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Transportation cost optimization

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Abstract:

Many manufacturing make their products in few locations and ship them to many different shops. In this paper work we use Evolver, IP - Solver and Microsoft Solver Foundation in order to optimize transportation cost of the window and door factory or to find the cheaper way to make and ship products to the customers and meet customer demand. Window and Door Company named "Proplast" is located in three different places in Ferizaj, Pristina and Prizren and will supply 9 shops in Kosovë, Albania, Macedonia Montenegro and Serbia. Mathematically speaking, our goal is to find minimal transportation cost and this problem will be set up as a linear programming model with the below definition:

- Minimize total production and transportation cost
- Constraints

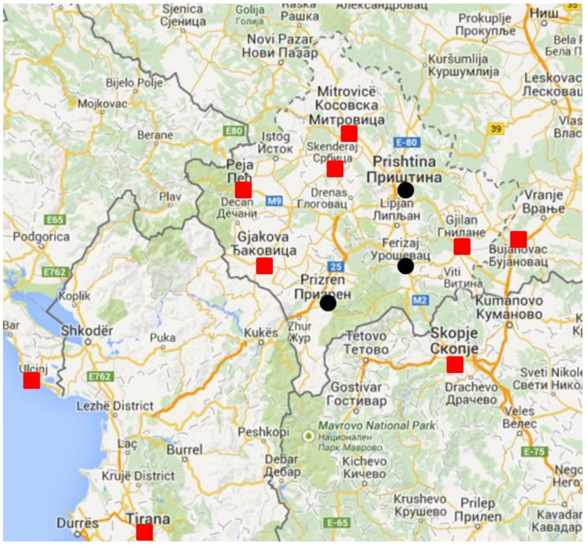
- ✓ The amount shipped from each factory cannot exceed plant capacity
- ✓ Every shop must receive its required demand
- ✓ Transportation trucks have the limit of loading quantity and
- ✓ Each shipping amount must be nonnegative

We will show Evolver, IP - Solver and Microsoft Solver Foundation results and will find the least expensive way. Also we will compare min and max cost for all software.

Keywords: Transportation Cost, Optimization, Evolver, IP - Solver and MS Solver Foundation.

Introduction

In this article we have chosen "Proplast" company that makes windows and doors in three different factories and transport its products in 9 different shops as shown in the map and graph below:



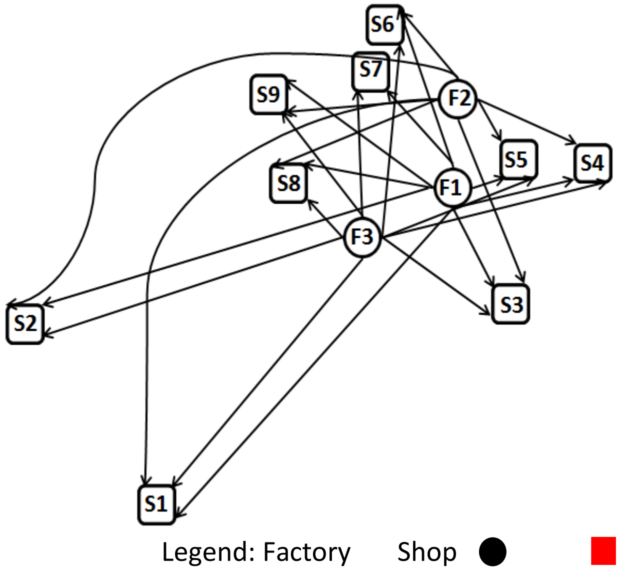


Figure 1. Distribution Network from Factory to the Shops

We will utilize the power of Evolver, IP Microsoft Solver and Microsoft Solver Foundation in order to optimize transportation cost. Technically speaking our objective is to find a lowest logistical cost.

Minimizing cost as optimization transportation problem is a classic problem in supply chain in the field of optimization. This problem is specifically essential in distribution and retail environments with the transportation management needs.

