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Research Article

Applying an İntegrated methodology of Supplier Selection with a Kraljic Matrix-based Strategic Decision-Making Tool

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Abstract

This paper offers a combined methodology to supplier selection problem which includes a multi-criteria decision making (MCDM) and total cost of ownership (TCO) approaches. The decision is made with the help of Pareto algorithm, which excludes suboptimal variants. The remaining suppliers are assessed using the strategic decision matrix based on a quantified and adopted to supplier evaluation Kraljic portfolio matrix. The introduced supplier selection method allows to compare financial benefit and potential risks, and make a strategically reasonable decision in the process of strategic sourcing or purchasing category management.

Keywords: *procurement, supply, supplier management, supplier evaluation and selection, rating method, Pareto set method, multicriteria optimization*

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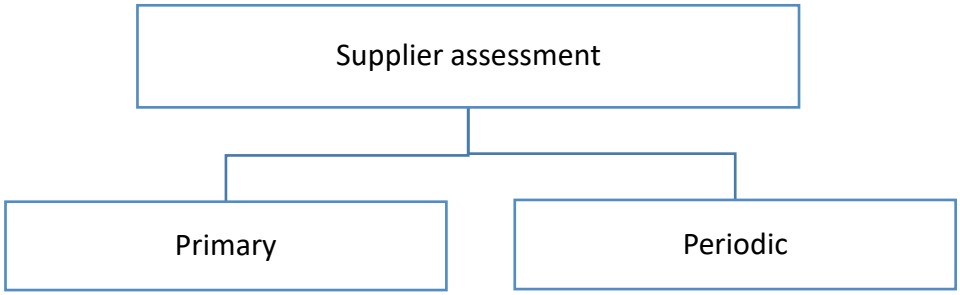
Introduction

Every manufacturing company that buys goods for the production process needs a formalized supplier-selection methodology which aims to provide objective and unbiased estimation. In other words, when ten or fifty purchasing managers are estimating the same set of suppliers, the outcome should be the same no matter who runs the estimation process.

Depending on the objects estimated the supplier assessment can be subdivided into primary and periodic.



Pic 1 Supplier assessment types

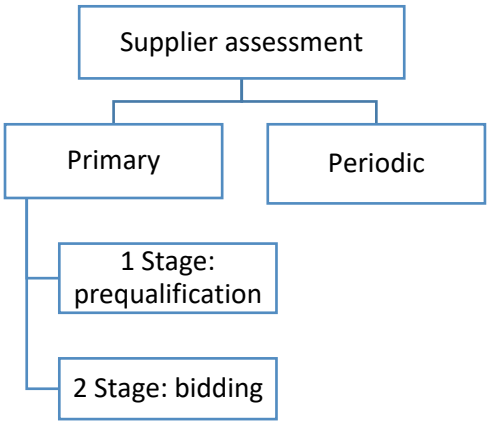
The primary assessment is done when comparing proposals of a number of vendors participating in a tender. Its aim is to select the best suppliers to fulfill the contract.

Periodic review is usually done once or twice a year in order to evaluate the quality of an existing supplier performance.

Thus the primary assessment is about evaluating new potential vendors and periodic review is made among the existing suppliers. This paper is concerned only with primary assessment, i.e. its aim is not classifying existing suppliers, but choosing best-possible new suppliers.

The primary assessment can be one-phased or two-phased. One-phased assessment usually assumes MCDM methods selecting a supplier with maximal total score. The two-phased assessment usually includes pre-qualification and bidding. Prequalification is a process of selecting the suppliers that meet certain constraints [3]. At this stage the suppliers might be ranked using threshold values on each criterion.

During the second phase the selected suppliers participate in bidding process where the only criteria is the price, or the total incoming cost of the purchase (TCO).



Pic 2 Two-phased supplier selection.

The problem of this approach is that many suppliers are rejected during the first stage of prequalification, while their participation in bidding could potentially lead to greater discounts. Therefore, we assume that supplier estimation on costs factors and any other meaningful criteria should be done simultaneously, which is reflected in the developed methodology.

