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MODERN METHODS OF EVALUATION EXISTING SUPPLIERS AND SUPPLIERS SELECTED BY CUSTOMER FOR SMALL AND MEDIUM-SIZED COMPANIES

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Abstract

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On existing conditions on global market (almost identical quality, almost identical purchasing values) companies have to definite the total rating of importance of evaluative criteria. In post-crisis period the problem of suppliers' evaluation is one of the biggest, because companies had to use all resources and all possibilities to develop their own business. Many authors wrote about collaborative planning and warehousing as one of possibilities to optimization work inside supply chain. For this paper define small and medium-sized enterprises (SME) as enterprises with the size of maximum 250 employers.
In literature was read we couldn't find information about own system of suppliers evaluation for small and medium-sized enterprises.
SME can have some different types of business and in this case need the universal system of evaluation. The research of this paper is oriented on small and medium-sized enterprises with different types of business. The new theoretical universal method of calculation for evaluation existing suppliers for small and medium-sized enterprises will present in this paper. This theoretical method is based on average values. This method includes traditional evaluative criteria (quality, delivery time) and other (mobility of supplier, possibilities of new level of partnership). This method of evaluation can not be used for continual manufacture. New method can improve the total evaluation of supplier in small and medium-sized enterprises.

evaluation procedure, small and medium-sized enterprises, selected bidder, existing supplier SCM (Supply Chain Management)

Nowadays small and medium-sized enterprises (SME) make up a large part of state economy. For this paper define small and medium-sized enterprises (SME) as enterprises with the size of maximum 250 employers. In literature was read we couldn't find information about own system of suppliers evaluation for small and medium-sized enterprises.

SME can have some different types of business and in this case need the universal system of evaluation. In post-crisis period this problem is one of the biggest, because companies had to use all resources and all possibilities to develop their own business. Only the right evaluation of supplier and the high quality of supply chain can help to make a profit for firms and win the war about customer. In literature was read we couldn't find information about own system of suppliers evaluation for small and medium-sized enterprises.

We have to find the universal mechanism of supplier's evaluation for operation management in SME. Literature reviews help us to work out modern methods and trends of evaluation of suppliers. This problem can be solved if we establish criteria and

formulas for universal evaluation of suppliers and supply goods.

In the paper "The universal evaluation of new suppliers for small and medium-sized companies" (Jurová, Sutormina, 2010) is written mechanism of evaluation of new suppliers. But nowadays the most of firms choose suppliers (deliveries) between new and existing. This paper is about the second part of work – evaluation of existing suppliers.

MATERIALS AND METHODS

(1) Selecting evaluative criteria

While using cluster analysis, one can prefix the number of clusters but cannot control the number of elements in the clusters. Since the supply base reduction problem requires reducing the number of suppliers in the supply base to a prefixed value, cluster analysis does not appear to be suitable for supply base reduction. However, we visualize a different use of cluster analysis in our proposed method for supply base reduction. It can be effectively used to group the selection criteria into long- and short-term categories (Ashutosh Sarkara, Pratap K. J. Mohapatrab, 2006).

Much of the information on unknown suppliers, collected through Internet, peer feedback and on-site visit, will lack quantitative measurement. Even information on known suppliers may not have been stored in a form that lends itself to a quantitative conversion (Ashutosh Sarkara, Pratap K. J. Mohapatrab, 2006).

To evaluate these suppliers against the factors mentioned earlier, the buying team has to resort to subjective, qualitative assessment, using their mental perceptions. Zadeh (1999), while presenting the computational theory of perceptions, emphasises the key role perceptions play in human recognition, decision, and execution processes. Rather than leave out the suppliers with such incomplete, qualitative information, we propose experts' opinion for a subjective evaluation of suppliers followed by a fuzzy set theoretic analysis to take care of the fuzzy nature of these evaluations. The use of crisp numbers to quantify human perceptions does not reflect the imprecision and partial truth that surrounds human perception and decisions (Ashutosh Sarkara, Pratap K.J. Mohapatrab, 2006).

The fuzzy set theoretic approach to supplier evaluation decision problem satisfies two of the four rationales that Zadeh (1999) advances: (1) the do not know rationale and (2) the don't need rationale. In a supply base reduction problem, the scores on each factor are not known with precision to justify the use of conventional methods of supplier evaluations (the first rationale). It is also not necessary that factor values are known very precisely (the second rationale) (Ashutosh Sarkara, Pratap K.J. Mohapatrab, 2006).

