WARP Shoe Company Analysis Report

Shreya Perumal [redacted]

Dhannusha Kaliappan [redacted]

12/02/2024

MIE262

Abstract

This report outlines the investigation conducted on Warp Shoes, a Canadian shoe manufacturer looking to maximize profits by optimizing their production process [1]. Using company provided data, a mathematical model was created to optimize the number of each shoe model produced in order to maximize profits.The model considered various factors such as available materials, budget, storage capacity and machine limits in order to deliver the optimal solution.This model was modelled using AMPL and solved with the Gurobi solver. The results indicated an optimal profit of approximately $11.5 million and achieved through the methodology and analysis provided below.

Introduction

The WARP Shoe Company is a longstanding Canadian company with a new production problem. There have been many competing shoe companies that existed during the early 2000's, and in the beginning of 2006, one such major competitor went out of business. Due to this, the WARP Shoe Company predicted an increase of demand for their own products in the upcoming month, and need to accommodate for this future influx of sales. The aim of this report is to develop the most profitable production plan for the company to help them decide how many of each type of shoe to produce in February 2006, based on several factors, such as demand, budget, and capacity.

To be more specific, there is a cost of $10/pair of shoes that do not meet the given demand, the budget for raw materials is $10 million dollars, and the capacity of each warehouse is given by the company. There are other considerations that must be kept in mind as well, such as the hourly rate of $25 for each worker (each machine is operated by a single worker), the cost of working each machine for 12 hours a day for 28 days, and the fact that the given price of each type of shoe must remain unchanged. The WARP Shoe Company also informed us that setup times and costs of the machine, transportation costs, and the manufacturing sequence can be ignored. To do this, we developed a linear programming model and used the software platform AMPL with the Gurobi extension to solve for the optimal production plan, to help decide how many of each shoe type to produce so the WARP Shoe Company can properly prepare their stocks for February 2006 [1].

Methodology

The purpose of this optimization is to determine how many of each type of shoe must be produced in order to maximize the profit of WARP Shoes. Therefore the variable being considered is the amount produced and the goal is to maximize the profit function. The revenue for the profit function comes from the Sales Price of each shoe produced while the cost is generated from the Raw Materials Purchased, Operating Expenses, Labour and Losses from Unmet Demand. The limiting factors observed were the Amount of Materials Available, the Raw Material Budget, the RunTime of

Machines and the Storage Capacity. The assumption made was that if the day ended before a machine finished working, it would continue from that point the next day.

The Objective Function:

See Appendix A for a detailed breakdown of the Profit Function.

$$Z = R_{Sales} - C_{Raw\ Materials} - C_{Operating} - C_{Labour} - C_{Losses}$$

$$Z = \sum_{i=1}^{557} P_i x_i - \sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r - \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{30} x_i t_{im} o_m - \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{72} t_{im} x_i - 10 \sum_{i=1}^{557} 2D_i - x_i$$

The Constraints:

Constraint 1: Raw Material Budget

$$\sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r \leq 10000000$$

In the problem statement the budget to purchase raw materials is given as $10,000,000. In the BOM table the set of Raw Material numbers for a particular product and the associated quantities per pair are given. In the RM_Master table the cost of each Raw Material number is given. Using these values, the total cost can be calculated, which the constraint restricts.

Constraint 2: Raw Material Limit

$$\sum_{i=1}^{557} x_i a_{ir} \leq A_r \qquad \forall_r = 1, 2, \ldots, 165$$

In the RM_Master table, the Available Quantity for a given raw material r is provided, thus the sum of material r used must fall below or equal to this value.

Constraint 3: Machine Time Limit

$$\sum_{i=1}^{557} 2t_{mi} x_i \leq 1290600 \qquad \forall_m = 1, 2, \ldots, 72$$

In the Machine_Master table, the time required for each shoe for certain machines is provided. Given that there are 2 shoes in a pair, and the variable x refers to the number of pairs being produced, the time should be doubled per pair. Additionally since the machines run 12 hours a day, for 28 days, the total time in seconds each machine can operate for is 1209600 seconds.

Constraint 4: Warehouse Capacity

$$\sum_{i=1}^{557} x_i \leq 140000$$

In the Warehouse_Master table, the capacities of all 8 individual warehouses are given, in total these Warehouses are able to store 140000 pairs of shoes, which is the storage capacity.

Putting the model together, we arrive at the following program.

The Integer Program:

$$\text{maximize } Z = \sum_{i=1}^{557} P_i x_i - \sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r - \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{30} x_i t_{im} o_m - \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{72} t_{im} x_i - 10MAX(0,\ 2D_i - x_i)$$

subject to

$\sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r \leq 10000000$		RM Budget
$\sum_{i=1}^{557} x_i a_{ir} \leq A_r$	$\forall_r = 1, 2, \ldots, 165$	Available Material
$\sum_{i=1}^{557} 2t_{mi} x_i \leq 1290600$	$\forall_m = 1, 2, \ldots, 72$	Machine Time Limit
$\sum_{i=1}^{557} x_i \leq 140000$		Warehouse Capacity
$x_i \in Z^+$	$\forall_i = 1, 2, \ldots, 557$	Non-Negativity

When using modelling software, it can often take too long to run an integer program thus the relaxed linear program is provided below.

The LP Relaxation Program:

$$\text{maximize } Z = \sum_{i=1}^{557} P_i x_i - \sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r - \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{30} x_i t_{im} o_m - \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{72} t_{im} x_i - 10MAX2D_i - x_i$$

subject to

$\sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r \leq 10000000$		RM Budget
$\sum_{i=1}^{557} x_i a_{ir} \leq A_r$	$\forall_r = 1, 2, \ldots, 165$	Available Material
$\sum_{i=1}^{557} 2t_{mi} x_i \leq 1290600$	$\forall_m = 1, 2, \ldots, 72$	Machine Time Limit
$\sum_{i=1}^{557} x_i \leq 140000$		Warehouse Capacity
$x_i \geq 0$	$\forall_i = 1, 2, \ldots, 557$	

Results

Implementation Details:

The first step of solving the model was determining the average demand for February for a given shoe model. This was done by using python to take the average for February of each shoe for the year data provided in the Product_Demand table. The main indexes of the model were the Product_Num called ID, RM_Num called RM and Machine_Num called M. These indexes were used to call the required data in the mod file. The table below shows the parameter declaration in the mod.

Table 1: Parameters

Parameter	Indexes	Table	Name in Table
Price	ID	Product_Master	Sales_Price
Demand	ID	Average_Demand_for_February	Average_Demand
RM_Cost	RM	RM_Master	Cost
Max_Quantity	RM	RM_Master	S_Quantity
Amt_Req	ID, RM	BOM	Quantity
Op_Cost	M	Machine_Master	OpCost_per_min
Time	ID, M	Machine_Assign	Avg_Duration

The optimization model optimizes decision variable x[i], the set of 557 x values that determines the amount of each shoe model produced. This variable is declared as integer x{ID}, for every Product_Num, however after further modelling it was determined that as a result of long run time, it would be more efficient to use a relaxed linear program and round to the nearest integer to get a close approximate.. The Profit Function and Constraints were declared as shown in the Methodology. See Appendix B for AMPL files (.mod, .dat, .run).

