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Expansion of the Cost Index on the Factors by Means of the Parameter "Index Attitude"

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Abstract: Given clause is devoted to a problem of factorial decomposition of a value index. In it is shown as by means of a new parameter — "the index attitude" the problem of decomposition of a total cost in absolute sizes is solved. The basic difference of the given method from earlier known methods that authors suggest to approach to a problem from the point of view of an alternative way developed and offered to discussion by authors. The offered way of decomposition of a parameter of a total cost of sales, in opinion of authors, represents model of rational "smoothing" of influence of kinds of averages and receptions of weighing on change of an end result to means of new statistics — individual (*ir*) and cumulative (*IR*) the index attitude to which in an offered way rather essential role is allocated.

Key words: an index method; the index attitude; factorial decomposition of a value index; model of rational "smoothing"

JEL codes: C4, C43, C430

1. Introduction

The index method, being the major analytical means of revealing of communications between the phenomena, is based on relative parameters of dynamics, spatial comparisons, performance of the plan, expressing the attitude of an actual level of an analyzed parameter in the accounting period to its level in the basic period.

By means of this method relative change of cost of realization of production (V) from change of quantity of sales (q) and the prices (p) is represented in the form of the following formula of the interconnected indexes:

$$I_V = \frac{\sum q_1 p_1}{\sum q_0 p_0} = I_q I_p \tag{1}$$

Where I_V — the general index of realization of a commodity output;

I_q — a factorial index of change of volume (quantity) of realization of production;

I_p — a factorial index of change of a market price for the goods sold by the enterprise.

The formula (1) is a subject of the long-term scientific discussion connected with the main problem of an index method of the analysis — a problem of a uniform way of calculation of indexes of quantity (I_q) and the prices (I_p).

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2. A Selected Review of Literature

The methodology of the analytical concept treats indexes as the parameters necessary for an estimation of influence of change of factors of the complex phenomenon on the general change of a level of this phenomenon. In this case the index methodology provides definition of influence of each of factors by elimination of influences of other factors on a level of the studied phenomenon. Such approach has allowed passing to practical construction of systems of the interconnected indexes and the factorial index analysis that was significant achievement of a domestic science.

The greatest contribution to development of the factorial index analysis such Russian scientists as Adamov has brought, Cormorants, Yezhov, Teroganyan, Mereste and others. Now this method continues to develop successfully in Suslov’s works, Ploshko and other scientists.

During different years such western scientists developed and continue to develop now the index theory as Fisher, Frish, Allen, Divisia, Kervish, Ihorn, Divert, Milton, Balk, Fiksler and others.

3. Methodology

In modern indexology there are two basic ways of representation of the formula (1). A methodological basis of these ways is the criterion of convertibility of the factors, demanding that product given I_q and initial I_p was equal to change of cost of the considered unit I_V (Kuritsyn A. V., Sologubov S. V., 2010 b).

According to way of construction of factorial indexes officially accepted in the Russian statistical practice, “if the generalizing economic parameter represents product of quantitative (volumetric) and qualitative parameters — factors at definition of influence of the quantitative factor the quality indicator is fixed at a basic level, and at definition of influence of the qualitative factor the quantity indicator is fixed at a level of the accounting period” (Bakanov M. I., Sheremet A. D., 2011).

Proceeding from the above-stated, in the formula (1) should be $I_q = \frac{\sum q_1 p_0}{\sum q_0 p_0}$ and $I_p = \frac{\sum q_1 p_1}{\sum q_1 p_0}$. But the alternative variant is possible also, at which $I'_q = \frac{\sum q_1 p_1}{\sum q_0 p_1}$ and $I'_p = \frac{\sum q_0 p_1}{\sum q_0 p_0}$. In both cases it is had

$$I_V = I_q I_p = I'_q I'_p$$

From the scientific point of view application both the first (official), and the second (alternative) ways absolutely equally accepted also is equal in rights.

