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LOGISTIC APPROACHES TO ECONOMIC-MATHEMATICAL MODELING OF PRICING INFLUENCE IN GOVERNMENT PROCUREMENT

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The article investigates the influence of controlled and uncontrolled factors on price formation in public procurement procedures. Advantages and drawbacks of competitive tender procedures in public procurement are analyzed. The economic and mathematical model for estimating the expected procurement price depending on the number of bidders with the interval price uncertainty on the buyer's part is offered.

Key words: economic modeling, pricing, procurement.

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ЛОГІСТИЧНІ ПІДХОДИ ДО ЕКОНОМІКО-МАТЕМАТИЧНОГО МОДЕЛЮВАННЯ ВПЛИВУ ЦІНОУТВОРЕННЯ НА ЗДІЙСНЕННЯ ДЕРЖАВНИХ ЗАКУПІВЕЛЬ

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Розглянуто контрольовані й неконтрольовані чинники, що впливають на ціноутворення в системі державних закупівель. Проаналізовано переваги та недоліки застосування конкурсних торгів у сфері державних закупівель. Запропоновано економіко-математичну модель оцінювання очікуваної ціни закупівлі залежно від кількості учасників торгів за інтервальною ціною невизначеності з боку замовника торгів.

Ключові слова: економіко-математичне моделювання, ціноутворення, державні закупівлі.

Statement of the problem

The market formation of government procurements of goods and services for the costs of the state and local budgets in the conditions of rising competition, the positive and negative trends, which are observed in the formation process of Government Procurement Logistics System (GPLS) – require increasing attention to the use, primarily, of economic instruments to stimulate the process of domestic products implementing at government procurement markets, the most significant of which is price. Its formation requires an objective approach to take into account all the factors that determine its level. Equally important is the fact that the defining of an objective real market price for purchased material resources in the process of tenders should optimize the spending of state and local budgets costs. Thus, the market capacity of centralized government

procurement according to government programs, and the State Budget of Ukraine in 2010 was about 2.7 billion UAH [17]. However, the government control is almost absent in this area, according to economic reasonableness of price tender offers, as well as any guidance and recommendations on these matters for the competitive (tender) committees of the relevant government agencies.

Analysis of recent research and publications

National and foreign scholars have been paying considerable attention to the problems outlining of the formation theory and practice of government procurement system in Ukraine, including M. Afanasiev, V. Zubar, Z. Maksymenko, O. Ovsianiuk – Berdadina, H. Pinkas, N. Tkachenko, O. Shatkovskiy etc. There are countless number of scientific publications on the implementation of economic activities in practice of logistic conception of resource flows management. However, there is not enough paid attention to the research and problems outlining, concerning the introduction of the logistic concept of the resource flows movement control in the system of government procurement in Ukraine. The pricing in GPLS also is not well studied. The absence of methodical guidance on the definition of “normal”, expected result of procurement tendering procedures complicates the assessment of the functioning efficiency of the government procurement system in Ukraine. In our opinion, such an assessment can be made only on the basis of a thorough economic – mathematical modeling of processes which occur during the competitive bidding.

The formulation of objectives

The purpose of the paper is in the factors defining that influence the price formation process within the implementation of competitive (tender) bidding and the development of economic – mathematical model for determining the expected purchase price during the tender procedures.

Presentation of main materials

Our research show that the formation of goods government procurements, works and services for the state and local budgets costs in the conditions of rising competition, the positive and negative “inflow and refluece” that occur at the twelfth year of the modern formation of public procurement logistics system, require more and more attention to the use of primarily economic instruments to encourage the implementation process of domestic producers at government procurement market, the most essential of which is price. Its formation needs an objective approach to take into account all the factors which determine its level. Equally important is the fact that the defining of an objective real market price for purchased material resources in the process of tenders should optimize the spending of state and local budgets costs, which is provided by the Budget provisions. Thus, the “price” (volume) of the market of only centralized government procurement according to government programs and to the State Budget of Ukraine for 2010 was about 2.7 billion UAH. [17]. However, the state control over the economic reasonableness of price tender offers is practically absent in this sphere, as well as any guidance and recommendations on these matters for the competitive bidding (tenders) committees of the relevant government agencies.

Despite the fact that in recent years a large number of scientific publications appeared on the problems of implementation in practice of economic activities of logistic conception of resource flows management, but the study of pricing problems in Ukraine government procurement system and respectively GPLS formation is presented only in the works of O. Andriushchenko and O. Melnikov [1; 14–16]. A price problem tender offer is mostly ignored by scientists, with few exceptions, including economic-mathematical modeling of pricing in GPLS, which in violation of the Ukraine current legislation provisions leads to prior agreements of customers with suppliers, and as a result to billions “kickbacks” of budget costs. For the sake of fairness, it should be noted that edition “Government Procurement of Ukraine” in recent years tried to fill the problem of “price niche” of tenders by the publication of opinions and research of various authors. In our view, the most interesting is “The issue of the initial contract price calculation, initiated by “Victoria Karasiova” in 2006 (№ 4) and continued in 2007 (№ 10, 11) and in the subsequent years.

