

Demand for services of existing engineering centers and formation of the list of required equipment, technologies and services in the business environment of the Republic of Tatarstan

Demanda de servicios de centros de ingeniería existentes y la formación del equipo necesario, las tecnologías y servicios, en el entorno de negocios de la República de Tartaristán

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ABSTRACT:

This article presents the results of market research conducted in June-September 2016, the purpose of which was to identify the demand for services of existing engineering centers of the Republic of Tatarstan as well as to draw up a list of required equipment, technologies and services in companies of engineering, polymer and petrochemical clusters of the Republic of Tatarstan. The article provides an overview of the conceptual apparatus needed for a more accurate representation of the object and subject of study (engineering, engineering activities, engineering services, engineering typology). The research reveals

RESUMEN:

Este artículo presenta los resultados de investigación de mercado realizada entre junio y septiembre de 2016, cuya finalidad fue identificar la demanda de servicios de centros de ingeniería existentes en la República de Tartaristán, así como para elaborar una lista del equipo necesario, tecnologías y servicios en empresas de ingeniería, polímero y racimos de petroquímica de la República de Tartaristán. El artículo ofrece generalidades sobre el aparato conceptual necesario para una representación más exacta del objeto y objeto de estudio (ingeniería, actividades de ingeniería, servicios de ingeniería, ingeniería de tipología). La

the main problems of existing engineering centers as well as the factors impeding the development of the sphere of engineering services and industrial design in the country.

Keywords: engineering, engineering centers, industrial design, shared-use center, outsourcing

investigación revela los principales problemas de los centros de ingeniería existentes así como los factores que impiden el desarrollo dentro del entorno de los servicios de ingeniería y diseño industrial en el país.

Palabras clave: Ingeniería, centros de ingeniería, diseño industrial, centro de uso compartido, outsourcing

Introduction

Currently, the development of engineering companies is an urgent task for the Russian economy. Their activity is very specific and, according to some researchers, could be an important link in the process chain of creating competitive products as well as serve as an agent of modernization, eliminating the existing infrastructural "gaps" in the innovation field (Gershman, 2013; Hochberg, 2003). The activity of engineering companies requires high professionalism of employees, thus forming the demand for the training of engineers needed in the Russian industry. The analysis of the demand for services of national engineering centers is of particular importance for the development of effective tools of the state scientific-technical and innovation policy. This, in turn, requires a special study to assess the effectiveness of engineering centers and identify critical factors for their development.

The lack of a clear interpretation of the concepts of "engineering" and "engineering activities" in the Russian legislation allowed a number of companies to "unreasonably present" themselves as engineering, while sometimes not having their own scientific and engineering base. However, having extensive connections with suppliers and contractors, they play a role of "work distributors" and are of no interest with regard to innovation.

The development rate of the world market of engineering services and their list shows a rapid growth. Therefore, it seems appropriate and relevant to analyze existing engineering centers, consider their activities and identify possible promising areas of the development of Russian companies' engineering services.

For a more detailed analysis of engineering services, the following objectives have been set:

1. To systematize the conceptual apparatus: engineering, engineering activity, engineering services; to carry out the typology of engineering.
2. To conduct a survey of enterprises in the region in order to identify:
 - the demand for equipment in accordance with the priority areas designated by the Government of the Russian Federation: computer engineering, laser and additive technology, industrial biotechnology, composite materials, robotics, machine tool industry;
 - the availability of internal modern equipment in the surveyed enterprises, designed for engineering and/or industrial design in accordance with the priority areas;
 - the current and expected demand for services and technologies in the field of engineering and industrial design;
3. To determine:
 - the availability/lack/demand for personnel engaged in the field of engineering and industrial design of products or equipment;
 - the volume of work in the field of engineering and industrial design of products or equipment, which is currently given to enterprises for outsourcing;
 - in the case of outsourcing orders, to determine to which engineering centers of the Russian Federation or abroad these orders are transmitted;
 - the volume of investment in the development of innovative products (or R&D) in the surveyed enterprises;
 - the readiness to place orders, subject to the availability of software and modern equipment in other enterprises or shared-use centers;

- the range of prices, which customer enterprises are ready to pay for engineering services;
- the need for technical and engineering consultation (energy, technology and environmental audit).

