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Problem-Solving in Deterministic Factor Analysis

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Abstract: The article is concerned with author's methods of factor analysis which allow one to draw conclusions about changes in financial position of a company in the most accessible and less time-consuming way and to estimate the impact of factors on index changes within the economic system and index change trends. The article contains numerical data based on traditional methods of factor analysis. The main task of the author's methods of factor analysis is to identify the factors which determine changes in economic index value in relation to the main factors being its components. The author's methods are aimed at obtaining key (more informative) parameters to have a comprehensive idea of changes in sales revenues.

Key words: Factor analysis · Profitability · «indecomposable rest» · Comparative indices · Effect of factor index changes

INTRODUCTION

An important methodological issue for economic analysis is to estimate influence degree of factors on the value of economic indices under consideration.

The main task of the author's methods of factor analysis (Filatov's methods [1-7]), as well as the traditional ones, is to identify the factors which determine the total industrial supply, i.e. the total changes in production volume in relation to the main factors being its components. The author's methods are aimed at obtaining key (more informative) parameters to have a comprehensive idea of changes in sales revenues.

The traditional methods of deterministic factor analysis cause some problems [8-10]. For example, when using the chain substitution method, results depend largely on the sequence of factor substitutions. According to the rule, first, one estimates the impact of quantitative factors characterizing extensity and then – the impact of qualitative factors characterizing intensity. It is the quantitative factors which the indecomposable rest falls to.

When using the integral method, calculations are based on planned values of indices and calculation errors (indecomposable rest) are distributed equally amongst factors unlike the chain substitution method using which the most part of the rest falls to the last qualitative factor. [11, 12].

Hence, the traditional methods of deterministic factor analysis have the disadvantages as follows:

- The sequence of factor changes is based on the principle according to which the quantitative (extensive) factor changes before the qualitative (intensive) one.
- When decomposing a performance index into its components characterizing the isolated impact of factors causing that change, the indecomposable rest (which is also referred to as a coeffect of factor indices) is formed.

The below given example serves as a proof of problem solving in deterministic factor analysis.

Initial data for an alternative factor analysis are shown in Table 1.

where:

*** 0** is the last (base) period (year) being a comparison base; **** I** is a period under review (current) (year); ***** Δ** is an annual change calculated as the difference between Fact and Plan (**I – 0).**

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Table 1: Initial data for an alternative factor analysis

No.	Indices	No. of an initial factor	Plan* 0	Fact** I	Deviation*** Δ
1	V - is a sales volume, RUR000's.		1424646,496	1757302,56	332656,064
2	Tsr - is an average number of IPP, person.	F_1	910	900	-10
3	Ksr - is an average number of workers, day.	F_2	239	249	10
4	Hsr - is an average shift length, hr.	F_3	7,12	7,54	0,42
5	Wsr - is an average hourly productivity per worker, RUR000's.	F_4	0,92	1,04	0,12

Table 2: Single-factor multiple comparative coefficients

Notation of a comparative coefficient	Calculation of coefficients	Value	Product of coefficients (value)
A_1	$F_{1(I)} / F_{1(0)}$	0,989010989	1,0
A_2	$F_{1(0)} / F_{1(I)}$	1,011111111	
A_3	$F_{2(I)} / F_{2(0)}$	1,041841004	1,0
A_4	$F_{2(0)} / F_{2(I)}$	0,959839357	
A_5	$F_{3(I)} / F_{3(0)}$	1,058988764	1,0
A_6	$F_{3(0)} / F_{3(I)}$	0,944297082	
A_7	$F_{4(I)} / F_{4(0)}$	1,130434783	1,0
A_8	$F_{4(0)} / F_{4(I)}$	0,884615385	

Table 3: Two-factor multiplicative comparative coefficients

Notation of a comparative coefficient	Calculation of coefficients	Factor multipliers	Value
B_1	$(F_{1(I)} * F_{2(I)}) / (F_{1(0)} * F_{2(0)})$	A_1*A_3	1,030392202
B_2	$(F_{3(0)} * F_{4(0)}) / (F_{3(I)} * F_{4(I)})$	A_6*A_8	0,835339727