Using the mechanism of competitive bidding in Ukraine is regulated by law [13], p.2 which establishes the mandatory use of competitive bidding mechanism in the implementation of “procurement of goods, works and services which are completely or partially realized with the help of public funds, on condition that the purchase price of goods (goods) procurement, service (services) is equal to or bigger than 100 thousand UAH, and works – 300 thousand UAH”. In the developed Western countries, these rules also have certain limitations. Implementation of government procurement in the USA is carried out according to the norms of legal standards which are governed by the “Regulations on the Federal Procurement” (Federal Acquisition Regulation – FAR) [7], which establishes a range of cost thresholds, excess of which gradually complicates the procurement procedure. Most commonly micropurchase threshold and simplified acquisition threshold are used. Micropurchase threshold is 3 thousand dollars; this section does not require from customer nor publication of procurement neither selection explanation of logistics provider. Procurements from 3 thousand to 100 thousand dollars may be done according to simplified procedure; in this case, the organization of competitive bidding is not required, but the customer must prove that the purchase price is reasonable and fair. It contains a number of other occasions. Government procurement are regulated by a number of international agreements and legislation of the European Commission in EU countries [7].

In our opinion, an important step at the beginning is factors research that affect the pricing in the system of government procurement. From this perspective, the use of each price in terms of domestic government procurement market needs peculiarities consideration of marketing activities of enterprises – participants in competitive bidding. It should be kept in mind that the system of current prices is not isolated. Under the influence of various factors, it is constantly changing and developing, prices are improving [2]. Pricing factors constantly affect the state and dynamics of the competitive bidding organized by state customers. They may create favorable conditions for entrepreneurship of different enterprises wishing to participate in the tender bid, or brake it, as it is explained by the peculiarities of lobbying interests, changes in correlation of prices influenced almost by open demands of kickbacks, etc. As a result, the market perception of production government procurement of companies and prices for it is changed.

According to V. Korenev, all pricing factors, depending on the nature of the manifestation, the ratio of enterprise to them and features of influence on marketing pricing process – may be grouped according to two main directions (fig. 1).

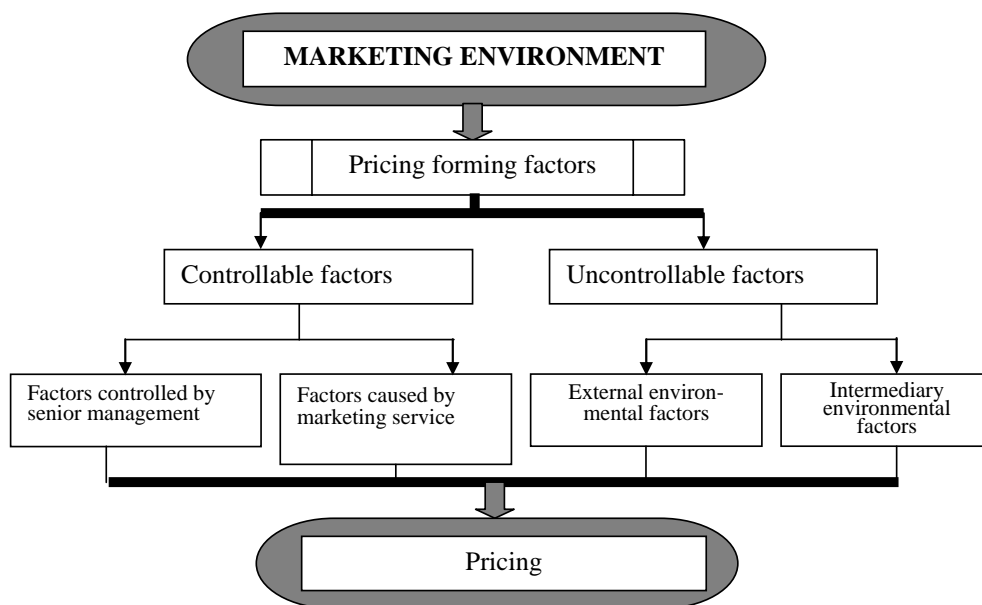


Fig. 1. Classification of factors that affect the pricing
Source: [12]

Depending on the capabilities of the company to control and influence their effect in the price formation, they are divided into controlled (internal) and uncontrolled (external) [12]. Controllable and uncontrollable factors in the complex should be considered when developing strategic and tactical directions of marketing pricing. It should be taken into consideration, that the pricing factors characterize the impact of marketing environment on the pricing in the enterprise conditions. From the perspective of market pricing, this action may be seen due to the relationship between the enterprise and market subjects of government procurement – managers of public funds during the buying – sale tenders). Affecting the price level and its use in products realization, these factors determine the nature and features of marketing pricing [12].

Controllable factors determine the peculiarities of micro-marketing influence of the process of marketing pricing. Their influence is taken into account in determining pricing purposes, the formation of expenditure rates, with a focus on the level of demand and the optimal use of the enterprise resource base and its production facilities, providing break-even activity etc. [21]. As a result, it is reflected in the formation of enterprise relationships with market subjects in the implementation process of its products. Controllable factors management occurs directly at the enterprise. Base decisions concerning the change of size and nature of the main factors influence taken are by senior management of the company. Here they are specified in the appropriate tasks for its structural units. Marketing enterprise services deals with other controllable factors. Coordination on marketing pricing issues is carried out at the level of the relevant structural departments.

Uncontrollable factors act in terms of the macro environment (fig. 3). The provided above classification shows that they are divided into factors of external and intermediary environments. Their peculiarity is that during the marketing activities the company can not influence their performance, but only react accordingly. The degree of influence of uncontrollable factors on the process of marketing pricing is much higher in comparison with controlled ones [18].