4. To draw up lists of equipment available in existing engineering centers for the examination of survey participants.

5. To identify the causes of the underutilization of existing engineering centers as well as the bottlenecks in their operations (lack of equipment, space, qualified professionals, promotion programs, problems in communications with enterprises, etc.).

2. Materials and Methods

The research methods include the analysis of secondary information when forming the base of enterprises, personal interviews of decision makers in enterprises (directors, development managers, chief designers, chief technologists, specialists), personal interviews of the heads of existing engineering and resource centers with the use of standardized tools and audio recording if needed.

2.1. Definition of engineering, engineering activity, engineering services

In the context of the research tasks in tooling development, the approaches to defining the notion of engineering, engineering activity and engineering services were analyzed. It should be noted that in the modern world, engineering is considered to be the main tool for the formation of the regional and global infrastructure of the economy and a scientific, technological and managerial foundation for the development and implementation of investment projects.

Engineering has a wide range of works and services: from the preparation of technical specifications and project proposals, the realization of engineering survey operations, including the construction of new and the reconstruction of existing industrial sites, the development of machinery, equipment and processing methods, to consultations of economic, financial and other character (Theory and practice of engineering, 2010).

According to the definition given by the Russian Engineering Union, engineering is "the total area of industrial, commercial, scientific and technical activities with the aim of obtaining optimal results from investments related to the realization of projects at the expense of the rational and efficient use of material, human, technological, intellectual and financial resources" (Smetana, 2015).

The American Engineers' Council for Professional Development gives the following definition: "Engineering is the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property" (Osika, 2010).

The engineering activity stages include: choice of technology, search for and selection of equipment, development of design documentation, development of the investment project, organization of construction works, purchase of equipment, installation of equipment, realization of pre-commissioning activities, start-up of production, production licensing, product certification, etc.

According to Article 148 of the Tax Code of the Russian Federation, engineering services include "engineering and consulting services for the preparation of the process of product manufacturing and realization (works, services), the preparation of the construction and operation of industrial, infrastructure, agricultural and other objects, pre-design and design services (the preparation of feasibility studies, design and engineering development, and other

similar services)" (Osika, 2010).

The forms of engineering services are being actively developed. The focus of modern engineering is aimed primarily at the development and use of technical solutions. The practical use of technical and technological solutions is the basis of engineering. Under market conditions, it should be done cost-effectively with the purpose of achieving necessary competitiveness. Therefore, the issues of the economy and the organization of business processes, the application of modern management systems and information technology as well as the implementation of regular management are as significant in engineering as the technological side (Osika and Kondratiev, 2007).

For the purposes of this study, "engineering and industrial design services" included: pre-design studies, industrial design, three-dimensional modeling, breadboarding, three-dimensional scanning, coordination of technical and technological production conditions, selection of materials, tooling design, accommodation in the workplace.

The National Research University "Higher School of Economics" developed a list definition of engineering services (Abdulbariyeva et al., 2015):

1. Engineering and technical design of products, technological (manufacturing) processes, capital construction objects.
2. Engineering and technical consultancy (not related to specific projects of engineering and technical design).
3. Project management.
4. Other engineering services.

2.2. Typology of engineering

In modern practice, the system integration of engineering services is being expanded. Depending on the situation, an engineering company can perform the role of consulting engineer, contracting engineer, managing engineer.

The execution of engineering services requires an effective management of business processes and business projects.

