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APPLICATION OF STATISTICAL METHODS FOR EVALUATING THE INNOVATIVE COMPANIES' INVESTMENTS EFFECTIVENESS

Anna A. Smokvina, Ph.D. in Economics, Assoc.Prof.

Odessa National Polytechnic University, Odessa, Ukraine

Смоквіна Г.А. Використання статистичних методів оцінки показників ефективності інвестицій інноваційно-активних підприємств.

У статті розглядаються і оцінюються показники ефективності інвестицій інноваційно-активних підприємств. Особливу увагу приділено конкретним статистичним методам що дозволяють оцінити ефективність інвестицій різних промислових комплексів регіону тричі різними способами, тим самим створюючи дієвий механізм пошуку резервів економічного зростання регіону.

Ключові слова: статистичні методи, інвестиції, інновації, методологія, аналіз, оцінка, ефективність, прибуток, підприємство, інноваційно-активні

Смоквина А.А. Использование статистических методов оценки показателей эффективности инвестиций инновационно-активных предприятий.

В статье рассматриваются и оцениваются показатели эффективности инвестиций инновационно-активных предприятий. Особое внимание уделено конкретным статистическим методом позволяющие оценить эффективность инвестиций различных промышленных комплексов региона трижды разными способами, тем самым создавая действенный механизм поиска резервов экономического роста региона.

Ключевые слова: статистические методы, инвестиции, инновации, методология, анализ, оценка, эффективность, прибыль

Smokvina A.A. Application of statistical methods for evaluating the innovative companies' investments effectiveness.

The article examines and assesses performance indicators investment of innovation active enterprises. Particular attention is paid to the specific statistical method to assess the effectiveness of various investment industrial complexes in the region three times in different ways, thus creating an effective search engine reserves the economic growth of the region.

Keywords: statistical methods, investment, innovation, methodology, analysis, evaluation, efficiency, profit, enterprise

The objective processes of actual national economy and its branches management, shifting the central authorities' competence to regional and municipal level do suppose activating a whole chain of essential economic growth factors [11].

Nowadays the economic growth is provided first of all due to scientific and technological progress as well as to the intellectualisation of basic productional factors at every sector of national economy. When speaking about the new knowledge share, embodied into goods, technologies, education and organization of manufacturing processes, at developed countries it reaches up to 70 - 85% of GDP [7]. That is why the global economical competition is won by the states creating favourable opportunities for innovations and investments in close relation to those novelties' development, implementation and use.

The general methodological and organizational principles and approaches to evaluating the investments' efficiency criteria do imply the application of new and non-conventional analytical methods. This is especially actual when monitoring the companies, actively implementing the innovations, contributing to the economic growth of a region.

Thus, there is no alternative to an efficient, flexible and effective administration of innovative activities at the regional level. Under current conditions, the specificity of the innovative companies' investments efficiency evaluation is determined with significant structural changes of functions and methods of research.

Analysis of recent researches and publications

Numerous well-known researchers from leading scientific institutions of Ukraine and the world have effected studies of the investments and innovations mechanism problematic field.

So, such authors as S. Filipina [12], A. Duca [6], O. Chemeris, A. Chemeris [13], O. Vovchak [3] et al have focused on the questions of producing companies investments' support. B. Burkinsky [1], A. Peresad [10], V.I. Zacharchenko, N. Korsikov, M. Merkulov [7], A. Zacharkin [8]. The problems of innovative corporations' activity effectiveness evaluation, organization, management and financing have been considered by V. Vernaliy [2], B. Danilishin [5], M.L. Fedulov [13], O. Yazenko [16], A. Griniov [4] and others, having enlightened

the nature of innovative activity of particular companies.

Unsolved aspects of the general problem

Having studied the experience of foreign and national scientists, upon evaluation of their contribution to the investigated problem, which is of great importance for the efficient growth of companies and the national overall progress, we revealed that none adequate representation of the innovative companies' investments effectiveness evaluation problem still is not suggested. First of all that is due to the multiple changes of investment activity conditions that determines the need in further investigations.

