Algorithmic approach based on logical qualifiers of subcontractors during creation of large machine-building complexes

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Abstract. The currently stepped price competition stage, in other words, the quality of competition is defined by whether the quality of engineering products depends both on the assembly and on those parts of the product, which is going. The suggested information-analytical tender system, including remote maintenance, connects with the help of web technologies the enterprise financial structure of the workstations operators and authorized persons of contractors located in different geographical areas of the world to form an effective infrastructure for the production, including the incorporation of Russian and foreign small and medium-sized businesses in the technological chain of transnational corporations.

Keywords: quality engineering products, information-analytical tender system, algorithm for automated processing and analysis of contractor tender cards.

1. Introduction

In modern conditions, when the scientific and technological progress stepped far enough to replace the subject specialization came to parts and equipment, the situation changed [1, 2]. Now, large companies are interested in high quality products, and this means that they do not care how they made these or those parts or assemblies, which hardware is made of any material. This is understandable, since the stepped stage of non-price competition, in other words, the quality of the competition is defined by whether the quality depends both on the assembly and on those parts, from which the product is going. This implies very different relationships between large and small firms, collaborating with each other rather than ones between just market linkages.

2. Contractor stability

Formal statement in terms of machine training is as follows [3]. The data set D is a table of N elements (records), which each ith entry is composed of individual attributes a_{i1}, $a_{i2}…a_{ik}$. An attribute may be either numerical or categorical, and describes the technical and economic contractor characteristics and other information received from external sources ("black" lists, etc.). Each contractor can be assigned to one of two classes: the "bad" and "good". The classifier $C = f(D)$ is based on the set D. Using classifier, the calculated error I and II type (bg and gb respectively). In order to solve the problem of form optimization $\varphi \to opt$, where the objective function is constructed with a view to minimize the disruption of supplies, and any other purposes consistent with the strategy of a large industrial enterprise.

2.1. Types of contractor systems analysis

By analogy with the financial and credit scoring [4, 5], the systematic analysis of a contractor can be divided into the following types:

The applicator systematic analysis of a contractor is the assessment of the economic stability of new applicants related to investments. It is implemented with a view to deciding whether it is possible to invest at the stage of the application.

The behavioral systematic analysis of a contractor is the assessment of the probability of target

use of already allocated investments and performance of the contract in terms of delivery of components and services. It is carried out in order to identify the risk of disruption of delivery dates and the adoption of measures to reduce these risks.

Reservoir systematic analysis of a contractor is to assess the possibility of full or partial delivery of components or services by a contractor in violation of the delivery deadline. It is carried out after the expiry of the investment period.

Fraudulent systematic analysis of a contractor consists in detecting and preventing from a fraudulent action on the part of potential and existing contractors– as well as in detecting and preventing from a fraudulent action on the part of potential and existing contractors.

On a method of creation of models of systematic analysis of a contractor, allocate [6]:

Expert (subjective) systematic analysis of a contractor – models are created through the use of intuition and experience of experts. Its advantage consists in the model of accumulated knowledge of the best organization specialists.

Statistical (objective) systematic analysis of a contractor is the construction of models by statistical data. The advantage consists in the absence of a subjective component in decision-making and the ability to take into account many factors.

Before the systematic analysis of the contractor, as a rule, the process goes through underwriting – the product is tested to meet the stringent requirements for technical and economic indicators. At the same time, the requirements to the terms and conditions of supply and the calculated allowable limit investment are put forward. In this calculation one of two coefficients – "D/I" or "C/I" are involved. The coefficient "Deliveries/Income" (D/I) is the ratio of the contractor's monthly supply to its revenue over the same period. It is believed that a significant amount of this ratio (over 40 %) indicates an increased risk for both the investor companies and contractors.