Currently, there are various classifications of the forms of engineering. The primary is the ranking of engineering by the United Nations Economic Commission for Europe, which marked the following types of engineering (The United Nations Convention on Contracts for the International Sale of Goods, 1992):

1. Consulting engineering
2. Technological engineering
3. Construction engineering
4. Technical assistance
5. Comprehensive engineering

The UN Manual on Statistics of International Trade in Services presented the classification of Services Sectoral Classification List - GNS/W/120 (Manual on Statistics of international trade in services, 2002). Engineering services in this classification are part of "architectural, engineering, scientific and other technical services". This section includes four subsections: engineering services; general engineering services; architectural services; services in the field of urban planning and architecture.

In international statistics, engineering is substantially associated with the design and construction of facilities. In some countries, engineering and construction services are practically inseparable (Methodological Guide for Developing Producer Price Indices for Services, 2006).

The UK Office for National Statistics presents the most broad interpretation of economic activities that may require the use of engineering services, without making them limited to the sphere of construction: engineering design activities in the field of industrial processes and production; engineering-related activities on scientific and technical advice; other engineering activities (UK Standard Industrial Classification of Economic Activities, 2009).

Russian practice is characterized by consulting or pure engineering (Brief economic dictionary, 2001) associated with pre-design studies, the design of construction projects and the implementation of supervision over the realization of design solutions. At the same time, technological and construction/general engineering is relatively little developed (Table 1).

Table 1. Types of engineering

Engineering types	Brief description
Organizational engineering	Constant changes and peculiarities of the modern environment require changes in companies' management practices. Organizational engineering is a new management methodology, focused on continuous monitoring, improvement and reformation of the company's organizational structure based on system-wide and engineering approaches (Altshuller, 1979).
Business engineering	An integrated design of interrelated business processes and business structures, providing the optimum balance between chaos and order in the business system as well as an optimal and constant adaption of the business system to changes in the external environment for achieving the fundamental objectives of business in any factual development scenario of the environment.
TIPS-engineering	Knowledge-intensive engineering, which accumulates the domestic theory of inventive problem solving (TIPS) (Altshuller, 1979), and value engineering (VE) aimed at implementing innovative projects.
Technological engineering	Provision of technology required for the construction and maintenance of industrial facilities etc.
Construction and/or general engineering	Engineering construction provision at any stage of realization of the investment and construction project (Lyubova et al., 2015).
Value engineering	A set of methods and means of cost management of the investment project at any stage of its life cycle.

As part of the research objectives, the classification of engineering is summarized in a single matrix by types of services provided, areas of activity, industries, and also in accordance with

