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E-mail: worldscience.uae@gmail.com
submission@ijite.org
Tel. +971 56 498 67 38

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ECONOMIC AND MATHEMATIC EVALUATION OF PRICE FLUCTUATIONS INFLUENCE ON ECONOMIC INTERESTS OF MARKET RELATIONS AGENTS

Ptashchenko L. O.

Doctor of Economic Sciences, Professor
Poltava National Technical Yuri Kondratyuk University, Ukraine

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ABSTRACT

Economic and mathematical model of price fluctuations influence on economic interests of basic market relations agents (represented by state, enterprises and households) is built. Factors of influence on price fluctuations and agent's welfare decrease are determined. On a basis of calculation of Kendall's concordance coefficient, conclusions about links absence between economic interests of market relations agents (in conditions of prices formation and governmental price regulation) are formed.

Introduction. According to conditions of competition and crises, manufacturer's price has great importance for economic system. The importance of pricing management is growing, as it has significant impact on enterprise's activity efficiency and its market place.

The price is a tool of harmonization of different agent's interests. According to this, the investigation of market pricing mechanism has great theoretical and practical importance.

Review of research on the issue. Scientists of different countries investigated theoretical aspects of prices formation. Own views on this issue were expressed by John Berman, P. Doyle, F. Kotler, M. Porter, T. Nehl, V. Pinishko and others [1-3]. Theoretical aspects of pricing tools investigated in scientific papers of Adam Smith, David Ricardo, A. Marshall, K. Buzhymska, I. Bakushevych, A. Kolesnikov and hothers [4-6]. At same time, the question of ensuring of all interests of manufacturer's contractors in aspects of adequate pricing is still urgent. At the same, time governmental competitive policy has great importance in aspect of price regulation on socially important commodity markets.

Primary material description. The most important component of antimonopoly policy in most countries is the policy regarding the sectors of social use, which contain natural monopoly segments (electricity, telecommunications, railway transportation). As effective form of these sectors regulation, can be creation of conditions for formation of prices, which satisfy both producers and consumers.

The problem of pricing optimization, in aspect of satisfaction of interests of producers, consumers and state has great urgency for science.

Furtherly will try to build economic and mathematical model of evaluation of pricing factors impact in cond of itions of commodity markets. We must define the set of attributes that are important for the formation of the social economics in society. That supposes determination of degree of prices fluctuation vulnerability of such subjects of national

economy as state, businesses and households. Ranking of prices volatility impact on welfare decrease of national economy subjects is based on 10-point scale based on expert estimates (Table 1).

Table 1

Ranking of significance of prices volatility impact on economic state of national economy subjects

№	Impact factors of prices volatility on socially important commodity markets	Ranking of prices volatility impact on welfare decrease of national economy subjects, points		
		State	Enterprises	Households
1	The unstable political climate in the country and inept management of national economy	4	3	3
2	The high level of the shadow economy and uncontrolled activity of oligopolies	5	2	3
3	Hyper inflationary processes in the national economy	2	4	4
4	The massive agiotage and increase of demand for the products	1	2	7
5	Price discrimination by the monopolies	1	6	3
6	Total points	13	17	20

Consistency of expert assessments is checked by determination of consent coefficient (E), which is a coefficient of multiple correlation formula:

$$E = \frac{\sum_{i=1}^{m}\sum_{l=1}^{m} R_{il}}{m^2}$$

Where m – the number of experts;

R_{il} – correlation coefficient of i and l experts assessments.

According to author's conception, economic interests, which appear in process of pricing regulation, are considered as a system of three agents – state, enterprises and households. Coordinates present their significance of values.

The analysis of assessments

a) All ranks must be R_j^i integers or multiples of 1/2;

b) $\sum_{j=1}^{n} R_j^i = \frac{n(n+1)}{2}; \quad (i = 1,2,...,m),$

There can be used Spearman's rank correlation coefficient and Kendall's coefficient of concordance. Spearman's rank correlation coefficient is more reliable.

According to results of calculations, we may ascertain the fact that market relations agents are uncoordinated in aspects of pricing regulation on commodity markets.

