HOW DIFFERENT TYPES OF INNOVATION INFLUENCE THE COMPETITIVENESS OF ENGINEERING BUSINESS

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Abstract

This article addresses the ways to increase the competitiveness of the engineering business through the use of different types of innovation. The link between the competitiveness and innovations seems to be frequently mentioned among engineering companies. It is not surprising, since the engineering activity is one of the fast growing areas in the economies of developed countries. On the other hand, the specific nature of innovations in engineering is still not sufficiently covered in scientific publications. One relatively unexplored question is to what degree various types of innovation determine the competitiveness of engineering projects. The aim of this study was to identify to what degree the use of different types of innovation influences the level of competitiveness in the engineering business. In this article, the authors improve the definitions of engineering as a kind of intellectual activity; reveal the role and types of innovations observed in this field. The authors also show the role of a customer in the selection of innovations for engineering services. The authors conducted a field research and collected the answers from the representatives of engineering companies in Russia.

Keywords: innovations, innovation-oriented companies, engineering business, competiveness.

JEL code: M310, M290

Introduction

The concept of engineering and its role in economic development is revealed in multiple studies conducted by Russian and international scholars (see Chuprin, 2008; Fernandez Stark, 2010; FIDIC – EFCA, 2013; Gohberg, 2016). In this article we refer to the engineering as comprehensive professional intellectual activity of scientific and technical nature carried out in connection with the development and further operation of industrial and infrastructure projects aimed at delivering the best possible results to customers who invest in those industrial or infrastructure projects. The essential characteristics of engineering innovations have been identified based on the analysis of the main features of intelligent activity. The list of such innovations includes co-production (Gassmann, 2007), individualization (Hertog, 2000), technological level (Miles, 2012), as well as so called customer's thesaurus of engineering services.

Co-production involves the active mutual participation of the supplier and the customer in the process of creating the final product. In the production of a technically complex engineering products, the nature of co-production is determined by the stage at which the customer is involved in the project: the stage of researching the customer's needs; the stage of finding technological solutions; the stage of production of the engineering object; the stage of operation of the new facility.

The concept of individualization in engineering differs from the similar concept on other markets. The authors propose the following levels of individualization in the engineering projects: 1) a unique engineering product tailored for a specific customer; 2) the engineering product which is modified for each customer, but presumes the use of standard components; 3) the case when an engineering company helps the customer to formulate needs in order to accurately determine the combination of the engineering services provided; 4) the case when the customer independently selects the combination of required engineering services.

The technological level of engineering services in this study is referred to as the full use of required scientific and technical knowledge, technologies and equipment. This concept can be further identified by the following markers: 1) when R&D is conducted during the production of the engineering product; 2) when the latest technical achievements are used in the industry; 3) when preliminary patent studies are conducted to locate available technical solutions; 4) when the engineering services are provided by the specialists with a high level of professional engineering education.

Engineering innovations might not be understood by the customer to a full extent. This barrier shall be taken into account on the basis of the client's competence level. The competence level (or, in other words, thesaurus) of the customer means the potential readiness for innovations in terms of the ability to use the results of engineering services (see Molchanov, Muraveva, 2013). It can be described in the following terms: 1) customers are capable to take part in the development of the engineering innovation; 2) the level of technological equipment used by customers is sufficient for the correct use of the engineering innovation; 3) the level of qualification of the customer's personnel is sufficient for the correct use of the engineering innovation; 4) the use of the engineering innovations by customers increases their need for their own innovation activity.

Methodology

The goal of this empirical study is to measure the impact of the aforementioned factors on the type of innovations in the engineering projects, as well as to determine the influence of the type of innovations on the overall competitiveness of the engineering business. To achieve this goal we used empirical research methods. The authors conducted a survey of 46 representatives of various engineering companies operating in Russia. Their characteristics are presented in table below. The data was processed using the IBM SPSS Statistics Ver 23.0. The analysis was performed using the following statistical methods: frequency analysis, Spearman rank correlation. The choice of methods for statistical processing was determined by the fact that qualitative data of rank orientation were analyzed. According to the criteria of the number of employees, types of engineering services, the number of years the company operates on the engineering market (Table 1), the research used diversified data describing the real market situation on the Russian market.

Table 1. Data on the sample of engineering companies

Number of employees	Number of engineering firms	Share of engineering firms (%)
≤ 15	7	15.2
16-100 people	26	56.5
101-250 people	9	19.6
> 250	4	8.7
Areas of engineering		
Consulting	17	37
Construction	11	23.9
Technological	13	28.3

Complex	5	10.9
Age of the company		
Less than 3 years	3	6.5
From 3 to 5 years	6	13.0
From 5 to 10 years	20	43.5
More than 10 years	17	37.0

Source: created by the authors.