The index method allows leading also decomposition under factors and absolute deviations of a generalizing parameter. For our case it looks as follows

$$\Delta V = V_1 - V_0 = \sum q_1 p_1 - \sum q_0 p_0 \tag{2}$$

Where ΔV — absolute change of cost of realization of production in the analyzed period (c.u.);

V_0 and V_1 — cost of sales in the basic and accounting periods, according to (c.u.).

The deviation (ΔV) was formed under influence of changes of quantity of realized production (ΔV_q) and a market price of its realization (ΔV_p). Change ΔV_q and ΔV_p on the first way of representation of a total cost yields to us following results

$$\Delta V_q = \sum q_1 p_0 - \sum q_0 p_0 = \sum ((q_1 - q_0) p_0)$$
$$\Delta V_p = \sum q_1 p_1 - \sum q_1 p_0 = \sum ((p_1 - p_0) q_1) \quad (3)$$

In case of application of the second way of representation ΔV it is received

$$\Delta V'_q = \sum q_1 p_1 - \sum q_0 p_1 = \sum ((q_1 - q_0) p_1)$$
$$\Delta V'_p = \sum q_0 p_1 - \sum q_0 p_0 = \sum ((p_1 - p_0) q_0) \quad (4)$$

As well as at relative calculation, absolute change of cost of the sales, calculated by both in the ways, gives the same value:

$$\Delta V = V_1 - V_0 = \Delta V_q + \Delta V_p = \Delta V'_q + \Delta V'_p \quad (5)$$

Many administrative decisions yielding sometimes opposite results also depend on a choice of this or that way of representation I_V and ΔV.

For example, the enterprise lets out five different kinds of products which are characterized by the following quantitative and quality indicators (Table 1).

Table 1 Calculation of the Basic Parameters

The goods	q_0	p_0	q_0p_0	q_1	p_1	q_1p_1	$i_q = \frac{q_1}{q_0}$	$i_p = \frac{p_1}{p_0}$	$i_v = \frac{q_1 p_1}{q_0 p_0}$	q_1p_0	q_0p_1
A	2787	31.9	88905.3	2348	332.8	77014.4	0.8425	1.0282	0.8663	74901.2	91413.6
B	575	35.3	20297.5	401	35.9	14395.9	0.6974	1.0170	1.4831	14155.3	20642.5
C	21652	1.8	38973.6	97016	1.5	145524.0	4.4807	0.8333	3.7339	174628.8	32478.0
D	383	24.8	9498.4	241	19.7	4747.7	0.6292	0.7944	0.4998	5976.8	7545.1
E	21629	3.2	69212.8	37752	3.7	139682.4	1.7454	1.1563	2.0182	120806.4	80027.3
Total	-	-	226887.6	-	-	381364.4	-	-	1.68085	390468.5	232106.5

According to Table 1 it is calculated:

$$I_q = \frac{\sum q_1 p_0}{\sum q_0 p_0} = \frac{390468.5}{226887.6} = 1.72098 \qquad I_p = \frac{\sum q_1 p_1}{\sum q_1 p_0} = \frac{381364.4}{390468.5} = 0.97668$$

$$I'_q = \frac{\sum q_1 p_1}{\sum q_0 p_1} = \frac{381364.4}{232106.5} = 1.64306 \qquad I'_p = \frac{\sum q_0 p_1}{\sum q_0 p_0} = \frac{232106.5}{226887.6} = 1.02300$$

As one would expect,

$$I_V = 1.70298 \otimes 0.97668 = 1.64306 \otimes 1.023 = 1.68085$$

However, if in an estimation of the tendency of change of the quantitative factor there are no differences in principle (in both cases an index of quantity of more unit) with an estimation of the tendency of change of the price not all so is unequivocal.

If in a basis of research to put the first way of representation of a value index we should recognize, that the average price in the accounting period has decreased to 97.7% in comparison with the period basic.

If to take for a basis the second way we are compelled to ascertain, that the average price has increased up to 102.3%.

So inconsistent results are difficult for interpreting unequivocally if, certainly, to not put as the purpose of research the proof of the fact of indispensable reduction of price or, on the contrary, the proof of its indispensable growth.