Thus, economic interests, which are considered as a system of three agents – state, enterprises and households – are contradictory to each other (this statement displayed on a Fig. 1).

According to the problem formulation, we have condition, which results the following systems:

1) HH – HH (household);
2) HH – E (enterprise), E-E;
3) E – S (state);
4) HH, E – S.

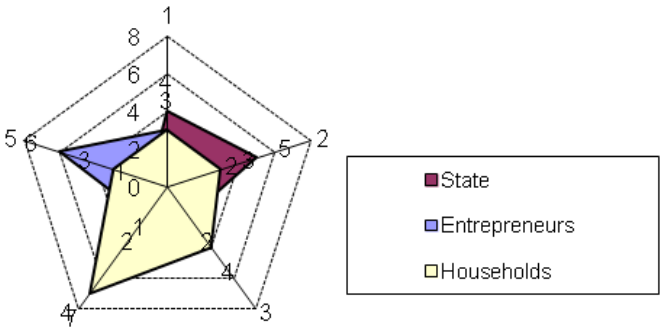

Fig. 1. Systems of economic interest of market relations agents

Paired relations are checked every time by the test of Spearman. "Counterparties E" can be limited by the number of i = 1,2, ..., N. Costs of "counterparty E" $c_i(y_i)$ are dependent on produced product y_i (where $y_i \in [0,\infty)$). The price of services is defined as λ. The objective function of i «counterparty E» is represented by difference of its income $E_i(y_i)$ (where $E_i(y_i) = \lambda y_i$) and costs $c_i(y_i)$:

$$f_i(y_i) = H_i(y_i) - c_i(y_i). \quad (1)$$

In a process of further model building the following class functions will be used:

$$c_i(y_i) = r_i(y_i - a)^3 + b. \quad (2)$$

This class of functions is useable for displaying of expenses dynamics of «counterparty E». There are following features of these functions:

– availability of fixed costs of pricing policy implementation;

– the price growth is accompanied by a value decrease of unit costs before the fracture point achievement, after which their increase begins.

Four mechanisms are proposed for discussion, which are mentioned above. Comparison of economic motivation is prepared by using of following parameters:

– *F (y)* – utility function «counterparty *C*»;
– *Y (y)* – the result of actions of «counterparties *E*»;
– *Fi (yi)* – profit of the *i*-th «counterparty *E*»;
– *W (y)* – the sum of target functions of system participants.

1) Utility function «counterparty *C*»

$$F(y) = \lambda \sum_{i=1}^{N} y_i^0 - \sum_{i=1}^{N} \left(r_i \left(y_i^0 - a \right)^3 + b \right). \quad (3)$$

Differentiate formula (3) on y_i^0 and equate the result to zero:

$$F(y)'_{y_i^0} = \lambda - 3r_i \left(y_i^0 - a \right)^2 = 0. \quad (4)$$

According to the last expression, the following can be obtained:

$$y_i^{0\pm} = a \pm \sqrt{\frac{\lambda}{3r_i}}. \quad (5)$$

It is obvious, that the maximum of «counterparty *E*» utility function can be achieved only in one case (5):

$$y_i^0 = a + \sqrt{\frac{\lambda}{3r_i}}. \quad (6)$$

According to the said, the total amount of utility functions of all participants in the system is defined by formula below:

$$W(y) = F(y) = \lambda aN + \frac{2}{3}\lambda\sqrt{\frac{\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}} - bN. \quad (7)$$

Spearman's rank correlation coefficient calculations confirm the lack of interrelation between the interests of market relations contractors (Table 2).

Table 2

The impact of price fluctuations on the economic interests of market relations agents

