CALCULATED INITIAL FIXED COST OF MADAMPE IS 7538.94
INITIAL VARIABLE COST OF MADAMPE IS 53503.20

INITIAL GROSS SAVING BY INCLUSION OF MADAMPE IN THE BASIS IS 11433.65
CONTRIBUTION TO NETT SAVING BY INCLUSION OF MADAMPE IS 3894.72

DEPOTS IN BASIS

DEPOT PRESENT THROUGHPUT FIXED COST VARIABLE COST CAPITAL BOND RATE

BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	884463.48	9850.00	115065.82	0.00	0.00
ANURPURA	451218.44	6000.00	90007.57	0.00	0.00
JAFFNA	1081888.76	9350.00	299824.18	0.00	0.00
RATNPURA	776732.82	3000.00	109497.06	0.00	0.00
GALLE	969285.31	8850.00	113858.85	0.00	0.00
CHINABAY	365903.61	11500.00	50930.86	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	538937.87	7538.94	53503.20	839703.51	10.39

CUMULATIVE CAPITAL REQUIREMENT = 1642938.47

FIXED COST OF CENTRAL SOURCE AND 12 DEPOT/S IS 510330.75
VARIABLE COST OF CENTRAL SOURCE AND 12 DEPOT/S IS 2035164.08

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2625629.21

INITIAL NETT SAVING BY INCLUSION OF MADAMPE IN THE BASIS IS 3894.72

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 95841.05

PERCENTAGE IMPROVEMENT = 3.52

DEPOT - MADAMPE CAPITAL COST = 839703.51 BOND RATE = 10.39

MANKULAM DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT MANKULAM IS 233958.10

CALCULATED INITIAL FIXED COST OF MANKULAM IS 7233.96
INITIAL VARIABLE COST OF MANKULAM IS 59051.07

INITIAL GROSS SAVING BY INCLUSION OF MANKULAM IN THE BASIS IS 9551.35
CONTRIBUTION TO NETT SAVING BY INCLUSION OF MANKULAM IS 2317.39

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	11985330.06	411000.00	545286.80	0.00	0.00
MATARA	640093.11	7200.00	101050.57	0.00	0.00
HAPUTALE	373927.57	6500.00	88098.50	0.00	0.00

JAFFNA	937790.18	9350.00	237329.50	0.00	0.00
RATNPURA	776732.82	3000.00	109497.06	0.00	0.00
GALLE	969285.31	8850.00	113858.85	0.00	0.00
CHINABAY	333047.50	11500.00	42463.45	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	538937.87	7538.94	53503.20	839703.51	10.39
MANKULAM	233958.10	7233.96	59051.07	783282.25	7.81

CUMULATIVE CAPITAL REQUIREMENT = 2426220.72

FIXED COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 517564.71
VARIABLE COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 2025612.73

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2623311.82

INITIAL NETT SAVING BY INCLUSION OF MANKULAM IN THE BASIS IS 2317.39

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 98158.44

PERCENTAGE IMPROVEMENT = 3.61

DEPOT - MANKULAM CAPITAL COST = 783282.25 BOND RATE = 7.81

CHVKCHRI DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT CHVKCHRI IS 535437.35

CALCULATED INITIAL FIXED COST OF CHVKCHRI IS 7535.44
INITIAL VARIABLE COST OF CHVKCHRI IS 144881.19

INITIAL GROSS SAVING BY INCLUSION OF CHVKCHRI IN THE BASIS IS 8121.51
CONTRIBUTION TO NETT SAVING BY INCLUSION OF CHVKCHRI IS 586.07

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	11985330.06	411000.00	545286.80	0.00	0.00
MATARA	640993.11	7200.00	101050.57	0.00	0.00
HAPUTALE	373927.57	6500.00	88093.50	0.00	0.00
PERDNIYA	2387219.27	15200.00	329088.36	0.00	0.00
BATICALO	385059.02	7000.00	106827.05	0.00	0.00
KURNGALA	884463.48	9850.00	115065.82	0.00	0.00

AMBLGODA	541810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	538937.87	7538.94	53503.20	839703.51	10.39
MANKULAM	150684.03	7150.68	34514.11	767876.55	6.54
CHVKCHRI	535437.35	7535.44	144881.19	839055.91	3.95

CUMULATIVE CAPITAL REQUIREMENT = 3249870.93

FIXED COST OF CENTRAL SOURCE AND 14 DEPOT/S IS 525016.87
VARIABLE COST OF CENTRAL SOURCE AND 14 DEPOT/S IS 2017491.23

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2622642.48

INITIAL NETT SAVING BY INCLUSION OF CHVKCHRI IN THE BASIS IS 669.34

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 98827.78

PERCENTAGE IMPROVEMENT = 3.63

DEPOT = CHVKCHRI CAPITAL COST = 839055.91 BOND RATE = 3.95

HAPUTALE DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
TO IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

RATNPURA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
TO IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

KAHAWATA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KAHAWATA IS 997790.43

CALCULATED INITIAL FIXED COST OF KAHAWATA IS 7997.79
INITIAL VARIABLE COST OF KAHAWATA IS 180721.04

INITIAL GROSS SAVING BY INCLUSION OF KAHAWATA IN THE BASIS IS 12052.85
CONTRIBUTION TO NETT SAVING BY INCLUSION OF KAHAWATA IS 4055.06

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]

ANURPURA	394215.03	6000.00	72167.44	0.00	0.00
JAFFNA	485626.90	9350.00	129063.56	0.00	0.00
GALLE	911104.81	8850.00	102832.48	0.00	0.00
CHINABAY	333047.50	11500.00	42463.45	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	533937.87	7538.94	53503.20	839703.51	10.39
MANKULAM	150684.03	7150.68	34514.11	767876.55	6.54
CHVKCHRI	535437.35	7535.44	144881.19	839055.91	3.95
KAHAWATA	997790.43	7997.79	180721.04	924591.23	10.01

HAPUTALE DEPOT HAS DROPPED OUT OF THE BASIS

RATNPURA DEPOT HAS DROPPED OUT OF THE BASIS

CUMULATIVE CAPITAL REQUIREMENT = 4174462.16

FIXED COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 523514.66
VARIABLE COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 2007594.24

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2611243.28

INITIAL NETT SAVING BY INCLUSION OF KAHAWATA IN THE BASIS IS 11399.20

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 110226.98

PERCENTAGE IMPROVEMENT = 4.05

DEPOT - KAHAUATA CAPITAL COST = 924591.23 BOND RATE = 10.01

KAHAWATA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
TO IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

OPANAIKE DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT OPANAIKE IS 718619.55

CALCULATED INITIAL FIXED COST OF OPANAIKE IS 7718.62
INITIAL VARIABLE COST OF OPANAIKE IS 140259.15

INITIAL GROSS SAVING BY INCLUSION OF OPANAIKE IN THE BASIS IS 10883.97
CONTRIBUTION TO NETT SAVING BY INCLUSION OF OPANAIKE IS 3165.35

DEPOTS IN BASIS

MATARA	378437.87	7200.00	88266.78	0.00	0.00
PERDNIYA	2281653.81	15200.00	307110.90	0.00	0.00
BATICALO	382731.37	7000.00	105984.40	0.00	0.00
KURNGALA	884463.48	9850.00	115065.82	0.00	0.00
ANURPURA	394215.03	6000.00	72167.44	0.00	0.00
JAFFNA	485626.90	9350.00	129063.56	0.00	0.00
GALLE	911104.81	8850.00	102832.48	0.00	0.00
CHINABAY	333047.50	11500.00	42463.45	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	538937.87	7538.94	53503.20	839703.51	10.39
MANKULAM	150684.03	7150.68	34514.11	767876.55	6.54
CHVKCHRI	535437.35	7535.44	144881.19	839055.91	3.95
OPANAIKE	718619.55	7718.62	140259.15	872944.62	8.85

KAHAWATA DEPOT HAS DROPPED OUT OF THE BASIS

CUMULATIVE CAPITAL REQUIREMENT = 4122815.55

FIXED COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 523235.49
VARIABLE COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 2014409.38

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2617779.25

INITIAL NETT SAVING BY INCLUSION OF OPANAIKE IN THE BASIS IS -6535.97

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 103691.01

PERCENTAGE IMPROVEMENT = 3.81

DEPOT = OPANAIKE CAPITAL COST = 872944.62 BOND RATE = 8.85

IR = 136

MATARA DEPOT WILL REMAIN IN THE BASIS

IMPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT MATARA IS 114488.59

FIXED COST OF MATARA IS 7200.00
ADDITIONAL VARIABLE COST OF MATARA IS 24324.35

ADDITIONAL GROSS SAVING BY RETENTION OF MATARA IN THE BASIS IS 5513.25
CONTRIBUTION TO NETT SAVING BY RETENTION OF MATARA IS 46449.50

DEPOTS IN BASIS

MATARA	690896.46	7200.00	110593.11	0.00	0.00
PERDNIYA	2281653.81	15200.00	307110.90	0.00	0.00
BATICALO	382731.37	7000.00	105984.40	0.00	0.00
KURNGALA	884463.48	9850.00	115065.82	0.00	0.00
ANURPURA	394215.03	6000.00	72167.44	0.00	0.00
JAFFNA	485626.90	9350.00	129063.56	0.00	0.00
GALLE	911104.81	8850.00	102832.48	0.00	0.00
CHINABAY	333047.50	11500.00	42463.45	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	538937.87	7538.94	53503.20	839703.51	10.39
MANKULAM	150684.03	7150.68	34514.11	767876.55	6.54
CHVKCHRI	535437.35	7535.44	144881.19	839055.91	3.95
OPANAIKE	718619.55	7718.62	140259.15	872944.62	8.85

CUMULATIVE CAPITAL REQUIREMENT = 4122815.55

FIXED COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 523235.49
VARIABLE COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 2008896.13

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2612266.00

ADDITIONAL NETT SAVING BY RETENTION OF MATARA IN THE BASIS IS 5513.25

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 109204.26

PERCENTAGE IMPROVEMENT = 4.01

RATNPURA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 548211.10

FIXED COST OF RATNPURA IS 3000.00
INITIAL VARIABLE COST OF RATNPURA IS 67137.16

INITIAL GROSS SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 5908.08
CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 2908.08

