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APPLYING OPTIMIZATION MODELS TO THE ORDER ALLOCATION PROCESS AMONG SELECTED VENDORS

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Abstract: *Vendor selection process includes the offer comparison submitted by multiple suppliers. Frequently the officers must combine orders from multiple vendors. The common reasons for this: one vendor might or might not cover the whole product range; the capacity of the vendor is lower than the demand. At this point a comparison of multicriterial objects need to be performed. At one side the officer might want to find the product or service that would match the best to the company's budget or terms. At second, all the obligatory constraints must be met. At third the context might be important. The task complexity of order allocation problem increases dramatically as the count of the variables (vendors, offers, products) or count of the conditions (max capacity, min order quantity, price, etc) increases. This paper suggests a spreadsheet model performing optimization methods over the order allocation problem. This model is built in Microsoft Excel solution. It shows good performance results on a set with two vendors and five products. As the count of vendors increases – the model often bypasses global optimum and suggests locally optimal feasible solutions.*
Keywords: *Vendor Selection, Supply Chains, Spreadsheet, Optimization Model, Solver*

INTRODUCTION

Solver tool is a professional tool for solving complex tasks modelled as linear or non-linear optimization problems. Ipsilandis presented a spreadsheet model for vendor selection, as a tool which compares complex subjects and finds the winner in multi-criterial comparison (Ipsilandis, Pandelis G., 2004 and 2008). This model, nevertheless, takes a few parameters into account – such as price and maximum capacity. Lam and Tang create a model, that take into account the usual cost objective and other important criteria in a multi-echelon supply chain ranging from the most upstream suppliers' quality to end customers' satisfaction level through a large-scale multi-objective linear programme (Lam, S. W., & Tang, L. C., 2006). Though such a model overcomes the limits of the usual Solver Tool coming as a standard part of Microsoft Excel. Another problem of the vendor selection and order allocation problem I uncertainty. Researchers Gupta, S., Gupta, N., Kamal, M. et al. (2025) developed a model which recognizes the presence of uncertainty in input parameters, captures and represents this uncertainty. The limitation of this model is working on 1 product at a time, that better fits the task of vendor selection but not order allocation. This paper represents a spreadsheet model that can allocate orders among multiple vendors

EXPOSITION

The author builds a model that allocates orders among the presented vendors and their offers. The model is fitted inside a spreadsheet file and can be recreated using common office software (Microsoft Excel or LibreOffice Calc (though by applying alternative solving methods)).

The model includes separate entities such as vendors, products, offers, order limitations. Each of these entities are described in separate tables. This allows the model to operate with complex logic and imply relatively wide range of rules and conditions (i.e. one vendor can have more than one offer for one product - for instance different price or free shipping service for orders above a particular volume). The model must find a solution for purchasing the needed products:

- Considering fulfilment of the demanded volumes for every product. It must be equal (unless the manager explicitly allows over purchasing)
- With minimal total cost (including the total cost of the products and total transportation costs)

The sample data is set in a way that it is impossible to be solved using only 1 vendor (there is no vendor capable to fulfil the whole demand.

Spreadsheet model

The model was prepared in a spreadsheet file using table processor Microsoft Excel. The optimization is proceed using Solver tool. The model has different zones to process changes in the key values for the presented entities (conditions, constraints, allocated orders, etc.)

- The spreadsheet model includes following zones:
- Demanded quantities,
- Transportation costs for each vendor/offer,
- Order allocation (guessing) zone,
- Price offers,
- Minimal order quantity (MOQ) for each product for each vendor/offer,
- Adapted MOQ zone (allowing purchasing either 0 or greater than MOQ)
- Maximum order quantity (vendor's capacity) for each vendor/offer,
- Order material costs (calculated values using prices and the orders allocations).

The demand table (example) shows the demanded volumes of each product. The allocated quantities of the products (among the vendors' offers) are stored in Order planning table. The model must find a solution when the values in the "Allocated" row will be equal to the values in the "Demand" row. Transport costs table has "Vendor switcher" column, which is activates the transportation cost for a particular vendor only if there are orders allocated to this vendor.