To achieve the goal of the study the authors suggested the following hypotheses. 1. The more customers are involved in the co-production of engineering services, the more innovative the projects are. 2. The higher the level of individualization of engineering services, the more innovative they are. 3. The higher the technological level of engineering services, the more innovative they are. 4. The higher the competency level of the customer, the more innovative engineering services are. 5. The more innovative engineering services are, the higher the level of competitiveness of the engineering business is.

We graphically present the general logic of the correlation analysis of the collected empirical data in the Figure 1.

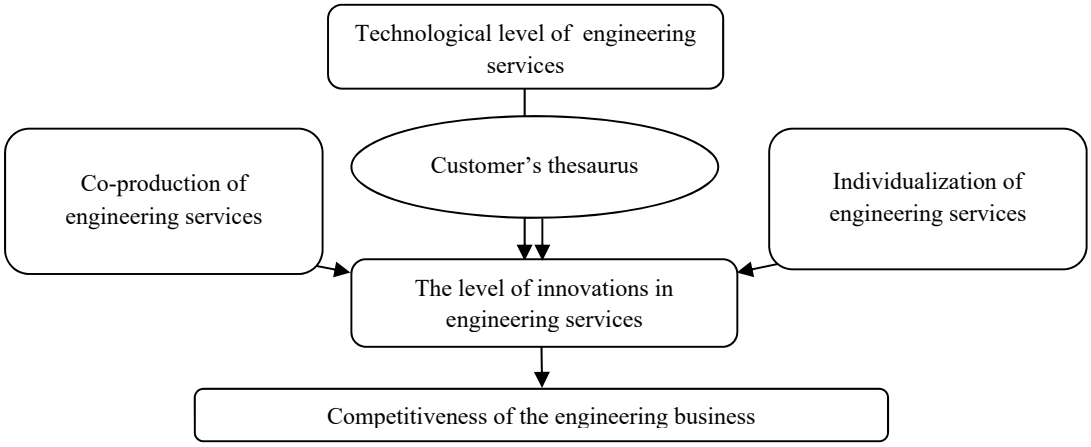

Figure 1. General scheme of the research and the suggested hypotheses
Source: created by the authors.

Research

Based on the suggested hypotheses and the graphical scheme presented we analyzed the obtained empirical results.

Hypothesis 1. The more customers are involved in the co-production of engineering services, the more innovative those engineering services are (Table 2).

Table 2. The nature of co-production of engineering services with customers vs. the nature of innovations in engineering services

	Product Innovations	Process Innovations	Marketing Innovations	Organizational Innovations
Our customers are involved in co-production of engineering services at the stage of determining the needs of this customer	0.136	0.292	0.085	0.453 **

Our customers are involved in co-production of engineering services at the stage of technological search for a solution that meets the requirements of this customer	0.084	-0.026	0.215	0.289
Our customers are involved in co-production of engineering services at the production stage	-0.212	-0.101	-0.218	0.180
Our customers are involved in co-production of engineering services during the operation phase of the facility	-0.231	-0.273	-0.184	0.064

Source: created by the authors.

(Here and hereafter, a single asterisk (*) indicates the presence of a weak link; two asterisks(**) - meaningful link between the search engines)

Some publications mention a positive relationship between the degree of customer involvement in the process of co-production of services and innovative level of those services (see Vargo, 2004; Doroshenko, 2011).

A significant relationship is found only between co-production at the stage of determining customer's needs and the implementation of organizational innovations (that increases overall innovation activity). In all other cases, the link is rather weak. It can be concluded that the nature of co-production practically does not affect the innovative level of engineering services in this sample. Nevertheless, joint production of services implies a higher level of customization of the obtained results.

Hypothesis 2. The higher the level of individualization of engineering services is, the more innovative engineering services are (Table 3).

Table 3. The level of individualization vs. the nature of innovations in engineering services

	Product Innovations	Process Innovations	Marketing Innovations	Organizational Innovations
Our company implements a unique engineering product based on unique components, initially created for a specific customer	0.453 **	0,468 **	0,399 **	0.179
The engineering product created by us is modified for each customer, but it is created on the basis of standard components	-0.486 **	-0,243	0.144	0.453 **
We help the customer to formulate needs in order to accurately determine the combination of the engineering services provided	-0.044	0.097	0,158	0.366 *
The customer chooses the combination of provided engineering services	-0.240	0.021	-0.068	0.250

Source: created by the authors.