Table 4: Three-factor multiplicative comparative coefficients

Notation of a comparative coefficient	Factor comparison	Factor multipliers	Value	Product of coefficients (value)
C_1	$(F_{1(I)} * F_{2(I)} * F_{3(I)}) / (F_{1(0)} * F_{2(0)} * F_{3(0)})$	B_1*A_5	1,091173764	1,0
C_2	$(F_{1(0)} * F_{2(0)} * F_{3(0)}) / (F_{1(I)} * F_{2(I)} * F_{3(I)})$	$A_2*A_4*A_6$	0,916444321	
C_3	$(F_{1(I)} * F_{2(I)} * F_{4(I)}) / (F_{1(0)} * F_{2(0)} * F_{4(0)})$	B_1*A_7	1,164791185	1,0
C_4	$(F_{1(0)} * F_{2(0)} * F_{4(0)}) / (F_{1(I)} * F_{2(I)} * F_{4(I)})$	$A_2*A_4*A_8$	0,858522981	
C_5	$(F_{1(I)} * F_{3(I)} * F_{4(I)}) / (F_{1(0)} * F_{3(0)} * F_{4(0)})$	$A_1*A_5*A_7$	1,183962593	1,0
C_6	$(F_{1(0)} * F_{3(0)} * F_{4(0)}) / (F_{1(I)} * F_{3(I)} * F_{4(I)})$	B_2*A_2	0,844621279	
C_7	$(F_{2(I)} * F_{3(I)} * F_{4(I)}) / (F_{2(0)} * F_{3(0)} * F_{4(0)})$	$A_3*A_5*A_7$	1,247206341	1,0
C_8	$(F_{2(0)} * F_{3(0)} * F_{4(0)}) / (F_{2(I)} * F_{3(I)} * F_{4(I)})$	B_2*A_4	0,801791946	

The assumption formula for carrying out factor analysis is (1):

$$V = Tsr * Ksr * Hsr * Wsr \quad (1)$$

Supportive data on comparative coefficients for carrying out factor analysis are represented in Tables 2, 3 and 4.

The ten author's (alternative) methods of deterministic factor analysis (formulas 1.1 – 10.4) are shown in Tables 5, 6.

According to the effect of adjusting coefficients, methods 1.1 and 1.2, 2.1, methods 2.2, 3.1 and 3.2, 4.1, methods 4.2, 5.1 and 5.2 mirror each other.

Method 1.1 (formulas 1.1 – 1.4 in Table 5) is based on the difference between plan performance indices which are adjusted for comparative coefficients (A_1, B_1, C_1).

Method 1.2 (formulas 2.1 – 2.4 in Table 5) is based on the difference between actual performance indices which are adjusted for comparative coefficients (C_8, B_2, A_8).

Method 2.1 (formulas 3.1 – 3.4 in Table 5) is based on the deviation of an original factor from an original plan factor multiplied by a plan performance index which is adjusted for comparative coefficients (A_1, B_1, C_1).

Method 2.2 (formulas 4.1 – 4.4 in Table 5) is based on the deviation of an original factor from an original actual factor multiplied by an actual performance index which is adjusted for comparative coefficients (C_8, B_2, A_8).

Method 3.1 (formulas 5.1 – 5.4 in Table 6) is based on the difference between actual and plan performance indices which are adjusted for comparative coefficients (A_1, B_1, C_1).

Method 3.2 (formulas 6.1 – 6.4 in Table 6) is based on the difference between actual and plan performance indices which are adjusted for comparative coefficients (C_8, B_2, A_8).

Method 4.1 (formulas 7.1 – 7.4 in Table 6) is based on the deviation of a performance factor from the difference between actual and plan performance factors which are adjusted for comparative coefficients (A_1, B_1, C_1).

Table 5: Methods 1.1, 1.2, 2.1 and 2.2 of alternative factor analysis using comparative coefficients