Findings:

The results of our investigation indicate that the ideal production plan would produce a profit of $11, 528, 762.10 for the WARP Shoe Company in February 2006. The number of each type of shoe that must be purchased in order to get the optimal profit is available in Appendix C, and is based on the solution modelled and solved in AMPL developed. There are multiple different types of shoes that will need to be produced by the WARP shoe production plant, and also types of shoes that should not

be produced at all. The model was initially developed as an integer program, and was later relaxed into a linear program to increase efficiency in solution development.

Once the integer program was relaxed to an LP, two of the initial constraints were violated: the Material_Available constraint and the Machine_Time_Limit constraint. To be more specific, out of the 557 different types of shoes, 41 used up more than the available amount of raw material. Out of the 72 total machines, the 63rd and 64th machines were working for longer than 12 hours a day, for the 28 days.

The constraints Material_Available and Machine_Time_Limit are binding. Specifically, the Material_Available constraint is binding for the production of the first 165 specific types of shoes and has used up all the raw material available for each. The second constraint Machine_Time_Limit is binding for the 63rd, 64th, and 68th machines, meaning that in the WARP shoe production plant, those specific machines are working for the entire 12 hours a day, for the 28 days in February.

In a scenario where the company is able to buy additional storage space, it is not recommended to purchase any at all, given that it will not improve the objective value. The current solution to the model already does not fill up the warehouse space available. In other words, the slack for the warehouse space constraint is already not zero in the original model, so purchasing more would not be economical. Thus, the optimal amount of space to buy in this situation is zero. After running the model with the additional warehouse space, the additional space required is -59406.00 boxes, indicating that there is already empty room that needs to be filled up, and no additional purchase is required.

In a scenario where the machines are available for only 8 hours per day instead of 12, the solution (optimal profit) becomes $11, 516, 660.30, which is a decrease from the original solution. The same constraints Material_Available and Machine_Time_Limit are binding, however there are a lot more machines that are now working for the entire 8 hours (a lot more bound machines). Also, some of the specific types of shoes that were previously constrained by the Material_Available constraint are no longer bound, meaning that because there are less shoes being produced by the machines, there is less of the material being used up. This new solution seems unrealistic, as there is a loss of profit and lack of efficiency being demonstrated. Working the machines for only 8 hours a day seems to be a waste of resources, as it causes $12 101.8 in profit to be lost.

In a scenario where an additional $7 million was added to the raw materials budget, there is no recommended change, as the profit of the reformulated solution is the exact same as the current solution. Increasing the budget to purchase the raw materials does not change the optimal profit, as the binding constraint is the amount of the raw material available, not the budget constraint. The budget constraint already has a lot of slack. Therefore, expanding the budget would not affect the solution, and would not have any impact on the model.

For a full list of profits, production numbers, binding constraints and constraint violations related to Original or Modified Solutions, see submission folder.

Conclusion

As outlined in the report, given the aforementioned constraints and increase in demand, the maximized profit of the WARP Shoe Company for February 2006 is $11, 528,762.10, with the specific amount of each type of shoe that must be produced available in Appendix C. We determined this by developing a mathematical model using the company's current production plan data and creating an AMPL program with the Gurobi extension to predict the demand for each type of shoe and the maximum profit that can be made. The program was initially an Integer Program that was relaxed to a Linear Program and solved to determine the greatest earnings for the WARP Shoe Company in February 2006. Given that the most limiting constraint was the Available Material, it is advised that the company increase the amount of where possible Available Material.

References

[1] D. M. Aleman, "MIE262: Operations Research I, Lab project: WARP Shoe Company," University of Toronto, Toronto, Canada.

Appendix A - Profit Function Information

The Profit Function is the difference between the revenue and the associated production costs, the breakdown of each parameter in the function is given below.

Profit Function Breakdown	Parameters
$R_{Sales} = \sum_{i=1}^{557} P_i x_i$	i = product number P = price of product i x = amount of product i
$C_{Raw\ Materials} = \sum_{i=1}^{557} \sum_{r \in BOM(i)} x_i a_{ir} c_r$	i = product number r = materials for a associated product i x = amount of product i c = cost of material r a = amount of material r required for product i
$C_{Operating} = \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{30} x_i t_{im} o_m$	i = product number m = machine required for the associated product i x = amount of product i t = time machine m is required per shoe i in seconds o = cost per minute of machine m Given that t is the time per shoe, we multiply by 2 and given that the time is in seconds and cost per minute is in minutes we divide by 60 providing the constant 1/30.
$C_{Labour} = \sum_{i=1}^{557} \sum_{m \in MM(i)} \frac{1}{72} t_{im} x_i$	i = product number m = machine required for the associated product i t = time machine m is required per shoe i in seconds x = amount of product i Given that t is the time per shoe, we multiply by 2 to account for the pair in product and since labour is $25/hour that becomes $1/144 per second giving us the constant.
$C_{Losses} = 10 \sum_{i=1}^{557} 2D_i - x_i$	i = product number D = demand for product i x = amount of product i

	Given that the loss per pair not sold $10, and the demand is estimated to be double that of the data averaged from previous years, the constants are 10 for the sum and 2 for the demand.

Appendix B - AMPL Files

trial.mod

```
#Shreya_Perumal_perumal9_1010207107
#Dhannusha_Kaliappan_kaliapp1_1010544234

#Sets
set ID; #Product Number
set RM; #Raw Material Number
set M; #Machine Number

#Parameters
param Price{ID}; #Sales Price per pair
param Demand{ID}; #Number of Pairs

param RM_Cost{RM}; #Cost per material
param Max_Quantity{RM}; #Max material available
param Amt_Req{ID, RM} default 0; #Amount of material per pair

param Op_Cost{M}; #Operating cost of machine per min per shoe
param Time{ID, M} default 0; #Time required in seconds

#Constant Parameters
param B default 17000000; #budget
param Max_Machine_Time default 1290600; #max machine time per machine in seconds
param Warehouse_Cap default 140000; #max number of pairs of shoes in warehouse

#Variables
var x{ID} >=0; #Number Of Pairs of Shoes

#model
        maximize Profit:

                (sum {i in ID} x[i] * Price[i])
                - (sum {i in ID} 10*max(0,(2*Demand[i]) - x[i]))
                - (sum {i in ID, r in RM} x[i] * Amt_Req[i,r] * RM_Cost[r])
```

```
                - (sum {m in M, i in ID} (x[i] * Time[i,m] * Op_Cost[m] / 30))
                - (sum {m in M, i in ID} (x[i] * Time[i,m] / 72));


        subject to Raw_Material_Cost{r in RM}: sum {i in ID} (x[i] * Amt_Req[i,r] * RM_Cost[r])
<= B;
        subject to Material_Available{r in RM}: sum {i in ID} (x[i] * Amt_Req[i,r]) <=
Max_Quantity[r];
        subject to Machine_Time_Limit{m in M}: sum{i in ID} (2 * x[i] * Time[i,m]) <=
Max_Machine_Time;
        subject to Warehouse_Capacity: sum{i in ID} x[i] <= Warehouse_Cap;


/*
Question 5
Take out warehouse constraint and add:
(Warehouse_Cap - sum{i in ID} x[i])

Question 6
Max_Machine_Time = 8*28*60*60 = 806400

Question 7
B = 17000000
*/
```