The authors paid attention to the following. First, the maximum number of positive responses corresponds to the creation of a unique engineering product based on unique components through the range of all types of innovations. Second, the negative relationship between the modified products based on standard components and product innovations is clearly visible.

Hypothesis 3. The higher the level of technology in engineering services is, the more innovative engineering services are (Table 4).

Table 4. The technological level of engineering services vs. the nature of innovations in engineering services

	Product Innovations	Process Innovations	Marketing Innovations	Organizational Innovations
To provide engineering services, we conduct preliminary R&D	0.597 **	0.517 **	0.265	0.045
When providing engineering services, we use the latest technical achievements in the industry	0.502 **	0.510 **	0.404 **	-0.033
To provide engineering services, we conduct patent studies	0.588 **	0.377 **	0.180	-0,024
Engineering services are provided by specialists with high level of engineering education	0.249	0.313 *	0.180	0.022

Source: created by the authors.

The data of paired correlations demonstrates a close relationship between the R&D performed, usage of the latest technical achievements, implementation of patent researches, and introduction of product, process, and organizational innovations. Two more facts have attracted our attention: first, a high level of specialists with engineering education correlates with process innovations; second, the use of the latest achievements in the industry influences the implementation of marketing innovations.

Hypothesis 4. The higher the competency level of the customer is, the more innovative engineering services are (Table 5).

Table 5. The competency level of the customer vs. the nature of innovations in engineering services

	Product Innovations	Process Innovations	Marketing Innovations	Organizational Innovations
Our customers are competent enough to participate in the development of engineering innovation	0.055	0.085	0.041	0.348 *
The level of technological equipment of customers is sufficient for the correct use of the results of engineering services	-0.067	0.203	0.105	0.278
The level of qualification of the customer's personnel is sufficient for the correct use of the results of engineering services	-0.112	-0.023	0.190	0.215
The use of engineering services by customers increases the need for their own innovation activity	0.358 *	0.297 *	0.035	0.131

Source: created by the authors.

Positive weak connections are observed between the participation of customers in the development of innovations and organizational innovations, as well as between the increased need of customers for innovation and product and process innovations.

The following hypothesis reflects the impact of different types of innovation in engineering on the competitiveness of engineering businesses.

Hypothesis 5. The more innovative engineering services are, the higher the level of competitiveness of engineering business is (Table 6).

The data presented in the table reflects that the competitiveness of engineering business is mostly affected by the product and process innovations. At the same time, an increase in the innovation level resulting from organizational innovations can negatively affect the implementation of services given the target profitability. Perhaps this could be explained by the incorrect implementation of organizational innovations. We also must admit that our study has not fully confirmed the suggested hypotheses.

Table 6. The nature of innovations in engineering services vs. the level of competitiveness of engineering business

	The company provides engineering services with the desired profitability	When a company participates in a contest for a government contract, it wins it	Disagreements with the customer are resolved through negotiations	The company fully fulfills its obligations to the customer
Product Innovations	0.329 *	0.338 *	0.384 **	0.333 **
Process Innovations	0.205	0.197	0.234	0.134
Marketing Innovations	0.135	0.091	0.078	0.193
Organizational Innovations	-0.249	0.109	0.068	-0.014

Source: created by the authors.

Within the framework of this study the authors also identified additional factors that influence the customer's decision to choose a supplier of engineering services. For this purpose we suggest a two-level model of competitiveness of engineering business. In our approach we use two sets of parameters that reflect competitive advantages – technical and operational parameters (their high values can only be achieved by the technological innovations) and marketing parameters (their values are determined by the marketing and organizational innovations). The level of innovations in engineering services is the basic factor affecting the competitiveness of engineering business. According to the latest data, about half of consumers need non-standard engineering solutions; the other half is interested in the lowest possible price, which can be achieved, for example, by the implementing of process innovations (Gohberg, 2016). In the engineering services, the level of technological innovations is reflected in the values of the technical and operational characteristics that should be higher than the similar values of the competitors.

In the framework of the M. Porter's diamond competitiveness concept modified by S.V. Valdaytsev to the enterprise-level, one of the factors affecting the company's innovativeness and, consequently, its competitiveness is demanding customers. We first need to determine what customers usually expect from engineering services. To identify the internal factors of engineering service competitiveness which are significant for consumers, we conducted a survey of the customers and the suppliers of engineering services. We wanted to find the criteria used by the customers for selecting a supplier of engineering services. Also we wanted to find out how engineering firms could manage their competitiveness. We put our finding in the Table 7 along with some comments to each parameter explaining its decision-making implication.