	Formulas / calculations	
No. of a formula	Formula basis	Adjustment coefficients
1.1	$\Delta V\ (F_1) = V_0*(A_1) - V_0$	-
1.2	$\Delta V\ (F_2) = (V_0*(A_3) - V_0)*$	A_1
1.3	$\Delta V\ (F_3) = (V_0*(A_5) - V_0)*$	(A_1*A_3) или B_1
1.4	$\Delta V\ (F_4) = (V_0*(A_7) - V_0)*$	$(A_1*A_3*A_5)$ или C_1
2.1	$\Delta V\ (F_1) = (V_1 - V_1 * (A_2))*$	$(A_8*A_6*A_4)$ или C_8
2.2	$\Delta V\ (F_2) = (V_1 - V_1 * (A_4))*$	(A_8*A_6) или B_2
2.3	$\Delta V\ (F_3) = (V_1 - V_1 * (A_6))*$	A_8
2.4	$\Delta V\ (F_4) = V_1 - V_1 * (A_8)$	-
3.1	$\Delta V\ (F_1) = (\Delta F_1/F_{1(0)})*V_0$	-
3.2	$\Delta V\ (F_2) = (\Delta F_2/F_{2(0)})*V_0*$	A_1
3.3	$\Delta V\ (F_3) = (\Delta F_3/F_{3(0)})*V_0*$	(A_1*A_3) или B_1
3.4	$\Delta V\ (F_4) = (\Delta F_4/F_{4(0)})*V_0*$	$(A_1*A_3*A_5)$ или C_1
4.1	$\Delta V\ (F_1) = (\Delta F_1/F_{1(1)})*V_1*$	$(A_8*A_6*A_4)$ или C_8
4.2	$\Delta V\ (F_2) = (\Delta F_2/F_{2(1)})*V_1*$	(A_8*A_6) или B_2
4.3	$\Delta V\ (F_3) = (\Delta F_3/F_{3(1)})*V_1*$	A_8
4.4	$\Delta V\ (F_4) = (\Delta F_4/F_{4(1)})*V_1$	-

Table 6: Methods 3.1, 3.2, 4.1, 4.2, 5.1 and 5.2 of alternative factor analysis using comparative coefficients

	Formulas / calculations	
No. of a formula	formula basis	formula basis
5.1	$\Delta V\ (F_1) = V_1*(C_8) - V_0$	-
5.2	$\Delta V\ (F_2) = (V_1*(C_6) - V_0)*$	A_1
5.3	$\Delta V\ (F_3) = (V_1*(C_4) - V_0)*$	(A_1*A_3) или B_1
5.4	$\Delta V\ (F_4) = (V_1*(C_2) - V_0)*$	$(A_1*A_3*A_5)$ или C_1
6.1	$\Delta V\ (F_1) = (V_1 - V_0*(C_7))*$	$(A_8*A_6*A_4)$ или C_8
6.2	$\Delta V\ (F_2) = (V_1 - V_0*(C_5))*$	(A_8*A_6) или B_2
6.3	$\Delta V\ (F_3) = (V_1 - V_0*(C_3))*$	A_8
6.4	$\Delta V\ (F_4) = V_1 - V_0*(C_1)$	-
7.1	$\Delta V\ (F_1) = \Delta V - (V_1 - (V_0*A_1)$	-
7.2	$\Delta V\ (F_2) = \Delta V - (V_1 - (V_0*A_3))*$	A_1
7.3	$\Delta V\ (F_3) = \Delta V - (V_1 - (V_0*A_5))*$	(A_1*A_3) или B_1
7.4	$\Delta V\ (F_4) = \Delta V - (V_1 - (V_0*A_7))*$	$(A_1*A_3*A_5)$ или C_1
8.1	$\Delta V\ (F_1) = \Delta V - ((V_1 *A_2) - V_0)*$	$(A_8*A_6*A_4)$ или C_8
8.2	$\Delta V\ (F_2) = \Delta V - ((V_1 *A_4) - V_0)*$	(A_8*A_6) или B_2
8.3	$\Delta V\ (F_3) = \Delta V - ((V_1 *A_6) - V_0)*$	A_8
8.4	$\Delta V\ (F_4) = \Delta V - ((V_1 *A_8) - V_0)*$	-
9.1	$\Delta V\ (F_1) = \Delta V - (V_1 - (V_1*C_8))$	-
9.2	$\Delta V\ (F_2) = \Delta V - (V_1 - (V_1*C_6))*$	A_1
9.3	$\Delta V\ (F_3) = \Delta V - (V_1 - (V_1*C_4))*$	(A_1*A_3) или B_1
9.4	$\Delta V\ (F_4) = \Delta V - (V_1 - (V_1*C_2))*$	$(A_1*A_3*A_5)$ или C_1
10.1	$\Delta V\ (F_1) = \Delta V - ((V_0*C_7) -V_0)*$	$(A_8*A_6*A_4)$ или C_8
10.2	$\Delta V\ (F_2) = \Delta V - ((V_0*C_5) -V_0)*$	(A_8*A_6) или B_2
10.3	$\Delta V\ (F_3) = \Delta V - ((V_0*C_3) -V_0)*$	A_8
10.4	$\Delta V\ (F_4) = \Delta V - ((V_0*C_1) -V_0)$	-

Method 4.2 (formulas 8.1 – 8.4 in Table 6) is based on the deviation of a performance factor from the difference between actual and plan performance factors which are adjusted for comparative coefficients (C_8, B_2, A_8).