Table 1. The demanded and allocated quantities (A=article, D=demand (1000 pcs), AO=allocated ordes (1000 pcs))

A	D	AO
A1	5	5
A2	10	10
A3	2	2
A4	5	5
A5	3	3

Table 2. Transport costs (V=vendor, TC=transport cost (1000 euro), VS=vendor switch

V	TC	VS	Total TC
V1	1000	1	1
V2	2000	1	2
V3	1500	1	0
V4	1600	0	0
V5	1800	0	0

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The prices zone represents the offered unit prices for each product from each vendor. If a vendor does not offer a product - it is acceptable to put any value in the particular cell (the product availability is managed in the Maximum order quantity table), but it is more intuitive to write 0 value in this situation.

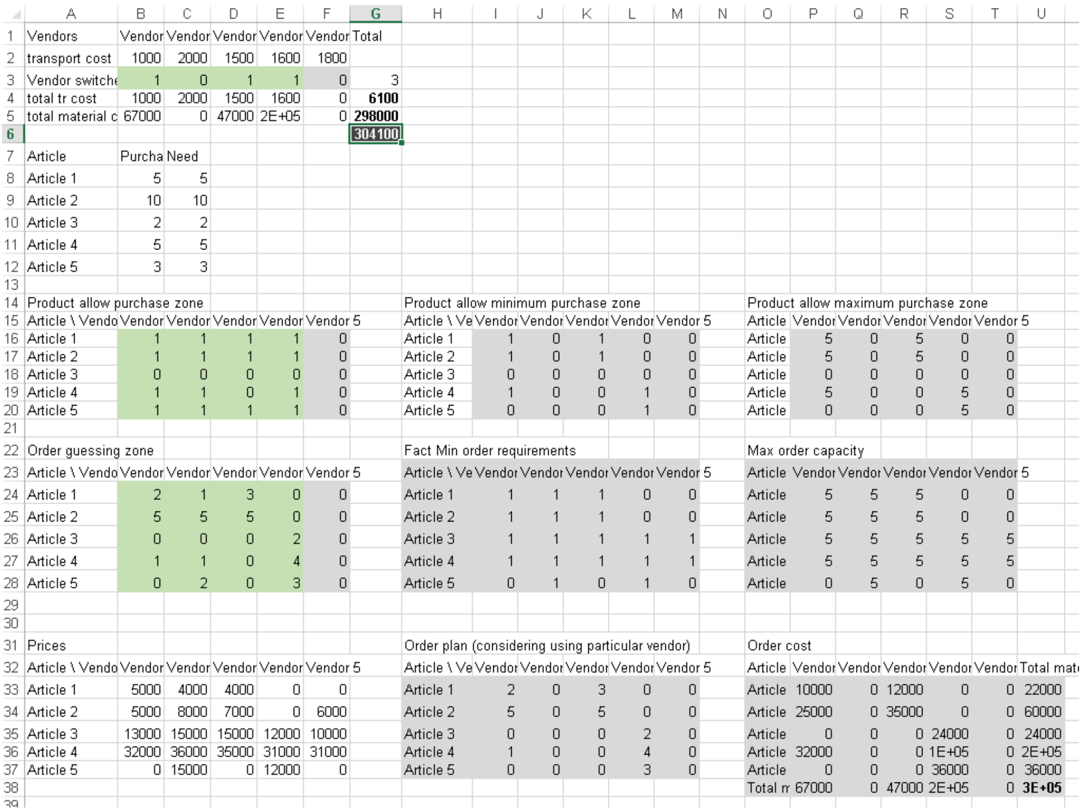
Table 3. Prices in offers (for 1000 pcs). Articles and Vendors. Example

	V1	V2	V3	V4	V5
A1	5000	4000	4000		
A2	5000	8000	7000		6000
A3	1300	15000	15000	12000	10000
A4	3200	36000	35000	31000	31000
A5		15000		12000	

The model has an order allocation zone. The values there will reflect over the purchased quantities for each product for each vendor. In this way the model accepts splitting the purchase for one product between several vendors.