Table 7. The list of parameters of engineering services affecting the customer's choice of supplier

Parameter	Implication for Decision-Making
1. Availability of all necessary licenses and certificates	For most contracts, this condition could be a normative parameter; in case of non-compliance, the conclusion of a contract for engineering services will not take place
2. Customer-oriented approach	Consideration of specific requirements of a particular customer, customization of the services provided; services from a position of loyal attitude to the customer
3. Maximum quality	Even with a "low price" it is important to ensure that the quality of services offered is higher than that of the competitors
4. High level of service during the warranty and post-warranty period	Before signing the contract it is important to have the firm evidence of high quality of extended service for the engineering product
5. Place of origin of the equipment and spare parts	The reputation of the manufacturer of the equipment and spare parts influences the decision on signing the contract
6. Innovative solutions	This factor is important in the case of the customer's needs in a unique engineering product
7. Extended warranty period and trouble-free operation of the facility after the service is rendered	If the warranty period is longer than that of the competitors or what is required by law, it proves the highest quality, and even in the case of additional services needed, saves customer's costs
8. Business reputation of the engineering firm	Positive image and reputation as well as presence of a recognizable brand help to position the provider of engineering services in comparison to competitors
9. The number of successfully fulfilled contracts	This number, especially if the firm already has a portfolio of completed contracts, positively affects the credibility of the company
10. High rating of the company on the market	This factor is obviously related to the image and the number of successfully completed contracts; at the same time it is another dimension of trust, when the rating agency gives the company a top ranking
11. Commitment to declared terms and fulfillment of all obligations in time	The customer can assess the probability of keeping the terms and schedules under control based on the previous contracts
12. Presence of unique specialists (smart angels)	For some contracts, this factor can become a normative parameter, just like the availability of necessary licenses and certificates
13. Smooth and conflict-free cooperation, absence of complains and claims	Along with the number of successfully completed orders the absence of claims from other customers also has a positive impact on the customer's decision to participate in the transaction
14. Flexible terms of payment	Flexible pricing system increases the level of competitiveness of engineering services
15. The costs of consumption	Costs of operation for the engineering object; the lower the costs are, the more attractive the engineering product is
16. Optimum price	The optimal price for the customer and engineering firms helps to facilitate the deal

Source: suggested by the authors.

The parameters listed in the Table 7 can be divided into separate layers: the basement layer and the reinforcement layer, or primary and secondary levels of customer needs. The primary level consists of those parameters that define the technical-operational characteristics of the engineering innovations. Among them there are the maximal quality and innovative engineering solutions. The reinforcement layer consists of market parameters relevant to the customer, which may be recorded in physical units or points. Among them there are the following parameters: customer-oriented approach, the place of origin and the manufacturer of the equipment, the period of trouble-free operation of the object, the image and reputation of

subcontractors, the duration of the entire range of services and its separate stages, the absence of complains and claims to the engineering firm and its subcontractors, the presence of smart angels employed by the supplier, the rating of the engineering company, the number of successfully implemented similar engineering projects, the warranty period and prompt troubleshooting. Another parameter from the Table 7 requires special comments. Despite the fact that the availability of all necessary licenses and certificates was named by the respondents as one of the factors influencing the competitiveness of the engineering service, this requirement should be considered as normative and mandatory for all engineering services. If the required license or certificate is missing, the service cannot be provided, therefore, it is ultimately uncompetitive.

The central element of the proposed model of engineering innovations contains co-production, technology level, individualization of services and customer thesaurus. However, the innovative factor needs to be reinforced by the group of marketing parameters relevant for each particular consumer of engineering innovations (Figure 2). A customer's satisfaction with two levels of parameters – technical and operational (basic level), which are based on engineering innovation, and a group of marketing parameters (level of reinforcement) – increases the probability of signing the contract with the engineering firm.