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	11983330.06	411000.00	545286.80	0.00	0.00
MATARA	690896.46	7200.00	110593.11	0.00	0.00

GALLE	911104.81	8850.00	102832.48	0.00	0.00
CHINABAY	333047.50	11500.00	42463.45	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34
MADAMPE	538937.87	7538.94	53503.20	839703.51	10.39
MANKULAM	150684.03	7150.68	34514.11	767876.55	6.54
CHVKCHRI	535437.35	7535.44	144881.19	839055.91	3.95
OPANAIKE	718619.55	7718.62	140259.15	872944.62	8.85

CUMULATIVE CAPITAL REQUIREMENT = 4122815.55

FIXED COST OF CENTRAL SOURCE AND 14 DEPOT/S IS 526235.49
VARIABLE COST OF CENTRAL SOURCE AND 14 DEPOT/S IS 2002988.04

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2609357.91

INITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 2908.08

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 112112.35

PERCENTAGE IMPROVEMENT = 4.12

GALLE DEPOT WILL REMAIN IN THE BASIS

IMPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT GALLE IS 58180.50

FIXED COST OF GALLE IS 8850.00
ADDITIONAL VARIABLE COST OF GALLE IS 11026.37

ADDITIONAL GROSS SAVING BY RETENTION OF GALLE IN THE BASIS IS 793.58
CONTRIBUTION TO NETT SAVING BY RETENTION OF GALLE IS 28176.64

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	11985330.06	411000.00	545286.80	0.00	0.00
MATARA	632715.96	7200.00	98773.16	0.00	0.00
PERDNIYA	2281653.81	15200.00	307110.90	0.00	0.00
BATICALO	382731.37	7000.00	105984.40	0.00	0.00
KURNGALA	884463.48	9850.00	115065.82	0.00	0.00
ANURPURA	394215.03	6000.00	72167.44	0.00	0.00
JAFFNA	485626.90	9350.00	129063.56	0.00	0.00
RATNPURA	548211.10	3000.00	67137.16	0.00	0.00

OPANAIKE	718619.55	7718.62	140259.15	872944.62	8.85

CUMULATIVE CAPITAL REQUIREMENT = 4122815.55

FIXED COST OF CENTRAL SOURCE AND 14 DEPOT/S IS 526235.49
VARIABLE COST OF CENTRAL SOURCE AND 14 DEPOT/S IS 2002194.46

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2608564.33

ADDITIONAL NETT SAVING BY RETENTION OF GALLE IN THE BASIS IS 793.58

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 112905.93

PERCENTAGE IMPROVEMENT = 4.15

RATNPURA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
TO IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

OPANAIKE DEPOT WILL REMAIN IN THE BASIS

IMPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT OPANAIKE IS 277602.38

CALCULATED ADDITIONAL FIXED COST OF OPANAIKE IS 277.60
ADDITIONAL VARIABLE COST OF OPANAIKE IS 37335.93

ADDITIONAL GROSS SAVING BY RETENTION OF OPANAIKE IN THE BASIS IS 705.11
CONTRIBUTION TO NETT SAVING BY RETENTION OF OPANAIKE IS 3592.86

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST	CAPITAL	BOND RATE
KOLONAWA	12255938.78	411000.00	576103.83	0.00	0.00
MATARA	632715.96	7200.00	98773.16	0.00	0.00
PERONIYA	2281653.81	15200.00	307110.90	0.00	0.00
BATICALO	382731.37	7000.00	105984.40	0.00	0.00
KURNGALA	884463.48	9850.00	115065.62	0.00	0.00
ANURPURA	394215.03	6000.00	72167.44	0.00	0.00
JAFFNA	485626.90	9350.00	129063.56	0.00	0.00
GALLE	969285.31	8850.00	113858.85	0.00	0.00
CHINABAY	333047.50	11500.00	42463.45	0.00	0.00
AMBLGODA	341810.64	7341.81	32125.27	803234.97	3.34

CUMULATIVE CAPITAL REQUIREMENT = 4174171.99

FIXED COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 523513.09
VARIABLE COST OF CENTRAL SOURCE AND 13 DEPOT/S IS 2003210.27

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2606857.75

ADDITIONAL NETT SAVING BY RETENTION OF OPANAIKE IN THE BASIS IS 1706.58

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 114612.51

PERCENTAGE IMPROVEMENT = 4.21

DEPOT - OPANAIKE CAPITAL COST = 924301.06 BOND RATE = 9.26

IR = 17

END OF ITERATIONS

OPTIMAL DISTRIBUTION PATTERN

DESTINATION THROUGHPUT SOURCE COST PER GALLON TRANSPORT COST

SUM OF VARIABLE COSTS TO ALL DESTINATIONS IS 2003210.27

ALLOCATION OF DESTINATIONS TO SOURCES

SOURCE DESTINATION THROUGHPUT COST PER GALLON TRANSPORT COST
FINAL THROUGHPUT AT KOLONAWA IS 12255938.78
FIXED COST OF KOLONAWA IS 411000.00
VARIABLE COST OF KOLONAWA IS 576103.83

FINAL THROUGHPUT AT MATARA IS 632715.96
FIXED COST OF MATARA IS 7200.00
VARIABLE COST OF MATARA IS 98773.16

FINAL THROUGHPUT AT PERDNIYA IS 2281653.81

```
FINAL THROUGHPUT AT KURNGALA IS   884463.48
FIXED COST OF KURNGALA IS   9850.00
VARIABLE COST OF KURNGALA IS  115065.82

FINAL THROUGHPUT AT ANURPURA IS   394215.03
FIXED COST OF ANURPURA IS   6000.00
VARIABLE COST OF ANURPURA IS   72167.44

FINAL THROUGHPUT AT JAFFNA   IS   485626.90
FIXED COST OF JAFFNA   IS   9350.00
VARIABLE COST OF JAFFNA   IS  129063.56

FINAL THROUGHPUT AT GALLE    IS   969285.31
FIXED COST OF GALLE    IS   8850.00
VARIABLE COST OF GALLE    IS  113658.85

FINAL THROUGHPUT AT CHINABAY IS   333047.50
FIXED COST OF CHINABAY IS  11500.00
VARIABLE COST OF CHINABAY IS   42463.45

FINAL THROUGHPUT AT AMBLGODA IS   341810.64
REVISED FIXED COST OF AMBLGODA IS   7341.81
VARIABLE COST OF AMBLGODA IS   32125.27

FINAL THROUGHPUT AT MADAMPE  IS   538937.87
REVISED FIXED COST OF MADAMPE  IS   7538.94
VARIABLE COST OF MADAMPE  IS   53503.20

FINAL THROUGHPUT AT MANKULAM IS   150684.03
REVISED FIXED COST OF MANKULAM IS   7150.68
VARIABLE COST OF MANKULAM IS   34514.11

FINAL THROUGHPUT AT CHVKCHRI IS   535437.35
REVISED FIXED COST OF CHVKCHRI IS   7535.44
VARIABLE COST OF CHVKCHRI IS  144881.19

FINAL THROUGHPUT AT OPANAIKE IS   996221.93
REVISED FIXED COST OF OPANAIKE IS   7996.22
VARIABLE COST OF OPANAIKE IS  177595.09


TOTAL FIXED COST OF CENTRAL SOURCE AND SELECTED DEPOTS IS   523513.09
TOTAL VARIABLE COST OF OPTIMAL PATTERN IS  2003210.27

TOTAL COST OF ALL COLLECTIONS =   80134.38


TOTAL OVERALL COST OF OPTIMAL PATTERN IS  2606857.75

IMPROVEMENT OVER COST OF PRESENT SYSTEM =   114612.51

PERCENTAGE IMPROVEMENT =   4.21
```

FINAL THROUGHPUTS AND COSTS OF SELECTED DEPOTS

(ZERO THROUGHPUT INDICATES NON-UTILISATION OF DEPOT)

DEPOT	FINAL THROUGHPUT	FIXED COST	VARIABLE COST	
KOLONAWA	12255938.78	411000.00	576103.83	
MATARA	632715.96	7200.00	98773.16	
KUTAGALA	0.00	13000.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
HAPUTALE	0.00	6500.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
PERDNIYA	2281653.81	15200.00	307110.90	
BATICALO	382731.37	7000.00	105984.40	
KURNGALA	884463.48	9850.00	115065.82	
ANURPURA	394215.03	6000.00	72167.44	
JAFFNA	485626.90	9350.00	129063.56	
RATNPURA	0.00	3000.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
GALLE	969285.31	8850.00	113858.85	
KILINCHI	0.00	4200.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
NEWPERAD	0.00	4200.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
CHINABAY	333047.50	11500.00	42463.45	
MORATUWA	0.00	0.00	0.00	
PANADURA	0.00	0.00	0.00	
WADDUWA	0.00	0.00	0.00	
KALUTARA	0.00	0.00	0.00	
ALUTGAMA	0.00	0.00	0.00	
AMBLGODA	341810.64	7341.81	32125.27	NEW DEPOT LOCATION
HIKADUWA	0.00	0.00	0.00	
HABRDUWA	0.00	0.00	0.00	
WELIGAMA	0.00	0.00	0.00	
JA-ELA	0.00	0.00	0.00	
NEGOMBO	0.00	0.00	0.00	
LUNUWILA	0.00	0.00	0.00	
MADAMPE	538937.87	7538.94	53503.20	NEW DEPOT LOCATION
CHILAW	0.00	0.00	0.00	
BATLUOYA	0.00	0.00	0.00	
PUTTALAM	0.00	0.00	0.00	
RAGAMA	0.00	0.00	0.00	
GAMPAHA	0.00	0.00	0.00	
VEYNGODA	0.00	0.00	0.00	
MIRIGAMA	0.00	0.00	0.00	
ALAWWA	0.00	0.00	0.00	
POLGHWLA	0.00	0.00	0.00	
MAHO	0.00	0.00	0.00	
GALGMUWA	0.00	0.00	0.00	
MADWCHYA	0.00	0.00	0.00	
VAVUNIYA	0.00	0.00	0.00	
MANKULAM	150684.03	7150.68	34514.11	NEW DEPOT LOCATION
EL. PASS	0.00	0.00	0.00	
PALLAI	0.00	0.00	0.00	
CHVKCHRI	535437.35	7535.44	144381.19	NEW DEPOT LOCATION
CHUNAKAM	0.00	0.00	0.00	
K.K.S.	0.00	0.00	0.00	
KEKIRAWA	0.00	0.00	0.00	
HABARANA	0.00	0.00	0.00	
GALOYA	0.00	0.00	0.00	
KANTALAI	0.00	0.00	0.00	
TRINCMLI	0.00	0.00	0.00	