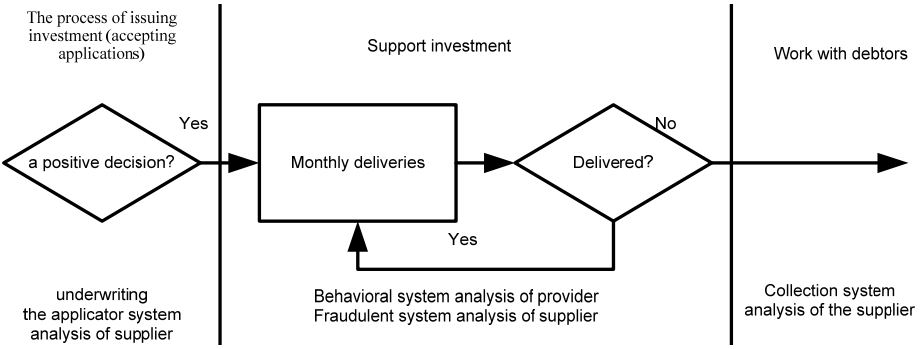

Fig. 1. Contractor system analysis in the life cycle of contractor investments

The ratio "Commitments/Income" (C/I) is the ratio of the contractor's monthly obligations to its income for the same period, taking into account withholding taxes. The commitments included the costs associated with the supply of components and services to the investor's enterprise, as well as having other long-term obligations (payments on any loans, required tax payments and so forth). It is believed that the size of the monthly obligations of the contractor should not exceed 50-60 % of its total net revenue.

Tender applications of contractors who have not passed the underwriting receive waiver and did not even get on a systematic analysis of the contractor. Therefore, on an entrance of the procedure of the contractor system analysis, it is more profitable to submit not the income of the contractor, but the relation "D/I" or "C/I".

Thus, with the help of various types of contractor system analysis, the work with the contractor carried out throughout the life cycle of investment – by granting it before returning to the form of supply. Fig. 1 schematically illustrates these relationships.

2.2. Information development process and analytical tender cards

The information development process and analytical bidding cards (and indeed the applicator system analysis of contractor models) include the following stages [7]:

1. Preparation of initial data (consolidation). It includes the collection of baseline data by contractors, settings of contract profiles and tenders.

The important point here is the separation of the contractors on the "bad" and "good": the good one is the desired state contractor now and in the future; and the bad one is an undesirable condition that can lead to the disruption of terms supply and which does not need to be allowed in the portfolio of tenders.

Contractors in the automated systems are not divided on "bad" and "good" ones: by only the facts of deliveries, the number of the allowed delays. For each range of products and type of services defined by its recommended and acceptable delivery times, violation of acceptable terms admits failure of terms of deliveries. The fact of failure of deliveries equates the entity contractor to "bad" contractors.

The open question is: what is the minimum number of investment needed for constructing a model of the system analysis of the contractor? A number of reputable foreign authors in the field of credit and financial scoring shows that the scoring is required in 1500 of "good" and 1,500 "bad" loans, in some cases, another 1,000 applications rejected. These figures appeared to be derived empirically in the 60s, when procedure of data collection represented a difficult task generally because of a poor development of technologies of the automated storage and data processing. But they are indicative, and, in practice, should strive to have at their disposal more precedents. At the same time, we note that the main difficulty is to collect "bad" investments, as at 1 bad score accounts for 10-20 good. The initial sampling in the contractor system analysis always has an uneven distribution of the classes of contractors, but today there are special techniques in machine learning, which allow dealing with the imbalance (this is discussed later).

2. Cleaning and pre-processing of data. Actual data for analysis are rarely of a good quality. The need for data pre-processing occurs regardless of the technology and algorithms, which are used. At this stage of action with the data, including: filling the gaps, there is definition of rules that will be filled with missing values in the source data when loaded in a consolidated source; data filtering for an indication of the criteria and verification, in which the initial data are rejected with incorrect values; the transformation is a departure from the absolute values of the parameters on the relative ratios, such as "delivery/income" or "liability/income"; sampling is the process of selection of the original set of sample data of interest for analysis. Special selection method is used in the implementation of sampling, which must ensure the representativeness of the sample in terms of the problem to be solved. The easiest is to make a random sampling, in which a set of data are randomly extracted from n % examples.

3. Creation of models of contractor system analysis. To sample applied statistical methods and machine learning, the problem of binary classification is solved. The most important property of any model, which it must acquire in the process of learning (iterative procedure of parameters control), is the ability to generalize. If the model is trained and has acquired this ability, it will give the correct result when it applies to its input, not only the data on which it was trained, but the data which did not participate in the learning process.

To test the model's ability to generalize, the whole training set is divided into two sets - training and testing. Examples of the training set are directly used to test the model. Examples of test sets for training are not applied, and are used to test the generalization ability of the model. Separation of examples in the training and testing sets are usually carried out at random or different sampling methods.