Table 4. Order allocation table. Rows: articles, columns: vendors. Example

A\V	V1	V2	V3	V4	V5	Total
A1	0	5	0	0	0	5
A2	5	5	0	0	0	10
A3	2	0	0	0	0	2
A4	5	0	0	0	0	5
A5	0	3	0	0	0	3



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Vendors	Vendor	Vendor	Vendor	Vendor	Vendor	Total														
2	transport cost	1000	2000	1500	1600	1800															
3	Vendor switche	1	0	1	1	0	3														
4	total tr cost	1000	2000	1500	1600	0	**6100**														
5	total material c	67000	0	47000	2E+05	0	**298000**														
6							304100														
7	Article	Purcha	Need																		
8	Article 1	5	5																		
9	Article 2	10	10																		
10	Article 3	2	2																		
11	Article 4	5	5																		
12	Article 5	3	3																		
13																					
14	Product allow purchase zone							Product allow minimum purchase zone							Product allow maximum purchase zone						
15	Article \ Vendo	Vendor	Vendor	Vendor	Vendor	Vendor 5		Article \ Ve	Vendor	Vendor	Vendor	Vendor	Vendor 5		Article	Vendor	Vendor	Vendor	Vendor	Vendor 5	
16	Article 1	1	1	1	1	0		Article 1	1	0	1	0	0		Article	5	0	5	0	0	
17	Article 2	1	1	1	1	0		Article 2	1	0	1	0	0		Article	5	0	5	0	0	
18	Article 3	0	0	0	0	0		Article 3	0	0	0	0	0		Article	0	0	0	0	0	
19	Article 4	1	1	0	1	0		Article 4	1	0	0	1	0		Article	5	0	0	5	0	
20	Article 5	1	1	1	1	0		Article 5	0	0	0	1	0		Article	0	0	0	5	0	
21																					
22	Order guessing zone							Fact Min order requirements							Max order capacity						
23	Article \ Vendo	Vendor	Vendor	Vendor	Vendor	Vendor 5		Article \ Ve	Vendor	Vendor	Vendor	Vendor	Vendor 5		Article	Vendor	Vendor	Vendor	Vendor	Vendor 5	
24	Article 1	2	1	3	0	0		Article 1	1	1	1	0	0		Article	5	5	5	0	0	
25	Article 2	5	5	5	0	0		Article 2	1	1	1	0	0		Article	5	5	5	0	0	
26	Article 3	0	0	0	2	0		Article 3	1	1	1	1	1		Article	5	5	5	5	5	
27	Article 4	1	1	0	4	0		Article 4	1	1	1	1	1		Article	5	5	5	5	5	
28	Article 5	0	2	0	3	0		Article 5	0	1	0	1	0		Article	0	5	0	5	0	
29																					
30																					
31	Prices							Order plan (considering using particular vendor)							Order cost						
32	Article \ Vendo	Vendor	Vendor	Vendor	Vendor	Vendor 5		Article \ Ve	Vendor	Vendor	Vendor	Vendor	Vendor 5		Article	Vendor	Vendor	Vendor	Vendor	Vendor	Total mat
33	Article 1	5000	4000	4000	0	0		Article 1	2	0	3	0	0		Article	10000	0	12000	0	0	22000
34	Article 2	5000	8000	7000	0	6000		Article 2	5	0	5	0	0		Article	25000	0	35000	0	0	60000
35	Article 3	13000	15000	15000	12000	10000		Article 3	0	0	0	2	0		Article	0	0	0	24000	0	24000
36	Article 4	32000	36000	35000	31000	31000		Article 4	1	0	0	4	0		Article	32000	0	0	1E+05	0	2E+05
37	Article 5	0	15000	0	12000	0		Article 5	0	0	0	3	0		Article	0	0	0	36000	0	36000
38															Total m	67000	0	47000	2E+05	0	**3E+05**
39																					