Passing to absolute calculation, we receive (Table 2):

Table 2 Two Ways of Representation of a Value Index

The goods	$\Delta V = V_1 - V_0$	Including			
		The First way of representation		The Second way of representation	
		$\Delta Vq = \sum q_1 p_0 - \sum q_0 p_0$	$\Delta Vp = \sum q_1 p_1 - \sum q_1 p_0$	$\Delta Vq' = \sum q_1 p_1 - \sum q_0 p_1$	$\Delta Vp' = \sum q_0 p_1 - \sum q_0 p_0$
A	-11890.9	-14004.1	2113.2	-14399.2	2508.3
B	-5901.6	-6142.2	240.6	-6246.6	345.0
C	106550.4	135655.2	-29104.8	113046.0	-6495.6
D	-4750.7	-3521.6	-1229.1	-2797.4	-1953.3
E	70469.6	51593.6	18876.0	59655.1	10814.5
Total	154476.8	163580.9	-9104.1	149257.9	5218.9

The data resulted in Table 2, do not give the unequivocal answer: whether the price policy of the enterprise has resulted, concentrated which expression is change of the price, for growth of cost of sales on 5218.9 c.u. or to its decrease on 9104.1 c.u.?

The reason of so ambiguous interpretation of the received results is covered that indexes $I_q = \frac{\sum q_1 p_0}{\sum q_0 p_0} = \frac{\sum i_q q_0 p_0}{\sum q_0 p_0}$ and $I'_p = \frac{\sum q_0 p_1}{\sum q_0 p_0} = \frac{\sum i_p q_0 p_0}{\sum q_0 p_0}$ is an essence average arithmetic indexes from individual indexes $i_q = \frac{q_1}{q_0}$ и $i_p = \frac{p_1}{p_0}$ and while indexes $I'_q = \frac{\sum q_1 p_1}{\sum q_0 p_1} = \frac{\sum q_1 p_1}{\sum \frac{q_1 p_1}{i_q}}$ and $I_p = \frac{\sum q_1 p_1}{\sum q_1 p_0} = \frac{\sum q_1 p_1}{\sum \frac{q_1 p_1}{i_p}}$ — averages harmonious from the same individual indexes. The various kinds of averages used at calculation of indexes, give different values of indexes of the price and quantity. Simultaneously at change of a kind of average in modular indexes there is a replacement of weights. For example, in calculation of the unit of the price replacement of weights «q_1» ($\frac{\sum q_1 p_1}{\sum q_1 p_0}$) on weights «$q_0$» ($\frac{\sum q_0 p_1}{\sum q_0 p_0}$) leads diametrically opposed to result: instead of the loss our enterprise receives the income.

In this connection there is a question: whether such way of decomposition of the general value index in which there would be no problem of a choice of weights at calculation of indexes of the price and quantity, on the one hand, and a problem of a choice of a kind of average is possible at calculation of indexes I_q and I_p, with another?

To answer a brought attention to the question, we shall consider in the beginning process of formation of an individual value index (i_v) as criterion of product of individual indexes of quantity (i_q) and the prices (i_p)

$$i_v = i_q i_p = \frac{q_1 p_1}{q_0 p_0}$$

Let's enter a new parameter $ir = \frac{i_p}{i_q} = \frac{q_0 p_1}{q_1 p_0}$, which we shall name the individual index attitude describing relative change of the price (i_p) in comparison with relative change of quantity (i_q).