Literature Review

There is no single universally accepted method for evaluating suppliers. Its search has been attracting the attention of researchers since the 1960s. Since then, many review publications have been made on the comparative analysis of supplier evaluation methods and supplier selection, [3, 14, 4, 10, 5].

Based on these reviews, the most popular methods in modern foreign literature are: Analytic Hierarchy Process (AHR), or Analytic network process (ANP), Fuzzy sets (AHP), Fuzzy ANP, mathematical programming, Data envelopment analysis (DEA), Neural networks, categorical methods, Total Cost of Ownership methods (TCO) Artificial intelligence (AI-based models) and others.

Sometimes supplier selection models include multiple stages, there are examples of two-phased [9] or even four-phased [7] supplier selection.

There are also bi-objective models, which combine procurement cost with other important criteria sets, like operations costs, using Pareto optimization [1].

Strategic supplier selection

The most wide-spread in business supplier selection models can be limited to the following:

1) Price or total-cost based supplier selection [Filip Roodhooft, Jozef Konings]. This method is being widely criticized due to ignoring other non-financial supplier choice criteria.
2) Linear weighting models which actually estimate pricing factors indirectly, by assigning weights to prices. While the actual cost differences can be critical for the company management, this method is often replaced by simple cost –based supplier selection.

In one of the previous papers [2], we considered detailed evidence that multi-criteria weighted methods scarcely can be used to estimate the cost parameters. The article gives an example of an estimate based on five criteria, which clearly shows that by evaluating suppliers with a score-rating method, we evaluate indirectly, ignoring the difference in the cost of annual purchase between competing offers, which might be crucial for the organization.

In this work a new bi-objective supplier selection model is proposed that combines total costs evaluation with multicriteria weighted risks assessment. The two scales (risk scale and financial benefit scale) are compared and using Pareto method and thus the optimal solutions are determined.

The most known procurement paper, the uses the same scales is Peter Kraljic [8] work, that introduced supply portfolio matrix, which uses the same scales. Since the paper was issued in 1983 a lot of critical and supportive discussions have arised [6].

Few attempts to quantify Kraljic Portfolio Matrix have been made [11].

Based on Kraljic portfolio matrix we developed a complimentary strategic supplier selection tool, which helps to check whether the Pareto-optimal suppliers meet the company’s strategic aims.