In particular essential is to review closer the possibility to apply various statistical methods while analysing the innovative enterprises' investments efficiency as an important component of the regional innovations and investments-based development policy. The main research goal therefore embodies the practical adaptation of statistical methods, the key importance from among which have the methods of factorial, regressive-correlative analysis and the methods of manufacturing functions analysis.

Main goal of the study

The evaluation of the investments' effectiveness is one of key milestones at management. A reliable and comprehensive evaluation is essential for assessing the payback period, possibilities for alternative investments and additional profit of the company expected in the further period. Such reliability and comprehensiveness of investments evaluation is implied when modern methods of research applied

Departing from the studied economical sources analysis we can summarize that the researchers are tackling the investments evaluation through dividing the evaluation (either leaving it "as is") into several groups using criteria, shown at table 1.

Analysing Table 1 we observe that every researcher has its own way to analyse the effectiveness of investment's evaluation. Though almost all of them do evolve such key indices as net present value, internal rate of return, rate of return and ratio of investments. The listed criteria represent main factors are used for evaluation of investments efficiency in the global practice. Due to this reason the specified parameters are considered as those showing the economical effectiveness of investments.

The aforementioned parameters do not consider the factors allowing evaluation of the innovative companies' investments' effectiveness. This problem solution would depart from the three groups of statistical methods/ such as index numbers, correlative-regressive analysis and Cobb-Douglas function.

The links established between economic occurrences as well as between parameters, representing those occurrences, have an unique character. Their important characteristic is that every economic occurrence in reality is bound to some another. Such analysis methodology represents an important part of economical analysis. The links between the factors and profit-and-loss indicator at similar tasks can be sought from the cause-and-effect viewpoint. The tasks related to the innovative investment activity's factor index analysis are following:

1) Evaluation of the factors relative changes' impact by relative changes of profit-and-loss indicator, as this indicator refers to such important parameter as the profit amount;

2) Evaluation of each factor total changes' influence onto total changes of profit-and-loss indicator;

3) Measuring the relation between growth ratio due to each factor's changes and the value of profit share for the basic period;

4) Measuring the share of total growth caused by each factor's changes at the total increment of profit-and-loss indicator.

The multivariable multiplicative paradigm for the factor index analysis is built by the factor indicators' separation. Thus, the prime bi-factor paradigm of innovative companies' profit (Y, Thou. UAH) can be sought as an product of profit share multiplication with the investment profit. Further evolving other factors we obtain final multiplicative paradigm (Y) as a product of nine factor indicators:

$$Y = a \cdot b \cdot c \cdot d \cdot e \cdot g \cdot h \cdot k \cdot l ,$$

where a is the average annual productivity of basic staff, UAH; b is an average duration of a working day, hours; c is an average duration of a working period (year), days; d is a share of basic staff at total amount of producing personnel, the unit fraction; e is the total quantity of producing personnel, number of persons; g is the share of shipped products counted as fraction to the total amount of produced goods, the unit fraction; h is a ratio of sold goods counted as fraction to the total of shipped goods, the unit fraction; k is a ratio of balance profit counted as quotient to the total amount of sold products, (sold products profitability) the unit fraction; l is a ratio of investment profit counted as fraction to the total amount of gross profit.

When using the paradigm we must follow such principles:

— The factor's position at the model should correspond to its economic influence onto the total phenomenon given level generation. A factor's grow leads to its indicator increase, that does means that the paradigm should include namely this factor and not its reciprocal value. And contrarily if the growth of the factor leads to that factor indicator's decrease, we must operate such a reciprocal value. The analysis economic results' interpretation is not possible when neglecting this rule, and the results will be controversial to the model's logics;

— The paradigm is built up by sequential evolving the qualitative factor's components (sub-factors). This allows shifting backwards to its bigger scale by reintroducing a product of two sequential

factors into the paradigm. A perfect situation represents the factor increase bi-directional opportunities: leftwards from the right and rightwards from the left (for example when average number of personnel multiplication with the basic staff share we'll get as product the basic staff number).