CLASSIFICATION OF ENGINEERING

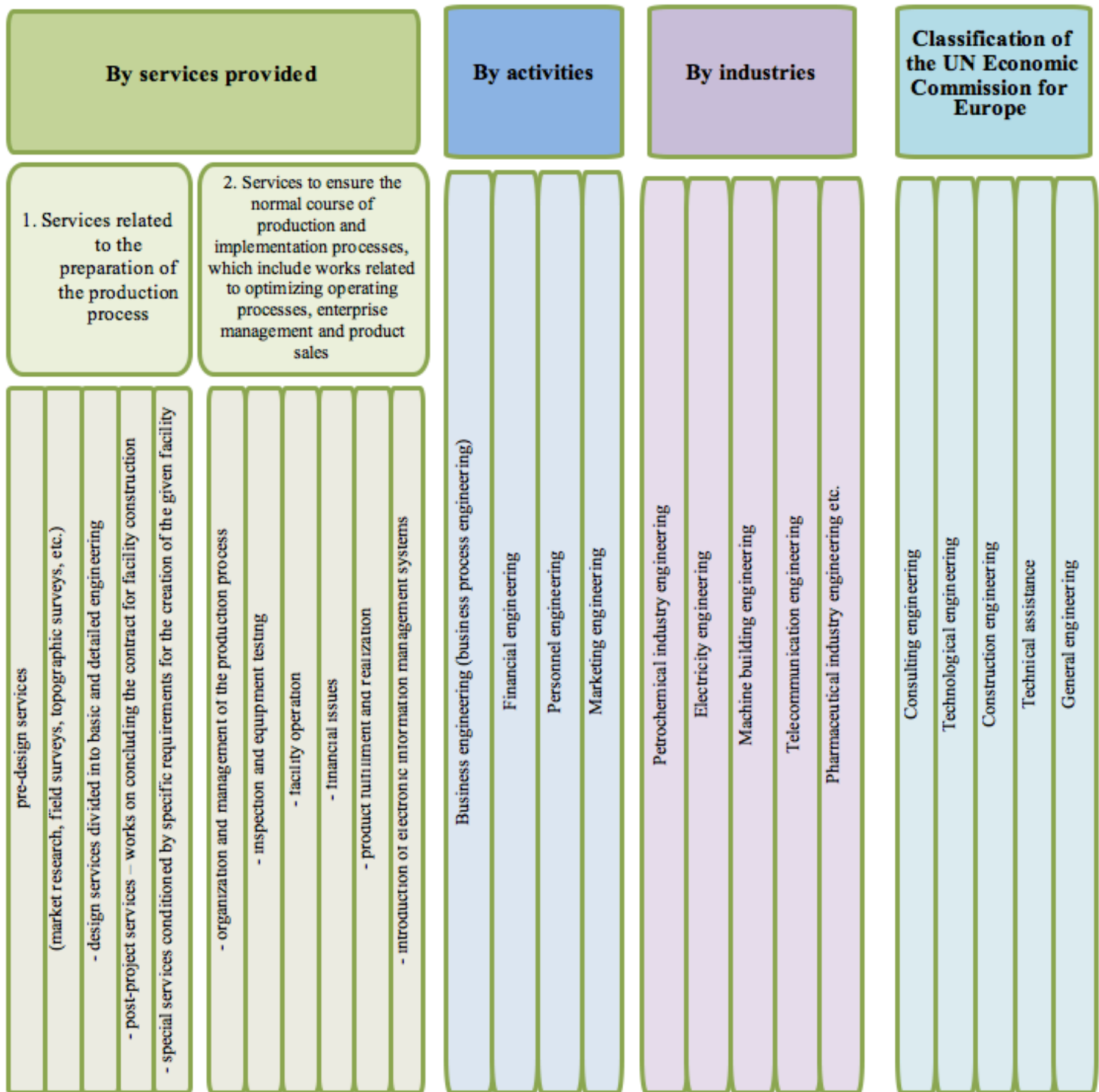


Figure 1. Classification of engineering

3. Results

400 enterprise managers were interviewed in the course of this study. The industry classification of the respondents was distributed as follows: 61.2% of all enterprises relate their activity to mechanical engineering; manufacturers and processors of polymers amounted to 18.5%; the category of other industrial equipment (trade, heating, ventilation, equipment for

power transmission, air conditioning, etc.) included 6.5% of the respondents; the activity of other companies was classified as the category of "other", namely metallurgy/metalworking, foundry, fabrication of metal work, tool, equipment, construction, woodworking, etc.

On the basis of the average number of employees, more than a third of the companies surveyed are micro-enterprises - 36.7%. Another third (34.4%) are small businesses. 11.8% and 17.2% are medium and large enterprises respectively.

The classification of the respondents by income gives a different picture: more than four companies out of five belong to micro-enterprises, only one in twenty - to medium, and about 6% - to large enterprises, which greatly affects the aspects of innovation, introduction of new products to the market, realization of research and development.

Over the past three years, 61.5% of the companies have brought new products or services to the market.

More than half of the respondents (54.7%) said that currently they (2015-2016) had been developing innovative products or technologies; 45.3% of the enterprises accounted only for the current release of products without the introduction of new developments.

The most important indicator of the innovativeness of products is the possibility of their patenting, which involves the comparison of the technical level and availability of inventions with product analogues.

To the question whether the companies submitted any patent or invention application over the past three years, 20.1% replied positively. In 2015-2016, all of the companies filed 190 patent and invention applications. The largest number of applications for protection documents was filed in the classification of "a utility model" - 101 applications (53.2%). 58 applications were filed for invention (30.0%), another 26 applications (13.7%) - for the registration of industrial designs, and 5 applications (2.6%) - for the registration of computer programs.