Aouam *et al.* (2003) used outranking intensity represented by a fuzzy number to evaluate competing alternatives. Kahraman *et al.* (2003) used fuzzy AHP for the multi-criteria supplier selection problem. Cheng and Lin (2002) evaluated the best main battle tank using expert opinions that are described by linguistic variables. The linguistic variables are expressed in terms of trapezoidal fuzzy numbers and are used in a fuzzy Delphi method to arrive at a consensus. The use of fuzzy scale for capturing the expert's opinion is well justified from the point that it becomes easier for experts to specify a range representing their score for qualitative criteria. Raj and Kumar (1998, 1999) used linguistic variables for capturing expert's opinion and proposed a methodology based on weighted average method for aggregating the individual scores.

1) Dickson (1966) listed 23 criteria as the most important ones had been considered to date, however more recently, Verma and Pullman (1998) had an investigation on decision criteria in this field and found that the quality is the most important factor from managers' points of view. It is also declared by them that managers actually select their suppliers mostly upon suggested prices from suppliers. By the way, as today criteria have changed from the past ones, some other criteria, such as environmental criteria (Humphreys, McIvor, & Chan, 2003; Çelebi & Bayraktar, 2007), have been devoted in the field.

An enterprise intended to outsource construction of their second building. Four construction companies are introduced as the alternatives. The enterprise regards 6 criteria:

- price, C1;
- quality, C2;
- finish time, C3;
- company's rank, C4;
- company's antecedents, C5, and
- company's economic status, C6) to choose the best company to which out sources the building (Jafar Razmi, Hamed Rafiei, Mahdi Hashemi, 2009). In the next step, criteria are grouped into two clusters; company's status (including C1, C2, and C3), and performance (including C4, C5, and C6). The dependencies between criteria are as follows:
- price, quality and finish time are dependent to economic status;
- quality and finish time are directly affected by company's antecedents;
- company's rank influence on price, quality, finish time and economic status; and
- economic status depends on price as company's rank and economic status are dependent to quality (Jafar Razmi, Hamed Rafiei, Mahdi Hashemi, 2009).

2) Environmental management

These criteria are usage of environment friendly technology (C1), environment friendly materials (C2), green market share (C3), partnership with green organizations (C4), management commitment to green practices (C5), adherence to environmen-

tal policies (C6), involvement in green projects (C7), staff training (C8), lean process planning (C9), design for environment (C10), environmental certification (C11), and pollution control initiatives (C12).

3) Quality-based supplier selection

Yuan (1991) proposed a ranking method which is satisfied with four reasonable criteria on sorting fuzzy numbers such as fuzzy preference presentation, rationality of fuzzy ordering, distinguish ability, and robustness (Ming-Hung Shu a, Hsien-Chung Wub, 2009).

4) De Toni and Nassimbeni (2001) present a framework for the evaluation of supplier's co-design effort. They suggest capabilities in co-design activities, most of them are concurrent engineering techniques, offered by suppliers in the development stages as evaluation criteria such as support in product simplification, support in component selection, and support in design for manufacturing/ assembly activities, etc. It has been stated in the literature that the use of these techniques lead to substantial improvement in quality, cost and delivery performance (Maffin and Braiden, 2001; Talluri and Narasimhan, 2004; De Toni and Nassimbeni, 2001). Hence, it is essential to consider these factors in supplier evaluation.

(2) Selecting procedure

Literature review on supplier selection and evaluation

Many methods have been suggested for supporting supplier selection decisions.

Some researchers have tried to give an overview of the different supplier selection problems and methods: (Weber *et al.*, 1991; De Boer *et al.*, 2001). Recently, De Boer *et al.* (2001) reported that a supplier selection problem typically consists of four phases:

- problem definition,
- formulation of criteria,
- qualification of suitable supplier (or pre-qualification) and
- final selection.

1) Selecting procedure and application

To increase the understandability of our proposed method, a step-by-step procedure for selecting the preferable suppliers using fuzzy quality data is summarized as follows.