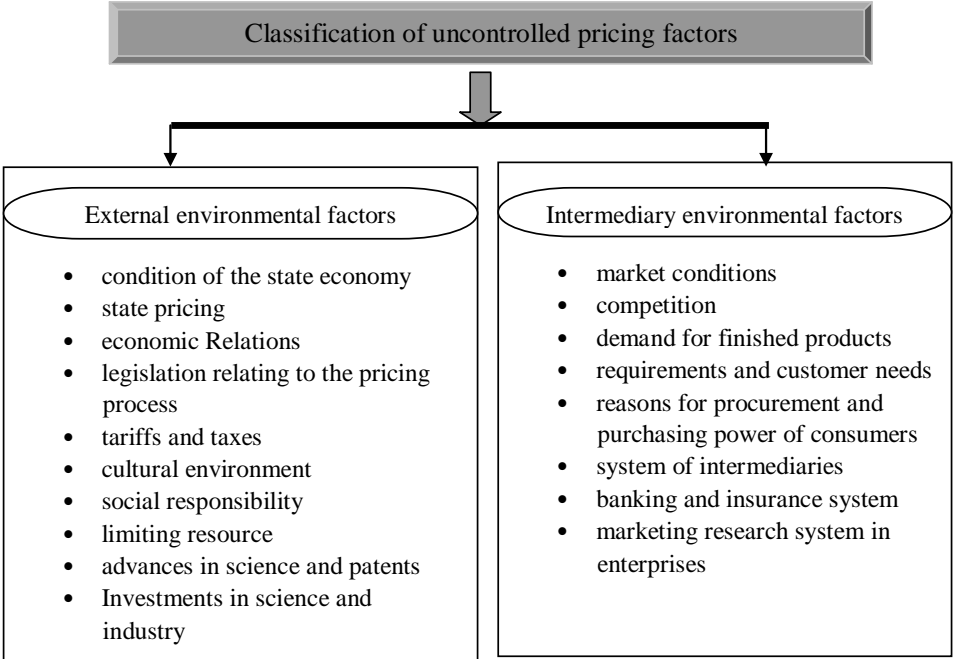


Fig. 2. Main uncontrollable pricing factors
Source: [18]

Moreover, being quite variable, they help to create conditions for the occurrence of risk situations during products realization on the market. In this regard, the company should closely monitor changes in the nature of pricing factors of external and intermediary marketing environment. Results of its own or booked marketing research as well as external current statistical information may be used.

Environmental factors determine the economic, technological, natural and geographical, political, legal and socio-cultural aspects of the marketing environment. Regarding the pricing process at the enterprise, these features appear more specific. Pricing factors of intermediary environment is mainly focused on the formation of the relationship because of the price between the company and other market subjects, who are the primary suppliers of logistical and material resources, marketing intermediaries, competitors and customers, including government and municipal customers, budget funds entities. The peculiarity of these factors is that they characterize the demand for purchased products, works and services and affect the results of their implementation at the market.

In addition to pricing factors considered classification there are other ones. This is due to different purposes of market research of the pricing process at enterprises and in the system of procurement for state costs. Thus, these factors can be grouped according to their functional purpose in the relevant areas. Each of them determines the appropriate direction of the marketing process of pricing in the studied subjects of government procurements market. Along with a provided marketing environment for a better understanding of pricing at the government procurement market, in our view, it is important to monitor the behavior of economic agents (procuring entities who are members of the competitive tenders) in the process of consumer choice of goods and services.

Research of tenders practice, namely the movement of resource flows in the procurement logistics, particularly in the logistics system of state and municipal procurement of goods, works and services for the state and local budget costs – allows to follow for the behavior of economic agents in decision-making process, and, in particular, consumer choice realization. Analyzing the practical features of consumer choice with respect to the prices of goods there are several reasons, which act as factors of influence on the level of price and for which the consumer (organizer of budget costs) tend to think of the price of goods is not absolute, but with some error.

First of all, the absolute threshold of goods price perception is determined by the existence of the minimum coin. This threshold is objective in the sense that it is the same for all consumers. Price range scale of the goods value is essentially discrete.

The second reason for the approximate price perception is the uncertainty which arises because of the incompleteness of information available to the agent and which is associated with available at markets, including government procurement, imperfect competition “price dispersion” [25].

Opportunity cost of product search (selection) with the lowest price may exceed the expected benefits (savings of public funds) of the price difference. Thus the allowed prices scattering at the market is estimated by consumer – purchaser in a subjective way and the scattering range greatly exceeds the minimum threshold, set by subsidiary coin.

The third reason is “operating with senior level” during initial familiarization of goods price according to the limited amount of RAM. An example of such a “threshold” price interval perception is the policy of “odd prices”, which is studied by psychologists and widely used in marketing of the U. S. and other countries. For example, the price of 9999 \$ or UAH, generally is perceived by consumers according to the first (upper) meaningful category (sometimes according to two higher categories), it means that there is a “not-mathematical” rounding of prices to the lower threshold of 9,000 \$ (or 9900 UAH), but not in a bigger way with a small error of 1 UAH.

The same error of perception is present in the measurement of consumption amount. One of the practical evidence of approximate perception is the phenomenon of the individually approached goods purchase at the agricultural market, where the consumer evaluates the purchased products volume, “by eye/ approximately”. It is possible to provide other parameters of estimated perception of information in economic decision making, which allows, in general, to form a hypothesis about the interval type of perception, which is based on the subjective evaluation of price and quantity parameters. So, from physiological and practical points of view, the approximate interval perception of prices and consumption volume is obvious. D. Davydov and A. Tarasov in their works provided a thorough research of aspects of physiological and practical approximate interval perception of prices as well as interval modeling of consumer behavior [4].