trial.dat

```
#Shreya_Perumal_perumal9_1010207107
#Dhannusha_Kaliappan_kaliapp1_1010544234
table table1 "ODBC" "./WARP.mdb" "Product_Master":
        ID <- [Product_Num], Price ~ Sales_Price;
read table table1;

table table2 "ODBC" "./FebAvgDem.mdb" "Average_Demand_for_February":
        [Product_Num], Demand ~ Average_Demand;
read table table2;
```

```
table table3 "ODBC" "./WARP.mdb" "RM_Master":
        RM <- [RM_Num], RM_Cost ~ Cost, Max_Quantity ~ S_Quantity;
read table table3;

table table4 "ODBC" "./WARP.mdb" "BOM":
        [Product_Num, RM_Num], Amt_Req ~ Quantity;
read table table4;

table table5 "ODBC" "./WARP.mdb" "Machine_Master":
        M <- [Machine_Num], Op_Cost ~ OpCost_per_min;
read table table5;

table table6 "ODBC" "./WARP.mdb" "Machine_Assign":
        [Product_Num, Machine_Num], Time ~ Avg_Duration;
read table table6;
```

data.run

```
#Shreya_Perumal_perumal9_1010207107
#Dhannusha_Kaliappan_kaliapp1_1010544234

reset;

model trial.mod;

data trial.dat;

option solver gurobi;

solve;

#Out File

#Objective Value
printf "Optimal Objective Function Value: %.2f\n\n", Profit > WARP.out;
#Original X Values
printf "Optimal Number of Shoe Type Produced: \n\n" >> WARP.out;
display x >> WARP.out;
printf "\n\n" >> WARP.out;
#Rounded X Values for Relaxed LP
printf "Relaxed LP: \n\n" >> WARP.out;
for {i in ID} {
        display round(x[i]) >> WARP.out;
}

printf "\n\n" >> WARP.out;

#Binding Constraints
printf "Binding Constraints: \n\n" >> WARP.out;
for {i in 1..165}{
        if Raw_Material_Cost[i].slack < 1e-6 then
        printf "Raw_Material_Cost is binding.[%s]\n", i >> WARP.out;
}
for {i in 1..165}{
```

```
        if Material_Available[i].slack < 1e-6 then
        printf "Material_Available is binding.[%s]\n", i >> WARP.out;
}
for {i in 1..72}{
        if Machine_Time_Limit[i].slack < 1e-6 then
        printf "Machine_Time_Limit is binding.[%s]\n", i >> WARP.out;
}

if Warehouse_Capacity.slack < 1e-6 then
printf "Warehouse_Capacity is binding.\n" >> WARP.out;
```

Appendix C - Solution

Optimal Objective Function Value: 11528762.10

Optimal Number of Shoe Type Produced:

x [*] :=
SH001 0 SH141 0 SH281 0 SH421 416
SH002 448 SH142 398 SH282 416 SH422 0
SH003 464 SH143 0 SH283 422 SH423 466
SH004 0 SH144 170.54 SH284 494 SH424 0
SH005 244.394 SH145 173.394 SH285 39.9749 SH425 458
SH006 33.6762 SH146 0 SH286 0 SH426 351.776
SH007 0 SH147 400 SH287 410 SH427 478
SH008 0 SH148 0 SH288 0 SH428 0
SH009 101.961 SH149 435.024 SH289 308.768 SH429 235.823
SH010 0 SH150 426 SH290 450 SH430 430
SH011 434 SH151 0 SH291 0 SH431 0
SH012 77.3096 SH152 0 SH292 496 SH432 0
SH013 0 SH153 0 SH293 0 SH433 0
SH014 0 SH154 229.673 SH294 0 SH434 0
SH015 145.798 SH155 0 SH295 404 SH435 128.866
SH016 0 SH156 0 SH296 428.409 SH436 0
SH017 0 SH157 262.393 SH297 0 SH437 0
SH018 353.632 SH158 0 SH298 0 SH438 112.803
SH019 420 SH159 0 SH299 448 SH439 0
SH020 396.138 SH160 406 SH300 428 SH440 0
SH021 0 SH161 0 SH301 0 SH441 0
SH022 0 SH162 0 SH302 0 SH442 269.372
SH023 0 SH163 0 SH303 0 SH443 0
SH024 109.468 SH164 0 SH304 0 SH444 280.062
SH025 0 SH165 460 SH305 0 SH445 462
SH026 0 SH166 0 SH306 0 SH446 0
SH027 182.549 SH167 0 SH307 43.3715 SH447 21.4528
SH028 0 SH168 438 SH308 255.4 SH448 0
SH029 284.388 SH169 0 SH309 96.6729 SH449 423.993
SH030 0 SH170 420 SH310 0 SH450 0

SH031 298.407 SH171 0 SH311 0 SH451 456
SH032 239.704 SH172 0 SH312 476 SH452 3.1991
SH033 0 SH173 289.042 SH313 0 SH453 470
SH034 372 SH174 0 SH314 0 SH454 0
SH035 430 SH175 377.2 SH315 164 SH455 0
SH036 0 SH176 450 SH316 17.3108 SH456 430
SH037 0 SH177 0 SH317 410 SH457 126.24
SH038 478 SH178 363.212 SH318 226.596 SH458 0
SH039 390 SH179 0 SH319 0 SH459 134.43
SH040 249.433 SH180 0 SH320 462 SH460 0
SH041 353.834 SH181 0 SH321 0 SH461 0
SH042 206.539 SH182 0 SH322 474 SH462 187.546
SH043 0 SH183 54.3279 SH323 0 SH463 28.624
SH044 259.788 SH184 204.291 SH324 0 SH464 239.67
SH045 420 SH185 138.183 SH325 476 SH465 434
SH046 0 SH186 185.684 SH326 0 SH466 188.316
SH047 410 SH187 422 SH327 0 SH467 0
SH048 260.715 SH188 57.8222 SH328 0 SH468 70.6031
SH049 0 SH189 0 SH329 222.987 SH469 320.371
SH050 438 SH190 0 SH330 0 SH470 297.435
SH051 0 SH191 167.338 SH331 220.322 SH471 264.6
SH052 0 SH192 426.286 SH332 0 SH472 244.699
SH053 251.425 SH193 0 SH333 273.736 SH473 0
SH054 0 SH194 434 SH334 141.207 SH474 168.21
SH055 0 SH195 504 SH335 349.146 SH475 0
SH056 410 SH196 0 SH336 0 SH476 0
SH057 0 SH197 438 SH337 0 SH477 352.092
SH058 0 SH198 0 SH338 432 SH478 0
SH059 0 SH199 5.41557 SH339 0 SH479 488
SH060 96.1083 SH200 0 SH340 468 SH480 0
SH061 78.6841 SH201 240 SH341 352.977 SH481 15.1603
SH062 458 SH202 0 SH342 398 SH482 0
SH063 265.558 SH203 500 SH343 0 SH483 434
SH064 150.134 SH204 0 SH344 0 SH484 0
SH065 488 SH205 0 SH345 132.749 SH485 0
SH066 0 SH206 0 SH346 0 SH486 0
SH067 0 SH207 0 SH347 10.8181 SH487 203.236

