



Digital Product Pricing Algorithm Development

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Abstract—This study discusses the problem of pricing digital products related to the specifics of their creation, promotion and implementation. There is a lack of research on the development of pricing methods for digital products. The authors analyze the classical pricing approaches such as cost approach, profitable (parametric) and comparative approach. Based on this analysis authors highlight advantages and disadvantages for applying these approaches to digital products and the factors influencing pricing digital products. Taking into account the features of the digital products implementation, an algorithm for their pricing is proposed. Due to considered internal and external factors for the IT-product price evaluating six stages of digital products pricing are developed. The algorithm proposed by the authors can be used to develop a digital product pricing tool for companies or projects in the early stages of development.

Keywords—pricing, digital product, pricing algorithm, costs, value formation, pricing policy.

I. INTRODUCTION

In the context of transition to digital economy the share of gross domestic product (GDP) that is formed on the basis of digital products is increasing. The authors of the road map for ensuring sustainable economic growth of non-resource-based sector of Russian economy affirm that the share of digital sector in GDP will increase up to 5% by 2025. At the same time, the new technologies penetrate into all the spheres of economic life, accelerating the digital transformation of business, which, in its turn, shifts the points of value creation.

The problems of pricing for digital products, at any rate, are related to the difficulty of defining the factors, affecting the choice of the most real product price.

«Digital products» (hereinafter referred to as DP) are goods, works and services that are directly involving information handling and are realized using information systems and/or programs — everything that is created, developed and consumed in a digital environment.

From the point of view of theoretical economics digital products are public or collective goods which are provided privately [1]. The ways to supply these goods determine their particular features and immediacy of the problem of their pricing. In other words, it is not the manufacturing costs, but rather the transaction costs that prevail in the structure of the prime cost of DP, which means the channels of product delivery to the consumer.

In the article [2], digital products are divided into three groups based on the characteristics of their production and consumption: 1) products in a digital form that do not

have a material prototype (for example, software, electronic books, films) or material copies. These products have the same value, which is different for different consumers (for example when one buys a cinema ticket or watches a film on a pirate web site); 2) digital copies of conventional products that retain the functional qualities of their prototypes (for example, copies of films that were originally shot materially, digitized books or works of art). These products are often of lower value than the original; 3) digital representations of conventional products that allow more efficient control of the consumption of the prototype product (for example, Uber, Airbnb, Booking). Each car (in the case of Uber) or apartments (in the case of Airbnb) corresponds to its digital image, which allows to optimize the process of using the service.

It should be noted that all three groups of digital products are characterized by the costs representing the losses from such negative phenomena as piracy, copyright and related rights protection, investment return into protected content and spreading of undesirable information, as well as additional tax assessment, installation of additional equipment for collecting information on the Internet users, etc. [2, 3].

The main problem of the majority of high tech companies (company group Speech Technology Center, AO Fiber-optic systems, etc.), working with development and maintaining of digital products, currently is the absence of a flexible methodology of a digital product pricing. Most often these companies use the methods, that have no way to objectively assess the price of such products as software, music, e-books, developments, web-design elements, as well as different design and architecture projects etc. The company management often makes a decision based on how much the customers are ready to pay, which does not seem to be a completely valid method [2]. Therefore, the main objective of this article is to create a more optimal and flexible methodology of pricing for digital products.

II. METHODS

At present there is a vast variety of pricing methods [4]. Three main approaches to pricing of products are: cost-based, income-based (value-based, parametric) and comparative (market-based).

The cost-based approach, or pricing based on prime cost (derived from the English cost-based pricing), involves the addition of an extra charge to production

costs on the product [5, 6]. This approach is very common and is used both in wholesale and retail sales, however, when creating and launching an innovative product on the market, this approach is not always optimal due to the specific character of the product.

There are three main methods within the framework of the cost-based approach: the cost plus method, the break-even method and the direct cost method. The first method means calculating the cost of a product by adding a certain amount of profit to the current unit costs. The calculation can be made according to the formula (1):

$$Price = C(1 + R/100), \quad (1)$$

where Price – selling price; C – total costs per production unit; R – expected (normative) rate of return.

However, the fact that the product demand and competition on the market are not taken into account is a shortcoming of this method.