№	Pressure on price fluctuations on socially important commodity markets	Ranking of price fluctuations impact on welfare reduction of national economy entities, points			Comparison of ranks			The sum of lines	Squares amounts
		State	Entrepreneurs	Households	Rx	Ry	Rz	d_i	$\sum d_i^2$
1	State political instability and inept national economy management	4	3	3	4	3	2	9	81
2	High level of shadow economy and uncontrollable activities of oligopolies	5	2	3	5	1,5	2	8,5	72,25
3	Hyperinflationary processes in the national economy	2	4	4	3	4	4	11	121
4	The massive hype and increase of demand for the products	1	2	7	1,5	1,5	5	8	64
5	Price discrimination on the part of monopolies	1	6	3	1,5	5	2	8,5	72,25
6	Total points	13	17	20	15	15	15	45	410,5
7	The calculation of amount	Spearman's coefficient for			$\sum d_{xyi}^2 =$ 26,5	$\sum d_{yzi}^2 =$ 22,5	$\sum d_{xzi}^2 =$ 26,5	for Kendall's coefficient $\sum d_i^2 - \left(\sum d_i\right)^2 / n =$ 5,5	
8	Coefficients	Spearman			-0,325	-0,125	-0,325	Kendall 0,061111	
9	Assessment of significance	Using			Student's Criterion			Pearson's Criterion	
10	Investigated criterion value				-0,768	-0,282	-0,768	$\chi_{kp}^2 =$	0,733333
11	Critical values				0,7649	0,7649	0,7649	$\chi_{kp}^2 =$	9,487729

$$R_{yz} = 1 - \frac{6 \cdot \sum d_i^2}{n^3 - n}$$

According to formula, results of calculations are following:

$$R_{yz} = 1 - \frac{6 \cdot \sum d_i^2}{n^3 - n} = -0{,}125$$

Evaluation of Spearman's rank correlation coefficient χ^2

Investigated value is equal to:

$$t_\rho = R\sqrt{\frac{n-2}{1-R^2}} = -0{,}282\,.$$

According to the received results of calculations, an extremely weak inverse interrelation between enterprises and households is determined. That fact is proved by Spearman's coefficient, which values are statistically insignificant. Analogically, calculations for other systems are the same (for *HH - EE, EE – EE).*

The calculation of «Counterparty S» utility function is similar to (7):

$$F(y) = \gamma\lambda \sum_{i=1}^{N} y_i = \gamma\lambda \sum_{i=1}^{N} \left(a + \sqrt{\frac{(1-\gamma)\lambda}{3r_i}} \right) =$$

$$= \gamma\lambda \left(aN + \sqrt{\frac{(1-\gamma)\lambda}{3}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}} \right)$$

In this case the economic motivation mechanism involves the following points:

$$f_i(y_i) = 0$$

$$Y(y) = aN + \sqrt{\frac{\lambda}{3}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}}\,. \qquad (8)$$

Total sum of utility functions of all participants has the following form:

$$W(y) = F(y) + \sum_{i=1}^{N} f_i(y_i) =$$

$$= \lambda aN + \left(\lambda - \frac{(1-\gamma)\lambda}{3} \right) \sqrt{\frac{(1-\gamma)\lambda}{3}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}} - bN$$

Thus, the total sum of utility functions of all system participants has the following form:

$$W(y) = F(y) = \lambda aN + \frac{2}{3}\lambda \sqrt{\frac{\lambda}{3}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}} - bN. \qquad (9)$$

S – EE

In this case, provision of pricing services is logical at the price equal to λ, excluding some normative γ. This normative reflects the proportion of «counterparty E» income transmitted to «counterparty S» as a return of profit (of VAT). Normative γ belongs to interval of [0,1). The interval is open on the top side, so in case when γ=1 we has situation,

when «counterparty E» has benefit of being inactive. In other case, it is that activity of «counterparty E» will be unprofitable, what contradict to content of economic motivation mechanism.

Taking into these conditions, the benefit of *i-th* «counterparty E» $H_i(y_i)$ will be equal to $(1-\gamma)\gamma y_i$. The objective function has the following for these conditions be (including (1) and (2)):

$$f_i(y_i) = (1-\gamma)\lambda y_i - r_i(y_i - a)^3 - b. \quad (10)$$

Normative γ can be represented in a form of internal tax rate on income. In order to determine the actions of «counterparties E», there must be done operations similar to (4), (5):

$$f_i'(y_i) = (1-\gamma)\lambda - 3r_i\left(y_i^0 - a\right)^2 = 0. \quad (11)$$

$$y_i^{\pm} = a \pm \sqrt{\frac{(1-\gamma)\lambda}{3r_i}}. \quad (12)$$

Analogically to (6), its possible to determine the variant of probable maximum of «counterparty E» utility function:

$$y_i = a + \sqrt{\frac{(1-\gamma)\lambda}{3r_i}}. \quad (13)$$

The action, which chosen by «counterparty E», doesn't depend on value of *b*. According to his statement we can exclude this term from further calculations.