Method 5.1 (formulas 9.1 – 9.4 in Table 6) is based on the deviation of a performance factor from the difference between actual performance factors which are adjusted for comparative coefficients (A_1, B_1, C_1).

Method 5.2 (formulas 10.1 – 10.4 in Table 6) is based on the deviation of a performance factor from the difference between plan performance factors which are adjusted for comparative coefficients (C_8, B_2, A_8).

The result based on methods 1.1, 2.1, 3.1, 4.1, 5.1 is shown in Table 7. The result based on methods 1.2, 2.2, 3.2, 4.2, 5.2 is shown in Table 8.

Table 7: The result based on methods 1.1, 2.1, 3.1, 4.1 and 5.1

No.	Formula basis	------------------Adjustment coefficients-----------------		Result, RUR000's.
1	$\Delta V (F_1) = -15655{,}456$	-		-15655,456
2	$\Delta V (F_2) = 59608{,}640$	0,989010989	A_1	58953,600
3	$\Delta V (F_3) = 84038{,}136$	1,030392202	A_1*A_3	86592,240
4	$\Delta V (F_4) = 185823{,}456$	1,091173764	$A_1*A_3*A_5$	202765,680
	313814,776			332656,064

Table 8: The result based on methods 1.2, 2.2, 3.2, 4.2 and 5.2

No.	Formula basis	------------------adjustment coefficients----------------		Result, RUR000's.
1	$\Delta V (F_1) = -19525{,}584$	0,801791946	$A_8*A_6*A_4$	-15655,456
2	$\Delta V (F_2) = 70574{,}400$	0,835339727	A_8*A_6	58953,600
3	$\Delta V (F_3) = 97886{,}880$	0,884615385	A_8	86592,240
4	$\Delta V (F_4) = 202765{,}680$	-		202765,680
	351701,376			332656,064

Table 9: IFCE according to methods 1.1, 2.1, 3.1, 4.1 and 5.1

	Formulas / Calculations		
Index	ΔV (FCOn)	(1 - Kn)	Result, RUR000's.
$\Delta V (FK_1)$			0,000
$\Delta V (FK_2)$	59608,640	-0,01098901	-655,040
$\Delta V (FK_3)$	84038,136	0,030392202	2554,104
$\Delta V (FK_4)$	185823,456	0,091173764	16942,224
			18841,288

Table 10: IFCE according to methods 1.2, 2.2, 3.2, 4.2 and 5.2

	Formulas / Calculations		
Index	ΔV (FCOn)	(1 - Kn)	Result, RUR000's.
$\Delta V (FK_1)$	-19525,584	-0,19820805	3870,128
$\Delta V (FK_2)$	70574,400	-0,16466027	-11620,800
$\Delta V (FK_3)$	97886,880	-0,11538462	-11294,640
$\Delta V (FK_4)$			0,000
			-19045,312

I suppose the biggest challenge in conducting an analysis based on Filatov's methods was to implement comparative coefficients. The purpose of my studies was to propose new methods of deterministic factor analysis based on comparative coefficients in order to assess its results more reliably and with reason.

Based on the above considered author's methods, let us calculate the impact of factor change effect (comparative coefficients) on changes in performance index (formula 11).

$$\Delta V (Kn) = \Delta V (FCOn) * (1 - Kn) \quad (11)$$

where:

ΔV (Kn) – is the impact of factor change effect (hereinafter referred to as IFCE) on changes in performance index;

ΔV (FCOn) – is the impact of a relevant factor on changes in performance index according to the formula basis of the author's method.

K – is an adjustment coefficient;

n – is a number of a factor.

The IFCE according to the author's methods is shown in Tables 9, 10.

In order to conduct a factor analysis based on the author's methods, let us completely change the sequence of factors in the initial formula (formula 12):

$$V = Wsr * Hsr * Ksr * Tsr \quad (12)$$

As a consequence, results shown in Tables 7 and 8 completely coincide (regardless of the change of summands in formulas 1 and 13) with results in Tables 11 and 12.

The IFCE based on the author's methods with change of summands is represented in Tables 13, 14.

The comparison of IFCE with change and without change of factors is shown in Tables 15-17.