The method, based on the break-even analysis, estimates the level of sales necessary for an organization to receive target profit. The basis of the second method is the calculation according to formula (2).

$$Profit = Price \times S - (FC + VC \times S), \quad (2)$$

where Profit – profit for period; Price – price of product / service; S – sales volume; FC – fixed costs; VC – variable costs.

The direct cost method determines the price as the sum of variable costs and anticipated profit.

According to the income-based approach, pricing is based on the utility of the product and purchasing power. In a particular case, according to this approach, production costs can be reflected through the rate of profitability and financial result [7, page 463]. The income-based approach includes a group of parametric pricing methods, namely: the method of relative indicators, assembly method and score method.

The method of relative indicators allows determining the price of similar products based on one common parameter, the change of which determines the price of the product. But this method is not suitable for products that have several characteristics determining the price; moreover it does not take into account market and consumer aspects or overlooks the demand for goods.

The assembly method is used for products consisting of separate products or standard components. When this method is used, the price includes the sum of the prices of the separate structural parts of the products with the addition of the cost of new parts and standard profit.

The score method uses expert appraisal in the form of scores for certain significant parameters of the basic and new products. Adding together these scores allows making an assessment of the technical and economic and market level of the product. The advantage of this method is the ability to give a qualitative assessment of parameters that cannot be quantified (taste, fashion, etc.).

However, a group of parametric methods is used for products that complement or expand the product line. In addition, this method does not take into account the demand for the product.

The essence of the income-based approach consists in managing the demand of consumers of products and

services based on the formation and transformation of needs. A modern fact of the Russian DP market is the submission of manufacturers to the sphere of circulation, what we can see, analyzing the structure of Russian GDP, based on production volumes (2014, 2017 and 2018), which in its turn is determined by the level of quality of technology development that can produce absolutely any product based on knowledge of needs [8, page 23], [9]. The income-based approach can be defined as a base for forming the value of needs of direct buyers and their ability to purchase specific products (for example asset assessment of AO RVC (Russian venture company) or AO Rosnano etc.)

A comparative approach sets in motion a group of market methods of product pricing, when pricing is based on an analysis of various factors, taking into account the elasticity of demand and the value perception of products by the buyer. The group of market methods includes: the method of perceived value, the method of price barriers, the method of pricing based on competitors.

The method of perceived value consists in studying the consumer's perception of the price of a product through, for example, a focus group and establishing an acceptable level of price. The method of price barriers establishes the price of a product according to the identified price clusters, which the consumer creates based on the quality of the product and the product image component, for example, “cheap”, “common”, “expensive” and “elite”. The method of pricing based on competitors uses the analysis and comparison of the power of differentiation of the organization's products with competitors. This takes into account the competitive situation in a one particular market and the competitive position of the company itself.

The comparative approach takes into account factors that adversely affect product pricing. For example, the market value of an analogue product (cost from competitors) or the extra charge of the project initiators are taken into account, but the purchasing power of the consumer is not considered. Thus, this method can exclude the desired part of the target audience.

At present, the final evaluation of price of the enterprise's digital products is performed using the main approaches given above [10, 11, 12] Main advantages and disadvantages of each of the approaches are given in the table I [13, page 71-72].

TABLE I. DESCRIPTION OF APPROACHES TO PRICING AND PRICING METHODS

Pricing Approach	Pricing Methods	Disadvantages	Advantages
Cost approach	- a break-even method; - direct cost method; - the “cost plus” method.	- the difficulty of calculating the exact price of high-tech products, since most of its cost is R&D; - it does not take into account competition and the goods quality level.	- establishment of an upper price limit; - ease of calculation (if there is available information of R&D costs per unit of goods.
Profitable (parametric) approach	- point method; - aggregate method; - method of specific indicators.	- application of the approach is advisable only if all risks are calculated; - a group of parametric methods is used not for a new	- pricing may include R&D costs for the period of effective use of a high-tech product;

		product, but for a product that complements or extends the product line; - the upper price limit may not satisfy the customer.	- allows you to take into account the expected financial income from the use of a high-tech product.
Comparative approach	- a competitor-based pricing method; - method of price barriers; - method of perceived value; - demand-oriented method.	- it is applicable to a high-tech product only if competitors are present on the market, that is, goods of the same parametric series.	- it is a generalizing method and most accurately characterizing the product group.