From the formula follows $ir = \frac{i_p}{i_q}$, what $i_p = ir\ i_q$ and $i_q = \frac{i_p}{ir}$. Substituting the received values i_p and i_q in the formula of an individual value index, we define

$$i_v = i_q i_p = ir(i_q)^2 = \frac{(i_p)^2}{ir} \tag{6}$$

From here we find

$$i_q = \sqrt{\frac{i_v}{ir}} \quad \text{and} \quad i_p = \sqrt{i_v ir} \tag{7}$$

Absolute change of the individual index attitude gives us the result equal

$$\Delta ir = q_0 p_1 - q_1 p_0 = q_0 \Delta p - p_0 \Delta q = q_1 \Delta p - p_1 \Delta q \tag{8}$$

In the formula (8) $q_0\Delta p$ and $q_1\Delta p$ also is a change of a total cost of production due to change of the factor of the price «$\Delta v''_p$» at different «*q*» weights, and $p_0\Delta q$ and $p_1\Delta q$ — change of the same cost due to the factor of quantity «$\Delta v''_q$» at different «*p*» weights. Hence, at any receptions of weighing it is possible to approve, that $\Delta ir = \Delta v''_p - \Delta v''_q$. From here $\Delta v''_p = \Delta ir + \Delta v''_q$.

Having substituted this value $\Delta v = \Delta v''_q + \Delta v''_p$ in the formula, we shall receive

$$\Delta v = \Delta v''_q + \Delta v''_q + \Delta ir = 2\Delta v''_q + \Delta ir$$

From here

$$\Delta v''_q = \frac{\Delta v - \Delta ir}{2} \tag{9}$$

Having replaced «$\Delta v''_q$» on $\Delta v''_q = \Delta v''_p - \Delta ir$ in the formula $\Delta v = \Delta v''_q + \Delta v''_p$, we receive

$$\Delta v''_p = \frac{\Delta v + \Delta ir}{2} \tag{10}$$[1]

Thus, in formulas 7-10 at calculations $i_q = \sqrt{\frac{i_v}{ir}}$, $i_p = \sqrt{i_v ir}$, $\Delta v''_q = \frac{\Delta v - \Delta ir}{2}$ and $\Delta v''_p = \frac{\Delta v + \Delta ir}{2}$, also it is possible to involve simultaneously at once all four sets of cost weights of Fisher (q_0p_0, q_1p_0, q_0p_1, q_1p_1) and by that to solve a problem of weighing (Kuritsyn A. V., Sologubov S. V., 2010a).

If we now shall pass from individual indexes to indexes modular,

(1) instead of the individual index attitude ir it is received cumulative index attitude IR

$$IR = \frac{\sum q_0 p_1}{\sum q_1 p_0} = \frac{\sum i_p q_0 p_0}{\sum q_0 p_0} : \frac{\sum i_q p_0 q_0}{\sum p_0 q_0} = \frac{\sum q_1 p_1}{\sum \frac{q_1 p_1}{i_p}} : \frac{\sum q_1 p_1}{\sum \frac{q_1 p_1}{i_q}} = \frac{\sum irq_1 p_0}{\sum q_1 p_0} = \frac{\sum q_0 p_1}{\sum \frac{q_0 p_1}{ir}} \tag{11}$$

(2) individual value indexes of the goods are replaced with the general value index I_V

$$I_V = \frac{\sum q_1 p_1}{\sum q_0 p_0} = \frac{\sum i_v q_0 p_0}{\sum q_0 p_0} = \frac{\sum q_1 p_1}{\sum \frac{q_1 p_1}{i_v}} = \frac{\sum (i_q)^2 irq_0 p_0}{\sum q_0 p_0} = \frac{\sum q_1 p_1}{\sum \frac{q_1 p_1}{(i_q)^2 ir}} = \frac{\sum \frac{(i_p)^2}{ir} q_0 p_0}{\sum q_0 p_0} = \frac{\sum q_1 p_1}{\sum \frac{irq_1 p_1}{(i_p)^2}}$$

[1] Formulas (9) and (10) may be received by logorifmiing the formula (7) $\lg iq = \frac{\lg iv - \lg ir}{2}$; $\lg ip = \frac{\lg iv + \lg ir}{2}$. Crossing from relative values to their absolute meaning get formulas (9) and (10)

(3) individual indexes of quantity $i_q = \sqrt{\dfrac{i_v}{ir}}$ and the price $i_p = \sqrt{i_v \times ir}$ are replaced with cumulative indexes

$$I''_{\mathrm{q}} = \sqrt{\frac{I_V}{IR}} \quad \text{and} \quad I''_p = \sqrt{I_V IR} \tag{12}$$