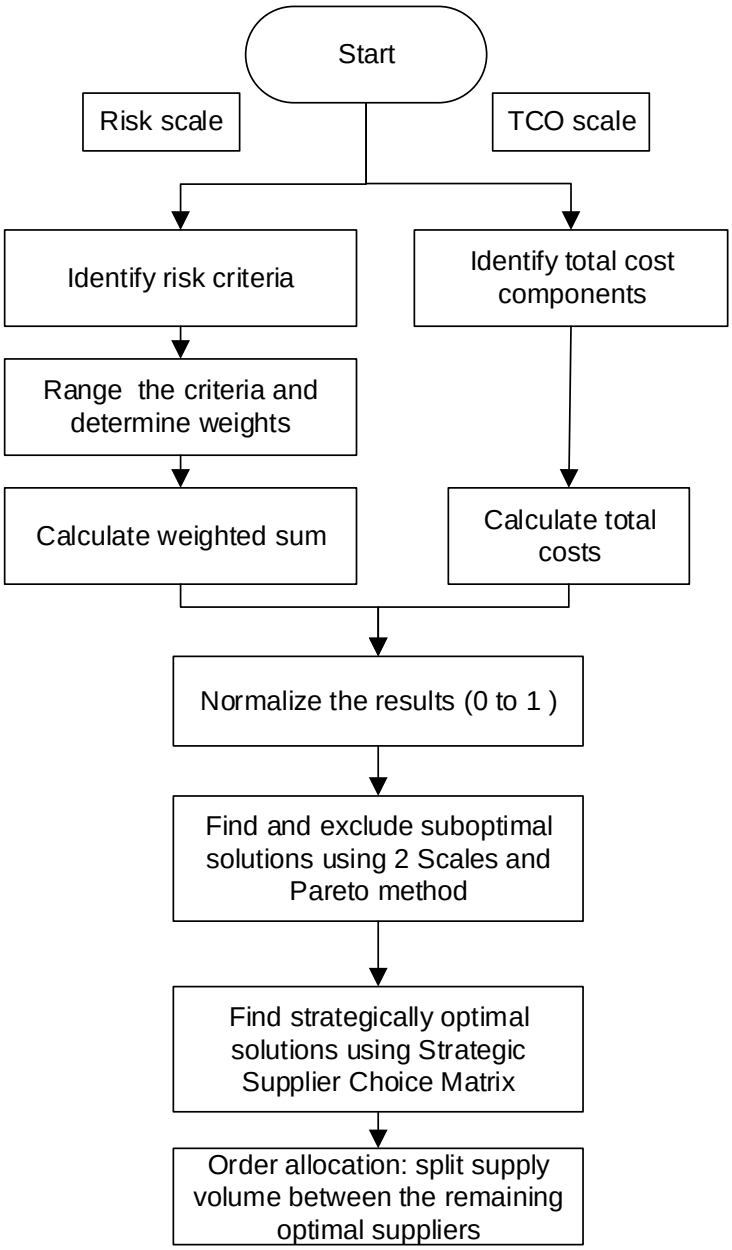


Figure 1 The proposed methodology flow chart

Assessment on the risk scale by MDCM.

For the initial supplier assessment, combining supplier risk assessment and costs valuation, a combined methodology is proposed that includes multi-criteria assessment and total costs valuation, as well as a tool for comparing results on two scales (using Pareto-optimal sets) and a strategic evaluation tool for alternatives based on the Kraljic matrix.

In this paper a case of a silicon dioxide supplier selection for fertilizer production is considered. A Russian manufacturing company purchases silicon dioxide as an additive in one of its products (fertilizer). The current supplier is an official distributor of a major

German manufacturer. In the course of working with the supply category, 11 offers were received from suppliers offering silicon dioxide produced in Germany, China and Russia.

The proposed multi-critical evaluation model limits the range of criteria that are recommended to be used. All criteria that affect total cost of ownership are not included in this model, and are assessed separately by the total cost evaluation method.

The following criteria were used in the risk scale assessment:

- Size of the authorized capital
- Existing contract (i.e. positive work experience)
- Net profit for 2020
- Availability of a specialized FAMI-S certificate
- Currency risks

The model assumes that the criteria should be ranked, the weights are to be determined according to the obtained rank.

The criteria weights could also be assigned by the experts or by AHP method (analytical hierarchy process) [13] or any other method. In this case we are more interested not in the process of weighting, but in the resulting weighted criteria estimates being normalized and presented in the form of a hundred-point scale assessment. Thus in the example reviewed (silicon dioxide case), the weights of all criteria were identified by experts as equal. All the criteria estimates were normalized.

If the lowest parameter value is preferred, the following normalization formula is used:

$$\hat{a}_{ij} = \frac{a_{ij} - a_j^-}{a_j^+ - a_j^-}, \quad j = \overline{1,n}, \text{ where n – the number of criteria} \qquad (1)$$

If the highest value parameter is preferred, the following normalization formula is used:

$$\hat{a}_{ij} = 1 - \frac{a_j^+ - a_{ij}}{a_j^+ - a_j^-}, \quad j = \overline{1,n}, \text{ where n - the number of criteria} \qquad (2)$$

Thus we obtain ranking of the given supplier parameters by the assessed criterion from 0 to 1, where 1 is assigned to the highest value of the parameter.