Table 1. Groups of existing methods of investments' effectiveness evaluation

Scientists	Groups, criteria and the evaluation method's general characteristic
Vovchak O.D. [3], Danilishin B.M.[5]	Traditional methods are estimating: – Estimation of investments effectiveness coefficient; – Term of return on investments; – Estimation of the investments' compared economic effectiveness factor
	Methods based on accounting reports' indicators are estimating: – Calculation of the investment project balance and total profitability
	Methods based on discounting indicators are estimating: – Consideration of time-related money value concept
	Statistic methods are estimating: – Term of return on investments; – Accounting rate of investment return.
	Dynamic methods are estimating: – Investments present net value; – Index of investments profitability; – Investments' internal rate of return.
Duka A.P. [6], Peresada A.A [10]	Statistical methods based on accounting and arising from traditional accounting approach to projects' financial evaluation
	Dynamic methods based on economic theory and application of discount concept
	Methods based on taking into account the investment risks
Zacharchenko V.I. [7], Momotenko D.U. [9]	Traditional methods are: – Based on connection between income and expenses.
	Accounting approach is based on accounting principles.
	Discounting methods are – Based on the theory of time-dependent money value.
Fedulova L.I. [13], Yatsenko O.V. [16]	Methods based on accounting: – Net profit value; – investments profitability coefficient; – Term of return on investments.
	Methods based on discounting: – Net discounted profit, – Investments profitability index, – Rate of return on investments
Griniov A.V. et al [6], Chemeris A.O. [14]	Methods not considering the discounting: 1. Methods of investments' total effectiveness: – Term of return on investments; – Rate of return on capital. 2. Methods of compared effectiveness of investments' alternatives: – Accumulated cash flow balance; – Compared effectiveness of production costs; – Comparison of profit.
	Discounting considering methods: – Net present value;(net discounted value, net flow value), – Internal rate of return; – Discounted investments payback period; – Profitability index; – Method of annuity.

— Upsizing the factors allow combination of two and more sequentially-positioned factors within the paradigm. The second and third rules do imply that regardless of the product's formal independence from multiplied cofactors' positioning, shaping a multi-factor model, which resulting factor is expressed in volumetric terms, always there exists the precondition that you can specify the unique possible factors' sequence satisfying the requirements of the second and third rules;

— A model specific with the result expressed in volumetric terms can at every instance be turned into a partial one by excluding the last sequential volumetric factor. In this case the quality factor is appearing as the result instead of the quantitative

one (at the sought case it will be the average annual productivity per one average personnel member employed as basic staff). Such a truncated paradigm will maintain all the aforementioned characteristics of pair-wise factors' products.

Chain factor analysis of investment profit of the Odessa region innovative companies group («Dessa» LLC, PJSV «Odessa radial-drilling machines plant», «GSDB «ODESAGRUNTOMASH» LLC, PJSV «STROMMASHINA», PE «FIRM MALEX») gave the following results (Table 2):

Table 2. Results of innovative companies investment profit factor analysis

Factor	Shift	
	Thou. UAH	ratio
Total amount of investment profit	-0,290	0,704
Including due to following factor:		
– average annual productivity of basic staff, «*a*»	5,104	1,233
– average duration of working day ,«*b*»	-0,549	0,996
– average duration of working period (year), «*c*»	-0,857	0,995
– quotient of basic from the total amount of producing personnel, «*d*»	2,854	1,166
– total amount of producing personnel, «*e*»	-0,640	0,728
– ratio of shipped products at total amount of produced goods, «*g*»	6,448	1,033
– ratio of sold goods at total of shipped goods, «*h*»	-8,925	0,920
– ratio of profit balance counted at total amount of sold products, «*k*»	-12,210	0,166
– ratio of profit investment as total amount of profit balance, «*l*»	4,454	2,593