In the B. Parker and D. Caine, Minimizing Transportation Costs: An efficient and effective approach for the spreadsheet user [3] is explain that Logistics problems often involve attempting to minimize the total costs of transporting materials from a number of sources to a variety of destinations. Sophisticated computer packages have been developed to help with this but the packages are normally only used by large organizations. The article show that the power of modern spreadsheet software, such as Microsoft 'Excel' allows all organizations to use a personal computer to produce optimal transportation allocations quickly and easily. In this article is demonstrated using a simple, worked instance.

In the Optimization of the supplier selection problem using discrete firefly algorithm [13] is showing a firefly optimization based algorithm which helps to choose the proper suppliers in a case of given order quantity of a given product. The developed algorithm takes account of the minimum and maximum order quantities at the different suppliers as constraints. The algorithm takes account of the capacity and the cost of the used transport vehicles too. The article describes the operation of the algorithm and the penalty functions applied. In the last part the firefly algorithm and the solution given by the MS Excel solver's general reduced gradient and the evolutionary algorithm is compared.

Minimizing Transportation Cost for Window and Door "Proplast" Company

Mathematical expression for calculation transportation cost per unit (window or door) is:

$$C=(c_k*L) / m \quad [1]$$

C – Total cost

c_k - Operator cost per 1 km

L – Total length between factory and demand shop

m – Truck Loading Capacity

The total cost (C) is in proportion with the length of the routes. Operator cost (c_k) includes maintenance and direct costs of operation (driver wage, fuel consumption, tires, brake shoes, etc.). Vehicle depreciation costs are included as a part of operator cost too. All cost in this paper is calculated in Euro. Based on the mathematical formula [1] and data's we will populate the table below with the transportation cost per unit:

Table 3. Transportation cost per unit from factories to the shops

Factory	Shop								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
F1	2.08	2.20	0.48	1.18	0.31	0.65	0.53	0.80	0.82
F2	2.26	2.38	0.79	1.49	0.47	0.37	0.45	0.75	0.75
F3	1.58	1.70	0.89	1.58	0.88	0.92	0.73	0.33	0.88

The mathematical model (integer linear programming formulation) for this task will look as below:

$$Min \sum_{i}^{m} \sum_{j}^{n} Cij * Sij$$

Constraints:

$$\sum_{j}^{n} Sij \leq Fi \qquad i = 1,\ldots,m$$

$$\sum_{i}^{m} Sij = Dj \qquad j = 1,\ldots,n$$

$$Sij \leq \max T \qquad i = 1,\ldots,m;\; j = 1,\ldots,n$$

$$Sij \geq 0 \qquad i = 1,\ldots,m;\; j = 1,\ldots,n$$

C_{ij} - is cost per unit from factory i to shop j

S_{ij} - Shipment amount from factory i to the shop j

F_i - Production capacity for factory F_1, F_2 or F_3

D_j - Shipment amount received in the shop j

Max T - is maximal loading truck capacity

Transportation Cost Minimization will be calculated using Evolver, IP Solver and MS Foundation will be set up with the below specifications:

- **Target cell** - Minimize total shipping cost.
- **Changing cells** - The amount made at every factory for shipping to every shop.
- **Constraints**
    - Shipping amount from each factory cannot exceed production factory capacity
    - Every demand point must receive at least its required demand
    - Each changing cell cannot be negative.

Target Cell is Total Min Cost. Changing cells are in C17:H19. Constraints shown under “Sent” column H17:H19 are less or equal to “Capacity” in column K17:K19. Constraints “Received” in row C20:G25 are bigger or equal to “Demand” in row C22:G22 which contains demands for each shop. “Capacity” in column K17:K19 is production capacity for each factory and C23 is Maximum truck transportation capacity.

Demand amount for each shop is on weekly bases. Each factory has only one heavy truck with maximum capacity of 500 units. Each factory have maximum production capacity on weekly bases; max F1 is 1,300 units, max F2 is 1,100 units and max F3 is 1,000 units. All above constrains are entered into Excel table below.