Calculation of «counterparty S» utility function is analogical to (7):

$$F(y) = \gamma\lambda\sum_{i=1}^{N} y_i = \gamma\lambda\sum_{i=1}^{N}\left(a + \sqrt{\frac{(1-\gamma)\lambda}{3r_i}}\right) =$$
$$= \gamma\lambda(aN + \sqrt{\frac{(1-\gamma)}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}}). \quad (14)$$

In this case, result of actions of all «counterparties E» is presented in the following form:

$$Y(y) = \sum_{i=1}^{N} y_i = aN + \sqrt{\frac{(1-\gamma)\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}}. \quad (15)$$

A benefit of the *i-th* «counterparty E» is represented by formula below:

$$f_i(y_i) = (1-\gamma)\lambda y_i - r_i(y_i - a)^3 - b =$$
$$= (1-\gamma)\lambda a + \frac{2}{3}(1-\gamma)\lambda\sqrt{\frac{(1-\gamma)\lambda}{3r_i}} - b. \quad (16)$$

Total utility functions of all participants has the following form:

$$W(y) = F(y) + \sum_{i=1}^{N} f_i(y_i) =$$

$$= \lambda aN + \left(\lambda - \frac{(1-\gamma)\lambda}{3}\right)\sqrt{\frac{(1-\gamma)\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}} - bN \ . \qquad (17)$$

It is obviously, that expressions (14)-(17) are dependent on normative «γ», which managed by «counterparty C». It is possible to determine optimal ratio of normative «γ» for «counterparty S». In order to do that we need to define the value of normative «γ», which will maximize the expression (14). At the same time, this value mast positive (16).

$$R_{xy} = 1 - \frac{6 \cdot \sum d_i^2}{n^3 - n}$$

$$R_{xy} = 1 - \frac{6 \cdot \sum d_i^2}{n^3 - n} = -0,325$$

Calculation of Spearman's rank correlation coefficient resulted the following value:

$$t_\rho = R\sqrt{\frac{n-2}{1-R^2}} = -0,768$$

According to received results, there is a weak inverse interrelation between enterprises and the state, and the COP is not statistically significant.

In this case, the price is the sum of cost for services provision and profit return ratio ρ, expressed as a percentage share of the cost. The rate of «counterparty E» profit return ρ is profitability. In case of profit return ratio ρ equal to 0, the situation refers to the first observed mechanism of economic interests.

Analogically to the first option, the implementation of planned y_i^0 objectives is optimal scenario for «counterparty E».

According to the conditions of this mechanism, reformulate form of (3) is the following:

$$F(y) = \lambda\sum_{i=1}^{N} y_i^0 - (1-\rho)\sum_{i=1}^{N}\left(r_i\left(y_i^0 - a\right)^3 + b\right). \qquad (18)$$

After differentiation (18), we simplified results and rejected unnecessary decisions. As result we received the following statements:

$$(F(y)'_{y_i^0} = \lambda - 3(1-\rho)r_i\left(y_i^0 - a\right)^2 = 0. \qquad (19)$$

$$y_i^{0\pm} = a \pm \sqrt{\frac{\lambda}{3(1-\rho)r_i}}. \qquad (20)$$

$$y_i^0 = a + \sqrt{\frac{\lambda}{3(1-\rho)r_i}}. \qquad (21)$$

According to calculations, for this economic motivation mechanism we has the following:

$$F(y) = \lambda \sum_{i=1}^{N} \left(a + \sqrt{\frac{\lambda}{3(1+\rho)r_i}} \right) - (1+\rho) \sum_{i=1}^{N} \left(r_i \left(\sqrt{\frac{\lambda}{3(1+\rho)r_i}} \right)^3 + b \right) =$$