4. Assessment and analysis of resulting model quality. At this stage, the properties of the information-analytical of tender cards that show the classification matrix, the Kolmogorov-Smirnov statistic, the ROC-curve, Lift-curve, cumulative curve distributions of estimated points and others, are mainly studied.

5. Determination of optimum cutting off point. Tender applications, which the score is less

than the predetermined threshold score cut-off, are not approved. Therefore, a threshold cut-off score should ensure the achievement of the purposes of a large industrial corporation, which corresponds to the chosen strategy (such cut-off scores are called optimal).

6. Integration of models in business processes of financial enterprise structure. The developed system analysis contractor models are integrated into the information infrastructure of the financial enterprise structure in several directions: with the front-office systems – for service companies-contractors; with a management system investment risks and storage of data – for accumulating of information about contractors.

7. Model actualization. In the operation of tender cards and the accumulation of new data in a portfolio of tenders, scores for attributes of characteristics of the contractor are subject to correction. Practice shows that it significantly improves its quality and predicative power.

The debt collection system contractor's analysis of the process of developing models differs from the sequence of actions in the applicator system contractor analysis. Unreliable contractors are subject to segmentation, which allows you to predict how effective is the use of certain actions for the contractor, which could lead to a positive result, that is, the resumption of the supply of components or services. The segmentation is carried out depending on various factors: parameters of case of the contractor (number of timely and thwarted deliveries, time since the last delivery before the disruption of supply, amount of allocated investment, contractor characteristics), history of contacts with the debtor, the results of previous actions. The segmentation result is the definition of species effects to be applied to a particular debtor.

3. Scoring information-analytical tender card

In its simplest form, the information-analytical tender card consists of a set of characteristics that are derived by statistical so "bad" contractors received low scores, and "good" ones-high ones. Table 1 shows an example of information-analytical system of a tender card.

Specifications for tender cards are withdrawn from any data source available to the financial structure of the company at the time of the application. This is, as a rule, the technical and economic performance of small and medium enterprises. Each attribute is assigned by points according to the table, and the result is summarized. The report provided in table 2 represents one of typical reports of a financial enterprise structure, which is formed for evaluating the quality of tender point card. Legend: 1 – range assessment score; 2 and 3 – simple number of investments and cumulative one (accumulation), respectively; 4 – number of "good" applications; 5 – cumulative number of "good" applications; 6 – number of "bad" applications; 7 – cumulative number of "bad" applications; 8 – share of overdue deliveries or services; 9 – delayed delivery or services in relation to all applications; 10 – level of approvals in number of applications %.

In the range of the estimated score of 700 to 755, the expected level of overdue deliveries or services will be 1,287 %; the level of overdue deliveries or services, calculated to the total volume of the under review the portfolio of applications will be in the amount of 0.965 %; the level of approvals is equal to 25.4, that is a percentage of contractors who have an estimated score greater than or equal to 894.

The information on risk assessment, accumulated in the tender map (or, if to put it mathematically – distribution evaluation points), in conjunction with other factors, is used to develop a variety of contractor investment strategies that optimize the ratio of "income"/ "level of overdue deliveries or services".

There is here an incomplete list of measures that can be resorted to, if the contractor does not gain enough evaluation points: reducing investment limit if the risk is very high; the establishment of a low initial investment limit; invoicing contractor stricter control conditions; entry application to the "check list" of contractors who are prone to potentially fraudulent transactions.

The direct analysis of the evaluation score can influence the decision-making business-processes on a request of, for example, a potential contractor with the highest score can be approved without further confirmation of additional options, valuation of assets, and so on.

Table 1. Example of information-analytical system of tender card of "Izhevsk radio factory project" in thou. rubles