Supplier/Criterion	Range	weight	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Authorized capital	1	0,2	18000	18000	30000	15	10	10	10	10	20	10	10
normalized (max)			0,60	0,60	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
weighted			0,12	0,12	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Existing contract, positive experience of cooperation	1	0,2	yes	yes	yes	no	no	no	no	no	no	no	no
bin			1,00	1,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
weighted			0,20	0,20	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Net profit, thousand roubles	1	0,2	141 000	141 000	436 000	224	808	119	119	119	6 100	17	414
normalized (max)			0,32	0,32	1,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00
weighted			0,06	0,06	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Certificate FAMI-QS available	1	0,2	yes	no	yes	yes	no	no	no	no	no	no	no
bin			1,00	0,00	1,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
weighted			0,20	0,00	0,20	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Currency risks	1	0,2	Europe	Europe	Asia	Asia	Russia	Russia	Russia	Russia	Asia	Asia	Russia
bin			0,00	0,00	0,50	0,50	1,00	1,00	1,00	1,00	0,50	0,50	1,00
weighted			0,00	0,00	0,10	0,10	0,20	0,20	0,20	0,20	0,10	0,10	0,20
Weighted sum	5	100%	**0,58**	**0,38**	**0,90**	**0,30**	**0,20**	**0,20**	**0,20**	**0,20**	**0,10**	**0,10**	**0,20**
100-point scale			58	38	90	30	20	20	20	20	10	10	20

Figure 2Risk assessment

The weighted sum of criteria estimates is presented in the form of a hundred-point scale assessment.

Assessment on the benefit scale by the method of TCO.

Further, the cost of silicon dioxide by each supplier was calculated. The cumulative cost assessment model has also uses the formula of normalization, presenting the distribution of total costs on a hundred-point scale.

EUR	92										
USD	76										
Annual demand	100000										
RFQ Data	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Currency	EUR	EUR	USD	руб	руб	руб	руб	руб	USD	USD	руб
Price per pcs, without VAT, RUB	186,76	183,08	142,50	97,23	113,17	180,00	160,00	156,00	118,56	120,08	82,50
Total costs during a year	18 676 000	18 308 000	14 250 000	9 722 500	11 317 000	18 000 000	16 000 000	15 600 000	11 856 000	12 008 000	8 250 000
Normalised	0,00	0,04	0,42	0,86	0,71	0,06	0,26	0,30	0,65	0,64	1,00
100-points scale	0	4	42	86	71	6	26	30	65	64	100

Figure 3 Benefit scale

The combined model includes supplier assessment on the Risk scale, which is carried out by a multi-critical assessment, and total costs assessment on the Benefit scale.

By calculating the vendor estimate on the two independent scales, which will be graphically presented as mutually perpendicular axes, the Pareto multi-set method is used to cut off some of the suboptimal solutions. The remaining solutions will be evaluated in terms of their strategic importance to the company through the use of the author's ‘strategic supplier selection matrix’, which is an adaptation of the Kraljic matrix.