Table 4. Target Cell, Changing Cells and Constrains

	Shipments									
	B	C	D	E	F	F	G	H	I	K
16		S1	S2	S3	S4	S8	S9	Sent		Capacity
17	F1	0	0	300	250	150	0	975	<=	1300
18	F2	0	0	0	0	275	125	1100	<=	1100
19	F3	500	475	0	0	25	0	1000	<=	1000
20	Received	500	475	300	250	450	125			
21		>=	>=	>=	>=	>=	>=			
22	Demand	500	475	300	250	450	125			
23	Max Truck Capacity	500								
24										
25	Total Min Cost	**2,842.38**								

Total min cost of 2,842.38 shown in cell C25 in above table is the same for three methods: Evolver, IP Solver and MS Foundation.

Optimization with Evolver

Evolver is an advanced, yet simple-to-use optimization add-in for Microsoft Excel. Evolver uses inventive genetic algorithm (GA) and linear programming technology to quickly solve problems in finance, distribution, resource allocation, manufacturing, engineering, and more. Practically any kind of problem that can be modeled in Excel can be solved by Evolver, including otherwise impossible, complex nonlinear problems [10].

After we get all constrains entered in evolver model and run the software we get the total minimal cost equal to 2,842.38.

Adjustable Cells and Hard Constrains are shown below:

Table 5. Adjustable Cells

Trial	Elapsed Time	Result	Adjustable Cells																										
			C17	D17	E17	F17	G17	H17	I17	J17	K17	C18	D18	E18	F18	G18	H18	I18	J18	K18	C19	D19	E19	F19	G19	H19	I19	J19	K19
2	0:00:02	2,842.38 €	0	0	300	250	275	0	0	150	0	0	0	0	0	0	325	375	275	125	500	475	0	0	0	0	0	25	0

Table 6. Hard Constraints

Hard Constraints											
SUM(C17:K17)<=1300	SUM(C18:K18)<=1100	SUM(C19:K19)<=1000	SUM(C17:C19)>=500	SUM(D17:D19)>=475	SUM(E17:E19)>=300	SUM(F17:F19)>=250	SUM(G17:G19)>=275	SUM(H17:H19)>=325	SUM(I17:I19)>=375	SUM(J17:J19)>=450	SUM(K17:K19)>=125
Met	Met	Met	Met	Met	Met	Met	Met	Met	Met	Met	Met

Optimization with IP Solver

Solver is part of a suite of commands sometimes called what-if analysis tools. With Solver, you can find an optimal (maximum or minimum) value for a formula in one cell - called the target cell - subject to constraints, or limit, on the values of other formula cells on a worksheet. Solver works with a set of cells, called changing cells or adjustable cells that participate in computing the formulas in the objective and constraint cells. Solver adjusts the values in the changes cells to satisfy the limits on constraint cells and produce the result we want for the target cell [11].

Table 1 and Table 2 will be used again in the IP Solver. Solver parameters will be entered, select Set Target Cell, Equal to Min, Changing cells and write constrains formulas in the Subject to the Constrains.

In below tables are shown Answer, Sensitivity and Limits report of the Microsoft IP Solver.

Table 7. Answer Report

Target Cell (Min)

Cell	Name	Original Value	Final Value
C25	Total Min Cost >=	$ 2,842.38	$ 2,842.38

Adjustable Cells

Cell	Name	Original Value	Final Value
C17	F1 S1	0	0
D17	F1 S2	0	0
E17	F1 S3	300	300
F17	F1 S4	250	250
G17	F1 S5	275	275
H17	F1 S6	0	0
I17	F1 S7	0	0
J17	F1 S8	150	150
K17	F1 S9	0	0
C18	F2 S1	0	0
D18	F2 S2	0	0
E18	F2 S3	0	0
F18	F2 S4	0	0
G18	F2 S5	0	0
H18	F2 S6	325	325
I18	F2 S7	375	375
J18	F2 S8	275	275
K18	F2 S9	125	125
C19	F3 S1	500	500
D19	F3 S2	475	475
E19	F3 S3	0	0
F19	F3 S4	0	0
G19	F3 S5	0	0
H19	F3 S6	0	0
I19	F3 S7	0	0
J19	F3 S8	25	25
K19	F3 S9	0	0