Source: developed by authors

Thus, it can be noted that when introducing a new digital product to the market, it is necessary to consider specific factors related to the characteristics of the external and internal environments of the organization, and also to develop pricing policies and strategy in advance.

The pricing process in the digital products and services market, without doubt, has some particular features that are only characteristic to this kind of market. As a whole the method for determining an optimal price for information product as an object of purchase and sale from the point of view of the manufacturing enterprise can be presented in a form of several successive stages (see Table II).

TABLE II. ALGORITHM FOR DETERMINING THE PRICE OF AN IT-PRODUCT

1 stage. Identification and analysis of pricing factors for the product	2 stage. Setting the goal of determining the product value	3 stage. Choosing a pricing method for a base product value
4 stage. A company's pricing strategy formation	5 stage. Adjustment of the product value according to the conditions dictated by the market	6 stage. Pricing insurance against external factors

Source: developed by authors based on [14]

At the initial stage it is necessary to find out the pricing factors, which influence the price of information product that the company wants to bring to the market. They can be divided into several groups: environment, demand, consumer choice, offers an alternative manufacturing capabilities [14, pages 127-129], [15]. The table III describes the prime cost factors that influence the DP price.

TABLE III. GROUPS OF PRIME COST FACTORS

Environmental Factors	Factors Determining Product Demand	Consumer Choice Factors	Supply Factors	Alternative Manufacturing Opportunities
the influence of the state	the level of buyer's savings on the purchase	the possibility of replacing the	the ratio of the volumes of the product, which is supposed to	the volume of products produced

	of the product	manufacturer's product with a competitor's product	be brought to the market by the manufacturer and other suppliers	on the additional production line in relation to the main activity
stakeholder influence	product quality characteristics, for example, accessibility, brand reputation	structure of prospective consumers needs	costs of production and circulation when selling the product on the market	other factors
promoting channels for a product	solvent customer demand for a particular product	possibility of comparing producer and competitor products	cost of production factors and human resources, which are necessary for the product release	
general state of the country's economy	useful properties of the product (product's ability to satisfy needs)	comparison of markets for similar products, for example, markets for printed and electronic books	various taxes, duties, excise stamps and other payments deducted to state funds	

Source: developed by authors based on [14], [15], [16]

Factors of environment reflect the impact of external conditions on doing business. Factors of demand determine the price for the product that the buyer suggests. Describing the third factor, it is worth noting its significant role in determining the competitiveness of a product in the market of analogue products. Factors of offer primarily determine the cost of the product that the seller wants to have. Alternative manufacturing capabilities characterize the quantity of another product, the manufacturing of which had to be stopped, in order to manufacture an additional unit of product.

However, in practice, organizations most often focus on several key factors when they form pricing policies: costs, profits, competitors, public opinion and product value. Whereas it is necessary to take into account both external and internal factors for assessing the value, the classification of which is shown in table IV [17, c. 116].

TABLE IV. INTERNAL AND EXTERNAL FACTORS FOR EVALUATING THE PRICE OF AN IT-PRODUCT

External factors	Internal factors
<ol style="list-style-type: none"> 1. Consumer income; 2. The factor of state regulation of product pricing; 3. The level of competition; 4. The degree of infrastructure development; 5. The possibility of price discrimination of buyers; 6. The level of innovative culture; 7. The pace of development of related industries - consumers of information products; 8. The technological level of production in the country; 9. The level of freedom of the economy; 10. The level of distribution of counterfeit products. 	<ol style="list-style-type: none"> 1. The degree of the goods conformity to individual consumer expectations; 2. The cost price of production and distribution of goods; 3. Pricing policy of the company; 4. Life cycle stage of the product; 5. Production facilities that determine the minimum required production volume; 6. The amount of advanced capital and the level of qualification of the workforce; 7. The ability to access additional sources of funding.

Socio-demographic and technological trends in the digitalization of the economy and the business community, which have a greater impact on the creation of conditions for the digital transformation of enterprises, determine the common system of internal and external factors. In their turn, these factors influence the process of transition from one principle of doing business and evaluating the company products to a new mechanism, which is the most transparent and has the highest quality.