SH068 0 SH208 0 SH348 488 SH488 0
SH069 0 SH209 436 SH349 0 SH489 362.199
SH070 0 SH210 0 SH350 61.4268 SH490 15.8209
SH071 444 SH211 0 SH351 0 SH491 477.782
SH072 149.278 SH212 0 SH352 396 SH492 0
SH073 414 SH213 436 SH353 412 SH493 0
SH074 46.1005 SH214 0 SH354 0 SH494 34.4822
SH075 0 SH215 0 SH355 2.86671 SH495 0
SH076 0 SH216 0 SH356 277.903 SH496 302.754
SH077 0 SH217 87.5461 SH357 0 SH497 450
SH078 341.439 SH218 0 SH358 0 SH498 385.378
SH079 0 SH219 0 SH359 0 SH499 0
SH080 410 SH220 0 SH360 0 SH500 346.546
SH081 210.422 SH221 468 SH361 418 SH501 420
SH082 273.413 SH222 0 SH362 130.029 SH502 0
SH083 0 SH223 410 SH363 0 SH503 0
SH084 29.5346 SH224 442 SH364 0 SH504 0
SH085 0 SH225 420.173 SH365 0 SH505 0
SH086 0 SH226 418 SH366 0 SH506 0
SH087 430 SH227 273.945 SH367 452 SH507 361.901
SH088 88.0707 SH228 0 SH368 0 SH508 426
SH089 0 SH229 0 SH369 273.882 SH509 0
SH090 347.934 SH230 89.8808 SH370 0 SH510 0
SH091 0 SH231 0 SH371 17.4194 SH511 398
SH092 259.702 SH232 438 SH372 153.987 SH512 390.534
SH093 0 SH233 304.613 SH373 374.937 SH513 448
SH094 102.101 SH234 389.871 SH374 0 SH514 215.251
SH095 99.9901 SH235 105.786 SH375 60.5619 SH515 0
SH096 452 SH236 0 SH376 68.6082 SH516 0
SH097 0 SH237 0 SH377 51.0343 SH517 60.1233
SH098 0 SH238 76.2473 SH378 422 SH518 0
SH099 0 SH239 454 SH379 234.977 SH519 0
SH100 0 SH240 0 SH380 0 SH520 348.781
SH101 0 SH241 190.053 SH381 0 SH521 349.91
SH102 0 SH242 0 SH382 0 SH522 66.7273
SH103 0 SH243 0 SH383 0 SH523 126.016
SH104 0 SH244 0 SH384 504 SH524 0

SH105 418 SH245 0 SH385 136.199 SH525 270.973
SH106 296.182 SH246 0 SH386 0 SH526 0
SH107 0 SH247 334.737 SH387 0 SH527 293.426
SH108 0 SH248 0 SH388 0 SH528 0
SH109 286.54 SH249 406 SH389 24.8096 SH529 0
SH110 418 SH250 0 SH390 0 SH530 128.477
SH111 0 SH251 0 SH391 102.078 SH531 0
SH112 0 SH252 0 SH392 0 SH532 290.444
SH113 454 SH253 52.2661 SH393 0 SH533 0
SH114 0 SH254 480 SH394 69.9591 SH534 41.5386
SH115 269.665 SH255 0 SH395 460 SH535 440
SH116 201.412 SH256 434 SH396 0 SH536 434
SH117 52.5443 SH257 0 SH397 0 SH537 0
SH118 0 SH258 0 SH398 0 SH538 111.651
SH119 130.71 SH259 116.067 SH399 378.214 SH539 0
SH120 129.089 SH260 78.2497 SH400 239.653 SH540 0
SH121 508 SH261 410 SH401 0 SH541 338
SH122 0 SH262 412 SH402 0 SH542 0
SH123 0 SH263 0 SH403 0 SH543 470
SH124 0 SH264 486 SH404 0 SH544 265.736
SH125 0 SH265 0 SH405 0 SH545 0
SH126 270.836 SH266 0 SH406 0 SH546 476
SH127 0 SH267 0 SH407 438 SH547 0
SH128 0 SH268 0 SH408 0 SH548 0
SH129 0 SH269 430 SH409 163.434 SH549 98.4539
SH130 386.94 SH270 0 SH410 192.652 SH550 0
SH131 0 SH271 209.978 SH411 420 SH551 0
SH132 301.2 SH272 0 SH412 0 SH552 0
SH133 0 SH273 366.311 SH413 0 SH553 340.782
SH134 259.349 SH274 0 SH414 0 SH554 0
SH135 0 SH275 0 SH415 438 SH555 0
SH136 0 SH276 411.965 SH416 0 SH556 424
SH137 252.369 SH277 422 SH417 434.852 SH557 372.543
SH138 0 SH278 0 SH418 430.095
SH139 0 SH279 364.844 SH419 382.337
SH140 0 SH280 0 SH420 0