MURUNKAN	0.00	0.00	0.00	
MANNAR	0.00	0.00	0.00	
TALMANAR	0.00	0.00	0.00	
KANDY	0.00	0.00	0.00	
KATGSTTA	0.00	0.00	0.00	
WATEGAMA	0.00	0.00	0.00	
MATALE	0.00	0.00	0.00	
RAMBKANA	0.00	0.00	0.00	
KADGNAWA	0.00	0.00	0.00	
GAMPOLA	0.00	0.00	0.00	
NAWLPTYA	0.00	0.00	0.00	
WATAWALA	0.00	0.00	0.00	
HATTON	0.00	0.00	0.00	
TALWKELE	0.00	0.00	0.00	
WATAGODA	0.00	0.00	0.00	
NANU OYA	0.00	0.00	0.00	
AMBAWELA	0.00	0.00	0.00	
BANDRWLA	0.00	0.00	0.00	
DEMODARA	0.00	0.00	0.00	
HALI ELA	0.00	0.00	0.00	
BADULLA	0.00	0.00	0.00	
PANITPYA	0.00	0.00	0.00	
HOMAGAMA	0.00	0.00	0.00	
PADUKKA	0.00	0.00	0.00	
AVISWELA	0.00	0.00	0.00	
EHELYGDA	0.00	0.00	0.00	
KURUWITA	0.00	0.00	0.00	
KAHAWATA	0.00	0.00	0.00	
OPANAIKE	996221 93	7996.22	177595.09	NEW DEPOT LOCATION

THE TOTAL CAPITAL REQUIREMENT OF 4174171.99 EXCEEDS THE MAXIMUM
AVAILABILITY OF 3000000 BY 1174171.99

DEPOTS ARRANGED IN DESCENDING ORDER OF BOND RATES

DEPOT	BOND RATE		
MADAMPE	10.39	27	839703.51
OPANAIKE	9.26	86	924301.06
MANKULAM	6.54	41	767876.55
CHVKCHRI	3.95	44	839055.91
AMBLGODA	3.34	20	803234.97

THE CAPITAL LIMIT HAS BEEN REACHED AFTER OPENING 3 DEPOTS. THEY ARE:-

MADAMPE	839703.51	10.39
OPANAIKE	924301.06	9.26
MANKULAM	767876.55	6.54

DEPOT	FINAL THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	12490042.82	411000.00	603180.17
MATARA	632715.94	7200.00	98273.16

KOLONAWA	12490042.82	411000.00	603180.17
MATARA	632715.96	7200.00	98773.16
PERDNIYA	2281653.81	15200.00	307110.90
BATICALO	382731.37	7000.00	105984.40
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	937790.18	9350.00	257529.30
GALLE	1076991.91	8850.00	126549.21
CHINABAY	333047.50	11500.00	42463.45
MADAMPE	538937.87	7538.94	53503.20
OPANAIKE	996221.93	7996.22	177595.09
MANKULAM	233958.10	7233.96	59051.07

TOTAL VARIABLE COST = 2018973.21

TOTAL FIXED COST = 508719.12

TOTAL COST OF ALL COLLECTIONS = 80134.38

TOTAL OVERALL COST = 2607826.71

TOTAL CAPITAL REQUIREMENT = 2547286.81

COMPLETION TIME = 07/44/56

END OF JOB

Comments on the Capital Constraints program

The potential of the program has been clearly demonstrated in this example. The result has been optimised within the arbitrarily assigned capital availability of Rs. 3,000,000/-.

The number of new depots in the new sub-optimal basis is three, and the capital requirement is Rs. 2,547,286.81.

APPENDIX "B"

The Maranzana Program - Listing and Results

A full listing and the full output of results (for Run No. 1) is presented in pages 85 to 93. The results only of Runs 2, 3 and 4 are on pages 94, 95 and 96 respectively. The mileage matrix has been excluded from these three results.

The core space requirement is given on page 89, and the duration of the computation can be obtained from the start and completion times on pages 89 and 93. The other runs took somewhat longer than the first run.

```
      MASTER COMPUTATION
      DIMENSION ID(40,40),LOGV(40),ISI(15),P(40),LUISA(40),JOB(10),JSK(1
     10),IVETT(40),JSI(40),A(40)
      COMMON N,KSCRG,ID,P,IVETT,COM
      CALL TIME(T)
      WRITE(2,9999)T
 9999 FORMAT(3X7HTIME = A8/)
   30 FORMAT(2I3)
   31 FORMAT(15I3)
   32 FORMAT(I3,6XF6.0,4XA8)
   33 FORMAT(20I3,1XI3)
   34 FORMAT(1H1,10X27HSOURCE ALLOCATION ALGORITHM)
   35 FORMAT(1X23HINITIAL SOLUTIONS WERE=,15(2H  ,I3))
   36 FORMAT(1X20HFINAL SOLUTIONS ARE=,15(2H  ,I3))
   37 FORMAT(1X37H    SINK NAMED   SERVED BY  SOURCE N.)
   38 FORMAT(2H  ,A8,11XI3)
   39 FORMAT(1H ,9I12)
   40 FORMAT(8H OBJ.F.=,E12.4)
      READ(1,30)N,KSCRG
  196 READ(1,31)(ISI(K),K=1,KSCRG)
  197 DO 41 IND=1,N
      READ(1,32)I,P(IND),A(IND)
   41 WRITE(2,500)A(IND),P(IND)
  500 FORMAT(3XA8,3XF6.0)
      DO 2 I=1,N
      DO 3 J=1,N
    3 ID(I,J)=1000000
    2 ID(I,I)=0
      DO 1 IND=1,N
      READ(1,33)(JOB(M),JSK(M),M=1,10),I
      DO 4 M=1,10
      IF(JOB(M))1,1,12
   12 J=JOB(M)
      ID(IND,J)=JSK(M)
      ID(J,IND)=JSK(M)
    4 CONTINUE
    1 CONTINUE
      DO 5 JA=1,N
    5 IVETT(JA)=0
  198 WRITE(2,34)
      WRITE(2,35)(ISI(K),K=1,KSCRG)
   60 L=0
      TED=0.
      DO 81 K=1,KSCRG
      KK=ISI(K)
      IF(IVETT(KK)-1)120,915,300
  120 CALL DIST(KK)
      IVETT(KK)=1
```

```
  915 DO 71 I=1,N
      LOGV(I)=1
      DO 61 IK=1,KSCRG
      IF(IK-K)62,61,62
   62 IIK=ISI(IK)
      IF(IVETT(IIK)-1)130,914,300
  130 CALL DIST(IIK)
      IVETT(IIK)=1
  914 IF(ID(I,KK)-ID(I,IIK))61,61,63
   63 LOGV(I)=0
      GO TO 71
   61 CONTINUE
      LUISA(I)=ISI(K)
   71 CONTINUE
      JCOM=IBAR(LOGV)
      TED=TED+COM
      JSI(K)=JCOM
      IF(JCOM-ISI(K))72,81,72
   72 L=1
   81 CONTINUE
      IF(L)301,74,66
   66 DO 67 LU=1,KSCRG
   67 ISI(LU)=JSI(LU)
      GO TO 60
   74 WRITE(2,36)(ISI(K),K=1,KSCRG)
      WRITE(2,40)TED
      WRITE(2,37)
      DO 99 L=1,N
   99 WRITE(2,38)A(L),LUISA(L)
  194 WRITE(2,39)((ID(I,J),I=1,N),J=1,N)
  193 CONTINUE
      GO TO 199
  300 PAUSE 777
  301 PAUSE 7777
  199 WRITE(2,510)
  510 FORMAT(3X10HEND OF JOB/)
      CALL TIME(T)
      WRITE(2,9999)T
      STOP
      END

END OF SEGMENT, LENGTH   484, NAME  COMPUTATION
```

```
      FUNCTION IBAR(LOGV)
      DIMENSION ID(40,40),P(40),LOGV(40),IVETT(40)
      COMMON N,KSCRG,ID,P,IVETT,COM,KONT
      K=0
      DO 213 J=1,N
      IF(LOGV(J)-1)213,204,301
  204 SUM=0.
      IF(IVETT(J)-1)436,437,301
  436 CALL DIST(J)
      IVETT(J)=1
    1 KONT=0
      DO 2 JP=1,N
    2 KONT=KONT+IVETT(JP)
  437 DO 206 I=1,N
      IF(LOGV(I)-1)206,401,301
  401 SUM=SUM+ID(I,J)*P(I)
  206 CONTINUE
      IF(K)207,207,209
  209 IF(COM-SUM)213,213,207
  207 COM=SUM
      K=1
      IBAR=J
  213 CONTINUE
  250 RETURN
  301 PAUSE 77
      GO TO 250
      END

END OF SEGMENT, LENGTH   126, NAME  IBAR
```

```
      SUBROUTINE DIST(K)
      DIMENSION ID(40,40)
      COMMON N,KSCRG,ID
  105 LS=0
      DO 108 L=1,N
      DO 108 J=1,N
      COM=ID(J,K)+ID(J,L)
      IF(COM-ID(L,K))107,108,108
  107 LS=1
      ID(L,K)=COM
      ID(K,L)=COM
  108 CONTINUE
      IF(LS)301,110,105
  110 RETURN
  301 PAUSE 7
      GO TO 110
      END

END OF SEGMENT, LENGTH    85, NAME  DIST
```

```
0139              FINISH

END OF COMPILATION -  NO ERRORS




CONSOLIDATED BY XPCL  7A      DATE    03/09/69    TIME 17/44/10
PROGRAM GP12
COMPACT DATA (15AM)
COMPACT PROGRAM (DBM)
CORE               7104


                SEG     COMPUTATION
                SEG     TIME
                SEG     DIST
                SEG     IBAR
  TIME = 17/44/42

  MILAN       50000.
  ROME        50000.
  TURIN       30000.
  GENOA       25000.
  PARMA       10000.
  BOLOGNA     15000.
  FIRENZE     15000.
  VENICE      10000.
  NAPLES      15000.
  TRIESTE     10000.
  BARI         5000.
  PALERMO      5000.
  VERONA       8000.
  TRENTO       3000.
  PADUA        7000
  PAVIA         500
  SONDRIO       300.
  NOVARA        500.
  BIELLA        200.
  LASPEZIA      200.
  PISA          100.
  LUCCA         100.
  FANO           30.
  SAVONA         50.
  PESARO        300
  PERUGIA       300.
  FOGGIA         25.
  AVELLINO        2.
  CAGLIARI     5000.
  SASSARI        15
  CATANIA         8
  SYRACUSE        4.
  FERRARA        40.
  PIACENZA        6.
  ALESANDR        6.
  SIENA          30.
  GROSETTO       15.
```