Thus, in terms of patent innovation applicability, the picture is not so optimistic and confirms the assumption about the diffusion of existing innovations in the region's enterprises.

One research objective was to determine the amount of funds allocated by the companies to produce innovative products, since this figure largely predetermines the range of prices that the companies are ready to pay for engineering services. The majority of the companies' managers had difficulty in answering this question. This is because these costs are neglected or taken into account in general expenses included in the prime cost, and no separate account is maintained. As far as these costs are not removed from the taxable base, a number of the managers referred to the confidentiality of this information.

On average for all the companies' categories, nearly 45% of the cost of engineering services was related to the payment for work performed in-house, more than 22% was spent on production, testing, installation, and pre-commissioning activities. About 13% was spent on services from third parties; engineering centers could potentially reckon on this amount, provided that orders will be given to them for fulfilment.

The share of new products in the total turnover of the companies in 2015 was more than 40% of the turnover in 27.4% of the companies, while this figure ranges from 6 to 15% in 26.5% of the respondents. A fifth of the companies (20.5%) noted that new products amounted from 15% to 40% in 2015.

Managers of 53.9% of the companies believe that their new technology or product has the potential to enter the international markets, 17.3% of the enterprises believe that their new technology or product does not have such potential, while 28.8% of the respondents do not set this task for their businesses.

The priority development areas of engineering centers, reported by the Ministry of Industry and Trade of the Russian Federation (Methodological materials on the implementation of mechanisms to support activities in the field of engineering and industrial design, 2014), are interdisciplinary in nature, belong to the sector of technological engineering and are a key tool

for the modernization of industrial industries such as automotive, light and textile, metallurgy, oil and gas engineering, agricultural machinery, transport engineering. The survey revealed that 34.3% of the companies have its own equipment and software designed for engineering and/or industrial design in accordance with the defined priorities.

Most often, the enterprises (80.2%) have computer software for engineering activities, 16.0% of the companies use robotics in production, 14.2% – apply composite materials, 12.3% – design and produce machine tools (mostly for the needs of their own production), and 9.4% of the companies use laser technology.

Among computer-aided design systems (CAD), the most commonly used in the companies surveyed are programs for construction engineering (38.7%) rather than for reverse engineering (30.6%) and production-support work (30.7%).

With regard to the software support for engineering design, the most commonly used is AutoCAD – 17.5% of responses. The family of computer-aided design systems "COMPASS" is also frequent – 13.6% of responses. It is followed by SolidEdge – 12.3% of responses, with the largest part in large enterprises – 22.7%, followed by medium-sized enterprises - 10.4%, small - 9.2% and, finally, micro-enterprises - 3.6%.

59.2% of the enterprises use no software products. In large enterprises, this percentage is 24.2% (mainly in subsidiaries of international companies), medium-sized - 37.5%, small - 54.6%, and micro-enterprises - 59.5%. Thus, the possibility of using software products is directly dependent on the size of the enterprise.

A separate set of questions was related to the problems of introducing new products to the market.

The most pressing issue, according to the respondents, is the lack of an effective infrastructure to support innovative small and medium businesses at the stage of entering the market, the transition from research and development work to manufacture - 35.0% of responses (Figure 2).

The lack of effective demand for high-tech projects within the country has been identified as a serious problem for 34.3% of the companies.

The lack of infrastructure for the manufacture of high-quality equipment is an insignificant problem for 26.2% of the enterprises, while for 17.8% this problem is assessed as severe (mainly for small and micro-enterprises, where 75.6% of the respondents reported this problem as severe).

For the objectives of this study, of particular significance were the questions on the severity of the problems "the lack of engineering and industrial design centers in the region" and "the high cost of services of engineering and industrial design centers". The lack of engineering and industrial design centers in the region is not a severe problem – this was the answer of 24.6% of the respondents; only 12.6% of the respondents identified this problem as severe.