Price as one of the characteristics of goods. The classical theory of consumer choice is based on the contrast of the output of consumer preferences (public customer) which are expressed by the usefulness function and budget constraint that links the price of the goods with a consumer fixed-income. Such opposing is not entirely consistent with modern consumers understanding about their choice: many of them tend to include the price of goods in their perceptions system favoring one or the other values and benefits during the implementation of the competitive goods procurement system, works and services for public and local budgets funds, and there are several explanations for this.

First of all, this is a consequence of the consumer variety, which is widespread due to the marketing policy of manufacturing companies and firms. The number of similar products varieties and variations, services at the consumer market reaches up to several tens or even hundreds of modifications. The policy of “price niche” leads to the fact that consumer starts to perceive the price as a signal on the quality of the product or as a signal on the presence of additional features of this brand or modification, which distinguishes from a large number of analogue – substitutes. Proof of this is the situation, which occurred at the market of government procurement of pharmaceutical companies’ products, particularly around procurement of insulin [1; 19] or prosthetic – orthopedic products [21]. At the same time, there are limitations at the pharmaceutical market of trade allowances to the wholesale prices of the producer (customs value) in their implementation according to the list, defined by the Ministry of Healthcare of Ukraine – no more than 35 % to the population through a pharmacies network 10 % during the implementation for budget institutions and for budget means [23]. It should be noted that the absence of legal definition of “wholesale price” allows interpreting it arbitrary by business structures and corresponding arbitrary overestimation of prices for medicine that leads to additional population and budget spending.

Secondly, it is indicated above the uncertainty of prices perception because of physiological reasons and aspirations for price rounding in the process of payments while making transactions in the market.

Thus, the user has some a priori interval idea on the price of the product and makes a decision on procurement based on the affiliation of the real market price to a given interval. In this case, the same nominal price difference is more noticeable to the consumer “in the beginning” of price range than the “in the end” of it [3, p. 68]. For example, in price range from 30 to 40 UAH – price difference of 32 and 34 UAH is usually more significant than the difference of 36 and 38 UAH, despite the fact that the net price difference in both cases is 2 UAH.

The inclusion of the goods price in the system of the consumer benefits can be made in different ways. In the simplest case, the price of each product can be entered in the utility function as additional anti-benefit. However, it is necessary to consider the demand for the product – functional dependence on market prices and consumer income, which is in similar interpretation, becomes implicit. It should be noted that the classical approach allows constructing a function of demand due to the assumption of independent consumer perceptions of price and quantity of goods. Besides that the prices of goods in the problem statement of the mentioned above scientists [3; 4] are not independent variables. They represent only the interval parameters, which generally nonlinearly are associated with relative shares of goods consumption.

In light of interval perception of goods price and quantity characteristics, the problem of optimal choice of the consumer turns to interval problem of nonlinear programming with constraints, namely equality that define the relationship between products and their specifications and budget constraints – inequality.

One of the fundamental principles of government procurement realization in the EU, together with transparency and non-discrimination of participants, is the so-called principle of “de minimis”, according to which the use of complex, costly and bureaucratic procedures are rather irrelevant in solving simple problems. In the area of government procurement, this principle establishes cost threshold meanings within which to conduct procurement – the competitive (tender) procedures are not necessary (table 1).

Limit “de minimis” in public procurement in the EU

Category of procurement	Limit (th. €)	Relevant EU Directives
Goods, services, design when ordering central government agencies	125	2004/18/EC, ст.7(a), 67(1)(a) 2004/18/EC, ст.7(b), 67(1)(b)
Goods, services, design when ordering other government agencies	193	2004/18/EC, ст.8(b),
The services are subsidized by the state more than 50 %	193	2004/17/EC, ст.16(a), 61
Utilities	387	2004/17/EC, ст.16(b),
Construction of hospitals, schools, stadiums and other civil structures	4845	2004/18/EC, ст.7(c), 8(a)
Concessions for civil construction and other public works	4845	2004/18/EC, ст.56,63(1),

Source: [6]

This information shows that the meaning of “de minimis” set by standards of Ukrainian legislation, are next lower order of magnitude than the corresponding norms of Western countries. This demonstrates the excessive bureaucratization of the government procurement process. Although GDP in Ukraine is several orders of magnitude lower than in the U. S. and the EU countries, that does not mean that the level of logistics costs for tender procedures is also proportionally smaller.

Taking into consideration the huge amount and public importance of government procurement in Ukraine, there is a need for expediency grounding for the use of competitive bidding in the procurement of certain material resources for public use providing and for budget costs.

The expected gain is economically feasible if it exceeds the cost for the realization of the one or other logistics operations. From this point of view, it represents the interest of budget costs saving sources in the organization of competitive bidding. These may be due to the involvement in bidding of a wide range of trades suppliers (manufacturers, intermediaries) who, according to pre-qualification are able to fulfill all the conditions of the contract for government procurement realization. Competition between logistics providers affords the government customer the potential possibility to get the necessary material resources at the best price, but the monetary evaluation of competitive advantage is not obvious there. First, it is necessary to select a base for comparison. It is logical to assume that in the absence of trades the vast majority of purchases will be carried out due to the average market price. Secondly, we should keep in mind the strategic interests of suppliers, consisting in maximizing of the own profits and can lead to quotations overestimation compared with the lowest prices accepted for them. Finally, we must determine the value of the expected price effect from the bid participation of several suppliers and the best offer selection by customer choice.