Appendix D - Results of Questions

D.1: Question 5

Optimal Objective Function Value: 11588168.10

Optimal Number of Shoe Type Produced:

x [*] :=

SH001 0 SH141 0 SH281 0 SH421 416

SH002 448 SH142 398 SH282 416 SH422 0

SH003 464 SH143 0 SH283 422 SH423 466

SH004 0 SH144 170.54 SH284 494 SH424 0

SH005 244.394 SH145 173.394 SH285 39.9749 SH425 458

SH006 33.6762 SH146 0 SH286 0 SH426 351.776

SH007 0 SH147 400 SH287 410 SH427 478

SH008 0 SH148 0 SH288 0 SH428 0

SH009 101.961 SH149 435.024 SH289 308.768 SH429 235.823

SH010 0 SH150 426 SH290 450 SH430 430

SH011 434 SH151 0 SH291 0 SH431 0

SH012 77.3096 SH152 0 SH292 496 SH432 0

SH013 0 SH153 0 SH293 0 SH433 0

SH014 0 SH154 229.673 SH294 0 SH434 0

SH015 145.798 SH155 0 SH295 404 SH435 128.866

SH016 0 SH156 0 SH296 428.409 SH436 0

SH017 0 SH157 262.393 SH297 0 SH437 0

SH018 353.632 SH158 0 SH298 0 SH438 112.803

SH019 420 SH159 0 SH299 448 SH439 0

SH020 396.138 SH160 406 SH300 428 SH440 0

SH021 0 SH161 0 SH301 0 SH441 0

SH022 0 SH162 0 SH302 0 SH442 269.372

SH023 0 SH163 0 SH303 0 SH443 0

SH024 109.468 SH164 0 SH304 0 SH444 280.062

SH025 0 SH165 460 SH305 0 SH445 462

SH026 0 SH166 0 SH306 0 SH446 0

SH027 182.549 SH167 0 SH307 43.3715 SH447 21.4528

SH028 0 SH168 438 SH308 255.4 SH448 0

SH029 284.388 SH169 0 SH309 96.6729 SH449 423.993
SH030 0 SH170 420 SH310 0 SH450 0
SH031 298.407 SH171 0 SH311 0 SH451 456
SH032 239.704 SH172 0 SH312 476 SH452 3.1991
SH033 0 SH173 289.042 SH313 0 SH453 470
SH034 372 SH174 0 SH314 0 SH454 0
SH035 430 SH175 377.2 SH315 164 SH455 0
SH036 0 SH176 450 SH316 17.3108 SH456 430
SH037 0 SH177 0 SH317 410 SH457 126.24
SH038 478 SH178 363.212 SH318 226.596 SH458 0
SH039 390 SH179 0 SH319 0 SH459 134.43
SH040 249.433 SH180 0 SH320 462 SH460 0
SH041 353.834 SH181 0 SH321 0 SH461 0
SH042 206.539 SH182 0 SH322 474 SH462 187.546
SH043 0 SH183 54.3279 SH323 0 SH463 28.624
SH044 259.788 SH184 204.291 SH324 0 SH464 239.67
SH045 420 SH185 138.183 SH325 476 SH465 434
SH046 0 SH186 185.684 SH326 0 SH466 188.316
SH047 410 SH187 422 SH327 0 SH467 0
SH048 260.715 SH188 57.8222 SH328 0 SH468 70.6031
SH049 0 SH189 0 SH329 222.987 SH469 320.371
SH050 438 SH190 0 SH330 0 SH470 297.435
SH051 0 SH191 167.338 SH331 220.322 SH471 264.6
SH052 0 SH192 426.286 SH332 0 SH472 244.699
SH053 251.425 SH193 0 SH333 273.736 SH473 0
SH054 0 SH194 434 SH334 141.207 SH474 168.21
SH055 0 SH195 504 SH335 349.146 SH475 0
SH056 410 SH196 0 SH336 0 SH476 0
SH057 0 SH197 438 SH337 0 SH477 352.092
SH058 0 SH198 0 SH338 432 SH478 0
SH059 0 SH199 5.41557 SH339 0 SH479 488
SH060 96.1083 SH200 0 SH340 468 SH480 0
SH061 78.6841 SH201 240 SH341 352.977 SH481 15.1603
SH062 458 SH202 0 SH342 398 SH482 0
SH063 265.558 SH203 500 SH343 0 SH483 434
SH064 150.134 SH204 0 SH344 0 SH484 0
SH065 488 SH205 0 SH345 132.749 SH485 0

SH066 0 SH206 0 SH346 0 SH486 0
SH067 0 SH207 0 SH347 10.8181 SH487 203.236
SH068 0 SH208 0 SH348 488 SH488 0
SH069 0 SH209 436 SH349 0 SH489 362.199
SH070 0 SH210 0 SH350 61.4268 SH490 15.8209
SH071 444 SH211 0 SH351 0 SH491 477.782
SH072 149.278 SH212 0 SH352 396 SH492 0
SH073 414 SH213 436 SH353 412 SH493 0
SH074 46.1005 SH214 0 SH354 0 SH494 34.4822
SH075 0 SH215 0 SH355 2.86671 SH495 0
SH076 0 SH216 0 SH356 277.903 SH496 302.754
SH077 0 SH217 87.5461 SH357 0 SH497 450
SH078 341.439 SH218 0 SH358 0 SH498 385.378
SH079 0 SH219 0 SH359 0 SH499 0
SH080 410 SH220 0 SH360 0 SH500 346.546
SH081 210.422 SH221 468 SH361 418 SH501 420
SH082 273.413 SH222 0 SH362 130.029 SH502 0
SH083 0 SH223 410 SH363 0 SH503 0
SH084 29.5346 SH224 442 SH364 0 SH504 0
SH085 0 SH225 420.173 SH365 0 SH505 0
SH086 0 SH226 418 SH366 0 SH506 0
SH087 430 SH227 273.945 SH367 452 SH507 361.901
SH088 88.0707 SH228 0 SH368 0 SH508 426
SH089 0 SH229 0 SH369 273.882 SH509 0
SH090 347.934 SH230 89.8808 SH370 0 SH510 0
SH091 0 SH231 0 SH371 17.4194 SH511 398
SH092 259.702 SH232 438 SH372 153.987 SH512 390.534
SH093 0 SH233 304.613 SH373 374.937 SH513 448
SH094 102.101 SH234 389.871 SH374 0 SH514 215.251
SH095 99.9901 SH235 105.786 SH375 60.5619 SH515 0
SH096 452 SH236 0 SH376 68.6082 SH516 0
SH097 0 SH237 0 SH377 51.0343 SH517 60.1233
SH098 0 SH238 76.2473 SH378 422 SH518 0
SH099 0 SH239 454 SH379 234.977 SH519 0
SH100 0 SH240 0 SH380 0 SH520 348.781
SH101 0 SH241 190.053 SH381 0 SH521 349.91
SH102 0 SH242 0 SH382 0 SH522 66.7273