OBJ.F.= 0.9642E 07

SINK NAMED	SERVED BY SOURCE N.
MILAN	1
ROME	2
TURIN	1
GENOA	1
PARMA	1
BOLOGNA	1
FIRENZE	2
VENICE	1
NAPLES	9
TRIESTE	1
BARI	9
PALERMO	9
VERONA	1
TRENTO	1
PADUA	1
PAVIA	1
SONDRIO	1
NOVARA	1
BIELLA	1
LASPEZIA	1
PISA	1
LUCCA	1
FANO	2
SAVONA	1
PESARO	1
PERUGIA	2
FOGGIA	9
AVELLINO	9
CAGLIARI	2
SASSARI	2
CATANIA	9
SYRACUSE	9
FERRARA	1
PIACENZA	1
ALESANDR	1
SIENA	2
GROSETTO	2
ANCONA	2
VITERBO	2
RIETI	2

0	190	40	49	39	62	105	85	218
105	242	328	40	66	58	29	20	18
38	65	81	80	118	75	102	162	207
255	256	299	357	363	81	19	38	123
147	136	169	222	190	0	184	141	172
149	85	221	28	241	115	138	200	226
194	161	210	172	192	125	119	110	93
219	109	49	150	65	66	109	167	173
171	175	163	67	43	88	21	32	40
184	0	43	67	90	99	125	212	145
270	322	80	106	98	33	60	22	36
59	75	74	146	35	130	190	235	249
250	293	351	357	112	47	21	117	141
164	163	216	49	141	43	0	54	77
56	127	169	147	256	279	82	108	100
20	69	31	51	16	32	31	133	78
117	177	222	206	207	250	308	314	99

281	339	345	45	20	65	128	152	97
174	204	62	149	90	77	23	0	133
72	177	92	180	287	51	77	45	57
82	68	88	93	109	108	56	125	40
100	145	214	215	258	316	322	22	43
88	151	175	74	170	181	105	85	99
56	110	133	0	183	113	203	200	223
138	164	156	76	125	87	107	40	34
25	178	134	173	134	235	150	151	194
252	258	155	90	78	18	42	173	64
117	85	221	125	127	73	72	183	0
249	23	252	359	45	71	27	107	105
103	123	143	159	158	128	160	112	172
217	286	287	330	388	394	80	93	123
201	225	146	242	253	218	28	212	169
200	177	113	249	0	269	87	110	228
254	222	189	238	200	220	153	147	138
121	247	137	77	122	37	94	137	139
145	199	203	191	95	71	116	49	60
105	241	145	147	93	92	203	23	269
0	272	379	65	91	47	127	125	123
143	163	179	178	148	180	132	192	237
306	307	350	408	414	70	113	143	221
245	166	262	273	242	115	270	256	203
180	200	252	87	272	0	197	231	257
225	237	262	248	268	240	234	225	124
305	140	145	35	50	181	224	226	232
202	223	268	182	158	106	136	147	328
138	322	279	310	287	223	359	110	379
197	0	338	364	332	299	348	310	330
263	257	248	231	357	247	187	232	147
204	247	29	35	309	313	301	205	181
226	159	170	40	200	80	82	28	51
138	45	228	65	231	338	0	26	18
62	60	58	78	98	114	113	107	115
91	151	196	265	266	309	367	373	41
48	78	156	180	125	202	232	66	226
106	108	54	77	164	71	254	91	257
364	26	0	44	88	86	84	104	124
140	139	133	141	117	177	222	291	292
335	393	399	67	74	104	182	206	151
228	258	58	194	98	100	46	45	156
27	222	47	225	332	18	44	0	80
78	76	96	116	132	131	101	133	85
145	190	259	260	303	361	367	23	66
96	174	198	119	215	226	29	161	33
20	34	57	76	107	189	127	237	299
62	88	80	0	49	11	31	36	52
51	113	68	97	157	202	226	227	270
328	334	79	14	31	94	118	131	140
193	20	210	60	69	59	82	125	105
238	125	262	348	60	86	78	49	0
38	58	85	101	100	138	95	122	182
227	275	276	319	377	383	101	39	58
143	167	156	189	242	18	172	22	31
45	68	87	103	200	123	248	310	58
84	76	11	38	0	20	47	63	62
124	57	108	168	213	237	238	281	339
345	90	25	20	105	129	142	151	204
38	192	36	51	65	88	107	123	220

94	133	174	238	190	191	234	292	298
115	50	38	58	82	167	104	157	81
119	75	32	86	109	34	159	147	179
234	257	114	140	132	52	101	63	83
16	0	15	165	110	149	168	254	184
185	228	286	292	131	66	54	52	76
183	98	151	80	110	74	31	85	108
25	158	138	178	225	248	113	139	131
51	100	62	82	15	15	0	164	109
148	159	253	175	176	219	277	283	130
65	53	43	67	182	89	142	118	93
146	133	79	56	178	128	121	148	124
231	107	133	101	113	138	124	144	149
165	164	0	181	16	44	89	158	159
202	260	266	78	99	144	160	136	18
114	125	75	219	35	78	102	125	134
160	247	180	305	357	115	141	133	68
95	57	71	94	110	109	181	0	165
225	270	284	285	328	386	392	147	82
56	152	176	199	198	251	102	109	130
117	63	40	173	112	137	132	140	247
91	117	85	97	122	108	128	133	149
148	16	165	0	60	105	174	175	218
276	282	62	83	128	176	132	34	130
141	162	49	190	177	123	100	134	172
77	192	145	187	151	177	145	157	182
168	188	174	168	159	44	225	60	0
110	114	115	158	216	222	122	143	188
116	92	39	70	81	207	150	235	222
168	145	235	217	122	237	35	232	196
222	190	202	227	213	233	238	254	253
89	270	105	110	0	85	216	259	261
267	167	188	233	217	193	71	171	182
255	65	249	206	237	214	180	286	37
306	50	147	265	291	259	226	275	237
257	190	184	175	158	284	174	114	85
0	131	174	176	182	236	240	228	132
108	153	86	97	256	66	250	207	238
215	151	287	94	307	181	204	266	292
260	227	276	238	258	191	185	176	159
285	175	115	216	131	0	43	233	239
237	241	229	133	109	154	87	98	299
109	293	250	281	258	194	330	137	350
224	247	309	335	303	270	319	281	301
234	228	219	202	328	218	158	259	174
43	0	276	282	280	284	272	176	152
197	130	141	357	167	351	308	339	316
252	388	139	408	226	29	367	393	361
328	377	339	359	292	286	277	260	386
276	216	261	176	233	276	0	64	338
342	330	234	210	255	188	199	363	173
357	314	345	322	258	394	145	414	232
35	373	399	367	334	383	345	365	298
292	283	266	392	282	222	267	182	239
282	64	0	344	348	336	240	216	261
194	205	81	171	112	99	45	22	155
50	199	70	202	309	41	67	23	79
101	90	110	115	131	130	78	147	62
122	167	236	237	280	338	344	0	65
110	173	197	96	192	203	19	175	47

20	40	38	54	53	144	56	128	188
233	228	229	272	330	336	110	45	0
96	120	162	142	195	123	67	117	74
128	151	18	201	95	221	182	205	156
182	174	94	143	105	125	58	52	43
160	152	176	116	217	132	133	176	234
240	173	108	96	0	24	155	46	99
147	43	141	98	152	175	42	225	71
245	158	181	180	206	198	118	167	129
149	82	76	67	136	176	152	92	193
108	109	152	210	216	197	132	120	24
0	131	22	75	136	88	164	151	97
74	173	146	116	166	106	226	125	151
119	131	156	142	162	167	183	182	18
199	34	39	71	153	154	197	255	261
96	117	162	155	131	0	109	120	169
21	163	120	174	170	64	242	49	262
136	159	202	228	215	140	189	151	171
104	98	89	114	198	130	70	171	86
87	130	188	194	192	154	142	46	22
109	0	53	222	32	216	173	204	181
117	253	60	273	147	170	232	258	226
193	242	204	224	157	151	142	125	251
141	81	182	97	98	141	199	205	203
207	195	99	75	120	53	0		

END OF JOB

TIME = 17/46/14

```
        SOURCE ALLOCATION ALGORITHM
INITIAL SOLUTIONS WERE=    2    1    9   12
FINAL SOLUTIONS ARE=    2    1    9   12
OBJ.F.=  0.9091E 07
    SINK NAMED    SERVED BY  SOURCE N.
 MILAN                    1
 ROME                     2
 TURIN                    1
 GENOA                    1
 PARMA                    1
 BOLOGNA                  1
 FIRENZE                  2
 VENICE                   1
 NAPLES                   9
 TRIESTE                  1
 BARI                     9
 PALERMO                 12
 VERONA                   1
 TRENTO                   1
 PADUA                    1
 PAVIA                    1
 SONDRIO                  1
 NOVARA                   1
 BIELLA                   1
 LASPEZIA                 1
 PISA                     1
 LUCCA                    1
 FANO                     2
 SAVONA                   1
 PESARO                   1
 PERUGIA                  2
 FOGGIA                   9
 AVELLINO                 9
 CAGLIARI                 2
 SASSARI                  2
 CATANIA                 12
 SYRACUSE                12
 FERRARA                  1
 PIACENZA                 1
 ALESANDR                 1
 SIENA                    2
 GROSETTO                 2
 ANCONA                   2
 VITERBO                  2
 RIETI                    2
```