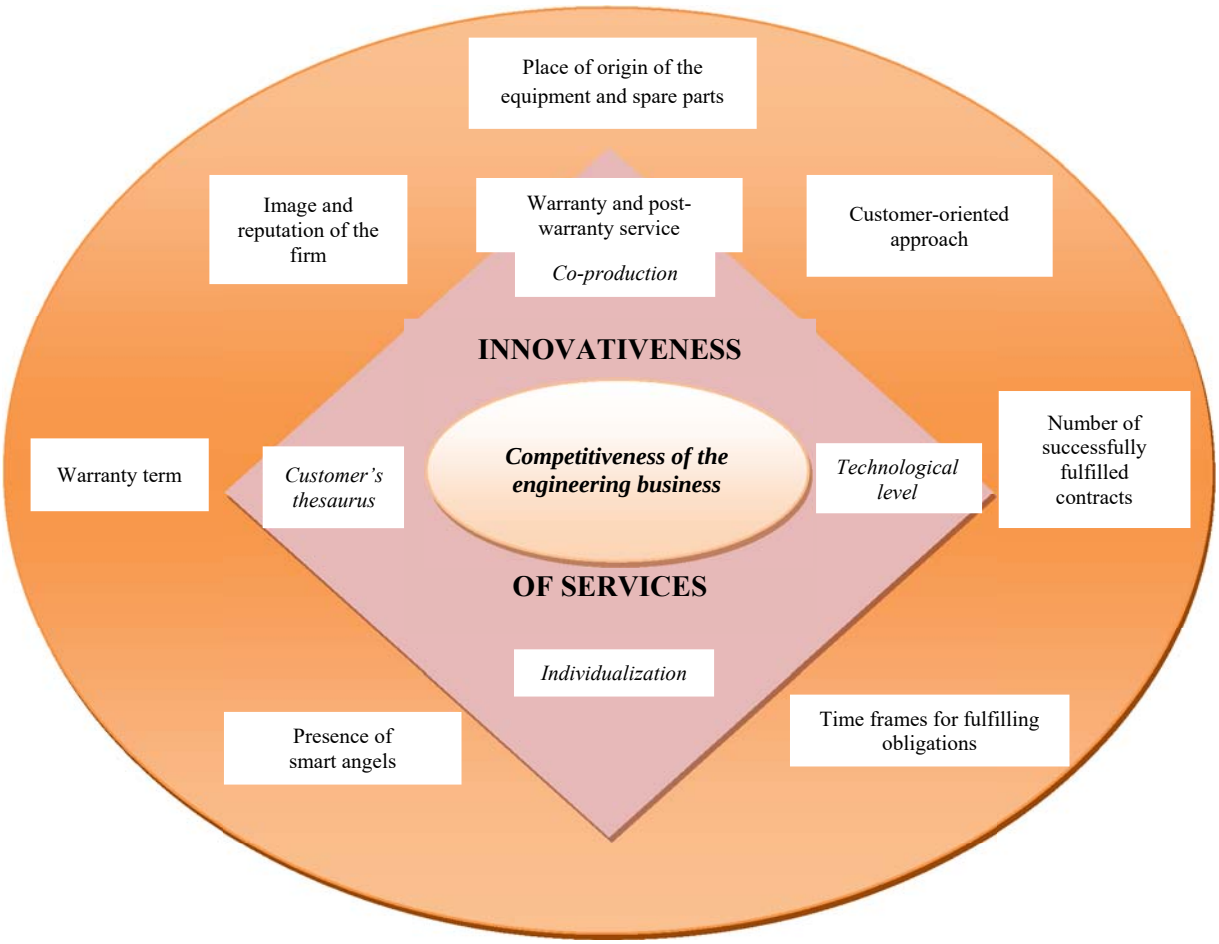

Figure 2. The model of engineering business competitiveness
Source: suggested by the authors.

This model proposed by the authors represents the purchasing behavior of customers when choosing an engineering company. It takes into account the characteristics that determine

the innovative engineering solutions, as well as a group of ancillary factors influencing the competitiveness of the engineering business.

Conclusion

It the way of conclusion we mention the following:

- Analysis of the empirical data of engineering companies showed that the nature of innovations is mainly reflected in product and process innovations. They also affect the overall quality, that is the technical and operational characteristics of the engineering product, being a necessary, but not a determining factor in the competitiveness of engineering business.
- The nature of innovations in engineering is weakly determined by the stage of co-production of the product and significantly determined by the level of individualization and technological level of engineering services; at the same time, the competence level of the customer does not produce any effect on the nature of innovations.
- The level of competitiveness of engineering business is mostly influenced by engineering services that involve product or process innovations; marketing innovations also have some influence on the level of competitiveness, while the implementation of organizational innovations has rather negative impact on the level of competitiveness of engineering business.
- The model of engineering business competitiveness represents the purchasing behavior of customers when choosing an engineering company and takes into account determine and ancillary factors.

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