To assess the effect it is proposed [11] to consider a mathematical model where the selection of the procurement object is carried out exclusively by the price criterion. Assuming that M operates at the market of goods suppliers (works, services) which are purchased, then the minimum price at which the i-th supplier agrees to sell the goods to the bids customer – can be marked as P_i ($i = 1, \dots, M$) and further to call it as redundant price. If such prices are the same in all existing suppliers, tendering procedures are not necessary, since, according to the price criterion, there is no choice. So, procurement organization by competitive mechanism is advisable only when there is some variation in prices from different suppliers. If these values are known to the customer, then obviously it would be the best to choose the supplier with the lowest price. However, as a rule, the customer does not know nor real, redundant participants prices, neither their personalities (namely, what vendors will participate in the bidding). Therefore, in his view, the value of p_1 should be considered as random variables. Let's suppose that redundant prices of different suppliers are independent, identically distributed by random variables with distribution function $F_p(x) = P(p_1 \leq x)$, where $P(A)$ denotes the probability of event A (this assumption is typical for the economic theory of auctions) [14].

If the supplier selection was carried out in the market randomly, then the expected purchase price \bar{P}_m (m – from market) would be equal to the mathematical expectation of a random variable p_i ;

$$\bar{P}_m = M [p_i] = \int_0^{\infty} x dF p(x). \quad (1)$$

Choosing the supplier due to the tender procedure gives customer the opportunity to choose from the submitted proposals, the best, namely with the lowest price. The relationship between the suppliers redundant prices and their tender offers – depends on the scheme of bidding organization and is quite a complex issue that has been the subject of quite intensive research of economic theory and game theory over the last 50 years [10].

A quick overview of theoretical results can be important for future material presentation. According to current law, competitive bidding in Ukraine is carried due to the scheme of the best prices reverse auction with undisclosed bids. In the world practice of government procurement, classical “English” auctions at a price reduction with open participants offers are also widely used. It is anticipated in this format to conduct electronic bids and their implementation is expected in the nearest future in Ukraine [20]. At this auction the bidding stops when there is only one participant left. For this, the winner must be offered a lower price than in the penultimate bidder. For participants, it makes sense to stay in the auction until the current price exceeds the reserved level. Therefore, if we neglect the discreteness of price steps the purchase price will be equal to the second from the bottom among the reserved price of bidders. Scientists noticed that in other way the same result can be obtained at the auction with undisclosed bids if the contract with the winner will be conducted due to the second dimension of the suggestions given [26]. He also proved that under this scheme, the “frank” strategy will be the best (dominant) for participants, which means submitting a proposal at the level of the own reserved price. At the auctions of best price with undisclosed bids (the winner gets a contract at a price equal to his bid) “frank” strategy, obviously, can not be optimal because it leads to zero gain of their members. Consequently, the proposal will exceed redundant prices. The most important result of the theory of auctions, there is the so-called theorem on the income equivalence, which establishes that (under certain technical assumptions) the expected result of the customer in all these types of auctions is the same. Based on these two results, we conclude that for purchase price estimation there is need to find the division of the second from bottom reserved price of bidders.

It is known from the probability theory, that the distribution density of k -th order statistics y_{kn} vector $y = (y_1, \dots, y_n)$ of independent identically distributed random variables is given by the formula

$$f_{k:n}(x) = \frac{n!}{[k-1]![n-k]} [F(x)]^{k-1} [1-F(x)]^{n-k} f(x), \quad (2)$$

where $F(x)$ and $f(x)$ – accordingly the law and density of the vector y distribution.

Based on the assumptions made earlier, the participation in the auction n participants, the purchase price p_1 (t – to tender) will be the second order statistics of the vector (P_1, \dots, P_n) . Thus, due to the formula (2) the distribution density will be:

$$f_{p_1}(x;n) = n [n-1] F_p(x) [1-F_p(x)]^{n-2} f_p(x), \quad (3)$$

and the expected purchase price will be equal to:

$$\bar{p}_1(n) = M [p_1] = \int_0^{\infty} z f_{p_1}(zn) dz. \quad (4)$$

For some popular distributions in econometrics (uniform, exponential, extreme values) integral in formula (4) is calculated analytically. In other cases (namely for a normal distribution) calculations can be carried out using standard numerical methods.

Figure 4 shows the density of purchase price distribution for the standard uniform $U(0; 1)$ and the normal $N(\mu = 1/2; \sigma = 1/6)$ of redundant prices distributions¹ of individual suppliers. In the first of these

¹ The distribution parameters are selected in such a way that due to the three-sigma rule the main mass was concentrated at the unit interval .

cases, $\mathbf{FP}(\mathbf{x}) = \mathbf{x}$, $\mathbf{fp}(\mathbf{x}) = \mathbf{1}$, and the direct substitution of these functions in formula (3) leads to the conclusion that the purchase price would have β – distribution with parameters $\mathbf{a} = \mathbf{2}$; $\beta = \mathbf{n} - \mathbf{1}$. For the normal law the density of purchase price distribution can not be obtained in analytical form, but the calculations do not constitute difficulties. As the graph shows, the increase in the number of bidders shifts density of purchase price distribution to the left and to lower prices.