The high cost of services of engineering and industrial design centers is also not a problem for 18.8% of the companies, while it was underlined by 19.4% of the respondents.

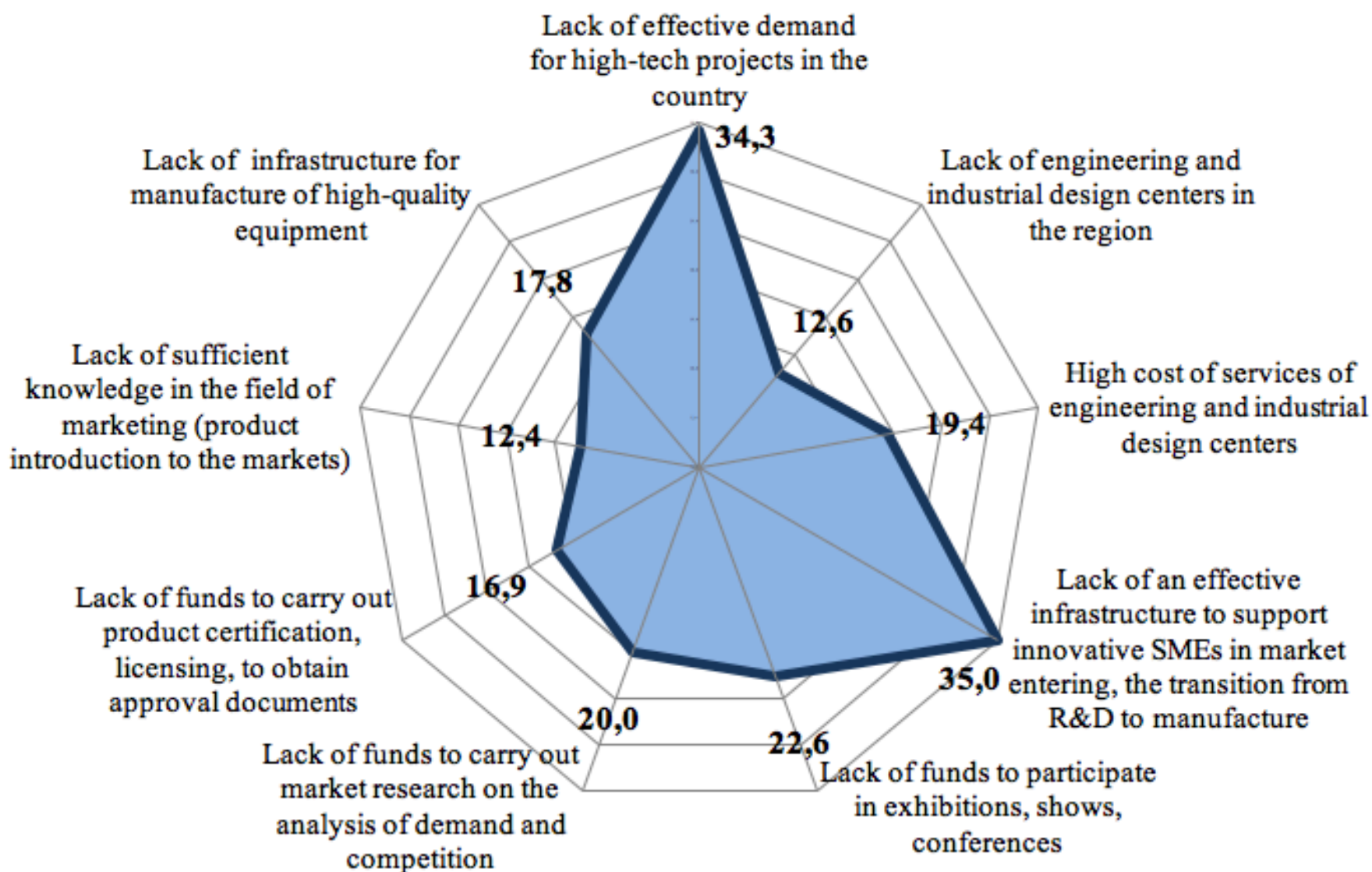


Figure 2. The problem severity in the introduction of new products to the market, %