Table 8. Limits Report

Cell	Target Name	Value
C25	Total Min Cost >=	$2,842.38

Cell	Adjustable Name	Value	Lower Limit	Target Result	Upper Limit	Target Result
C17	F1 S1	0	0	2842.38	325	3518.06
D17	F1 S2	0	0	2842.38	325	3556.08
E17	F1 S3	300	300	2842.38	500	2938.5
F17	F1 S4	250	250	2842.38	500	3137.13
G17	F1 S5	275	275	2842.38	500	2912.65
H17	F1 S6	0	0	2842.38	325	3054.15
I17	F1 S7	0	0	2842.38	325	3015.54
J17	F1 S8	150	150	2842.38	475	3100.95
K17	F1 S9	0	0	2842.38	325	3109.14
C18	F2 S1	0	0	2842.38	0	2842.38
D18	F2 S2	0	0	2842.38	0	2842.38
E18	F2 S3	0	0	2842.38	0	2842.38
F18	F2 S4	0	0	2842.38	0	2842.38
G18	F2 S5	0	0	2842.38	0	2842.38
H18	F2 S6	325	325	2842.38	325	2842.38
I18	F2 S7	375	375	2842.38	375	2842.38
J18	F2 S8	275	275	2842.38	275	2842.38
K18	F2 S9	125	125	2842.38	125	2842.38
C19	F3 S1	500	500	2842.38	500	2842.38
D19	F3 S2	475	475	2842.38	475	2842.38
E19	F3 S3	0	0	2842.38	0	2842.38
F19	F3 S4	0	0	2842.38	0	2842.38
G19	F3 S5	0	0	2842.38	0	2842.38
H19	F3 S6	0	0	2842.38	0	2842.38
I19	F3 S7	0	0	2842.38	0	2842.38
J19	F3 S8	25	25	2842.38	25	2842.38
K19	F3 S9	0	0	2842.38	0	2842.38

Table 9. Sensitivity Report

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
C20	Received S1	500	2.079	500	325	0
D20	Received S2	475	2.1645	475	25	150
E20	Received S3	300	0.4806	300	200	300
F20	Received S4	250	1.179	250	250	250
G20	Received S5	275	0.3123	275	225	275
H20	Received S6	325	0.4158	325	175	150
I20	Received S7	375	0.4977	375	125	150
J20	Received S8	450	0.7956	450	325	150
K20	Received S9	125	0.7911	125	275	125
L17	F1 Sent	975	0	1300	1E+30	325
L18	F2 Sent	1100	-0.045	1100	150	275
L19	F3 Sent	1000	-0.4635	1000	150	25

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C17	F1 S1	0	0	2.079	0.225	0.0315
D17	F1 S2	0	0.0315	2.196	1E+30	0.0315
E17	F1 S3	300	0	0.4806	0.3582	0.4806
F17	F1 S4	250	0	1.179	0.36	1.179
G17	F1 S5	275	0	0.3123	0.207	0.3123
H17	F1 S6	0	0.2358	0.6516	1E+30	0.2358
I17	F1 S7	0	0.0351	0.5328	1E+30	0.0351
J17	F1 S8	150	0	0.7956	0.0297	0.045
K17	F1 S9	0	0.0297	0.8208	1E+30	0.0297
C18	F2 S1	0	0.225	2.259	1E+30	0.225
D18	F2 S2	0	0.2565	2.376	1E+30	0.2565
E18	F2 S3	0	0.3582	0.7938	1E+30	0.3582
F18	F2 S4	0	0.36	1.494	1E+30	0.36
G18	F2 S5	0	0.207	0.4743	1E+30	0.207
H18	F2 S6	325	0	0.3708	0.2358	0.4158
I18	F2 S7	375	0	0.4527	0.0351	0.4977
J18	F2 S8	275	0	0.7506	0.045	0.0297
K18	F2 S9	125	0	0.7461	0.0297	0.7911
C19	F3 S1	500	-0.0315	1.584	0.0315	1E+30
D19	F3 S2	475	0	1.701	0.0315	2.1645
E19	F3 S3	0	0.8712	0.8883	1E+30	0.8712
F19	F3 S4	0	0.8685	1.584	1E+30	0.8685
G19	F3 S5	0	1.0278	0.8766	1E+30	1.0278
H19	F3 S6	0	0.9657	0.918	1E+30	0.9657
I19	F3 S7	0	0.6912	0.7254	1E+30	0.6912
J19	F3 S8	25	0	0.3321	0.4635	0.0315
K19	F3 S9	0	0.5526	0.8802	1E+30	0.5526