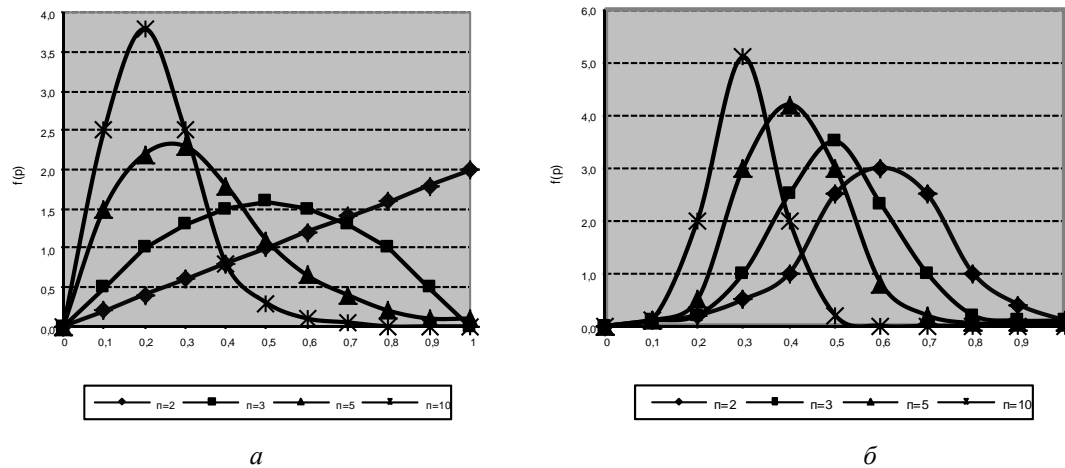


Fig. 3. The density of purchase price distribution for uniform (a) $U(0, 1)$ and normal (b) $N(1/2, 1/6)$ of prices distribution of individual suppliers based on the number of bidders
Source: [24]

Figure 4 shows the dependence of the expected purchase price of the number of bidders for the uniform $U(0, 1)$ and normal $N(1/2; \sigma)$ distributions of redundant prices at $\sigma = 1/6$ and $\sigma = 1/10$.

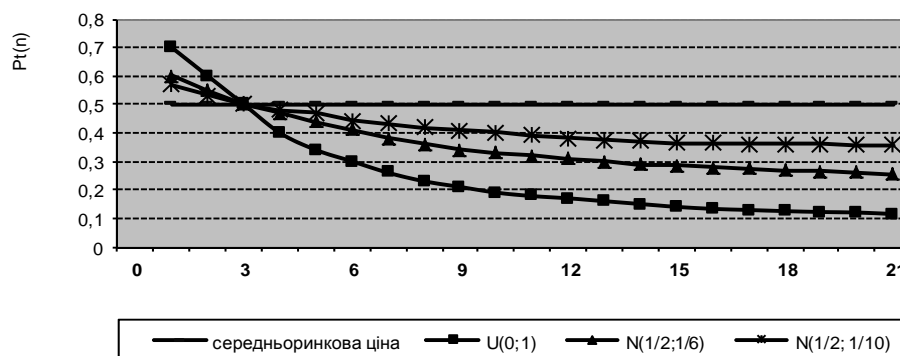


Fig. 4. Mathematical expectation for purchase price using tender procedures, depending on the number of bidders
Source: [15]

In all the cases, increasing the suppliers number leads to a decrease of the expected purchase price, but the speed of this process depends on the dispersion of the reserved prices. Uniform distribution has the largest dispersion¹, and therefore, the expected purchase price in this case is most sensitive to the number of bidders. It is also worth noting that the marginal effect of attracting additional participant decreases with the increase of the total quantity.

The expected price gain of bids customer because of the use of tender procedures Δp will be equal to the difference between the values of RM and $\bar{p}_1(n)$.

$$\Delta p(n) = \bar{p}_m - \bar{p}_1(n). \tag{5}$$

¹ For the random variable with standard uniform distribution, the dispersion is equal to 1/12.

To get the full benefit, the expected price difference (5) should be multiplied by the volume of purchases. It should be noted that the calculation on the formula (5) need only the integral calculation (4). Therefore, the model is quite easy to generalize for the case of free distribution of suppliers reserved prices. If joint distribution of such prices is set – $F(P_1, \dots, P_n)$, the integral (4) can be calculated without the distribution density receiving for the procurement price explicitly using the Monte Carlo method.

Next, we consider the costs associated with the tendering procedures. Costs of trades customer consist of the following elements:

- Preparation of tender documents.
- Preparing and placing advertisements on the competitive bidding.
- The time that members of the Tender Committee spent for the consideration of the received proposals.
- Preparation of opening protocols and evaluation of tenders.
- Providing answers and clarifications to bidders.
- Possible costs for re-bids and others.

Bidders bear costs that are mainly associated with the preparation and submission of tender applications. Bidding also often envisage providing bid security in the form of cash contributions, which indicates the seriousness of the participants intents. Although it is returned to the participant, but we should take into account the time value of money given as bid providing. We denote the total expenditure of the customer as F , and as for each participant – as v .

There are two approaches to assess the feasibility of the auction. From the customer point of view, trades make sense when:

$$qM[\Delta p(n)] > F, \quad (6)$$

where the mathematical expectation operator is set due to the number of bidders, which in most cases should also be considered as a random variable. O. Melnykov believes that during the calculation of this mathematical expectation, it is better to use the empirical distribution of bidders for a particular market. As detailed statistics of this indicator is quite difficult to obtain, further calculations are done with the assumption that the number of participants is false. The costs of bidders are not counted in such case. It should be noted that they are to some extent compensated to successful winner of tenderers only. From the public point of view, it is appropriate to take into account the costs of trades customer as well as their participants. Feasibility condition of bidding in this case would be as follows:

$$qM[\Delta p(n)] > F + vM[n]. \quad (7)$$

According to formula (7), the full costs of tendering increase linearly with the number of participants increasing, while the additional benefit of attracting a larger number of suppliers is gradually reducing. Therefore, there is optimal, from the social point of view, number of bidders.