0	190	40	49	39	62	105	85	218
105	242	328	40	66	58	29	20	18
38	65	81	80	118	75	102	162	207
255	256	299	357	363	81	19	38	123
147	136	169	222	190	0	184	141	172
149	85	221	28	241	115	138	200	226
194	161	210	172	192	125	119	110	93
219	109	49	150	65	66	109	167	173
171	175	163	67	43	88	21	32	40
184	0	43	67	90	99	125	212	145

```
FINAL SOLUTIONS ARE=   18    2   15   29
OBJ.F.=  0.7837E 07
    SINK NAMED    SERVED BY   SOURCE N.
  MILAN              18
  ROME                2
  TURIN              18
  GENOA              18
  PARMA              18
  BOLOGNA            15
  FIRENZE             2
  VENICE             15
  NAPLES              2
  TRIESTE            15
  BARI                2
  PALERMO             2
  VERONA             15
  TRENTO             15
  PADUA              15
  PAVIA              18
  SONDRIO            18
  NOVARA             18
  BIELLA             18
  LASPEZIA           18
  PISA               18
  LUCCA              18
  FANO                2
  SAVONA             18
  PESARO             15
  PERUGIA             2
  FOGGIA              2
  AVELLINO            2
  CAGLIARI           29
  SASSARI            29
  CATANIA             2
  SYRACUSE            2
  FERRARA            15
  PIACENZA           18
  ALESANDR           18
  SIENA               2
  GROSETTO            2
  ANCONA              2
  VITERBO             2
  RIETI               2
```

0	190	40	49	39	62	105	85	218
105	242	328	40	66	58	29	20	18
38	65	81	80	118	75	102	162	207
255	256	299	357	363	81	19	38	123
147	136	169	222	190	0	184	141	172
149	85	221	28	241	115	138	200	226
194	161	210	172	192	125	119	110	93
219	109	49	150	65	66	109	167	173
171	175	163	67	43	88	21	32	40
184	0	43	67	90	99	125	212	145
270	322	80	106	98	33	60	22	36
59	75	74	146	35	130	190	235	249
250	293	351	357	112	47	21	117	141
164	163	216	49	141	43	0	54	77
56	127	169	147	256	279	82	108	100
20	69	31	51	16	32	31	133	78
117	177	222	206	207	250	308	314	99

```
                SOURCE ALLOCATION ALGORITHM
INITIAL SOLUTIONS WERE=   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
FINAL SOLUTIONS ARE=   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
OBJ.F.=  0.7026E 06
     SINK NAMED    SERVED BY  SOURCE N.
  MILAN              1
  ROME               2
  TURIN              3
  GENOA              4
  PARMA              5
  BOLOGNA            6
  FIRENZE            7
  VENICE             8
  NAPLES             9
  TRIESTE           10
  BARI              11
  PALERMO           12
  VERONA            13
  TRENTO            14
  PADUA             15
  PAVIA              4
  SONDRIO            1
  NOVARA             1
  BIELLA             3
  LASPEZIA           4
  PISA               4
  LUCCA              7
  FANO               6
  SAVONA             3
  PESARO             6
  PERUGIA            2
  FOGGIA            11
  AVELLINO           9
  CAGLIARI           2
  SASSARI            2
  CATANIA           12
  SYRACUSE          12
  FERRARA            6
  PIACENZA           1
  ALESANDR           3
  SIENA              7
  GROSETTO           7
  ANCONA             6
  VITERBO            2
  RIETI              2
```

0	190	40	49	39	62	105	85	218
105	242	328	40	66	58	29	20	18
38	65	81	80	118	75	102	162	207
255	256	299	357	363	81	19	38	123
147	136	169	222	190	0	184	141	172
149	85	221	28	241	115	138	200	226
194	161	210	172	192	125	119	110	93
219	109	49	150	65	66	109	167	173
171	175	163	67	43	88	21	32	40
184	0	43	67	90	99	125	212	145
270	322	80	106	98	33	60	22	36
59	75	74	146	35	130	190	235	249
250	293	351	357	112	47	21	117	141
164	163	216	49	141	43	0	54	77
56	127	169	147	256	279	82	108	100

APPENDIX "C"

Results - Feldman, Lehrer & Ray program

The full listing of the Feldman, Lehrer & Ray program has not been presented. Howver, a full listing of the results is given on pages 98 to 102.

The core space requirement for the 40 x 40 problem is given on page 98, namely, 22208. This should be compared with the requirement of 22720 for the 86 x 613 problem as tackled by the new method (see page 56). The duration of the program as given by the start and completion times on pages 98 and 102 was 15 minutes and 7 seconds. However, this time was taken when the program was run on full Trace. When the Trace was removed, the time dropped to 8 minutes and 7 seconds. The optimum distribution pattern is given on pages 100 and 101/102.

```
END OF SEGMENT, LENGTH   985, NAME  INPRNT

      SUBROUTINE READER

END OF SEGMENT, LENGTH   621, NAME  READER

      FINISH

END OF COMPILATION -  NO ERRORS

S/C SUBFILE:    269 BUCKETS USED


CONSOLIDATED BY XPCK  8A      DATE   18/06/70   TIME 22/20/19
PROGRAM G426
COMPACT DATA (15AM)
COMPACT PROGRAM (DBM)
CORE              22208

  BINARY PROGRAM OCCUPIES     230 BUCKETS IN PROGRAM OVLY  (1)

IME = 22/22/12

THE BEST SINGLE WAREHOUSE SOLUTION.

FACTORY   1 SUPPLIES WAREHOUSE(S)     1
WAREHOUSE  1 SUPPLIES CUSTOMERS    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15
                                  16   17   18   19   20   21   22   23   24   25   26   27   28   29   30
                                  31   32   33   34   35   36   37   38   39   40

BREAKDOWN OF DISTRIBUTION COST BY WAREHOUSE
WAREHOUSE      THRUPUT   OPERATING COST      FIXED COST       TRANSP COST          TOTAL COST
                                                              FACTORY TO WHSE      WHSE TO CUSTOMER
-------------------------------------------------------------------------------------------------------------------

     1      269735.00       2238.80          15000.00          2238.80            72241.81           91719.41
-------------------------------------------------------------------------------------------------------------------
TOTALS      269735.00       2238.80          15000.00          2238.80            72241.81           91719.41


WAREHOUSE    4 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF           94440.06 COMPARED
WITH COST OF          91719.41 FOR EXISTING SYSTEM.


WAREHOUSE    6 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF           97202.04 COMPARED
WITH COST OF          91719.41 FOR EXISTING SYSTEM.


WAREHOUSE    9 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF           92493.97 COMPARED
WITH COST OF          91719.41 FOR EXISTING SYSTEM.
```

WAREHOUSE 11 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 92713.31 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 13 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 94535.32 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 14 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 92763.28 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 15 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 93563.84 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 16 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 95217.73 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 17 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 92747.93 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 18 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 105672.42 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 19 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 92731.45 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 24 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 96242.20 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 30 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 96151.81 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 33 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 98311.68 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

WAREHOUSE 34 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 100577.37 COMPARED
WITH COST OF 91719.41 FOR EXISTING SYSTEM.

FACTORY 1 SUPPLIES WAREHOUSE(S) 1
FACTORY 1 SUPPLIES WAREHOUSE(S) 2
WAREHOUSE 1 SUPPLIES CUSTOMERS 1 4 5 6 7 8 9 10 13 14 15 16 17 18 19
20 21 22 23 24 25 33 34 35 36 38
WAREHOUSE 2 SUPPLIES CUSTOMERS 2 3 11 12 26 27 28 29 30 31 32 37 39 40

BREAKDOWN OF DISTRIBUTION COST BY WAREHOUSE

WAREHOUSE	THRUPUT	OPERATING COST	FIXED COST	TRANSP COST	TOTAL COST	
				FACTORY TO WHSE	WHSE TO CUSTOMER	
1	189362.00	1571.70	15000.00	1571.70	21122.51	39265.92
2	80373.00	667.10	6000.00	16098.71	5474.81	28240.62
TOTALS	269735.00	2238.80	21000.00	17670.42	26597.33	67506.54

WAREHOUSE 3 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 70102.21 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 5 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 69979.38 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 7 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 68832.60 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 8 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 67943.51 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 12 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 67943.76 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 20 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 70865.66 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 21 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 68640.10 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

WAREHOUSE 22 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF 68272.43 COMPARED
WITH COST OF 67506.54 FOR EXISTING SYSTEM.

```
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   26 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68499.71 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   27 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            67967.40 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   28 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68388.71 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   29 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68579.73 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   31 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68361.57 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   32 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68481.53 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   36 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68705.17 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   37 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            69862.10 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   38 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68072.12 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   39 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68508.56 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.

WAREHOUSE   40 REMOVED FROM FURTHER CONSIDERATION. USING IT INCURS COST OF            68506.68 COMPARED
WITH COST OF            67506.54 FOR EXISTING SYSTEM.
RECOMMENDED FACTORY-WAREHOUSE-CUSTOMER CONFIGURATION.

FACTORY    1 SUPPLIES WAREHOUSE(S)     1
FACTORY    1 SUPPLIES WAREHOUSE(S)     2
```

[illegible]	[illegible]	OPERATING COST	FIXED COST	TRANSP COST FACTORY TO WHSE	TOTAL COST WHSE TO CUSTOMER	
1	189362.00	1571.70	15000.00	1571.70	21122.51	39265.92
2	80373.00	667.10	6000.00	16098.71	5474.81	28240.62
TOTALS	269735.00	2238.80	21000.00	17670.42	26597.33	67506.54

IME = 22/37/19

COMMENTS ON RESULTS - FELDMAN, LEHRER & RAY METHOD

The best single warehouse solution contains (coincidentally) as its source the factory/depot at Milan. In calculating the total cost of this system, the algorithm has included the factory cost of .0083/unit and the factory to factory/depot cost of .0083/unit. These costs have not been included in the calculations carried out in the new algorithm (Appendix "D"). The first item is common to all bases, while the second item has been double-counted. We have therefore to deduct the total costs on account of these items, 2238.80 each. The total cost, when reduced by (2238.80 x 2) becomes 87241.81, which corresponds to the cost of 87240.47, which the new method calculates for supply from the central source only. The difference of 1.34 may be due to the fact that the transport costs fed into this program were rounded off to 6 decimal places.