(4) influence of absolute change of volume «$\Delta v''_q$» and the price «$\Delta v''_p$» on change $\Delta v = \Delta v''_q + \Delta v''_p$ of cost also vary in the appropriate image

$$\Delta V = \Delta V''_q + \Delta V''_p \tag{13}$$

Where $\Delta V''_q = \dfrac{\Delta V - \Delta IR}{2}$, $\Delta V''_p = \dfrac{\Delta V + \Delta IR}{2}$.

Let's consider the resulted algorithm from positions of the offered approach.

According to table 1 it is found

$$IR = \frac{\sum q_0 p_1}{\sum q_1 p_0} = \frac{232106.5}{390468.5} = 0.59443$$

Then, using formulas (12), we define

$$I''_{\mathrm{q}} = \sqrt{\frac{1.68085}{0.59443}} = \sqrt{2.82767} = 1.68157 \text{ or} \approx 168.16\%$$

$$I''_p = \sqrt{1.68085 \otimes 0.59443} = \sqrt{0.99915} = 0.99957 \text{ or} \approx 99.96\%$$

Hence, the cumulative index of physical volume under the offered approach has made 168.16%, i.e., the volume of realization of a commodity output on the enterprise has grown on 68.16%, that in absolute calculation has given the additional income at a rate of 156419.4 c.u. the Cumulative index of the price has made 99.96%, i.e., the price was reduced to 0.04% that 1942.6 c.u. (Table 3) have led to loss of profitableness from sales for the sum.

Table 3 Calculation of Relative and Absolute Change Value Index (Including Under Factors)

The goods	$ir = \dfrac{i_p}{i_q} = \dfrac{q_0 p_1}{q_1 p_0}$	$\Delta ir = q_0 p_1 - q_1 p_0$	$\Delta v = v_1 - v_0 = = q_1 p_1 - q_0 p_0$	Including	
				$\Delta v''_q = \dfrac{\Delta v - \Delta ir}{2}$	$\Delta v''_p = \dfrac{\Delta v + \Delta ir}{2}$
A	1,22046	16512,4	-11890,9	-14201,65	2310,75
B	1,45829	6487,2	5901,6	-6194,4	292,8
C	0,18598	-142150,8	106550,4	124350,6	-17800,2
D	1,26240	1568,3	-4750,7	-3159,5	-1591,2
E	0,66244	-40779,1	70469,6	55624,35	14845,25
Total	0,59443	-158362,0	154476,8	156419,4	-1942,6

4. Results

The offered way of decomposition of a parameter of a total cost of sales, in opinion of authors, represents model of rational "smoothing" of influence of kinds of averages and receptions of weighing on change of an end result to means of new statistics — individual (ir) and cumulative (IR) the index attitude to which in an offered way rather essential role is allocated. The last is caused by that, first, from the point of view of micro-economics ir and IR is original "watershed" between market interests of the seller and the buyer as by virtue of dual character of a supply and demand.

- the seller, offering in the market the goods, asks the buyer of money, aspiring smaller quantity of the goods (in our case as the indicator of this interest acts $i_q < 1$ or $I''_q < 1$) to sell under higher price ($i_p > 1$ or $I''_p > 1$). That is the seller is interested in, that $ir = \frac{i_p > 1}{i_q < 1} > 1 \to \max$, no less than as $IR = \frac{I''_p > 1}{I''_q < 1} > 1 \to \max$ in this case the seller maximizes the function of utility;

- the buyer, on the contrary, offering money, asks the necessary goods the seller, aspiring for smaller money ($i_p < 1$ or $I''_p < 1$) to buy a lot of the goods ($i_q > 1$ or $I''_q > 1$). Thus, maximizing the function of utility, the buyer is interested in it, that $ir = \frac{i_p < 1}{i_q > 1} < 1 \to \min$ or $IR = \frac{I''_p < 1}{I''_q > 1} < 1 \to \min$.