	Scales	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
	Benefit scale	0,00	3,53	42,45	85,88	70,58	6,48	25,67	29,50	65,41	63,96	100,00
	Risk scale	58,46	38,46	90,00	30,01	20,04	20,00	20,00	20,00	10,29	10,00	20,02
Benefit scale												
S1	0,00	1	2	2	2	2	2	2	2	2	2	2
S2	3,53	0	1	2	2	2	2	2	2	2	2	2
S3	42,45	0	0	1	2	2	0	0	0	2	2	2
S4	85,88	0	0	0	1	0	0	0	0	0	0	2
S5	70,58	0	0	0	2	1	0	0	0	0	0	2
S6	6,48	0	0	2	2	2	1	2	2	2	2	2
S7	25,67	0	0	2	2	2	0	1	2	2	2	2
S8	29,50	0	0	2	2	2	0	0	1	2	2	2
S9	65,41	0	0	0	2	2	0	0	0	1	0	2
S10	63,96	0	0	0	2	2	0	0	0	2	1	2
S11	100,00	0	0	0	0	0	0	0	0	0	0	1
Risk scale												
S1	58,46	1	0	2	0	0	0	0	0	0	0	0
S2	38,46	2	1	2	0	0	0	0	0	0	0	0
S3	90,00	0	0	1	0	0	0	0	0	0	0	0
S4	30,01	2	2	2	1	0	0	0	0	0	0	0
S5	20,04	2	2	2	2	1	0	0	0	0	0	0
S6	20,00	2	2	2	2	2	1	1	1	0	0	2
S7	20,00	2	2	2	2	2	1	1	1	0	0	2
S8	20,00	2	2	2	2	2	1	1	1	0	0	2
S9	10,29	2	2	2	2	2	2	2	2	1	0	2
S10	10,00	2	2	2	2	2	2	2	2	2	1	2
S11	20,02	2	2	2	2	2	0	0	0	0	0	1
Pair comparison												
S1		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
S2		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
S3		S3	S3	S3	S4	S5	S3	S3	S3	S9	S10	S11
S4		S1	S2	S3	S4	S4	S4	S4	S4	S4	S4	S11
S5		S1	S2	S3	S4	S5	S5	S5	S5	S5	S5	S11
S6		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
S7		S1	S2	S3	S4	S5	S7	S7	S8	S9	S10	S11
S8		S1	S2	S3	S4	S5	S8	S8	S8	S9	S10	S11
S9		S1	S2	S3	S4	S5	S6	S7	S8	S9	S9	S11
S10		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
S11		S1	S2	S3	S4	S5	S11	S11	S11	S11	S11	S11
	Solution	SUBoptimal	SUBoptimal	optimal	optimal	SUBoptimal	SUBoptimal	SUBoptimal	SUBoptimal	SUBoptimal	SUBoptimal	optimal

Figure 4 The result of the algorithm of identifying Pareto-suboptimal solutions by pair comparisons.

In the picture given (Figure 3). each vendor is compared by each parameter to each other vendor. If the vendor has a lower rating, it is given a 0, if it equal - 1, and if it exceeds - 2.

The ‘pair comparison’ table spells out the name of the current vendor if there is no vendor that outperforms it. That is, one of the conditions is not fulfilled:

The current vendor is worse than the one it is compared to (in both tables - 0) or one option is worse, and the second is not better (combination 0 and 1).

If the ‘Pair Comparison’ table in the current vendor's column detects the name of another vendor, the system writes that the solution is ‘suboptimal’.

Thus, it was possible to detect automatically the Pareto-suboptimal solutions. Suppliers S3, S4 and S11 were determined as optimal solutions.

Strategic supplier selection matrix

To select a supplier on two disparate scales, we will use the Kraljic Matrix (Figure 4).