The optimum basis is found to be depots 1 and 2 (the factory/depot at Milan and the depot at Rome), with a total cost of 67506.54. Here too, when the factory cost of 2238.80 and the double-counted factory to factory/depot cost of 1571.70 (making a total of 3810.50) are deducted, one obtains the resultant cost of 63696.04, which corrrsponds exactly to the final cost obtained by the new method.

The allocation of destinations to the two sources is identical with that of the new method.

The rejection of the other 38 depots (on the basis of cost increase) includes an indication of the cost incurred if each such depot is used. This corresponds to the Sensitivyty Analysis of the newmethod.

APPENDIX "D"

Results of the new program

The listing of the new program has been excluded as it is already presented in the main thesis. Pages 105 to 121 contain the full print out of the results including the Sensitivity Analysis. The core space requirement of 23168 as given on page 105 is the figure for the original 86 x 613 problem. (Page 39 contains a figure of the same order for the 86 x 613 Capital Constraints program). This figure should be compared with the 22720 required by the Feldman, Lehrer & Ray program for the 40 x 40 problem. Computation times can be determined from the times given on pages 105, 111 and 121. The total time required was 4 minutes and 23 seconds, which compares very favourably with the 8 minutes and 7 seconds used by the Feldman, Lehrer & Ray program.

```
FORTRAN COMPILATION BY #XFAE MK 4B     DATE  05/05/70  TIME  14/02/02

         SEND TO (ED,ICLA-DEFAULT.AXXX)
         PROGRAM(GP03)
         INPUT1=CR0
         COMPRESS INTEGER
         OUTPUT2=LP7
         TRACE0
         END
         MASTER DISTRIBUTION COST ANALYSIS

END OF SEGMENT, LENGTH  4906, NAME  DISTRIBUTIONCOSTANALYSIS

UTD1          (SEMI-COMPILED)

UTD2          (SEMI-COMPILED)

         FINISH

END OF COMPILATION -  NO ERRORS

S/C SUBFILE:      98 BUCKETS USED

CONSOLIDATED BY XPCK  8A      DATE    05/05/70   TIME 14/03/18
PROGRAM GP03
COMPACT DATA (15AM)
COMPACT PROGRAM (DBM)
CORE           23168

START TIME = 14/03/48

   SUMMARY OF COUNTRY WIDE DEMAND PATTERN

   DESTN     DEPOT          DEMAND    COST
  MILANO    MILANO          50000.    415.0
  ROMA      ROMA            50000.  *10430.0
  NAPOLI    ROMA            15000.   3918.6
```

BOLOGNA	MILANO	15000.	2188.7
FIRENZE	ROMA	15000.	6053.3
VENEZIA	MILANO	10000.	2032.6
TRIESTE	MILANO	10000.	2491.3
BARI	NAPOLI	5000.	2180.7
PALERMO	NAPOLI	5000.	2578.9
VERONA	MILANO	8000.	728.2
TRENTO	MILANO	3000.	479.0
PADUA	MILANO	7000.	897.7
PAVIA	MILANO	500.	36.2
SONDRIO	MILANO	300.	13.8
NOVARO	MILANO	500.	21.1
BIELLA	MILANO	200.	17.4
LASPEZIA	MILANO	200.	32.4
PISA	MILANO	100.	19.9
LUCCA	MILANO	100.	19.6
FANO	ROMA	30.	12.7
SAVONA	MILANO	50.	8.8
PESARO	MILANO	300.	71.3
PERUGIA	ROMA	300.	93.0
FOGGIA	NAPOLI	25.	13.7
AVELLINO	NAPOLI	2.	0.6
CAGLIARI	ROMA	8000.	1799.9
SASSARI	ROMA	15.	6.9
CATANIA	NAPOLI	8.	4.7
SYRACUSE	NAPOLI	4.	2.4
FERRARA	MILANO	40.	7.8
PIACENZA	MILANO	6.	0.2
ALESANDR	MILANO	6.	0.5
SIENA	ROMA	30.	10.9
GROSETTO	ROMA	15.	4.5
ANCONA	ROMA	4000.	1641.7
VITERBO	ROMA	2.	0.5
RIETI	ROMA	2.	0.5

TOTAL DELIVERIES = 269735.00

FIXED COST OF EXISTING NETWORK = 23500.00

VARIABLE COST OF EXISTING NETWORK = 44657.87

TOTAL COST OF EXISTING NETWORK = 68157.87

THIS PROGRAM WILL ARRANGE SUPPLY FROM THE CENTRAL SOURCE = MILANO
AND SOME OF THE 39 LIKELY DEPOT LOCATIONS TO REDUCE TOTAL DISTRIBUTION
COST. OF THESE, THE FIRST 2 DEPOTS COMPRISE THE EXISTING DISTRIBUTIVE
NETWORK

NAPOLI	0.0083	0.2200	0.0083	0.2366
TORINO	0.0083	0.0400	0.0083	0.0566
GENOVA	0.0083	0.0510	0.0083	0.0676
PARMA	0.0083	0.0370	0.0083	0.0536
BOLOGNA	0.0083	0.0600	0.0083	0.0766
FIRENZE	0.0083	0.1070	0.0083	0.1236
VENEZIA	0.0083	0.0850	0.0083	0.1016
TRIESTE	0.0083	0.1050	0.0083	0.1216
BARI	0.0083	0.2400	0.0083	0.2566
PALERMO	0.0083	0.3300	0.0083	0.3466
VERONA	0.0083	0.0400	0.0083	0.0566
TRENTO	0.0083	0.0660	0.0083	0.0826
PADOVA	0.0083	0.0580	0.0083	0.0746
PAVIA	0.0083	0.0310	0.0083	0.0476
SONDRIO	0.0083	0.0200	0.0083	0.0366
NOVARA	0.0083	0.0180	0.0083	0.0346
BIELLA	0.0083	0.0380	0.0083	0.0546
LASPEZIA	0.0083	0.0670	0.0083	0.0836
PISA	0.0083	0.0830	0.0083	0.0996
LUCCA	0.0083	0.0820	0.0083	0.0986
FANO	0.0083	0.1160	0.0083	0.1326
SAVONA	0.0083	0.0730	0.0083	0.0896
PESARO	0.0083	0.1000	0.0083	0.1166
PERUGIA	0.0083	0.1600	0.0083	0.1766
FOGGIA	0.0083	0.2050	0.0083	0.2216
AVELLINO	0.0083	0.2570	0.0083	0.2736
CAGLIARI	0.0083	0.2580	0.0083	0.2746
SASSARI	0.0083	0.3010	0.0083	0.3176
CATANIA	0.0083	0.3590	0.0083	0.3756
SYRACUSE	0.0083	0.3650	0.0083	0.3816
FERRARA	0.0083	0.0810	0.0083	0.0976
PIACENZA	0.0083	0.0190	0.0083	0.0356
ALESNDRA	0.0083	0.0380	0.0083	0.0546
SIENA	0.0083	0.1250	0.0083	0.1416
GROSSETO	0.0083	0.1490	0.0083	0.1656
ANCONA	0.0083	0.1340	0.0083	0.1506
VITERBO	0.0083	0.1710	0.0083	0.1876
RIETI	0.0083	0.2240	0.0083	0.2406

INITIAL DISTRIBUTION PATTERN - ALL DESTINATIONS SUPPLIED
FROM THE CENTRAL SOURCE (MILANO)

FIXED COST OF MILANO IS 15000.00
VARIABLE COST OF SUPPLYING ALL DESTINATIONS FROM MILANO IS 72240.47

INITIAL OVERALL COST = 87240.47

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -19082.60

PERCENTAGE IMPROVEMENT = -28.00

ROMA DEPOT WILL ENTER THE BASIS

INITIAL VARIABLE COST OF ROMA IS 21573.52

INITIAL GROSS SAVING BY INCLUSION OF ROMA IN THE BASIS IS 29544.43
CONTRIBUTION TO NETT SAVING BY INCLUSION OF ROMA IS 23544.43

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLECOST/
MILANO	189362.00	15000.00	21122.51
ROMA	80373.00	6000.00	21573.52

FIXED COST OF CENTRAL SOURCE AND 1 DEPOT/S IS 21000.00
VARIABLE COST OF CENTRAL SOURCE AND 1 DEPOT/S IS 42696.04
REDUCED OVERALL COST = 63696.04

INITIAL NETT SAVING BY INCLUSION OF ROMA IN THE BASIS IS 23544.43

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 4461.83

PERCENTAGE IMPROVEMENT = 6.55

END OF ITERATIONS

OPTIMAL DISTRIBUTION PATTERN

DESTINATION	THROUGHPUT	SOURCE	COST PER GALLON	TRANSPORT COST
MILANO	50000.00	MILANO	0.0083	415.00
ROMA	50000.00	ROMA	0.2086	10430.00
NAPOLI	15000.00	ROMA	0.2612	3918.60
TORINO	30000.00	MILANO	0.0910	2730.60
GENOA	25000.00	MILANO	0.1138	2844.20
PARMA	10000.00	MILANO	0.0848	848.16
BOLOGNA	15000.00	MILANO	0.1459	2188.74
FIRENZE	15000.00	MILANO	0.2537	3805.73
VENEZIA	10000.00	MILANO	0.2033	2032.56
TRIESTE	10000.00	MILANO	0.2491	2491.28
BARI	5000.00	ROMA	0.5005	2502.35
PALERMO	5000.00	ROMA	0.5588	2794.22
VERONA	8000.00	MILANO	0.0910	728.16
TRENTO	3000.00	MILANO	0.1597	479.03
PADUA	7000.00	MILANO	0.1282	897.71
PAVIA	500.00	MILANO	0.0724	36.20
SONDRIO	300.00	MILANO	0.0459	13.77
NOVARO	500.00	MILANO	0.0421	21.07
BIELLA	200.00	MILANO	0.0869	17.38