III. RESULTS

Yu. I. Gribov identified the factors of the environment that limit the ability to conduct a quality evaluation of the cost of DP: state regulation, technologies and competition; resources, human factor, psychological and organizational barriers [18, page 258].

According to this classification we can identify: a) a state barrier including economical uncertainty and volatility of ruble, as well as normative limitations and absence of a list of standards for digital products usage and pricing; b) technological obstacles, such as lack of solutions in the field of pricing of digital products, that would take into account technological effectiveness, innovativeness of the digital products, as well as a low level of security of digital technologies [19]; c) resource barriers (monetary funds, materials, people and knowledge) that affect an artificial overpricing of a product, which has a negative effect on its sales; d) human factor that includes a lack of qualification of the employees, who form the value of a digital product. Thus, for the most clear and correct pricing for a digital product, an algorithm for calculating the price should be formed taking into account the expanded set of prime cost factors and factors of environment.

As the first stage we propose an evaluation of all the costs that make part of the process of a digital product creation, taking into account several limitations which are inherent to every separate case. The examples of calculation of costs for digital solutions can be found in the works of B.F. Bariev, S.K. Tokaev and A.V. Alborov, as well as Yu.A. Grunichev [20, 21, 22]. As a result of the first stage we will determine the minimum price of a digital product (MP). At the second stage we will find a minimal acceptable price (MPD), which is formed based on the value of the minimum product price (MP) and the distributed minimum income from low-risk investments (D). At the third stage we make a forecasting of the expected demand for the product, taking into account the potential decline in demand due to the possible emergence of substitute products and the non-linear growth in the number of customers. To do this we must consider two factors as a basis: a stage of the product life cycle and the level of competition. These factors are quite provisional, because they largely depend on the product marketing and must be determined separately for each case [23, 24]. At the fourth stage we determine the level of a minimum acceptable income of company from the digital product realization (MPC), that will satisfy the requirements of the company to development and realization profitability, based on the company price policy. At this stage it is evident that $MPC > MPD$, according to the definitions of the variables given above. At the fifth stage we establish the final product price (PRC) by finding out the maximum product price, which the consumer will be ready to pay for

the digital product taking into account the incomes of consumers (CP). PRC is defined as the average between MPD and CP. In case if MPD is higher than PRC it is necessary to calculate a possible costs reduction. At the sixth stage we perform analysis of competitors and calculate an average price throughout the market among the direct competitors (PC). At the same time PRC should be commensurate with PC, because if $PC < PRC$, there will be a difficulty to sell the product due to an unfavorable position on the market, whereas in case of an opposite situation ($PC > PRC$) there will be short-received profits, which is a contradiction for the company.

Consequently, the formula for calculating the price of a digital product will comprise several variables, such as the minimum price, the minimum acceptable price, the minimum acceptable income from realization, the highest possible price, as well as the average price throughout the market and the coefficient of decline in demand for a particular product. The relationship between the variables may vary due to different pricing policies of companies and due to the market conditions [25, 26].

IV. DISCUSSION

When performing pricing for a digital product both the internal and external factors of the environment should be considered. The algorithm of digital product pricing received as a result of our research can be used for the initial selection of the price of the product of companies operating in the IT market and, in case of absence of a rigid mechanism of state regulation of prices, it can be also used for products of a similar type. After determining the initial price, the price can vary during the product life cycle to achieve market equilibrium and the best sales figures.

The results of this paper will become a foundation for development of a digital product pricing method, which, when it is automated, will provide an instrument for managing the development of small and medium-sized businesses in the field of ICT.