The factor analysis allow us to detect the underlying processes, although the total investments amount at the reported period reached the 433,4 thou UAH, and the net profit amount decreased up to 328,6 thou UAH (11,8%) therefore and the investment profit of the innovative companies declined for 290 UAH (26,6%). Such processes are:

1) Investment profit of innovative companies declined at the expense of:

— Average duration of working day «*b*» up to -549 UAH (0,4%);
— Average duration of working period (a year) «*c*» up to -857 UAH (0,5%);
— Total amount of producing personnel «*e*» up to -640 UAH (28, 2%);
— Ratio of sold goods at the total of shipped goods «*h*» up to -8925 UAH (8%);
— Ratio of profit balance at the total amount of sold products «*k*» up to -12.210 UAH (83,4%);

2) Investment profit of innovative companies increased due to:

— Average annual productivity of basic staff «*a*» up to + 5.104 UAH (23, 3%);
— Quotient of basic staff at the total amount of producing personnel «*d*» up to + 2.854 UAH (16,6%);
— Ratio of profit investment at the total amount of profit balance «*l*» up to + 4.454 UAH (159,3%);
— Ratio of shipped products at nthe total amount of produced goods «*g*» up to + 6.448 UAH (3,3%).

Where applied to the group above the increment of produced goods sales has been analysed using the following factors:

— Number of companies involved at the innovative project $K_{\text{ін}}$;
— Amount of production sold by one innovative company or innovative productivity index $P_{\text{ін}}$.

Annual reports 2011-2012 have shown accordingly:

— Total amount of innovative companies' sold production – 2.197.219,6 and 2.241.765,6 Thou UAH (index of 102,02%);
— Number of innovative companies – 54 and 46 (index of 85,1%);
— Innovative productivity, counted as proportion between $P_{\text{ін}}$ to $K_{\text{ін}}$ 40.689,25 and 48.734,03 (index of 119, 77%).

The resulting bi-factor model of innovative companies' sold products is influenced with two factors: the number of innovative companies and the innovation productivity.

$$P_{\Pi\text{ін}} = P_{\text{ін}} \times K_{\text{ін}} .$$

The analysis shows that the total amounts of innovative companies' sold goods grew, making 2.241.765,6 - 2.197.219,6= 44.546 Thou UAH including due to the factors:

— Growth of innovative companies' number up to +7, which caused the goods' sales increase up to 8 x 40.689,25 = +325.514 Thou UAH (12,5%);
— Innovative productivity, which caused the amount of those companies' sold products up to 48.734,03 - 40.689,25 x 46= 370.059, 88 Thou UAH (19,7%).

The influence of mentioned factor indicators is registered as a quotient to proportion between individual and global growth of sales effected by innovative companies, that respectively does mean 1, 99% and 98,01%. This allows drawing conclusions on circumstances and changes within the innovative

activity of producing companies of the Odessa region. Due to combined influence of both factors the amount of innovative companies' sold products 2012 compared to 2011 ciphers increased to +44.546 UAH (2,0%). The main growth has been achieved due to innovative productivity (370 Thou UAH) and number of innovative companies within the region, that produced +325.514 Thou UAH.

In such a way the share in increase of innovative companies' products sales volume is due per 5,52% to those companies number, and +94,48% of that increase is caused by the innovative productivity.

More complex approach and convenient results can be achieved through of correlation-regression analysis, developing the economic statistic methods. The following functions have been applied to elaborate the best model of correlation between return on investments and factor indicators: linear, parabolic, and exponential. To selection the most suitable one the models have been calculated and analysed using the statistic indicators and criteria such as Fisher's *f*-criterion of dispersion, residual dispersion, average approximation error etc. The comparative economic analysis served to conclude about linear relation between results- and factor-based indexes. Applying a multistage regressive analysis of the paradigm, one-step filtering of factor indicators using the Student's *t*-criterion and considering the economic value obtained is the following regressive model of profitability level «Y»:

$$Y = -24{,}19 - 0{,}7 \cdot X_1 + 0{,}027 \cdot X_2 + 1{,}509 \cdot X_3 + \\ +29{,}655 \cdot X_4 - 0{,}027 \cdot X_5,$$

where Y is the innovative companies investment profitability level, %; X_1 is the growth of investments to the capital fund, %; X_2 is the annual growth of the personnel productivity, Thou UAH; X_3 is the coefficient of innovations effectiveness, %; X_4 is coefficient of the enterprise's specialisation, %; X_5 is one circulating assets turnover period when investments-based industrial production, days.