$$= \lambda aN + \frac{2}{3}\lambda \sqrt{\frac{\lambda}{3(1+\rho)}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}} - bN(1+\rho). \quad (22)$$

$$f_i(y_i) = \rho \left(r_i \left(\sqrt{\frac{\lambda}{3(1+\rho)}} \right)^3 + b \right). \quad (23)$$

$$Y(y) = aN + \sqrt{\frac{\lambda}{3(1+\rho)}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}}. \quad (24)$$

$$W(y) = F(y) + \sum_{i=1}^{N} f_i(y_i) =$$

$$= \lambda aN + \frac{\lambda}{3}\left(2 + \frac{\rho}{1+\rho}\right) \sqrt{\frac{\lambda}{3(1+\rho)}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}} - bN. \quad (25)$$

$$R_{yz} = 1 - \frac{6 \cdot \sum d_i^2}{n^3 - n}$$

Results of provided calculations: $R_{xz} = 1 - \frac{6 \cdot \sum d_i^2}{n^3 - n} = -0,375$

Evaluation of Spearman's rank correlation coefficient. According to calculation, we have received following results:

$$t_\rho = R\sqrt{\frac{n-2}{1-R^2}} = -0,768$$

HH– E – S

Objective function of «contractor S» has the following view:

$$f_i(y_i) = \Psi\lambda \sum_{i=1}^{N} y_i - r_i(y_i - a)^3 - b. \quad (26)$$

After differentiation (18), we simplified results and rejected unnecessary decisions. As result we received the following statements:

$$(f_i'(y_i) = \Psi\lambda - 3r_i(y_i - a)^2 = 0. \quad (27)$$

$$y_i^{\pm} = a \pm \sqrt{\frac{\Psi\lambda}{3r_i}}. \quad (28)$$

$$y_i = a + \sqrt{\frac{\Psi\lambda}{3r_i}}. \quad (29)$$

According to calculations, for this economic motivation mechanism we has the following:

$$F(y) = (1 - N\Psi)\lambda \left(aN + \sqrt{\frac{\Psi\lambda}{3}} \sum_{i=1}^{N} \sqrt{\frac{1}{r_i}} \right). \quad (30)$$

$$f_i(y_i) = \Psi\lambda\left(aN + \sqrt{\frac{\Psi\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}}\right) - r_i\left(\sqrt{\frac{\Psi\lambda}{3r_i}}\right)^3 - b. \quad (31)$$

$$Y(y) = aN + \sqrt{\frac{\Psi\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}}. \quad (32)$$

$$W(y) = \lambda\left(aN + \sqrt{\frac{\Psi\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}}\right) - \frac{\Psi\lambda}{3}\sqrt{\frac{\Psi\lambda}{3}}\sum_{i=1}^{N}\sqrt{\frac{1}{r_i}} - bN. \quad (33)$$

We use Kendall's concordance coefficient (see. Table 2) in order to confirm the absence of links between the economic interests of market relations agents in conditions of pricing and state pricing regulation.

According to the simplified formula, excluding connected ranks we have following results:

$$W = \frac{12 \cdot S}{m^2(n^3 - n)} = 0,0611; \quad S = \sum d_i^2 - \left(\sum d_i\right)^2 / n = 5,5,$$

Results of calculations are indicating the lack of communication between contractors.

Evaluation of Kendall's concordance coefficient by the criterion of χ^2. According to calculations. We have received following results:

$$\chi^2 = \frac{12 \cdot S}{m(n^2 - n)} = 0,733;$$

For each of the four systems (1– HH- HH; 2 – HH, E,E-E; 3– E-S; 4 – HH- E - S) there were developed and formulated following model parameters:

– For 1) – (7), (8) and (9);
– For 2) – (14) (15) (16) and (17);
– For 3) – (22) (23) (24) and (25);
– For 4) – (30) (31) (32) and (33).

Conclusions. Designed models are enabling the possibility to use the most flexible pricing policy, price discrimination and state pricing regulation. In its turn, it enables us to provide economic interests of producers, consumers and the state on the maximal degree. Thus, the every case is checked by Kendall's and Spearman's coefficients. Coefficients show a weak link between economic interests of agents. When we talk about state – there is lack of communication.

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