Hence, the substantial component *ir* and *IR* consists that the seller is interested in growth of the index attitude, and the buyer is interested in its decrease.

Secondly, formulas (7) and (12) give essentially other, differing from traditional, a variant of calculation of indexes of volume and the price. By means of these formulas individual and general value indexes are displayed by symmetric image on an index of the price and an index of quantity, instead of designed from them as it is accepted in traditional formulas $i_v = i_q \times i_p$ and $I_V = I_q \times I_p = I'_q \times I'_p$. Speaking in other words, formulas (7) and (12) is a quintessence of the direct factorial analysis, in which research is conducted by deductive way — from the general (i_v and I_V) to private (i_q and i_p, I''_q and I''_p).

In traditional formulas $i_q = \frac{q_1}{q_0}$, $i_p = \frac{p_1}{p_0}$, $I_q = \frac{\sum q_1 p_0}{\sum q_0 p_0}$, $I_p = \frac{\sum q_1 p_1}{\sum q_1 p_0}$, $I'_q = \frac{\sum q_1 p_1}{\sum q_0 p_1}$ and $I'_p = \frac{\sum q_0 p_1}{\sum q_0 p_0}$, research of relationships of cause and effect is carried out in the way of a logic induction — from private separate factors (i_q and i_p, I_q and I_p, I'_q and I'_p) to generalizing (i_v and I_V), that concerns to a prerogative of the return factorial analysis. Conceptually author’s scheme of a direct and return index method of the factorial analysis is presented on Figure 1.

Thirdly, in a context of formulas (9) and (10) individual index attitude is harmoniously entered in the theory of elasticity of a supply and demand. So, if factors of dot price elasticity on the beginning (E_H) and the end (E_K) the period to count under formulas (Chubakov G. N., 1995)

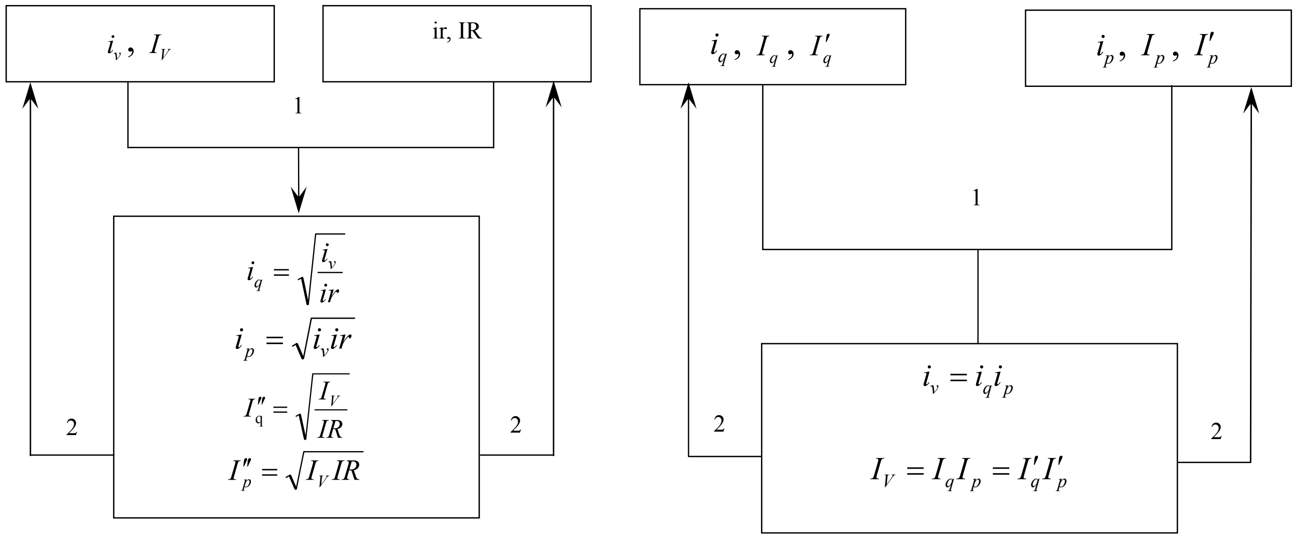
$$E_н = \frac{q_1 - q_0}{q_0} : \frac{p_1 - p_0}{p_0} = \frac{i_q - 1}{i_p - 1}$$