Step 1: Select q possible suppliers and collect quality data from them.

Step 2: Obtain the membership function for each supplier.

Step 3: Provide a value.

Step 4: The preferable group of suppliers is determined, where t is the number of preferable suppliers and any two suppliers in the group are indifferent.

Step 5: The decision-makers may randomly select one of the suppliers as the most preferable supplier. Of course, if the decision-makers decide to select more than one supplier to supply the required products, then the same procedure can be used to select the preferable suppliers (Ming-Hung Shu a, Hsien-Chung Wub, 2009).

2) Network formation

Network formation comprises two steps described as follows:

Clustering: Some clusters formed with respect to the criteria. Then, the criteria are assigned to the clusters to which are mostly related. Finally, alternatives make a separate cluster.

Connecting: In this step, the related clusters connected with respect to the dependencies between their corresponding criteria.

The connections which reflect interrelationships and feedback structure can be either inner (between two criteria within the same cluster) or outer (between two different clusters). An inner connection is like a loop on the corresponding cluster. Connection between two criteria is signed with an arrow from the affecting criterion to the dependent one.

3) Pair-wise comparisons

Pair-wise comparisons are performed between each pair of criteria with respect to a control criterion. Control criterion is the criterion to which some other criteria are dependent. In other words, the group of criteria connected to a specific (control) criterion is compared pair-wisely. In addition to the comparisons of criteria, clusters of the network must be compared pair-wisely with respect to the control cluster.

4) Fuzzy multicriteria approach for evaluating environmental performance of suppliers

The proposed fuzzy multicriteria approach for evaluating supplier's environmental performance consists of three steps:

2. Evaluation and selection of best alternative using selected criteria.
3. Conduct sensitivity analysis to determine the influence of criteria weights on decision making (Awasthi, A. *et al.*, 2010).

5) GA (genetic algorithm) solution model

This purpose of this research is to select the common and non-common part supplier, and work out through GA the optimal supplier combination and supply quantity under the limitation of production capacity.

The steps of finding best supplier combination and quantity provided by each supplier through GA are shown below:

Step 1: Chromosome structure. Supplier of each part is represented with two characters, selection of suppliers is expressed with binary coding and supply quantity provided by the supplier is determined with positive-integer number coding.

Step 2: Initial solution is produced according to production capacity of each supplier. The value of a gene to express the status of supplier selection is generated at random within [0, 1], where 0 is the supplier is not selected to provided parts, 1 is the supplier is selected. The value of a gene to express the supply quantity is generated at ran-

dom within [0,N], where N is the supply quantity of specific supplier which is not more than its upper limitation of production capacity. The total supply quantity from selected suppliers must equal the total demand quantity of the part that comes from orders. Substituting this chromosome into fitness function, and adding the relate data as most suitable operating programs.

Step 3: In order to achieve minimization, we perform an inverse objective function to be the fitness function in this research, and making it compatible with high fitness value possessing high selection probability, and making smaller fitness value corresponding to chromosome having higher reproduction probability.

Step 4: This research randomly selected two chromosomes for single point crossover.

Step 5: Randomly select a chromosome and randomly select two-set genes to perform the two-point mutation operator, each set contains two genes, selection of suppliers and supply quantity for specific part supplier.

Transform a given value of each selected gene; the generation mechanism of each new gene value is such as description is Step 2.

Step 6: If the best chromosome of filial generation is better than the worst chromosome parent generation, then it will be taken as the new population for the evolution of the next generation, otherwise no substitution will be conducted and parent chromosome will serve for the evolution of the next generation.

Step 7: Repeat Steps 3–6 until desired generation is reached; at this point evolution is stopped.

Step 8: Find the best suitable supplier combination and supply quantity (Z. H. Che; H. S. Wang, 2007).

In this literature we can't find solution for universal evaluation. Some authors wrote about problem operation evaluation for supply chain with multicriteria calculation. Some authors wrote about evaluation suppliers for SME and wrote that quality of evaluation hasn't enough level.