PERUGIA	300.00	ROMA	0.3099	92.98
FOGGIA	25.00	ROMA	0.5893	14.73
AVELLINO	2.00	ROMA	0.3577	0.72
CAGLIARI	5000.00	ROMA	0.3600	1799.89
SASSARI	15.00	ROMA	0.4586	6.88
CATANIA	8.00	ROMA	0.6324	5.06
SYRACUSE	4.00	ROMA	0.6477	2.59
FERRARA	40.00	MILANO	0.1941	7.76
PIACENZA	6.00	MILANO	0.0403	0.24
ALESANDR	6.00	MILANO	0.0869	0.52
SIENA	30.00	MILANO	0.3256	9.77
GROSETTO	15.00	ROMA	0.2975	4.46
ANCONA	4000.00	MILANO	0.3484	1393.57
VITERBO	2.00	ROMA	0.2481	0.50
RIETI	2.00	ROMA	0.2748	0.55

SUM OF VARIABLE COSTS TO ALL DESTINATIONS IS 42696.04

ALLOCATION OF DESTINATIONS TO SOURCES

SOURCE	DESTINATION	THROUGHPUT	COST PER GALLON	TRANSPORT COST
MILANO	MILANO	50000.00	0.0083	415.00
MILANO	TORINO	30000.00	0.0910	2730.60
MILANO	GENOA	25000.00	0.1138	2844.20
MILANO	PARMA	10000.00	0.0848	848.16
MILANO	BOLOGNA	15000.00	0.1459	2188.74
MILANO	FIRENZE	15000.00	0.2537	3805.73
MILANO	VENEZIA	10000.00	0.2033	2032.56
MILANO	TRIESTE	10000.00	0.2491	2491.28
MILANO	VERONA	8000.00	0.0910	728.16
MILANO	TRENTO	3000.00	0.1597	479.03
MILANO	PADUA	7000.00	0.1282	897.71
MILANO	PAVIA	500.00	0.0724	36.20
MILANO	SONDRIO	300.00	0.0459	13.77
MILANO	NOVARO	500.00	0.0421	21.07
MILANO	BIELLA	200.00	0.0869	17.38
MILANO	LASPEZIA	200.00	0.1620	32.39
MILANO	PISA	100.00	0.1987	19.87
MILANO	LUCCA	100.00	0.1964	19.64
MILANO	FANO	30.00	0.3027	9.08
MILANO	SAVONA	50.00	0.1757	8.79
MILANO	PESARO	300.00	0.2377	71.30
MILANO	FERRARA	40.00	0.1941	7.76
MILANO	PIACENZA	6.00	0.0403	0.24
MILANO	ALESANDR	6.00	0.0869	0.52
MILANO	SIENA	30.00	0.3256	9.77
MILANO	ANCONA	4000.00	0.3484	1393.57

FINAL THROUGHPUT AT MILANO IS 189362.00
FIXED COST OF MILANO IS 15000.00
VARIABLE COST OF MILANO IS 21122.51

ROMA	ROMA	50000.00	0.2086	10430.00
ROMA	NAPOLI	15000.00	0.2612	3918.60
ROMA	BARI	5000.00	0.5005	2502.35
ROMA	PALERMO	5000.00	0.5588	2794.22
ROMA	PERUGIA	300.00	0.3099	92.98

ROMA	SYRACUSE	4.00	0.6477	2.50
ROMA	GROSETTO	15.00	0.2975	4.46
ROMA	VITERBO	2.00	0.2481	0.50
ROMA	RIETI	2.00	0.2748	0.55

FINAL THROUGHPUT AT ROMA IS 80373.00
FIXED COST OF ROMA IS 6000.00
VARIABLE COST OF ROMA IS 21573.52

TOTAL FIXED COST OF CENTRAL SOURCE AND SELECTED DEPOTS IS 21000.00
TOTAL VARIABLE COST OF OPTIMAL PATTERN IS 42696.04

TOTAL OVERALL COST OF OPTIMAL PATTERN IS 63696.04

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 4461.83

PERCENTAGE IMPROVEMENT = 6.55

TOTAL CAPITAL REQUIREMENT = 0.00

FINAL THROUGHPUTS AND COSTS OF SELECTED DEPOTS

(ZERO THROUGHPUT INDICATES NON-UTILISATION OF DEPOT)

DEPOT	FINAL THROUGHPUT	FIXED COST	VARIABLE COST	
MILANO	189362.00	15000.00	21122.51	
ROMA	80373.00	6000.00	21573.52	
NAPOLI	0.00	2500.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
TORINO	0.00	0.00	0.00	
GENOVA	0.00	0.00	0.00	
PARMA	0.00	0.00	0.00	
BOLOGNA	0.00	0.00	0.00	
FIRENZE	0.00	0.00	0.00	
VENEZIA	0.00	0.00	0.00	
TRIESTE	0.00	0.00	0.00	
BARI	0.00	0.00	0.00	
PALERMO	0.00	0.00	0.00	
VERONA	0.00	0.00	0.00	
TRENTO	0.00	0.00	0.00	
PADOVA	0.00	0.00	0.00	
PAVIA	0.00	0.00	0.00	
SONDRIO	0.00	0.00	0.00	
NOVARA	0.00	0.00	0.00	
BIELLA	0.00	0.00	0.00	
LASPEZIA	0.00	0.00	0.00	
PISA	0.00	0.00	0.00	
LUCCA	0.00	0.00	0.00	

SASSARI	0.00	0.00	0.00
CATANIA	0.00	0.00	0.00
SYRACUSE	0.00	0.00	0.00
FERRARA	0.00	0.00	0.00
PIACENZA	0.00	0.00	0.00
ALESNDRA	0.00	0.00	0.00
SIENA	0.00	0.00	0.00
GROSSETO	0.00	0.00	0.00
ANCONA	0.00	0.00	0.00
VITERBO	0.00	0.00	0.00
RIETI	0.00	0.00	0.00

SENSITIVITY ANALYSIS

TIME = 14/05/57

EFFECT OF DROPPING ROMA DEPOT FROM THE FINAL BASIS

NAPOLI DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT NAPOLI IS 80358.00

FIXED COST OF NAPOLI IS 2500.00
INITIAL VARIABLE COST OF NAPOLI IS 25167.07

INITIAL GROSS SAVING BY INCLUSION OF NAPOLI IN THE BASIS IS 25945.08
CONTRIBUTION TO NETT SAVING BY INCLUSION OF NAPOLI IS 23445.08

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLECOST/
MILANO	189377.00	15000.00	21128.31
NAPOLI	80358.00	2500.00	25167.07

FIXED COST OF CENTRAL SOURCE AND 1 DEPOT/S IS 17500.00
VARIABLE COST OF CENTRAL SOURCE AND 1 DEPOT/S IS 46295.39
REDUCED OVERALL COST = 63795.39

INITIAL NETT SAVING BY INCLUSION OF NAPOLI IN THE BASIS IS -99.35

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 4362.48

RESULTANT DISTRIBUTION PATTERN

MILANO	50000.00	MILANO	0.0083	415.00
ROMA	50000.00	NAPOLI	0.2892	14462.00
NAPOLI	15000.00	NAPOLI	0.2366	3549.00
TORINO	30000.00	MILANO	0.0910	2730.60
GENOA	25000.00	MILANO	0.1138	2844.20
PARMA	10000.00	MILANO	0.0848	848.16
BOLOGNA	15000.00	MILANO	0.1459	2188.74
FIRENZE	15000.00	MILANO	0.2537	3805.73
VENEZIA	10000.00	MILANO	0.2033	2032.56
TRIESTE	10000.00	MILANO	0.2491	2491.28
BARI	5000.00	NAPOLI	0.4361	2180.72
PALERMO	5000.00	NAPOLI	0.5158	2578.90
VERONA	8000.00	MILANO	0.0910	728.16
TRENTO	3000.00	MILANO	0.1597	479.03
PADUA	7000.00	MILANO	0.1282	897.71
PAVIA	500.00	MILANO	0.0724	36.20
SONDRIO	300.00	MILANO	0.0459	13.77
NOVARO	500.00	MILANO	0.0421	21.07
BIELLA	200.00	MILANO	0.0869	17.38
LASPEZIA	200.00	MILANO	0.1620	32.39
PISA	100.00	MILANO	0.1987	19.87
LUCCA	100.00	MILANO	0.1964	19.64
FANO	30.00	MILANO	0.3027	9.08
SAVONA	50.00	MILANO	0.1757	8.79
PESARO	300.00	MILANO	0.2377	71.30
PERUGIA	300.00	NAPOLI	0.3462	103.86
FOGGIA	25.00	NAPOLI	0.5462	13.66
AVELLINO	2.00	NAPOLI	0.3131	0.63
CAGLIARI	5000.00	NAPOLI	0.4522	2260.99
SASSARI	15.00	NAPOLI	0.5843	8.76
CATANIA	8.00	NAPOLI	0.5894	4.72
SYRACUSE	4.00	NAPOLI	0.6046	2.42
FERRARA	40.00	MILANO	0.1941	7.76
PIACENZA	6.00	MILANO	0.0403	0.24
ALESANDR	6.00	MILANO	0.0869	0.52
SIENA	30.00	MILANO	0.3256	9.77
GROSETTO	15.00	MILANO	0.3865	5.80
ANCONA	4000.00	MILANO	0.3484	1393.57
VITERBO	2.00	NAPOLI	0.3379	0.68
RIETI	2.00	NAPOLI	0.3742	0.75

SOURCE	DESTINATION	THROUGHPUT	COST PER GALLON	TRANSPORT COST
MILANO	MILANO	50000.00	0.0083	415.00
MILANO	TORINO	30000.00	0.0910	2730.60
MILANO	GENOA	25000.00	0.1138	2844.20
MILANO	PARMA	10000.00	0.0848	848.16
MILANO	BOLOGNA	15000.00	0.1459	2188.74
MILANO	FIRENZE	15000.00	0.2537	3805.73
MILANO	VENEZIA	10000.00	0.2033	2032.56
MILANO	TRIESTE	10000.00	0.2491	2491.28
MILANO	VERONA	8000.00	0.0910	728.16
MILANO	TRENTO	3000.00	0.1597	479.03
MILANO	PADUA	7000.00	0.1282	897.71
MILANO	PAVIA	500.00	0.0724	36.20
MILANO	SONDRIO	300.00	0.0459	13.77
MILANO	NOVARO	500.00	0.0421	21.07