Table 11: The result according to methods 1.1, 2.1, 3.1, 4.1 and 5.1 with change of summands

No.	Formula basis	Adjustment coefficients		Result, RUR000's
1	$\Delta V\ (F_4) = 185823{,}456$	-		185823,456
2	$\Delta V\ (F_3) = 84038{,}136$	1,130434783	A_7	94999,632
3	$\Delta V\ (F_2) = 59608{,}640$	1,197117733	A_7*A_5	71358,560
4	$\Delta V\ (F_1) = -15655{,}456$	1,247206341	$A_7*A_5*A_3$	-19525,584
	313814,776			332656,064

Table 12: The result according to methods 1.2, 2.2, 3.2, 4.2 and 5.2 with change of summands

No.	Formula basis	Adjustment coefficients		Result, RUR000's
1	$\Delta V\ (F_4) = 202765{,}680$	0,916444321	$A_2*A_4*A_6$	185823,456
2	$\Delta V\ (F_3) = 97886{,}880$	0,970504239	A_2*A_4	94999,632
3	$\Delta V\ (F_2) = 70574{,}400$	1,011111111	A_2	71358,560
4	$\Delta V\ (F_1) = -19525{,}584$	-		-19525,584
	351701,376			332656,064

Table 13: The IFCE with change of summands according to methods 1.1, 2.1, 3.1, 4.1 and 5.1

	Formulas / Calculations		
Index	ΔV (FCOn)	(1 - Kn)	Result, RUR000's.
$\Delta V\ (FK_4)$			0,000
$\Delta V\ (FK_3)$	84038,136	0,130434783	10961,496
$\Delta V\ (FK_2)$	59608,640	0,197117733	11749,920
$\Delta V\ (FK_1)$	-15655,456	0,247206341	-3870,128
			18841,288

Table 14: The IFCE with change of summands according to methods 1.2, 2.2, 3.2, 4.2 and 5.2

	Formulas / Calculations		
Index	ΔV (FCOn)	(1 - Kn)	Result, RUR000's.
$\Delta V\ (FK_4)$	202765,680	-0,08355568	-16942,224
$\Delta V\ (FK_3)$	97886,880	-0,02949576	-2887,248
$\Delta V\ (FK_2)$	70574,400	0,011111111	784,160
$\Delta V\ (FK_1)$			0,000
			-19045,312

Table 15: Comparison of IFCE in RUR000's according to methods 1.1, 2.1, 3.1, 4.1, 5.1

Index	Without change of factors	With change of factors	Difference (3 - 2)
1	2	3	4
$\Delta V\ (FK_1)$	0,000	-3870,128	-3870,128
$\Delta V\ (FK_2)$	-655,040	11749,920	12404,960
$\Delta V\ (FK_3)$	2554,104	10961,496	8407,392
$\Delta V\ (FK_4)$	16942,224	0,000	-16942,224
	18841,288	18841,288	0,000

Table 16: Comparison of IFCE in RUR000's according to methods 1.2, 2.2, 3.2, 4.2 and 5.2

Index	Without change of factors	With change of factors	Difference (3 - 2)
1	2	3	4
$\Delta V\ (FK_1)$	3870,128	0,000	-3870,128
$\Delta V\ (FK_2)$	-11620,800	784,160	12404,960
$\Delta V\ (FK_3)$	-11294,640	-2887,248	8407,392
$\Delta V\ (FK_4)$	0,000	-16942,224	-16942,224
	-19045,312	-19045,312	0,000

Table 17: Comparison of IFCE in RUR000's according to mirror methods

Index	Methods 1.1, 2.1, 3.1, 4.1, 5.1	Methods 1.2, 2.2, 3.2, 4.2, 5.2	Difference (3 - 2)
1	2	3	4
$\Delta V\ (FK_1)$	-3870,128	-3870,128	0,000
$\Delta V\ (FK_2)$	12404,960	12404,960	0,000
$\Delta V\ (FK_3)$	8407,392	8407,392	0,000
$\Delta V\ (FK_4)$	-16942,224	-16942,224	0,000
	0,000	0,000	0,000

CONCLUSION

Thus, for the first time, we have mathematically proved the following conclusions about the nature of “indecomposable rest”:

- The rest is not errors in calculations (based on the traditional methods);
- The rest refers not only to quantitative factors;
- The rest refers not only to qualitative factors;
- The rest is a result of a combined impact of all factors involved in calculations;
- Its size depends on the size of all factors involved in calculations;
- Its positive and negative values depend on the sequence of factor impact estimation (regardless of the extensity or intensity of factors).

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