This paper is about the method for universal evaluation of suppliers. This task can be coped by mathematical methods of evaluation. By means of authors' recommendations and traditional criteria of evaluation we make up these criteria for suppliers' evaluation. This method is oriented on small and medium-sized companies. Evaluation is oriented on average value. It is universal evaluation because it can be used for different groups of suppliers. Value of each group for firm can select user. We can divide the evaluation into two parts: for new suppliers and for existing suppliers and suppliers selected of customer. Evaluation for existing suppliers and suppliers challenged of customer follows those evaluative groups:

1) Delivery time
2) Suppliers' qualification
3) Costs
4) Transportation
5) Mobility of supplier
6) Results of audit for existing suppliers (level of organization the processes).

Evaluative group "Delivery time" follows those criteria of evaluation:

- Correspondence between life time of product and average delivery time
- Possibility of transportation to final customer with suppliers' transport +time of transportation
- Possibility of shortening delivery time and related conditions

Evaluative group "Suppliers' qualification" follows those criteria of evaluation:

- Certification
- Supplier's experience (time on market)
- Reliability of supplier
- Existence the compensation for loyalty to supplier.

Evaluative group "Costs" follows criterion "Index total costs of purchasing"

Evaluative group "Transportation" follows criteria "Correspondence between distance to supplier and quantity of suppliers in region"

Evaluative group "Results of audit for existing suppliers (level of organization the processes)" follows there criteria:

- the level of management of suppliers' firm
- the level of the management of manufacturing (production) processes

Evaluative group "Mobility of supplier" follows those evaluative criteria:

- Possibility mobility of supplier
- Related costs

Each one of that evaluative criteria has own formula of calculation.

For example: Correspondence between life time of product and average delivery time for some supplier = (LTP /average LTP of all suppliers)*(DT / average DT of all suppliers)*evaluative coefficient, where

LTP – life time of product

DT – delivery time.

Other formulas for supplier' evaluation for this group is shown on Appendix 1.

Example of values you can find on Appendix 1: Delivery time 0,1; quality of products/ services 0,25; costs 0,2; transportation 0,1; mobility of supplier 0,15; results of audit for existing suppliers (level of organization the processes) 0,2.

RESULTS

Now we have a system of calculation for evaluation of suppliers. Next time will control our hypothesis in praxes. This system can be used to evaluate

the suppliers in different groups- discontinue manufacture, services and markets.

By this method we evaluate middle value for group of suppliers. The best supplier has the highest value. There are two groups of evaluation for new suppliers and for existing suppliers.

By means of this method user can select important groups of evaluation. Each group has some evaluate criteria. One of these groups is mobility of supplier. By means of this evaluate group firm can find the best supplier and build supply chain with the highest quality.

New method has some differences, such as:

- orientation on different groups of suppliers,
- orientation on SME,
- orientation on average value,
- different groups of evaluation with different criteria of evaluation.

User can select important criteria for firm.

This theoretical method will be verified in praxes next 2011 year on small and medium-sized Czech companies.

DISCUSSION

This system can use SME, which have businesses in different groups. This system is used for the total evaluation of suppliers and to provide the high quality of supply chain.

Other methods of evaluation of suppliers do not have the universal mechanism universal mechanism of evaluation. They do not have the system of calculation for evaluation. Some authors wrote about multi-criteria evaluation. But our method has not only multi-criteria evaluation, but has flexibility for users' system of evaluation and some new formulas to calculate the evaluation of suppliers. Next step is the evaluation of existing suppliers and suppliers challenged customer. Then we can evaluate information flows in company. In this study we evaluate suppliers and information flows of company. Now we are working out the software for this evaluation method. This theoretical method will be verified in practices.

This method of evaluation cannot be used for continual manufacture. Nowadays this theory is verifying with help questionnaire in Czech small and medium-sized firms. This questionnaire will be finished to end of 2010 year. The analyses of this questionnaire will publish next 2011year. Evaluative system will applied in 2011 year.

For using this system existing suppliers should have information about audit quality processes and quality of goods.

New method can improve the total evaluation of supplier in SME. This method will be used in planning software for firm.

SUMMARY

The aim of this paper is to develop an alternate method of evaluation of suppliers with regard to the characteristics of small and medium enterprises. Various ideas were explored choice of evaluation criteria such as fuzzy logic, cluster method, environmental management, environmental management etc. have been explored various options of the selection procedure, such as evaluations based on quality, forming a network connection between the factors, comparisons in pairs, using genetic algorithms. Evaluation group were identified and evaluation criteria related to the formula. Used rating system is still at the theoretical level. Publication of a practical verification method will carried out in the first half of 2011.