The proposed model makes it possible to carry out the experiments due to which we can determine the expected economic effect from the use of tender procedures in each case. Scheme of payments can be illustrated when the prices of suppliers are uniformly distributed in the interval $[a; b]$. The distribution function for uniform random variable is:

$$F_p(x) = \frac{x - a}{b - a}, \quad (8)$$

and its mathematical expectation (respectively, the average market price) is:

$$\bar{p}_m = \frac{a + b}{2} = a + \frac{1}{2} [b - a]. \quad (9)$$

Expected purchase price can be easily calculated by the formula (3) and (4) using the rule of parts integration. After simplifications we obtain:

$$\bar{p}_1(n) = a + \frac{2}{n + 1} [b - a] \quad (10)$$

From comparison of formulas (9) and (10) it follows that three suppliers should participate in the auction to obtain purchase price at the average market level, which itself is of great interest. According to the Ministry of Economic Development and Trade of Ukraine, in 2008 the average their number during the

competitive procedures constituted 2.9 of participant for a declared tender [22] that under the assumptions proves questionable effectiveness of government procurement sector, even without taking into account costs for tender procedures organization.

According to the formula (5), the expected price benefit of auction customers will be:

$$\Delta p(n) = a + \frac{b-a}{2} - \left[a + \frac{2[b-a]}{n+1} \right] = \frac{n-3}{2[n+1]} [b-a]. \quad (11)$$

Lets consider the issue on limiting the volume of purchases, which justify the use of tender procedures according to the criterion (6). Let's suppose that $n > 3$, and the number of bidders is known in advance to the customer. Then, according to formula (6) inequality should be performed:

$$q > \frac{F}{\Delta p(n)} = \frac{2F[n+1]}{[n-3][b-a]}, \quad (12)$$

To estimate the required volume of purchases in not absolute, but in value terms, we multiply both sides of formula (12) on the average market price \bar{p}_m

$$Q = q \bar{p}_m > \frac{[n+1]F[b+a]}{[n-3][b-a]} = \frac{2F[n+1]}{V_r[n-3]}, \quad (13)$$

where $V_r = \frac{b-a}{[a+b]/2}$ – oscillations rate (vibrations) of the redundant prices division.

Due to the criteria (7) we obtain similarly:

$$Q > \frac{2[F+vn]}{V_r} \frac{[n+1]}{[n-3]}, \quad (14)$$

For numerical calculations by these formulas it is necessary to estimate the parameters F , v , and V_r . Ratio of prices oscillations depends on the specific market. Direct calculation of customer costs F and participants (v) requires too many assumptions, but the evaluation of these quantities can be made by circumstantial evidence.

There is a very lively market of consulting services in Ukraine for the preparation of tender documents for customers and bidders. It is logical to assume that the prices for these services to some extent reflect organizations costs for an independent preparation of necessary documents. At the time of this paper writing, the price for the full cycle of competitive procedures information support for bidding customers amounted to almost 10 thousand UAH, for participants – about 2000 UAH. [9] Substituting these values in formulas (13) and (14), we can obtain the marginal volume of purchases by criteria (6) and (7). The results of these calculations are shown in table 2.

Table 2

Calculated marginal purchases volumes on equal distribution of the reserved price, depending on the expected number of bidders (n) and the oscillation coefficient of the reserved price distribution (V_r) *, th. UAN

$V_r \backslash n$	4	5	6
0,5	200/360	120/240	93/205
0,4	250/450	150/300	117/257
0,2	500/900	300/600	233/513
0,1	1000/1800	600/1200	467/1027

Source: [24]

We note that the rate of oscillation 0.4 corresponds to a considerable variation in market prices – $\pm 20\%$ of the average market price, but even then the calculated value of the purchases critical volume exceeds standards set by Ukrainian legislation. In normal and other distributions, of reserved prices of suppliers, limit values are even higher because, as follows from fig. 4.12, during the normal distribution the expected purchase

price decreases slower compared to the uniform one. Therefore, calculations by formulas (13) and (14) should be considered as a lower limit for economically justifiable amount of purchases).

Fig. 5 shows calculations of economic effect from the use of tender procedures compared to the procurement market average prices.

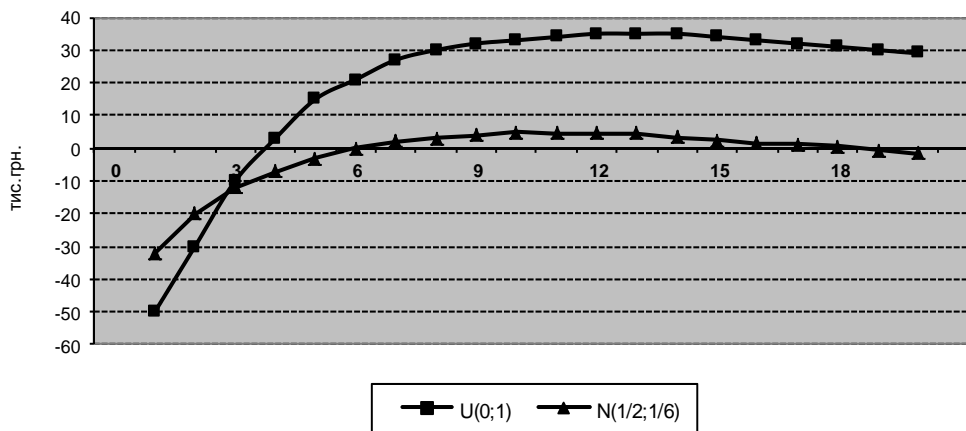


Fig. 5. The economic effect of the use of tender procedures, depending on the number of bidders on different prices distributions of individual suppliers
Source: [24]

Options: $F = 10,000$ UAH; $V = 2000$ UAH; $Q = 200000$ of different assumptions concerning the distribution of suppliers reserved prices. Calculations were carried out (at previously used parameters values) by the formula

$$E = \Delta p(n)q - F - vn. \quad (15)$$

For uniform distribution the expression for E can be obtained explicitly from formula (11); for normal – calculations were performed numerically.