It should be noted that in the category of severe problems mentioned by the respondents themselves and classified as "other" 83.2% of the companies named:

1. The internal problems of enterprises: lack of working capital; low demand for the products.
2. The external problems: lack of R&D grants for medium-sized enterprises; corruption; lack of support from the state in the introduction of products to the international market; poor performance of SME support programs. The high level of competition (especially on the part of Chinese manufacturers) as well as the lack of demand and potential customers were also mentioned. The respondents also noted the lack of enterprise cooperation in the city, when enterprises bought products, which can be made in the same city, in other regions.

The question about the factors hindering the development of the sphere of engineering services and industrial design in the Republic of Tatarstan implied the selection of several proposed indicators. In general, macro factors were determined that are relevant for the country as a whole and have a significant impact on the economy of the republic and specific enterprises.

An inefficient tax regime and an insufficient amount of internal financial resources hinder development most of all – both factors account for 28.5% of responses. High interest rates/unavailability of long-term loans is the next most popular factor, which accounts for 25.2% of responses.

Similar factors, according to almost a third of the respondents (32.6%), are the uncertain economic environment - 19.7% and the unstable exchange rate policy - 12.9%.

For every fifth respondent (20.7%) the acute barriers include the low level of innovative activity in the real economy sector - 9.4%, and the low level of investment activity - 11.3%.

Also, almost for every fifth company (19.4%) one of the barriers to the development of engineering services is the lack of modern domestic equipment. 14.5% of the respondents

underlined an increase in the prime cost of services provided (metal, utilities), another 12.9% mentioned an increase in energy prices.

The category of "other" included 29.1% of responses, more than half of which (58.9%) were "difficult to answer". The following factors were also mentioned: the lack of experts/competences (5.5% of responses); the incomprehensible government policy and administrative barriers (5.5%); the lack of demand for specific services (4.1%).

Such factors as "pressure from regulatory bodies" and "difficulties in obtaining approval documents" were on the back burner against the background of taxes, interest rates, the lack of working capital, and were marked by the respondents as the least significant (6.5% and 3.2%, respectively).

4. Discussion: general conclusions and recommendations

According to the results of this study, it can be noted that the main problem of the companies surveyed is a significant reduction in demand against the backdrop of rising costs, which generally leads to a fall in profitability. This reduces the possibility of financing new projects and the perspective long-term growth of the companies. Nevertheless, the process of the system integration of engineering services occurs in different industries. For example, for large and medium-sized enterprises general engineering "on a turnkey basis" is available from project design to facility creation and operation.

Demand for engineering services is formed on the strict condition that enterprises develop and bring new products to the market or introduce new technology. More than half of the companies are currently developing innovative products and technologies. In most cases, one can talk about technical implemented innovations with the realization of such criteria of innovation as practical embodiment and commercial feasibility. In most cases, there is a diffusion of innovation in companies (Abramshin et al., 2001) – the proliferation process of already developed and implemented innovations, i.e. the use of innovative products, services and technologies in new places and conditions. Customers forward their final drawings and the design and technological documentation to the enterprise, in which case products are not innovative, but the production of new equipment, tooling, devices as well as the improvement of the technological process is innovative for the enterprise-manufacturer, which increases its economic efficiency.

The list of areas, in which the development of innovative products and technologies in the companies surveyed is carried out, is quite extensive. The process of product diversification as well as output in other industries is also implemented, and the increased use of new materials and technologies is observed.

On average, the share of expenditure on the development and introduction of new products in the total turnover of each of the fifth company is more than 10 percent, the rest are characterized by much less figures. Moreover, 40 percent of businesses did not allocate the costs for the development of new products.

The survey found that a third of the enterprises have their own equipment and software designed for engineering and/or industrial design in accordance with the priorities outlined in government programs.