SOUHRN

Moderní metody hodnocení stávajících dodavatelů a dodavatelů vybraných zákazníkem pro malé a střední podniky

Cílem tohoto příspěvku je vytvoření alternativní metody hodnocení dodavatelů s ohledem na vlastnosti malého a středního podnikání. Byly prozkoumány různé názory výběru hodnoticích kritéria jako fuzzy logika, klastrová metoda, environmentální management atd. Byly prozkoumány různé varianty procedury výběru, jako jsou hodnocení založené na kvalitě, formovaní sítě souvislostí mezi faktory, srovnání ve dvojících, použití genetického algoritmu. Byly určeny hodnoticí skupiny a hodnoticí kritéria se souvisejícími vzorci výpočtu. Použitý systém hodnocení je zatím na teoretické úrovni. Zveřejnění praktického ověření metody se uskuteční v prvním pololetí roku 2011.

proces hodnocení, malé a střední podniky, vybraný dodavatel, existující dodavatel, SCM (Supply Chain Management)

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APPENDIX 1

Formulas for calculation values for existing suppliers and suppliers selected by customer

Evaluative group	Evaluative criteria	Evaluative coefficient
1) delivery time	Correspondence between life time of product and average delivery time	0,1
	Possibility of transportation to final customer with suppliers' transport +time of transportation	
	Possibility of shortening delivery time and related conditions	
2) Quality of products/ services	Certification	0,25
	Supplier's experience (time on market)	
	Reliability of supplier	
	Existence the compensation for loyalty to supplier	
3) Costs	Index total costs of purchasing	0,2
4) transportation	Correspondence between distance to supplier and quantity of suppliers in region	0,1
5) MOBILITY OF SUPPLIER	Possibility mobility of supplier	0,15
	Related costs	
6) Results of audit for existing suppliers (level of organization the processes)	the level of management of suppliers' firm	0,2
	the level of the management of manufacturing (production) processes	

1) DELIVERY TIME

Correspondence between life time of product and average delivery time

Life time of product (lTP)
1 0–1 month
2 1–3 months
3 4–7 months
4 8–12 months
5 13–36 months
6 7–60 months
7 61–96 months
8 More, than 96 months

Average delivery time (ADT)
8 0–12 hours
7 13–24 hours
6 25–36 hours
5 37–48 hours
4 48–60 hours
3 61–83 hours
2 84–108 hours
1 More, than 108 hours

(lTP / average LTP of all suppliers) *(ADT / average ADT of all suppliers) *evaluative coefficient (1)

Possibility transportation to final customer with suppliers' transport +time of transportation

Possibility yes (1) – no (0)
Time of transportation in case possibility of transportation suppliers' transport
8 0–5 hours
7 6–10 hours
6 11–15 hours
5 16–20 hours
4 21–25 hours
3 26–30 hours
2 31–35 hours
1,5 36–40 hours
1 More than 40 hours

Possibility * (Time of transportation /average time of transportation for all suppliers)*evaluative coefficient (1))

Possibility shorting of delivery time and related conditions

Possibility shorting of delivery time yes (1) = no (0)

Evaluate of conditions:
Conditions single supplier/ average conditions of all suppliers

1. Conditions a single supplier:
Shorting time of supply/ related price improvement
2. Average conditions of all suppliers:
Average shorting time of supply/ Average related price improvement
Possibility shorting of delivery time*(conditions of shorting of delivery time/average conditions of shorting delivery time)*evaluative coefficient (1))

(WlP /average WLP of all suppliers)*(ADT / average ADT of all suppliers)*evaluative coefficient (1) + Possibility * (Time of transportation /average time of transportation for all suppliers) *evaluative coefficient (1)) + Possibility shorting of delivery time *(conditions of shorting of delivery time/average conditions of shorting delivery time)*evaluative coefficient (1))

2) QUALITY OF PRODUCTS/ SERVICES

Certification

Existence due certificates of quality, if need will be due patents
Yes (1) – No (0)
Existence optional certificate of quality
Yes (2) – No (0)
Existence due certificates of quality, if need will be due patents + Existence optional certificate of quality)/ average evaluate certification of all suppliers* evaluative coefficient (1)