Characteristic	Attribute	Score
1. Availability of production guarantees		
1.1. Availability of production facilities	yes	46
1.2. Availability of necessary equipment	yes	42
1.3. Availability of qualified personnel	yes	39
1.4. Production experience of nomenclature of products	yes	45
2. State of entrepreneurship:		
2.1. Violations of reporting documentation	no	27
2.2. Retained earnings (uncovered loss) of last fiscal year	530481	25
2.3. Receivables	492181	19
3. Availability of own funds		
3.1. Availability of insurance contract	yes	25
3.2. Availability of guarantee –guarantee	yes	23
4. Status of documentation on financial and legal position company		
4.1. Providing copies of charter	yes	22
4.2. Provision of specimen signatures	yes	19
5. General characteristics		
5.1. Authorized capital	271010	16
5.2. Size of short-term loans and credits	59212	17
5.3. Business registration time	1993	47
5.4. Number of staff	985	46
5.5. Intangible assets	8314	13
5.6. Fixed assets	521905	47
5.7. Long-term investments	46475	38
5.8. Deferred tax assets	1986	15
5.9. Short-term investments	289921	48
5.10. Accounts payable	567841	33
5.11. Gross profit	100017	25
5.12. Revenue from sales	96392	23

Table 2. Sample report, drawn up based on of tender map of "Izhevsk radio factory"

1	2	3	4	5	6	7	8	9	10
[1036; 1091]	955	955	943	943	1	1	0.105	0.105	2.053
[980; 1035]	624	1579	613	1556	2	3	0.321	0.19	3.394
[924; 979]	687	2266	673	2229	5	8	0.728	0.353	4.871
[868; 923]	2200	4466	2173	4402	19	27	0.864	0.605	9.6
[812; 867]	1869	6335	1843	6245	18	45	0.963	0.71	13.618
[756; 811]	2451	8786	2413	8658	30	75	1.224	0.854	18.887
[700; 755]	3030	11816	2983	11641	39	114	**1.287**	**0.965**	**25.4**
[644; 699]	3887	15703	3823	15464	56	170	1.441	1.083	33.756
[588; 643]	2879	18582	2803	18267	68	238	2.362	1.281	39.945
[532; 587]	3479	22061	3403	21670	68	306	1.955	1.387	47.424
[476; 531]	4605	26666	4483	26153	114	420	2.476	1.575	57.323
[420; 475]	4323	30989	4183	30336	132	552	3.053	1.781	66.616
[364; 419]	3568	34557	3463	33799	97	649	2.719	1.878	74.286
[308; 363]	4532	39089	4363	38162	161	810	3.553	2.072	84.028
[252; 307]	1662	40751	1543	39705	111	921	6.679	2.26	87.601
[196; 251]	2119	42870	1993	41698	118	1039	5.569	5.569	92.156

There are two main ways of building the information and analytical tenders cards – expert and statistical ones, although it is possible to apply a combination of approaches (e.g., manual selection of relevant attributes in tree classifying rules). Expert approaches in the contractor system analysis are rarely justified by the complexity of the design and it is impossible to take into account the

expert a large number of factors, and combinations thereof. Therefore, modern information and analytical support of investment processes of contractors is not conceivable without the statistical methods of tender card construction. The basic algorithm here is a logistic regression.

4. Conclusions

An information and analytical tender system is developed, including remote maintenance, connecting with the help of web technologies the enterprise financial structure of workstations operators and authorized persons of contractors located in different geographical areas of the world to form an effective infrastructure for the production, including the incorporation of Russian and foreign small and medium-sized businesses in the technological chain of transnational corporations.

The most common mistakes were revealed in the design of business processes as a result of the analysis processes workflow applications of contractors in the financial structure of the enterprise. A model of tender contractor business process handling is provided. Reengineering processes are adapted in large corporations in the implementation of information-analytical system for monitoring the economic stability of the contractor's small and medium-sized companies.

The article shows that there are two main ways of tenders card construction – expert and statistic ones, though it is possible to have a combination of approaches (e.g., manual selection of relevant attributes in tree classifying rules). Expert methods are applied in a system analysis of a contractor, are rarely justified by the design complexity, and it is impossible to take into account a large number of factors, and combinations thereof. Therefore, modern information and analytical support of the processes tender distribution of investment contractors, integrated into a corporation, is not conceivable without the statistical methods of tenders card construction.

The methods are based on the formation of information-analytical system of contractor cards, including preparation of data, cleaning and pre-processing of information, building of information and analytical tenders models, assessment and analysis of the resulting model quality, determining the optimum score of cut-off contractors, non-compliant investor corporations, integrating models into business processes of the financial company structure, updating the model. An algorithm of the automated processing and analysis of contractor tender cards for the investment decision of a particular business entity is provided. The structure of the information-analytical system of tender cards and an algorithm for its automated processing and analysis are created for the acceptance or rejection of the decision to invest a particular contractor.

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