- 112 -

MILANO	SAVONA	50.00	0.1757	8.79
MILANO	PESARO	300.00	0.2377	71.30
MILANO	FERRARA	40.00	0.1941	7.76
MILANO	PIACENZA	6.00	0.0403	0.24
MILANO	ALESANDR	6.00	0.0869	0.52
MILANO	SIENA	30.00	0.3256	9.77
MILANO	GROSETTO	15.00	0.3865	5.80
MILANO	ANCONA	4000.00	0.3484	1393.57
NAPOLI	ROMA	50000.00	0.2892	14462.00
NAPOLI	NAPOLI	15000.00	0.2366	3549.00
NAPOLI	BARI	5000.00	0.4361	2180.72
NAPOLI	PALERMO	5000.00	0.5158	2578.90
NAPOLI	PERUGIA	300.00	0.3462	103.86
NAPOLI	FOGGIA	25.00	0.5462	13.66
NAPOLI	AVELLINO	2.00	0.3131	0.63
NAPOLI	CAGLIARI	5000.00	0.4522	2260.99
NAPOLI	SASSARI	15.00	0.5843	8.76
NAPOLI	CATANIA	8.00	0.5894	4.72
NAPOLI	SYRACUSE	4.00	0.6046	2.42
NAPOLI	VITERBO	2.00	0.3379	0.68
NAPOLI	RIETI	2.00	0.3742	0.75

TOTAL FIXED COST = 17500.00
TOTAL VARIABLE COST = 46295.39
TOTAL OVERALL COST = 63795.39

MINIMUM EXTRA COST IS 99.35

NAPOLI DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:=

NAPOLI	15000.00
BARI	5000.00
PALERMO	5000.00
FOGGIA	25.00
AVELLINO	2.00
CATANIA	8.00
SYRACUSE	4.00

THE TOTAL POTENTIAL SAVING IS 908.24

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1591.76

TORINO DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:=

TORINO	30000.00
SAVONA	50.00

THE TOTAL POTENTIAL SAVING IS 1034.94

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 2970.06

PISA 100.00
LUCCA 100.00
SAVONA 50.00
SIENA 30.00
GROSETTO 15.00

THE TOTAL POTENTIAL SAVING IS 2240.68

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 2808.82

PARMA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
PARMA 10000.00
BOLOGNA 15000.00
FANO 30.00
PESARO 300.00
FOGGIA 25.00
FERRARA 40.00
ANCONA 4000.00

THE TOTAL POTENTIAL SAVING IS 1356.09

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 2583.41

BOLOGNA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
BOLOGNA 15000.00
FANO 30.00
PESARO 300.00
PERUGIA 300.00
FOGGIA 25.00
FERRARA 40.00
ANCONA 4000.00

THE TOTAL POTENTIAL SAVING IS 1482.67

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1486.83

FIRENZE DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
FIRENZE 15000.00
PISA 100.00
LUCCA 100.00
SIENA 30.00
GROSETTO 15.00

THE TOTAL POTENTIAL SAVING IS 1961.13

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 563.37

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THE TOTAL POTENTIAL SAVING IS   2059.44

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS      940.56

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TRIESTE  DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                  VENEZIA           10000.00
                                                  TRIESTE           10000.00
THE TOTAL POTENTIAL SAVING IS     1659.44

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     1340.56

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BARI     DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                  BARI               5000.00
                                                  FOGGIA               25.00
THE TOTAL POTENTIAL SAVING IS     1225.86

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS      276.64

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PALERMO  DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                  PALERMO            5000.00
                                                  CATANIA               8.00
                                                  SYRACUSE              4.00
THE TOTAL POTENTIAL SAVING IS     1063.99

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS      437.21

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VERONA   DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                  VENEZIA           10000.00
                                                  TRIESTE           10000.00
                                                  VERONA             8000.00
                                                  TRENTO             3000.00
                                                  PADUA              7000.00
                                                  FANO                 30.00
                                                  FERRARA              40.00
THE TOTAL POTENTIAL SAVING IS     1675.11

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     3131.89

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MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1068.77

PADOVA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

VENEZIA	10000.00
TRIESTE	10000.00
PADUA	7000.00
FERRARA	40.00

THE TOTAL POTENTIAL SAVING IS 1930.84

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1773.16

PAVIA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

GENOA	25000.00
FIRENZE	15000.00
PAVIA	500.00
LASPEZIA	200.00
PISA	100.00
LUCCA	100.00
SAVONA	50.00
SIENA	30.00

THE TOTAL POTENTIAL SAVING IS 1224.23

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 3873.77

SONDRIO DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

SONDRIO	300.00

THE TOTAL POTENTIAL SAVING IS 2.79

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1027.21

NOVARA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

TORINO	30000.00
NOVARO	500.00
BIELLA	200.00
LASPEZIA	200.00
SAVONA	50.00
ALESANDR	6.00

THE TOTAL POTENTIAL SAVING IS 461.66

BIELLA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

BIELLA	200.00

THE TOTAL POTENTIAL SAVING IS 6.46

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1013.54

LASPEZIA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

GENOA	25000.00
FIRENZE	15000.00
LASPEZIA	200.00
PISA	100.00
LUCCA	100.00
AVELLINO	2.00
SIENA	30.00
GROSETTO	15.00

THE TOTAL POTENTIAL SAVING IS 1350.02

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 3694.68

PISA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

FIRENZE	15000.00
LASPEZIA	200.00
PISA	100.00
LUCCA	100.00
FOGGIA	25.00
SIENA	30.00
GROSETTO	15.00

THE TOTAL POTENTIAL SAVING IS 1285.38

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1261.62

LUCCA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

FIRENZE	15000.00
LASPEZIA	200.00
PISA	100.00
LUCCA	100.00
SIENA	30.00
GROSETTO	15.00

THE TOTAL POTENTIAL SAVING IS 1650.55

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 893.95

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                                                      PESARO           300.00
                                                      PERUGIA          300.00
                                                      FOGGIA            25.00
                                                      ANCONA          4000.00
    THE TOTAL POTENTIAL SAVING IS     1053.41

    MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS      912.09

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    SAVONA    DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      SAVONA            50.00
                                                      SIENA             30.00
    THE TOTAL POTENTIAL SAVING IS        4.78

    MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     1003.22

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    PESARO    DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      BARI            5000.00
                                                      FANO              30.00
                                                      PESARO           300.00
                                                      PERUGIA          300.00
                                                      FOGGIA            25.00
                                                      ANCONA          4000.00
    THE TOTAL POTENTIAL SAVING IS      852.18

    MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     1113.32

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    PERUGIA   DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      FANO              30.00
                                                      PERUGIA          300.00
                                                      FOGGIA            25.00
                                                      ANCONA          4000.00
    THE TOTAL POTENTIAL SAVING IS      408.89

    MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     1026.61

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    FOGGIA    DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      BARI            5000.00
                                                      FOGGIA            25.00
    THE TOTAL POTENTIAL SAVING IS     1041.64

    MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS      460.86
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AVELLINO DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

BARI	5000.00
FOGGIA	25.00
AVELLINO	2.00

THE TOTAL POTENTIAL SAVING IS 620.54

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 882.16

CAGLIARI DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

CAGLIARI	5000.00
SASSARI	15.00

THE TOTAL POTENTIAL SAVING IS 428.31

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 1073.19

SASSARI DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

SASSARI	15.00

THE TOTAL POTENTIAL SAVING IS 2.12

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 999.38

CATANIA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

PALERMO	5000.00
CATANIA	8.00
SYRACUSE	4.00

THE TOTAL POTENTIAL SAVING IS 646.18

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 855.02

SYRACUSE DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

PALERMO	5000.00
CATANIA	8.00
SYRACUSE	4.00

THE TOTAL POTENTIAL SAVING IS 526.22

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 974.98

FOGGIA 25.00
FERRARA 40.00
ANCONA 4000.00

THE TOTAL POTENTIAL SAVING IS 255.03

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 3654.47

PIACENZA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

GENOA	25000.00
PARMA	10000.00
BOLOGNA	15000.00
FIRENZE	15000.00
PAVIA	500.00
LASPEZIA	200.00
PISA	100.00
LUCCA	100.00
FANO	30.00
SAVONA	50.00
PESARO	300.00
FOGGIA	25.00
FERRARA	40.00
PIACENZA	6.00
SIENA	30.00
ANCONA	4000.00

THE TOTAL POTENTIAL SAVING IS 898.38

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 7139.72

ALESNDRA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

GENOA	25000.00
FIRENZE	15000.00
LASPEZIA	200.00
PISA	100.00
LUCCA	100.00
SAVONA	50.00
ALESANDR	6.00
SIENA	30.00

THE TOTAL POTENTIAL SAVING IS 763.85

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 4284.75

SIENA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

FIRENZE	15000.00
SIENA	30.00

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GROSSETO DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      FIRENZE       15000.00
                                                      SIENA            30.00
                                                      GROSETTO         15.00
                                                      VITERBO           2.00
THE TOTAL POTENTIAL SAVING IS       24.39

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     2480.31

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ANCONA   DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      BARI           5000.00
                                                      FANO             30.00
                                                      PESARO          300.00
                                                      PERUGIA         300.00
                                                      FOGGIA           25.00
                                                      ANCONA         4000.00
THE TOTAL POTENTIAL SAVING IS     1363.98

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS      601.52

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VITERBO  DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      SIENA            30.00
                                                      GROSETTO         15.00
                                                      VITERBO           2.00
THE TOTAL POTENTIAL SAVING IS        2.43

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     1002.27

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RIETI    DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
                                                      RIETI             2.00
THE TOTAL POTENTIAL SAVING IS        0.07

MINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS     1000.13


COMPLETION TIME = 14/06/25
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COMMENTS ON RESULTS - NEW METHOD

The cost of operating the present distribution network is 68157.87 units, the basis consisting of the factory/depot at Milan, and a depot each at Rome and Naples.

The cost of supplying all destinations from the central source onyl, i.e., the factory/depot at Milan, is 87240.47, making this an obviously retrograde move.

The introduction of a depot at Rome reduces the cost to 63696.04, and this is the optimum basis.

Retention of Naples in the basis (to form the present basis) increases costs, as would result by the introduction of any of the other 37 depots. If Rome is dropped, Naples comes into the basis, and the total cost goes up by 99.35 units. This indicates that Rome is a far more important depot than Naples.