The categorization of the companies participating in the survey showed that only one in nine companies can be attributed to innovators-leaders of the market, and one in ten - to innovators-followers of the market leaders. About 40 percent belong to the "majority of the market", and 40 percent – to the "lagging" category.

The analysis of the ratio of engineering works carried out by enterprises in partnership with outside organizations showed that every fifth company gives orders for outsourcing, where a significant role is played by the size factor of the company - the larger, the more opportunities for external cooperation. The survey helped identify regions and enterprises in the Russian

Federation, in partnership with which a number of projects in industrial design and engineering are implemented. It should be noted that there is significant unrealized potential for building intra-cooperative relations between enterprises as well as partnerships with outside organizations (including foreign) in the field of engineering and industrial design.

The study collected the supply proposals for the procurement of engineering cluster products by enterprises in the field of mechanical engineering and the automotive industry and organized them by types of equipment: machining, bending, cutting, welding, laser, plasma, casting, painting, measuring, and designed for thermal processing and printing on 3D-printers (additive). As a result of the cross-analysis of the availability of equipment and the demand for similar equipment in other companies, the possibility of establishing an intra-cluster cooperation has been established. For example, the greatest demand is observed for machining, measuring, laser, cutting and bending equipment. The largest supply of underloaded equipment is machining, bending and cutting, heat-treating.

The research revealed the companies' willingness to address shared-use centers: about half of them are ready in the future to apply to the Center for Collective Use (engineering center) on such terms as the acceptable price, speed of order execution, price/quality ratio, availability. The desire for preferential prices, discounts and a reasonable distance from the Centre were also noted. About 40 percent of the respondents categorically refuse to address these centers, the main reason of which is the presence of either their own equipment, or the unwillingness to place the necessary equipment outside their production.

The paper considered the enterprises' demand for establishing cooperative ties: two-thirds are interested in contacts with Russian companies, one-third - with the CIS countries, one enterprise in five - with Western countries.

5. Conclusions

The study identified the main activity problems of existing engineering centers, which include:

- The low awareness among managers of industrial enterprises of existing regional engineering centers, their services and equipment;
- The territorial remoteness of engineering centers from industrial companies;
- The mismatch between the equipment parameters and the requirements of customer enterprises;
- The absence of a system, the fragmentation of services, equipment and technology;
- The lack of quality regularity guarantees, competitive prices, speed of project execution;
- The lack of internal relations between engineering centers, their interdisciplinary interaction, low involvement in international projects;
- The insufficient qualification of specialists of engineering centers, the absence of orientation to search, research, and development;
- Defects in the formation of the price policy;
- The problem of making prototypes for European markets in accordance with European standards, where specialists of engineering centers are not involved in the subject matter of the promising areas of research and development;
- Inefficient tools of the promotion of services and equipment of regional engineering centers.

Together with the business community during the survey the following recommendations have been developed for regional engineering centers:

1. Due to the low awareness among managers of industrial enterprises of existing regional engineering centers, their services and equipment, to develop a program for the promotion of geographically remote industrial companies.
2. To develop effective tools for the promotion of services and equipment of regional

engineering centers. From the managers' point of view, more effective are individual meetings or meetings of experts working under the same category, but not competing with each other, as there are privacy issues in the development and implementation of projects. A free evaluation (technical audit) of narrow problem areas of the enterprise with suggestions how to solve them is also effective.

3. To design strategic development plans of the Regional Centre for Engineering based on the principles of threading, flexibility, and the possibility of re-equipment. To ensure the project regularity, quality, competitive price, and high speed of execution.

4. To develop a system of providing services for presenting the most complete solutions to specific innovative projects in the sector with the aim to overcome fragmentation. To study the possibility of compliance with the chain of engineering activity: consulting-engineering-construction-equipment-management-support of the project.

5. To elaborate the price policy of engineering centers and to introduce customer companies' managers to the peculiarities of payment for services and discounts.

6. To consider the possibility of making prototypes for European markets in accordance with European requirements, to carry out special activities for specialists of operating engineering centers for immersion in the subject matter of promising international research and development areas.

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