Optimization with Microsoft Foundation Solver

Microsoft Solver Foundation is a set of advance tools for mathematical simulation, optimization and modeling that relies on a managed execution environment and the common language runtime (CLR). You can use any CLR language including Visual C#, Visual Basic, Visual F#, and IronPython. Since these languages use the functionality of the .NET Framework, you can also use technologies such as ASP.NET and Silverlight in your mathematical applications [12].

Solver Foundation OML (Optimization Modeling Language) with constrains is shown below:

```
Model[
 Parameters[
 Sets[Any],
 SRC,
 DST
 ],
 Parameters[
 Reals[-Infinity, Infinity],
 Cost[SRC, DST]
 ],
 Decisions[
 Reals[0, 500],
 Shipments[SRC, DST]
 ],
 Constraints[
 Constraint1 ->
Shipments[0,0]+Shipments[0,1]+Shipments[0,2]+Shipments[0,3]+Shipments[0,4]+Shipment
s[0,5]+Shipments[0,6]+Shipments[0,7]+Shipments[0,8]<=1300,
 Constraint2 ->
Shipments[1,0]+Shipments[1,1]+Shipments[1,2]+Shipments[1,3]+Shipments[1,4]+Shipment
s[1,5]+Shipments[1,6]+Shipments[1,7]+Shipments[1,8]<=1100,
 Constraint3 ->
Shipments[2,0]+Shipments[2,1]+Shipments[2,2]+Shipments[2,3]+Shipments[2,4]+Shipment
s[2,5]+Shipments[2,6]+Shipments[2,7]+Shipments[2,8]<=1000,
 Constraint4 -> Shipments[0,0]+Shipments[1,0]+Shipments[2,0]>=500,
 Constraint5 -> Shipments[0,1]+Shipments[1,1]+Shipments[2,1]>=475,
 Constraint6 -> Shipments[0,2]+Shipments[1,2]+Shipments[2,2]>=300,
 Constraint7 -> Shipments[0,3]+Shipments[1,3]+Shipments[2,3]>=250,
 Constraint8 -> Shipments[0,4]+Shipments[1,4]+Shipments[2,4]>=275,
 Constraint9 -> Shipments[0,5]+Shipments[1,5]+Shipments[2,5]>=325,
```

```
Constraint10 -> Shipments[0,6]+Shipments[1,6]+Shipments[2,6]>=375,
Constraint11 -> Shipments[0,7]+Shipments[1,7]+Shipments[2,7]>=450,
Constraint12 -> Shipments[0,8]+Shipments[1,8]+Shipments[2,8]>=125
],
Goals[
Minimize[
 TotalCost -> Annotation[Sum[{i, SRC}, {j, DST}, Cost[i, j]*Shipments[i,j]], "order", 0]
]
]
]
```

After all solver foundation parameters and OML are entered we get results as below:

Table 10. Solver Foundation Results

Solver Foundation Results	
Name	**Value**
Solution Type	Optimal
TotalCost	2842.38
Shipments[0, 0]	0
Shipments[0, 1]	0
Shipments[0, 2]	300
Shipments[0, 3]	250
Shipments[0, 4]	275
Shipments[0, 5]	0
Shipments[0, 6]	0
Shipments[0, 7]	150
Shipments[0, 8]	0
Shipments[1, 0]	0
Shipments[1, 1]	0
Shipments[1, 2]	0
Shipments[1, 3]	0
Shipments[1, 4]	0
Shipments[1, 5]	325
Shipments[1, 6]	375
Shipments[1, 7]	275
Shipments[1, 8]	125
Shipments[2, 0]	500
Shipments[2, 1]	475
Shipments[2, 2]	0
Shipments[2, 3]	0
Shipments[2, 4]	0
Shipments[2, 5]	0
Shipments[2, 6]	0
Shipments[2, 7]	25
Shipments[2, 8]	0

When we change Optimization Goal to Maximum in cell C25 we will get Maximum Transportation cost of 4,816.31 Euro for Evolver, IP Solver and Microsoft Foundation.