Fig. 1. The spreadsheet model solving the task for 4 vendors and 5 products

The values in the allocation table are the changing cells for the model. These values are pushed to the Order plan table, applying a filter on them - the vendor switcher. If the switcher is on - the model forwards the value from the Guessing table to the Order plan table. If the vendor switcher is off - the model forwards 0 pieces to the Order plan table. For example, if the vendor switcher for Vendor 4 is off - guessing table might have any values, but the Order plan table will show values 0 for each product from Vendor 4.

If there are no orders allocated to a vendor - no transportation cost will be considered for this vendor. The value of vendor switcher will be set to 0.

Maximum order quantity table represents the vendor's capacity to execute the purchase order. If value is 0 - then this vendor does not offer this product. If capacity is unlimited - it is acceptable to put any value, bigger than the demand value. It may be more intuitive to put the demand value in these situations.

Solver settings

The objective cell represents a sum of all transport and material costs. Variable cells: the switches for vendors (binary), the switches for products (binary), the order allocation cells (integer). The model considers 4 constraints:

- The purchased quantities must be equal to the demanded.
- The allocated order quantities must be integer (and non-negative).
- The allocated order quantities must be higher than the MOQ level for the article from particular vendor (though 0 pcs is applicable)
- The allocated order quantities must be lower than the capacity of the vendor.

The chosen solving method is "GRG" as it performs calculations relatively fast. For finding global minimum Evolutionary method can be used, but it requires very long time to solve. Though GRG is often stuck in a local optimum or can't find any solutions in some runs. The good practice is to repeat the calculations at least 2 or 3 times.

Computer configuration

The described model was tested on a computer configuration:

- CPU: Intel Xeon E5-2690 (2 physical processors, 4 virtual processors),
- RAM: 32GB,
- Software: Windows Server 2012 Datacenter, Microsoft Excel 2013, Solver Add-in (standard MS Excel component).

Results

Solver utilizes 75% of 1 core of the CPU as it cannot run in multiple cores simultaneously.

The model often struggles finding optimal solution, especially with 4 and more vendors. This problem is caused by the logical function in the minimum order quantity zone: the same cell must accept 0 as a minimum order quantity (when there no any quantities allocated to this product/vendor) But if at least 1 pc of this product from this vendor is allocated in the order - the same cell must show the relevant value of minimal order quantity.

Table 5. Result 1 of order allocation after the optimization.

Vendor count	Product count	Solution	Execution time (s)
2	5	319000	0.187
3	5	316500	3.422
4	5	304100	29
5	5	312900	33

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From Table 5 can be seen, that Solver manages to decrease costs for purchasing for the sets up to 4 vendors. There is no reasons to accept the higher costs in the 5 vendors scenario. It means, that the model can't get out of the local optimum solution.

Limitations

The model can be used for solving the order allocation problem (for a list of pre-selected vendors). It is not suitable for vendor benchmarking tasks. It considers some important factors, i.e. prices, fixed transportation costs, vendor's capacity, and vendor's requirements on the minimal order quantity. But it does not take into account any other factors, i.e. uncertainty, lead time, defect rate, variable transportation cost, etc., that are crucial in vendor selection and can be important in tasks for order allocation.

The represented model finds the global optimum solution in a relatively tiny range of cases. It showed best results resolving the order allocation problem with 2, 3 and 4 vendors.

CONCLUSION

The order allocation problem is a complex task. Nevertheless, it can be automated using standard tools – spreadsheet processor and embedded Solver tool. This paper represents a spreadsheet model that can allocate orders among multiple vendors. It shows good results for scenarios with 2, 3, and 4 vendors. Nevertheless, the scenario with 5 vendors and 5 products cannot be solved fast and efficiently using the current cofigurations.

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