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The Subjects of Automated Competitiveness Monitoring of Science-Intensive Products in Engineering

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Abstract. Manufacturing competitive science-intensive engineering products is one of the most important tendencies of the modern stage of Russian economy development. Various means are applied to assess the competitiveness including automated competitiveness monitoring of science-intensive products at machinery production. A separate issue is building a team of experts for the survey. To solve this problem we engage a forward-looking businessman, a professional manager, an independent expert and a potential consumer as the subjects of the dialogue.

Introduction

Any country needs regulatory mechanisms ensuring normal functioning of its economy [1]. One of such regulators at the current stage of Russian economy development is manufacturing competitive science-intensive products (SIP). Efficient economic development involves manufacturing and marketing products satisfying both the manufacturer and the consumer in terms of price and quality. Until the recent time the problem of competitiveness was not paid proper attention to by the Russian manufacturers. But the international practices show that the companies cannot break even without competitive SIP. Many authors were solving the problems of competitive science-intensive products and the problems of competitive companies in general. The list includes Fakhrutdinov R.A., Osipov Yu.M., Bykov S.N., Grigorieva A.A., Maslov A.V. and others. But these and other authors considered the problem of SIP competitiveness from the technical and economic viewpoints without considering its social significance.

In this respect the problem of reliable estimation of science-intensive product competitiveness and making rational decisions about its production, creating an automated system of decision-making for SIP manufacturing and consuming is of major importance and determines the relevance of the given study.

To solve the given problem we have developed the system of automated competitiveness monitoring of science-intensive products (ACM of SIP) in engineering [2].

Subject automated monitoring

When developing the ACM of SIP system in engineering and applying technical, economic, ecological and social indicators for product estimation it is helpful to bring to bear experts as subjects of the dialogue possessing theoretical knowledge and practical skills for solving problems in the considered subject area (knowledge of certain market, structure of technical and economic indicators of the company's activities, the quality indicators of the given product, etc.). For our purposes the subjects of the dialogue can be divided into four basic groups: forward-looking businessman, professional manager, independent expert and potential customer. It is also necessary to consider the general requirements to the subjects of the dialogue: productivity, trainability and self-trainability, ability to discuss the inconsistencies, knowledge of current scientific and technology opportunities and limitations, ability to give explanations.

The forward-looking businessman takes the most active part at the initial and final stages of the research. At the initial stage, basing on the public needs and scientific and technological trends, he highlights the basic lines of developing and estimating the innovative product. After obtaining the research results he agrees with them or suggests improving the estimation criteria and continue the dialogue.

The professional manager participates at all stages and in all procedures of developing and estimating the ACM of SIP. He controls the processes of collecting and processing information, makes the decision on appropriateness of further research, strikes the compromise between the subjects of the dialogue, forms the report on the results of competitiveness estimation.

When organizing the ACM of SIP dialogue a group of independent experts [3] is formed. The independent expert analyses the opinion of the forward-looking businessman and suggests the most relevant and significant criteria of competitiveness estimation and, together with the professional manager, forms reference tables, using the market research results, provides objective estimation of the innovative product. Managers and top specialists of production, estimating and marketing subdivisions of the engineering company appear as experts depending on the indicator being estimated. It is also a good practice to involve competent representatives of potential customers who may account for 25-30% of the experts. Increasing the amount of experts is characteristic of large companies manufacturing standard products. This increases expert group representativeness of the general population of customers.

The potential customer highlights the most significant parameters of competitiveness indicators of specific science-intensive product, ranks the parameters in the descending order and rates them. The obtained information is systematized, processed and send to the independent expert. In the course of independent expert evaluation the experts establish assessment of science-intensive product competitiveness according to the following indicators “significance of engineering decision” (Sed), “significance of economic event” (See), “significance of ecological decision” (Secd) and “significance of social effect” (Sse) [4]. The obtained expert information enters the ACM of SIP system.

Of all the subjects of the dialogue the professional manager faces the most high-level requirements. Beside the general requirements mentioned above they are to make the best use of their intuition, personal experience and knowledge which can not be obtained from other sources, share information in the concentrated and organized form corresponding to the language and regulations of the dialogue.

In general, the processes of knowledge extraction completed by the subjects of the dialogue when developing and estimating the criteria are characterized by high labor intensity and significant intellectual work associated with consolidation of large amounts of reference information which conditions the necessity of applying computer-aided decision-making.

When developing the indicators of ACM of SIP in engineering we can distinguish the following stages of knowledge elicitation from the subjects of the dialogue: identification, conceptualization, formalization, realization and testing.

At the stage of identification the subjects of the dialogue reveal and formulate the problem and the basic tasks of competitiveness assessment for the given product; indicate possibility and relevance of developing a certain competitiveness indicator; identify the candidates for the roles of forward-looking businessman, independent expert, professional manager; identify prospective users of research results, efficiency and reliability criteria of the results.