The Cobb-Douglas-function is estimated quite promising and of high actuality for investigating the mechanism of investments into innovation activity.

Departing from the bi-factor production function we obtain, through reducing all other resource factors, two of them: capital funds «*K*» and the workforce «*L*». Though in our opinion essential is to take into account all main factors without limitation to capital funds and workforce.

On the basis of Cobb-Douglas –function never alternating the scale and adding several important factors of productivity and regional management we propose to broaden the function at the expense of increased investments into main capital «*M*» and reducing the expenses «*N*» [15]:

$$Y = a \cdot K^{\alpha} L^{\beta} M^{\gamma} N^{\sigma},$$

where Y is total amount of profit balance, Thou UAH; a is total productivity of production factors; K, L, M and N are accordingly capital funds reserve, workforce expenses, innovative investments of enterprises, Thou UAH; α, β, γ, σ are parameters of profit balance elasticity enterprises connected to several factors of resource expenses. They are calculated by assuming the normal equation.

For the group of innovative enterprises of machine-building complex of the region of Odessa our function will appear as following:

$$Y = 0{,}034 \cdot K^{1{,}202} L^{0{,}772} M^{0{,}452} N^{0{,}468}.$$

All of the parameters are statistically significant in respect of *t*-criterion: their actual value exceed the tabulated one ($t = 1{,}72$) by the level of materiality $\alpha = 0{,}05$ (probability of 0,95). The paradigm significance is confirmed by actual value (16,418) exceeding the tabulated ciphers of Fisher's *f*-criterion (2,87) at unchanged level of materiality $\alpha = 0{,}05$. That does mean the model is confirmed with a high level of probability, 0,95 (95%), which is enough for practical management.

The connection between the total amount of profit balance of the producing region's machine-building complex representing a sampling from the generality, and the factor indicators (K, L, M and N), is very close: mutual correlation index is 0,876. The mutual determination index ($R2 = 0{,}767$), allows supposing that approximately 76,7 % of the total profit balance sum variation is determined by the variety of resource factors data. This is underlining the elaborated model quality, its practical weight and value. The four factors' parameters amount (1,35) exceeds cipher «one» confirming the positive effect of production's expanding.

Though each parameter is less than one, their total amount can be less than one, equalise to one and exceed «one» cipher, that illustrates the effect of simultaneous proportional growth of workforce and manufacturing funds:

— Total amount equal to one: *m*-times increasing resources do augment the productivity of machine-building complex *m*-times accordingly. In such a case the function represents a so-called homogenous first-degree equation;
— Total amount exceeds «one»: *m*-times increasing resources do augment the volume of productivity over *m*-times. Positive effect of productivity scale;
— Total amount of less than one: *m*-times increasing resources do augment the productivity less then *m*-times. Negative effect of productivity scale.

The elaborated analytic tools are useful both the region's for segmented periodic analysis of investment environment and for investors of regional industrial complexes and innovative enterprises.

Conclusion

Summarising, it is reasonable to include the following factors for evaluating the innovative enterprises investments' effectiveness:

1) Factor of innovative company investment profit by using the factor index analysis;

2) Return on investment of innovative enterprise's investments (quotient) by using regressive model for the measuring of profitability's level;

3) Expanded production function connecting the index of investment expenses, profits from investments into innovation and profit of those investments use.

Such triple evaluation of investment factors for innovative enterprises of various regional industrial complexes multiplies the ways for searching a functional mechanism identifying available reserves of the region for further innovative investments.

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Смоквіна Ганна Анатоліївна / Anna A. Smokvina
smokvinaann@te.net.ua

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