Experience of supplier (time on market)

1 0–12 months
2 13–30 months
3 31–48 months
4 49–84 months
5 85–110 months
6 More than 110 months
Experience of single supplier/ average of experience of selected suppliers* evaluative coefficient (1)

Reliability of supplier

Reliability of suppliers in the required time (in %) = number of factual items delivered / planned number of units delivered in due time * 100%
Supplier reliability* evaluative coefficient

Existence the compensation for loyalty to supplier
0,5 yes
0 no
Existence the compensation for loyalty to supplier*evaluative coefficient

Existence due certificates of quality, if need will be due patents + Existence optional certificate of quality)/ average evaluate certification of all suppliers* evaluative coefficient+ Experience of single supplier/ average of experience of selected suppliers* evaluative coefficient+ Supplier reliability* evaluative coefficient + Existence the compensation for loyalty to supplier*evaluative coefficient

3) COSTS

Index of total costs of purchasing;

Purchasing value
Transportation costs (Ct), we evaluate here cost on transportation, before we were evaluated possibility changes and related costs
Packing costs(Cp)
Warehousing costs (Cw)
Customs costs (Cc)
(Average of purchasing value / purchasing value + (average of (Ct + Cp + Cw + Cc))/ (Ct + Cp + Cw + Cc) of selected supplier) *evaluative coefficient

4) TRANSPORTATION (1) 0,1

Correspondence between distance to supplier and quantity of suppliers in region

Distance to supplier; km (DS)
14 0–10
13 11–30
12 31–60
11 61–100
10 101–200
9 201–300
8 301–400
7 401–500
6 501–600
5 601–700
4 701–800
3 801–900
2 01–1000
1 1001 and more

quantity of suppliers in region (QS)
1 1supplier
2 2–3 suppliers
3 4–6 suppliers
4 7–10 suppliers
5 11–15 suppliers
6 16–20 suppliers
7 More than 20 suppliers

(DS /average of DS)*(QS/average of QS)*evaluative coefficient (1)

5) MOBILITY OF SUPPLIER (2)0,2

Possibility mobility of supplier

Possibility of online ordering
1–0 Yes = No
Possibility of modification product in agreement with demands of firm
1–0 Yes = No
Possibility of communication at creating of ordering product
1–0 Yes = No
Possibility of transfer a part of processes (activities)/services (services for customer transfer to supplier)
1–0 Yes = No
Possibility of online ordering + Possibility of modification product in agreement with demands of firm+ Possibility of communication at creating of ordering product Possibility of transfer a part of processes (activities)/services, (services for customer transfer to supplier))/average of possibilities*evaluative coefficient (1) 0,1

Related costs:

4+1–3%
3+4–9%
2+10–15%
1+16–30%
0 more than 30%
Related costs/ average of related costs*evaluative coefficient (1) 0,1

Possibility of online ordering + Possibility of modification product in agreement with demands of firm+ Possibility of communication at creating of ordering product Possibility of transfer a part of processes (activities)/services (services for customer transfer to supplier))/average of possibilities*evaluative coefficient(1)0,1+ Related costs/ average of related costs*evaluative coefficient (1) 0,1

6) RESULTS OF AUDIT FOR EXISTING SUPPLIERS (LEVEL OF ORGANIZATION THE PROCESSES)

The level of management of suppliers' firm 1/3

Management responsibilities, 0–5
personnel training, 0–5
Financial considerations in quality management, 0–5
Process Safety 0–5
Management responsibilities+ personnel training+ Financial considerations in quality management +Process Safety)/average level of management (2,5 + 2,5 + 2,5 + 2,5)*evaluative coefficient

The level of the management of manufacturing (production) processes 2/3

Spatial resolution 0–5
Information Security 0–5
Course material flow 0–5
(Spatial resolution +Information Security +Course material flow)/ average level of organization of the production process (2.5+2.5+2.5)*evaluative coefficient
(Management responsibilities+ personnel training+ Financial considerations in quality management +Process Safety)/average level of management (2,5+2,5+2,5+2,5)*evaluative coefficient+ (Spatial resolution +Information Security +Course material flow)/ average level of organization of the production process(2.5+2.5+2.5)*evaluative coefficient

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