SH103 0 SH243 0 SH383 0 SH523 126.016
SH104 0 SH244 0 SH384 504 SH524 0
SH105 418 SH245 0 SH385 136.199 SH525 270.973
SH106 296.182 SH246 0 SH386 0 SH526 0
SH107 0 SH247 334.737 SH387 0 SH527 293.426
SH108 0 SH248 0 SH388 0 SH528 0
SH109 286.54 SH249 406 SH389 24.8096 SH529 0
SH110 418 SH250 0 SH390 0 SH530 128.477
SH111 0 SH251 0 SH391 102.078 SH531 0
SH112 0 SH252 0 SH392 0 SH532 290.444
SH113 454 SH253 52.2661 SH393 0 SH533 0
SH114 0 SH254 480 SH394 69.9591 SH534 41.5386
SH115 269.665 SH255 0 SH395 460 SH535 440
SH116 201.412 SH256 434 SH396 0 SH536 434
SH117 52.5443 SH257 0 SH397 0 SH537 0
SH118 0 SH258 0 SH398 0 SH538 111.651
SH119 130.71 SH259 116.067 SH399 378.214 SH539 0
SH120 129.089 SH260 78.2497 SH400 239.653 SH540 0
SH121 508 SH261 410 SH401 0 SH541 338
SH122 0 SH262 412 SH402 0 SH542 0
SH123 0 SH263 0 SH403 0 SH543 470
SH124 0 SH264 486 SH404 0 SH544 265.736
SH125 0 SH265 0 SH405 0 SH545 0
SH126 270.836 SH266 0 SH406 0 SH546 476
SH127 0 SH267 0 SH407 438 SH547 0
SH128 0 SH268 0 SH408 0 SH548 0
SH129 0 SH269 430 SH409 163.434 SH549 98.4539
SH130 386.94 SH270 0 SH410 192.652 SH550 0
SH131 0 SH271 209.978 SH411 420 SH551 0
SH132 301.2 SH272 0 SH412 0 SH552 0
SH133 0 SH273 366.311 SH413 0 SH553 340.782
SH134 259.349 SH274 0 SH414 0 SH554 0
SH135 0 SH275 0 SH415 438 SH555 0
SH136 0 SH276 411.965 SH416 0 SH556 424
SH137 252.369 SH277 422 SH417 434.852 SH557 372.543
SH138 0 SH278 0 SH418 430.095
SH139 0 SH279 364.844 SH419 382.337

SH140 0 SH280 0 SH420 0

;

D.2: Question 6

Optimal Objective Function Value: 11516660.30

Optimal Number of Shoe Type Produced:

x [*] :=

SH001 0 SH141 0 SH281 0 SH421 237.509

SH002 0 SH142 0 SH282 0 SH422 59.1352

SH003 464 SH143 0 SH283 422 SH423 140.591

SH004 0 SH144 0 SH284 0 SH424 103.217

SH005 222 SH145 180.925 SH285 396.004 SH425 218.955

SH006 426 SH146 0 SH286 0 SH426 0

SH007 0 SH147 0 SH287 410 SH427 471.494

SH008 0 SH148 0 SH288 0 SH428 0

SH009 158.494 SH149 0 SH289 0 SH429 474

SH010 396 SH150 426 SH290 450 SH430 331.94

SH011 434 SH151 0 SH291 0 SH431 389.452

SH012 0 SH152 149.094 SH292 496 SH432 478

SH013 0 SH153 0 SH293 0 SH433 0

SH014 169.327 SH154 0 SH294 0 SH434 0

SH015 0 SH155 45.2471 SH295 404 SH435 0

SH016 79.6363 SH156 92.9541 SH296 462 SH436 0

SH017 258.369 SH157 0 SH297 0 SH437 0

SH018 512.094 SH158 0 SH298 0 SH438 0

SH019 360.584 SH159 0 SH299 448 SH439 367.571

SH020 426 SH160 0 SH300 0 SH440 0

SH021 466 SH161 413.953 SH301 0 SH441 0

SH022 31.6943 SH162 442 SH302 20.7188 SH442 221.251

SH023 0 SH163 0 SH303 0 SH443 405.642

SH024 0 SH164 0 SH304 0 SH444 0

SH025 0 SH165 55.4378 SH305 0 SH445 0

SH026 446 SH166 256.226 SH306 0 SH446 482

SH027 0 SH167 0 SH307 416 SH447 0

SH028 0 SH168 438 SH308 46.9795 SH448 462

SH029 168.983 SH169 74.8179 SH309 239.357 SH449 0
SH030 0 SH170 0 SH310 0 SH450 0
SH031 450 SH171 147.101 SH311 51.521 SH451 436.642
SH032 0 SH172 0 SH312 0 SH452 2.95039
SH033 0 SH173 0 SH313 288.162 SH453 331.404
SH034 201.431 SH174 152.113 SH314 0 SH454 18.142
SH035 0 SH175 0 SH315 0 SH455 0
SH036 0 SH176 450 SH316 0 SH456 0
SH037 0 SH177 241.236 SH317 272.726 SH457 0
SH038 0 SH178 191.775 SH318 482 SH458 0
SH039 226.141 SH179 154.375 SH319 68.6383 SH459 0
SH040 99.0657 SH180 298.761 SH320 194.332 SH460 458
SH041 430 SH181 71.6262 SH321 404 SH461 402
SH042 0 SH182 420 SH322 0 SH462 402
SH043 0 SH183 303.22 SH323 0 SH463 0
SH044 0 SH184 269.456 SH324 355.507 SH464 413.877
SH045 420 SH185 165.151 SH325 0 SH465 0
SH046 0 SH186 432 SH326 0 SH466 0
SH047 26.2265 SH187 0 SH327 446 SH467 0
SH048 406 SH188 0 SH328 1.76447 SH468 124.295
SH049 0 SH189 366 SH329 0 SH469 428
SH050 0 SH190 260.095 SH330 0 SH470 0
SH051 384 SH191 0 SH331 296.649 SH471 226.002
SH052 0 SH192 436 SH332 0 SH472 0
SH053 440 SH193 412 SH333 188.234 SH473 0
SH054 470 SH194 434 SH334 0 SH474 246.491
SH055 120.087 SH195 0 SH335 392 SH475 0
SH056 407.135 SH196 204.787 SH336 0 SH476 0
SH057 477.133 SH197 143.007 SH337 0 SH477 379.46
SH058 211.796 SH198 86.0807 SH338 302.995 SH478 0
SH059 0 SH199 145.754 SH339 0 SH479 0
SH060 0 SH200 368.45 SH340 96.2215 SH480 0
SH061 0 SH201 206.716 SH341 430 SH481 0
SH062 172.058 SH202 438 SH342 102.158 SH482 406
SH063 0 SH203 0 SH343 181.215 SH483 76.1087
SH064 107.698 SH204 195.96 SH344 70.3003 SH484 470
SH065 0 SH205 0 SH345 0 SH485 125.721