Comparison between Minimal and Maximal Total Cost

Below chart shows minimal and maximal cost for Evolver, IP Solver and Microsoft Foundation Solver. We have same cost in all three software. Maximal cost for all three software's are around 40% higher than minimal cost. Using optimal distribution network will impact cost and time saving.

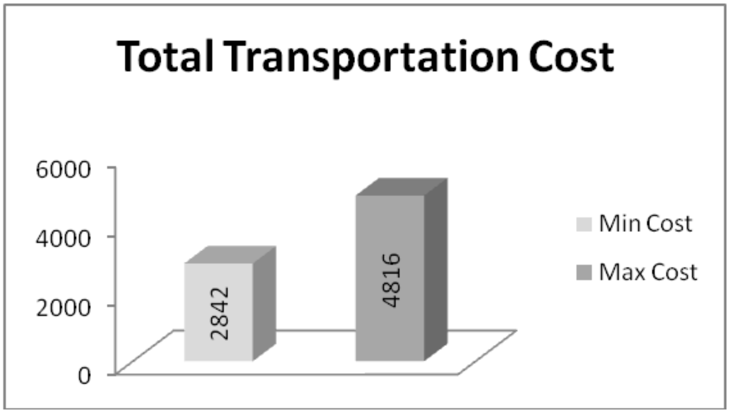


Figure 2. Comparison between Minimal and Maximal Cost

Conclusion

Logistical route system is flexible based on the circumstances and demands. Optimization problems in many fields can be modeled and solved using Evolver, IP Solver or Microsoft Foundation Solver. In this paper work we have used them to resolve logistical route optimization problem in order to reduce transportation cost. Matrices range in this paper work is 3 x 9 but the same procedure can be applied in the cases with higher range of the matrices N x M. Optimization problems in general are real world problems we meet in many fields such as mathematics, science, engineering, business or finances. In this matter, we find the optimal or most efficient way of using limited resources to reach objective of the situation. In this paperwork the main goal is to maximize profit, minimize cost, minimizing the total distance travelled and using this can be done very well using Evolver, IP Solver and Microsoft Foundation Solver.

References

[1] Andrew J. Mason Solving Linear Programs using Microsoft EXCEL Solver
[2] B. Çerkini, V. Prifti, R. Kosova, Logistical Route Optimization to Reduce

Transportation Cost, Conference ICCSIS2014 in Durres

[3] B. Parker and D. Caine, Minimizing Transportation Costs: An Efficient and Effective Approach for the Spreadsheet User

[4] Edwin K.P. Chong and Statislaw H. Zak, An introduction to Optimization, Third Edition

[5] Leslie Chandrakantha Using Excel Solver in Optimization Problems

[6] http://lpsolve.sourceforge.net/5.5/MSF.htm, Using IP solver from Microsoft Solver Foundation, 15 January 2015

[7] http://msdn.microsoft.com/en-gb/devlabs/hh145003.aspx, Microsoft Solver Foundation, 05 January 2015

[8] http://www.codeproject.com/Tips/744558/CSP-Programming-of-Microsoft-Solver-Foundation, Code Project, 02 February 2015

[9] http://office.microsoft.com/en-us/excel-help/using-solver-to-solve-transportation-or-distribution-problems-HA001124597.aspx, Using Solver to Solve Transportation or Distribution Problems, 29 January 2015

[10] http://www.palisade.com/evolver/, Find the Best Solutions to any Optimization Problem10 February 2015

[11] https://support.office.com/en-za/article/Define-and-solve-a-problem-by-using-Solver-9ed03c9f-7caf-4d99-bb6d-078f96d1652c, Define and Solve a Problem by Using Solver, 08 February 2015

[12] https://msdn.microsoft.com/en-us/library/ff524509%28v=vs.93%29.aspx, Microsoft Solver Foundation 3.1, 17 January 2015

[13] K. László Optimization of the Supplier Selection Problem Using Discrete Firefly Algorithm