$$E_к = \frac{q_1 - q_0}{q_1} : \frac{p_1 - p_0}{p_1} = \frac{i_q - 1}{i_p - 1} \otimes \frac{i_p}{i_q}$$

that is easy for noticing, that $E_к = E_н ir$. Whence $ir = \frac{E_к}{E_н}$, that is the individual index attitude is an attitude of factors of dot price elasticity of the goods on the end and the beginning of the period describing change of elasticity of demand (offer) between these dates. On the other hand, the attitude of formulas (9) and (10) gives us factor of average (arc) elasticity

$$\overline{E} = \frac{q_1 - q_0}{q_0 + q_1} : \frac{p_1 - p_0}{p_0 + p_1} = \frac{\Delta v - \Delta ir}{\Delta v + \Delta ir} = \frac{\Delta v''_q}{\Delta v''_p},$$

describing price elasticity of a supply and demand during any period.



(a) the straight line index factorial analysis (b) the return index factorial analysis

Figure 1 The Conceptual Scheme of a Direct and Return Index Method of the Factorial Analysis

Fourthly, from expressions (11) follows, that the cumulative index attitude is indifferent and to a problem of a choice of a kind of average[2], and to a problem of a choice of weights at calculation of indexes of the price and quantity as its size remains constant, and, means, steady and stable as at use of various kinds of average, and various variants of cost weighing.

Fifthly, the opportunity of an involvement as in individual ($i_q = \sqrt{\frac{i_v}{ir}}$, $i_p = \sqrt{i_v ir}$), and modular ($I''_q = \sqrt{\frac{I_V}{IR}}$, $I''_p = \sqrt{I_V IR}$) indexes of volume and the price equivalent and equivalent individual (*ir*) and average (*IR*) index attitudes provides a uniform way of calculation of these indexes, removing that the main problem of an index method of the factorial analysis.

Sixthly, mathematically individual indexes of the price ($i_p = \sqrt{i_v ir}$) and quantities ($i_q = \sqrt{\frac{i_v}{ir}}$) are coordinates of the point laying on a gradient of function $I_V = I_q I_p$. The vector of a gradient of this function looks like

$$grad\,(I_V) = \frac{\partial}{\partial I_p} I_V (I_q, I_p) i + \frac{\partial}{\partial I_q} I_V (I_q, I_p) j = I_p i + I_q j$$

The formula grand (I_v) means, that for any spatial point with coordinates (I_q, I_p, I_V) abscise I_q and the ordinate I_p is coordinates of a vector of a gradient which is a directing vector for a straight line $I_p = IRI_q$ laying on plane I_qOI_p. Easier speaking, the cumulative index attitude characterizes a direction of the quickest increase of function $I_V(I_q,I_p)$.

5. Concluding Remarks

Thus, methodological features of application of the index attitude, its mathematical and statistical contents[3] testify to importance of this parameter for an index method of the factorial analysis. On the other hand,

[2] Here we speak about average arithmetical, average harmonic and average geometrical.
[3] About other mathematical and statistic features IR may be learnt in Dzukha V. et al. (2011), Fisher I. (1922), International Labour Office (2004), Kuritsyn A. V., Sologubov S. V. (2011) and Kuritsyn A. V., Sologubov S. V. (2009).

microeconomic aspects and harmonious coordination with the theory of elasticity allow to hope, that by means of the index attitude in indexology new turn to economic problems of indexes, to research of their internal, economic maintenance will be outlined. It will allow to give to a quantitative estimation influence of changes of the price and quantity on formation of the value index, a main task of the indexes considered today, new economic sense in which basis studying the social and economic attitudes developing between subjects of the market as a result of economic activities lays.

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