To assess the robustness of formulas (13) and (14) to assumptions about the distribution form of the reserved prices of suppliers, let's consider an example. As the object for purchase we choose gasoline A-95 as one of the most frequently purchased products. 44 suppliers were present at this market, in Ukraine. Empirical density of prices distribution for gasoline A -95 is shown in Figure 6, and its numerous features – in the table 6 [y].

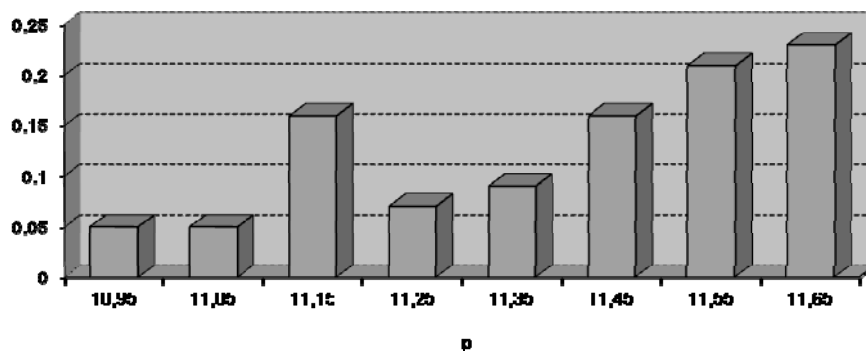


Fig. 6. Empirical density of prices distribution for gasoline A -95
Source: Price as of 28.09.2012 ([http://. www. biz. liga. net/tek/oil/a-95. htm](http://www.biz.liga.net/tek/oil/a-95.htm))

Visually, the histogram in fig. 6 is not like any of the known analytical distributions. Therefore, for the expected purchase price estimation it is advisable to use a Monte Carlo method [x]. Imitation experiments were conducted in such a way. With the help of generator of pseudo random variables we choose 4 bidders according to scheme without repetition, and as the price of purchase – the second best

price of participants. As a result of a large number of imitation experiments it is possible to obtain empirical distribution of purchases price and calculate its statistical characteristics. 500 of such experiments according to this scheme give the following results:

The expected purchase price for 4 participants $\bar{d}_1(4)$ is equal to 11.3041; standard deviation – 0.1742; 95 – percent credibility interval for the expected purchase price – [10.9628, 11.6455];

The expected price benefit of the trading customer $\Delta \bar{d}(4) = 0.06859$ UAH. / L;

A critical volume of purchases in absolute terms due to the criteria (6) and (7) at $F = 10000$ UAH and $v = 2000$ UAH – respectively, 145 880 and 262 439 liters capacity;

A critical volume of purchases in value units under the same assumptions is, respectively, 1658 thousand UAH and 2,985 thousand UAH.

Table 3

Numerical characteristics of prices distribution for gasoline A-95

Characteristics	Value
Min, p_{min}	10,9
Max, p_{max}	11,65
Average, \bar{p}_m	11,37
Extend, R	0,75
The coefficient of oscillation, V_R	0,066
Standard deviation, σ	0,226
Number of observations, M	44

Source: [24]

However, calculations by formulas (13) and (14) give the following critical volume of purchases: 1516 thous. and 2,729 thousand UAH, with a relative error for the true values of about 8 %. Thus, formulas (13) and (14) can be used for approximate estimation of purchases critical volume.

Conclusions

The analysis of pricing factors and study of their classification, firstly, enables enterprises, tenders participants, from scientific objectively reasonable positions to approach the process of prices level determining on products, including marketing goals and enterprises objectives in the long or short term perspectives. Moreover, our study allows in the process of enterprise price activity to respond to the impact of pricing factors, easy to adapt to changes of its condition at the government procurement market, have permanent advantages in competing as well as successfully control its financial situation.

Secondly, this paper provides the arguments in favor of interval description of consumer choice processes with regard to interval perception not only quantitative but also pricing options. Empirical confirmation of interval perception leads to the need to find solutions and development of new mathematical methods for studying interval optimization problems and their applications to problems of consumer choice.

Based on the concepts of interval selection and pricing perception structure, it is possible to formulate some hypotheses regarding the micro-and macroeconomic consequences of the accepted agents' decisions.

Based on the model we may provide the following conclusions:

1. Economic benefits from bidding is directly related with the degree of prices variation at a particular market. In small dispersion of individual suppliers price proposals, using tenders brings significant benefits to the customer only at very high volume of state orders. It is therefore advisable to set “de minimis”, more differentiated, taking into account the specifics of particular economic branch.

2. To create a competitive environment at the auction with the expected purchase price at the average market level requires participation at least of 3 suppliers in them. The main part of gains from

decreasing of purchase prices is realized with the participation of 3 – 6 suppliers. Spending money to attract more participants is impractical.

3. On realistic values of the cost parameters, bidding makes a noticeable effect if the value of purchases substantially exceeds the “de minimis” norms, set in the Ukrainian legislation.

Prospects for future research

Considering these provisions in the legislation will improve the efficiency of funding of government procurement in Ukraine.

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