At the conceptualization stage the subject of the dialogue carry out the most labor intensive and complicated activities on elicitation of the basic amount of knowledge used by the specialist when solving the formulated problem. It is the stage when the criteria (coefficients) for every indicator are developed, the criteria are layered, base points are attributed to each level. Here the subjects of the dialogue have to apply structural, strategic and supplementary types of knowledge. The strategic knowledge includes procedures, heuristics, solving rules and strategies, “applied” by the subject to the structural knowledge to solve the problem. Supplementary types of knowledge include various explanations and substantiations of relations and conditions.

Knowledge elicitation at the stage of conceptualization is not a uniform process. At the beginning when the amount of entering source information is insignificant the analytical component prevails. The analytical component is associated with identification of the basic requirements of outside environment and scientific and technological trends. In the course of information obtaining the synthetic component starts playing a more and more important role. The synthetic component is associated with forming the assessment criteria of science-intensive product competitiveness which have a significant influence upon the process of further knowledge elicitation. The essence of the developed criteria becomes more specific and the process of knowledge elicitation takes the form of interpretation and attribution of base points in assessment tables.

At the stage of formalization the main functions of the subjects are choosing the method of alternatives assessment, developing the formal algorithm of assessment, developing the recommendations for the programmer of the system.

At the stage of realization the use of knowledge is insignificant, being actually reduced to improvement and correction of the formal algorithm in the process of dialogue between the professional manager and the programmer. At this stage the knowledge obtained at the previous stages is converted into the elements of subsystems of models and ACM of SIP data control.

At the testing stage the intensity of information obtaining from the subjects increases significantly. At this stage the aims of knowledge elicitation are testing the relevance of the chosen methods and assessment indicators of innovations competitiveness, error elimination in the computer program.

Ian important characteristic of the process of ACM of SIP development in engineering is complete and consistent presentation of knowledge by the subjects of the dialogue in the system. The sources of incompleteness and errors vary due to the level of knowledge elicitation – cognitive, linguistic, operational.

The knowledge of the subjects of the dialogue at the cognitive level reflecting their qualification in the problem area can be incomplete and misrepresentative. At the linguistic level there may occur mistakes associated with inexactness and ambiguity of the expert's natural professional language as well as with verbalization of his erroneous ideas. Besides presentation of the knowledge from the cognitive level at the linguistic one can be incomplete due to the principal impossibility of appropriate verbalization. When presenting the knowledge at the operational level reduction of precision and completeness of reality description may also occur due to the objective inadequacy of the software tools to the language of the dialogue.

The quality of information exchanged by the subjects of the dialogue significantly depends upon the method of its obtaining. If the person applies the units of measurement he is accustomed to when assessing the alternatives according to some criterion, he does not have any serious problems. For example the experts dealing with technical problems use their experience of many years to provide reliable assessments of physical characteristics of the objects. On the other hand, in ACM of SIP the experts have to express their assessment in points according to the criteria of indicators Sed , See, Secd and *Sse*. This leads to difficulties as this kind of information is unfamiliar for the experts and the new scale of measurements may reduce the reliability of the information obtained and the consistency of assessments.

The processes of information processing by the subjects of the dialogue have their special features which depend not so much upon their personal characteristics as upon the human memory organization common for all people. It is too optimistic to suppose that "a man can do everything", "an expert can provide any information, reliably and in any form". From the viewpoint of ACM of SIP operation in engineering the most important are the problems of weight ranging and direct scoring of competitiveness criteria.

Determining the rank of the criteria is far from being easy for the expert as when weighing he must consider statistically average scoring of the criteria, the scale range of the criterion, etc. The results of the study show significant differences between the weights set by the person and those which can be educed from his actions. As a rule the importance of insignificant criteria is overvalued and that of the most important is undervalued and the given deviations demonstrate very little

correspondence to the subject of dialogue expertise as they are characteristic for businessmen, for experts and for managers as well.
Analysis of criteria scoring results of the developed indicators for ACM of SIP in engineering also showed that the subjects of the dialogue can often be inconsistent and intransitive. It became evident when comparing the results of direct scoring to those of pair-wise comparisons and alternatives.
At the same time the given facts do not mean that the subjects of the dialogue cannot solve the application tasks. Their main principle is transforming and simplifying the complex situation applying a lot of various heuristics. In any case one of the main problems is determining the permissible amount of work carried out by the expert. This amount of work is determined by the number of specific criteria of product competitiveness. The results of the study [5] show that the experts are quite reliable and consistent when the number of analysis objects (criteria of the indicator, criteria levels, etc.) does not exceed 10. Beyond this limit the behavior of the experts changes abruptly, the number of mistakes and contradictions increases. Thus, the human limits for the considered operation for information obtaining are stated. These limits are taken into consideration when developing ACM of SIP at Yurga Engineering plant where the number of criteria and their levels in most procedures is stated from 5 to 9.

Conclusion

When developing the decision-making algorithms for the problem of determining SIP competitiveness in engineering the main requirement is adequacy of the methods of obtaining information from the experts to the real opportunities of obtaining reliable information from them. The selected methods of ACM of SIP at engineering production satisfy the given requirement. It is conditioned by unification of ACM of SIP algorithms and relative easiness of expert training for the technology of work with the criteria of competitiveness assessment. Besides, in the developed system we take into consideration the type of subject (businessman, expert, manager, consumer) who uses the recommendations of the system.

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