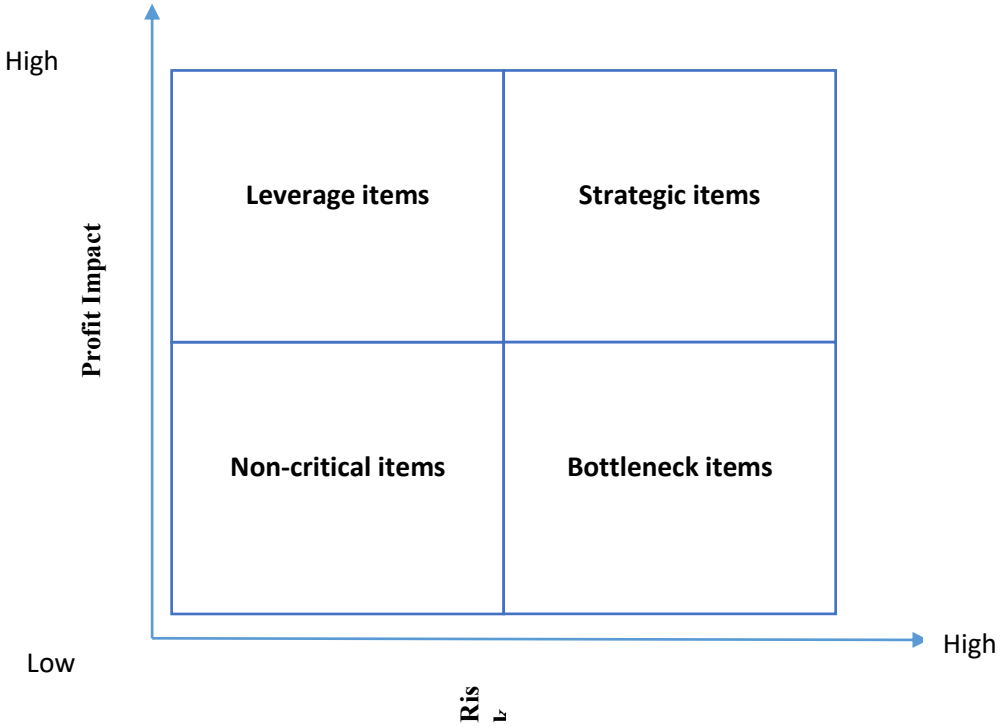


Figure 5 The Kraljic Matrix

By placing the scales of risk and benefit assessment according to the matrix, we will get four quadrants with certain strategic characteristics. According to the adapted matrix received, the S3 supplier is not profitable. So the choice is to be made between suppliers S4 and S11, and it is better to divide between them supply volumes to secure risks.

Criteria	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Risk scale	58	38	90	30	20	20	20	20	10	10
Benefit scale	0	4	42	86	71	6	26	30	65	64
Pareto result	SUBoptimal	SUBoptimal	optimal	optimal	SUBoptimal	SUBoptimal	SUBoptimal	SUBoptimal	SUBoptimal	SUBoptimal

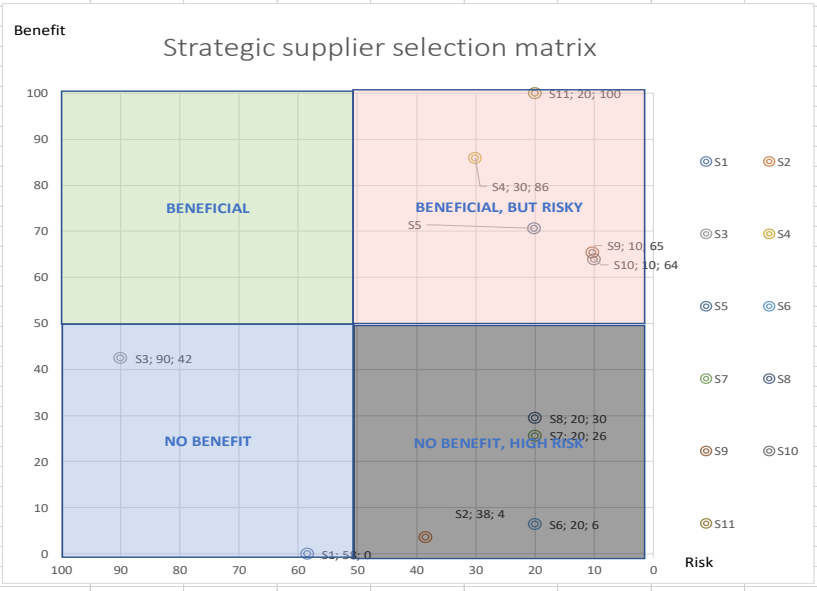


Figure 6 Strategic Supplier Selection Matrix

The developed methodology includes a multi-criteria assessment of suppliers and a strategic assessment of the Kraljic matrix. It will avoid biased assessment of financial factors, expand the range of parameters assessed to those enterprises that focus only on price comparison, and introduce an element of strategic evaluation of alternatives in the decision-making of the choice of supplier, and thus move from the operational function of choosing a supplier based on a multicriteria or TCO model to the level of strategic sourcing.

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