REFERENCES

- [1] Demsetz, H. (1970). "The Private Production of Public Goods", *Journal of Law and Economics*. – vol. 13. – pg. 293–306.
- [2] Kozyrev A. N. Digital products and digital transformation of business / CEMI-RAS Central Economics and Mathematics Institute of CEMI // URL: <https://medium.com/cemi-ras/digital-products-digital-transformation-business-b67c585e4875> (accessed February 10, 2020)
- [3] Hui K. L., Chau P. Y. K. Classifying digital products // *Communications of the ACM*. – 2002. – vol. 45. – No. 6. – pg. 73-79.
- [4] Kryuchkova O. N., Popov E. V. Classification of pricing methods // *Marketing in Russia and abroad*. - 2002. - vol. 4. - pg. 32-53.
- [5] Banker R. D., Hansen S. C. The adequacy of full-cost-based pricing heuristics // *Journal of Management Accounting Research*. – 2002. – vol. 14. – No. 1. – pg. 33-58.
- [6] Shin J., Sudhir K., Yoon D. H. When to "fire" customers: Customer cost-based pricing // *Management Science*. – 2012. – vol. 58. – No. 5. – pg. 932-947.
- [7] Gurina, E.V. Modern approaches to pricing / E.V. Gurina, A. A. Sologub, A. A. Ruban // *Instrument-making-2018: materials of the 11th International Scientific and Technical Conference, November 14-16 2018, Minsk, Republic of Belarus / editorial board: O.K. Gusev (chairman) [et al.]*. - Minsk: BNTU, 2018. - pg. 463-465.
- [8] Burykin A. D. Value approach in pricing // *Modern trends in the development of science and technology*. - 2017. - No. 3(13). - pg. 23-25.
- [9] Bulletin of current trends in the Russian economy. Dynamics and structure of Russia's GDP. // Analytical Center under the Government of the Russian Federation. - Electronic document. / URL: <https://ac.gov.ru/files/publication/a/21974.pdf> (accessed: 12.29.2019)
- [10] Krishnan T. V., Bass F. M., Jain D. C. Optimal pricing strategy for new products // *Management Science*. – 1999. – vol. 45. – No. 12. – pg. 1650-1663.

- [11] Hinterhuber A., Liozu S. Is it time to rethink your pricing strategy? // MIT Sloan management review. – 2012. – vol. 53. – No. 4. – C. 69.
- [12] Nylén D., Holmström J. Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation // Business Horizons. – 2015. – vol. 58. – №. 1. – pg. 57-67.
- [13] Baimova L. A., Yolkina L. G. Pricing for an innovative product // Science Alley. - 2018. – vol. 8. - No. 5. - pg. 569-573.
- [14] Piryazev M. S. Features of pricing in the market of information products and services // Journal of Economic Theory. - 2005. - No. 1. - pg. 127-132.
- [15] Pfouts R. W. The theory of cost and production in the multi-product firm // Econometrica: Journal of the Econometric Society. – 1961. – pg. 650-658.
- [16] Curlo E. Marketing strategy, product safety, and ethical factors in consumer choice // Journal of Business Ethics. – 1999. – vol. 21. – No. 1. – pg. 37-48.
- [17] Yakovleva T. V., Kolyshkin A. V. Problems of digital transformation in Russian enterprises // Editorial board. - 2019. - pg. 113-117.
- [18] 18. Griбанov Yu. I. Factors and conditions for the digital transformation of socio-economic systems // Bulletin of the Altai Academy of Economics and Law. - 2019. - No. 2(2). - pg. 253-259.
- [19] Dutta S., Zbaracki M. J., Bergen M. Pricing process as a capability: A resource- based perspective // Strategic management journal. – 2003. – vol. 24 (7). – pg. 615-630.
- [20] Bariev B.F. Principles of building cost accounting and pricing in an IT outsourcing company // Actual problems of economics and law. - 2011. - No. 4 (20).
- [21] Tokaeva S.K., Alborova A.V. Cost and taxation in the digital economy // Scientific News. - 2018. - No. 12. - pg. 81-83.
- [22] Grunichev Yu.A. Evaluation of the cost-effectiveness of outsourcing IT services // Century of quality. - 2009. - No. 5. - pg. 54-56.
- [23] Huang K. W., Sundararajan A. Pricing digital goods: Discontinuous costs and shared infrastructure // Information Systems Research. – 2011. – vol. 22(4). – pg. 721-738.
- [24] Mysen C. C., Chen J. Automatically adaptive pricing for digital goods : patent. 8332260 USA. – 2012.
- [25] Tan Y., Carrillo J. E. Strategic analysis of the agency model for digital goods // Production and Operations Management. – 2017. – vol. 26. – No. 4. – pg. 724-741.
- [26] Goldberg A. V., Hartline J. D., Wright A. K. Systems and methods for pricing and selling digital goods : patent. 6985885 USA. – 2006.