SH066 0 SH206 0 SH346 0 SH486 0
SH067 0 SH207 0 SH347 0 SH487 172.438
SH068 0 SH208 0 SH348 0 SH488 414
SH069 0 SH209 436 SH349 0 SH489 442
SH070 0 SH210 123.772 SH350 216.291 SH490 0
SH071 236.654 SH211 0 SH351 0 SH491 0
SH072 292.306 SH212 0 SH352 0 SH492 0
SH073 414 SH213 258.888 SH353 412 SH493 0
SH074 80.3103 SH214 0 SH354 261.818 SH494 214.234
SH075 0 SH215 159.316 SH355 0 SH495 0
SH076 0 SH216 0 SH356 430 SH496 0
SH077 0 SH217 0 SH357 91.5354 SH497 0
SH078 408 SH218 38.2565 SH358 285.77 SH498 137.109
SH079 0 SH219 152.491 SH359 265.032 SH499 420
SH080 0 SH220 80.7949 SH360 0 SH500 110.488
SH081 50.4546 SH221 0 SH361 308.472 SH501 180.082
SH082 428 SH222 105.028 SH362 14.437 SH502 59.0323
SH083 41.2703 SH223 0 SH363 0 SH503 0
SH084 444 SH224 0 SH364 0 SH504 0
SH085 444 SH225 0 SH365 0 SH505 348.36
SH086 0 SH226 0 SH366 2.14157 SH506 372
SH087 430 SH227 362 SH367 0 SH507 442
SH088 0 SH228 0 SH368 430 SH508 341.008
SH089 0 SH229 71.9496 SH369 133.325 SH509 450
SH090 129.311 SH230 439.889 SH370 0 SH510 434
SH091 0 SH231 404 SH371 0 SH511 94.5807
SH092 0 SH232 0 SH372 0 SH512 246.097
SH093 0 SH233 107.018 SH373 0 SH513 448
SH094 252.573 SH234 0 SH374 390 SH514 0
SH095 211.41 SH235 0 SH375 0 SH515 0
SH096 92.0084 SH236 0 SH376 186.564 SH516 0
SH097 0 SH237 406 SH377 0 SH517 396
SH098 141.99 SH238 0 SH378 0 SH518 0
SH099 0 SH239 258.434 SH379 422 SH519 0
SH100 394 SH240 0 SH380 0 SH520 169.138
SH101 257.551 SH241 254.233 SH381 0 SH521 0
SH102 199.972 SH242 0 SH382 4.3405 SH522 394.877

SH103 175.903 SH243 0 SH383 0 SH523 341.484
SH104 432 SH244 0 SH384 0 SH524 2.47112
SH105 418 SH245 182.602 SH385 476 SH525 18.6852
SH106 0 SH246 388.142 SH386 347.898 SH526 0
SH107 46.0004 SH247 0 SH387 0 SH527 351.169
SH108 0 SH248 0 SH388 0 SH528 0
SH109 291.639 SH249 406 SH389 0 SH529 0
SH110 328.158 SH250 0 SH390 454 SH530 0
SH111 63.6753 SH251 54.3333 SH391 0 SH531 378
SH112 464 SH252 0 SH392 0 SH532 54.4027
SH113 157.148 SH253 0 SH393 422 SH533 338.931
SH114 0 SH254 480 SH394 185.885 SH534 406
SH115 46.5697 SH255 0 SH395 253.033 SH535 440
SH116 123 SH256 434 SH396 0 SH536 0
SH117 0 SH257 0 SH397 110.508 SH537 0
SH118 159.518 SH258 474 SH398 91.1027 SH538 420
SH119 432 SH259 336.186 SH399 0 SH539 0
SH120 429.251 SH260 37.6996 SH400 430 SH540 0
SH121 200.974 SH261 410 SH401 0 SH541 0
SH122 264.677 SH262 412 SH402 121.899 SH542 0
SH123 147.871 SH263 0 SH403 246.225 SH543 182.947
SH124 207.207 SH264 486 SH404 0 SH544 288.527
SH125 0 SH265 0 SH405 0 SH545 0
SH126 426.867 SH266 0 SH406 0 SH546 366.963
SH127 10.7063 SH267 0 SH407 0 SH547 358.875
SH128 0 SH268 0 SH408 462 SH548 351.739
SH129 383.77 SH269 430 SH409 70.1837 SH549 5.98798
SH130 326.272 SH270 0 SH410 0 SH550 484
SH131 0 SH271 442 SH411 114.275 SH551 0
SH132 0 SH272 0 SH412 123.084 SH552 0
SH133 445.6 SH273 176.225 SH413 0 SH553 92.6827
SH134 11.8382 SH274 0 SH414 462 SH554 277.944
SH135 0 SH275 0 SH415 438 SH555 0
SH136 0 SH276 416 SH416 181.726 SH556 146.975
SH137 85.099 SH277 422 SH417 0 SH557 470
SH138 0 SH278 0 SH418 0
SH139 0 SH279 372 SH419 0

SH140 359.386 SH280 0 SH420 23.4232

;

D.3: Question 7

Optimal Objective Function Value: 11528762.10

Optimal Number of Shoe Type Produced:

x [*] :=

SH001 0 SH141 0 SH281 0 SH421 416

SH002 448 SH142 398 SH282 416 SH422 0

SH003 464 SH143 0 SH283 422 SH423 466

SH004 0 SH144 170.54 SH284 494 SH424 0

SH005 244.394 SH145 173.394 SH285 39.9749 SH425 458

SH006 33.6762 SH146 0 SH286 0 SH426 351.776

SH007 0 SH147 400 SH287 410 SH427 478

SH008 0 SH148 0 SH288 0 SH428 0

SH009 101.961 SH149 435.024 SH289 308.768 SH429 235.823

SH010 0 SH150 426 SH290 450 SH430 430

SH011 434 SH151 0 SH291 0 SH431 0

SH012 77.3096 SH152 0 SH292 496 SH432 0

SH013 0 SH153 0 SH293 0 SH433 0

SH014 0 SH154 229.673 SH294 0 SH434 0

SH015 145.798 SH155 0 SH295 404 SH435 128.866

SH016 0 SH156 0 SH296 428.409 SH436 0

SH017 0 SH157 262.393 SH297 0 SH437 0

SH018 353.632 SH158 0 SH298 0 SH438 112.803

SH019 420 SH159 0 SH299 448 SH439 0

SH020 396.138 SH160 406 SH300 428 SH440 0

SH021 0 SH161 0 SH301 0 SH441 0

SH022 0 SH162 0 SH302 0 SH442 269.372

SH023 0 SH163 0 SH303 0 SH443 0

SH024 109.468 SH164 0 SH304 0 SH444 280.062

SH025 0 SH165 460 SH305 0 SH445 462

SH026 0 SH166 0 SH306 0 SH446 0

SH027 182.549 SH167 0 SH307 43.3715 SH447 21.4528

SH028 0 SH168 438 SH308 255.4 SH448 0

SH029 284.388 SH169 0 SH309 96.6729 SH449 423.993
SH030 0 SH170 420 SH310 0 SH450 0
SH031 298.407 SH171 0 SH311 0 SH451 456
SH032 239.704 SH172 0 SH312 476 SH452 3.1991
SH033 0 SH173 289.042 SH313 0 SH453 470
SH034 372 SH174 0 SH314 0 SH454 0
SH035 430 SH175 377.2 SH315 164 SH455 0
SH036 0 SH176 450 SH316 17.3108 SH456 430
SH037 0 SH177 0 SH317 410 SH457 126.24
SH038 478 SH178 363.212 SH318 226.596 SH458 0
SH039 390 SH179 0 SH319 0 SH459 134.43
SH040 249.433 SH180 0 SH320 462 SH460 0
SH041 353.834 SH181 0 SH321 0 SH461 0
SH042 206.539 SH182 0 SH322 474 SH462 187.546
SH043 0 SH183 54.3279 SH323 0 SH463 28.624
SH044 259.788 SH184 204.291 SH324 0 SH464 239.67
SH045 420 SH185 138.183 SH325 476 SH465 434
SH046 0 SH186 185.684 SH326 0 SH466 188.316
SH047 410 SH187 422 SH327 0 SH467 0
SH048 260.715 SH188 57.8222 SH328 0 SH468 70.6031
SH049 0 SH189 0 SH329 222.987 SH469 320.371
SH050 438 SH190 0 SH330 0 SH470 297.435
SH051 0 SH191 167.338 SH331 220.322 SH471 264.6
SH052 0 SH192 426.286 SH332 0 SH472 244.699
SH053 251.425 SH193 0 SH333 273.736 SH473 0
SH054 0 SH194 434 SH334 141.207 SH474 168.21
SH055 0 SH195 504 SH335 349.146 SH475 0
SH056 410 SH196 0 SH336 0 SH476 0
SH057 0 SH197 438 SH337 0 SH477 352.092
SH058 0 SH198 0 SH338 432 SH478 0
SH059 0 SH199 5.41557 SH339 0 SH479 488
SH060 96.1083 SH200 0 SH340 468 SH480 0
SH061 78.6841 SH201 240 SH341 352.977 SH481 15.1603
SH062 458 SH202 0 SH342 398 SH482 0
SH063 265.558 SH203 500 SH343 0 SH483 434
SH064 150.134 SH204 0 SH344 0 SH484 0
SH065 488 SH205 0 SH345 132.749 SH485 0

SH066 0 SH206 0 SH346 0 SH486 0
SH067 0 SH207 0 SH347 10.8181 SH487 203.236
SH068 0 SH208 0 SH348 488 SH488 0
SH069 0 SH209 436 SH349 0 SH489 362.199
SH070 0 SH210 0 SH350 61.4268 SH490 15.8209
SH071 444 SH211 0 SH351 0 SH491 477.782
SH072 149.278 SH212 0 SH352 396 SH492 0
SH073 414 SH213 436 SH353 412 SH493 0
SH074 46.1005 SH214 0 SH354 0 SH494 34.4822
SH075 0 SH215 0 SH355 2.86671 SH495 0
SH076 0 SH216 0 SH356 277.903 SH496 302.754
SH077 0 SH217 87.5461 SH357 0 SH497 450
SH078 341.439 SH218 0 SH358 0 SH498 385.378
SH079 0 SH219 0 SH359 0 SH499 0
SH080 410 SH220 0 SH360 0 SH500 346.546
SH081 210.422 SH221 468 SH361 418 SH501 420
SH082 273.413 SH222 0 SH362 130.029 SH502 0
SH083 0 SH223 410 SH363 0 SH503 0
SH084 29.5346 SH224 442 SH364 0 SH504 0
SH085 0 SH225 420.173 SH365 0 SH505 0
SH086 0 SH226 418 SH366 0 SH506 0
SH087 430 SH227 273.945 SH367 452 SH507 361.901
SH088 88.0707 SH228 0 SH368 0 SH508 426
SH089 0 SH229 0 SH369 273.882 SH509 0
SH090 347.934 SH230 89.8808 SH370 0 SH510 0
SH091 0 SH231 0 SH371 17.4194 SH511 398
SH092 259.702 SH232 438 SH372 153.987 SH512 390.534
SH093 0 SH233 304.613 SH373 374.937 SH513 448
SH094 102.101 SH234 389.871 SH374 0 SH514 215.251
SH095 99.9901 SH235 105.786 SH375 60.5619 SH515 0
SH096 452 SH236 0 SH376 68.6082 SH516 0
SH097 0 SH237 0 SH377 51.0343 SH517 60.1233
SH098 0 SH238 76.2473 SH378 422 SH518 0
SH099 0 SH239 454 SH379 234.977 SH519 0
SH100 0 SH240 0 SH380 0 SH520 348.781
SH101 0 SH241 190.053 SH381 0 SH521 349.91
SH102 0 SH242 0 SH382 0 SH522 66.7273

SH103 0 SH243 0 SH383 0 SH523 126.016
SH104 0 SH244 0 SH384 504 SH524 0
SH105 418 SH245 0 SH385 136.199 SH525 270.973
SH106 296.182 SH246 0 SH386 0 SH526 0
SH107 0 SH247 334.737 SH387 0 SH527 293.426
SH108 0 SH248 0 SH388 0 SH528 0
SH109 286.54 SH249 406 SH389 24.8096 SH529 0
SH110 418 SH250 0 SH390 0 SH530 128.477
SH111 0 SH251 0 SH391 102.078 SH531 0
SH112 0 SH252 0 SH392 0 SH532 290.444
SH113 454 SH253 52.2661 SH393 0 SH533 0
SH114 0 SH254 480 SH394 69.9591 SH534 41.5386
SH115 269.665 SH255 0 SH395 460 SH535 440
SH116 201.412 SH256 434 SH396 0 SH536 434
SH117 52.5443 SH257 0 SH397 0 SH537 0
SH118 0 SH258 0 SH398 0 SH538 111.651
SH119 130.71 SH259 116.067 SH399 378.214 SH539 0
SH120 129.089 SH260 78.2497 SH400 239.653 SH540 0
SH121 508 SH261 410 SH401 0 SH541 338
SH122 0 SH262 412 SH402 0 SH542 0
SH123 0 SH263 0 SH403 0 SH543 470
SH124 0 SH264 486 SH404 0 SH544 265.736
SH125 0 SH265 0 SH405 0 SH545 0
SH126 270.836 SH266 0 SH406 0 SH546 476
SH127 0 SH267 0 SH407 438 SH547 0
SH128 0 SH268 0 SH408 0 SH548 0
SH129 0 SH269 430 SH409 163.434 SH549 98.4539
SH130 386.94 SH270 0 SH410 192.652 SH550 0
SH131 0 SH271 209.978 SH411 420 SH551 0
SH132 301.2 SH272 0 SH412 0 SH552 0
SH133 0 SH273 366.311 SH413 0 SH553 340.782
SH134 259.349 SH274 0 SH414 0 SH554 0
SH135 0 SH275 0 SH415 438 SH555 0
SH136 0 SH276 411.965 SH416 0 SH556 424
SH137 252.369 SH277 422 SH417 434.852 SH557 372.543
SH138 0 SH278 0 SH418 430.095
SH139 0 SH279 364.844 SH419 382.337

SH140 0 SH280 0 SH420 0

;