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DEVELOPMENT OF FINANCIAL MODELS UNDER PARTIAL UNCERTAINTY

Abstract. The author examines the problems related to initial data partial uncertainty for the purposes of financial modeling. It has been demonstrated that the currently used methods contain a number of contradictions with the actual economic processes, which may result in inappropriate final forecasts obtained. To ensure due account of initial data uncertainty, it has been proposed to use interval algebra mathematical tools to develop financial models. The author has used investment project assessment challenge to illustrate the main ideas of the approach proposed to be employed. It shows simple methods which are supported by the interval model to evaluate both financial forecast uncertainty and investment project risk.
Keywords: financial model; interval; risk; uncertainty.
JEL Classification: O21, C53

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РОЗРОБКА ФІНАНСОВИХ МОДЕЛЕЙ В УМОВАХ ЧАСТКОВОЇ НЕВИЗНАЧЕНОСТІ
Анотація. У статті розглянуто проблеми врахування часткової невизначеності вихідних даних у задачах фінансового моделювання. Показано, що використовувані нині методи містять у собі ряд протиріч із реальними економічними процесами, що може спричиняти неадекватність одержуваних підсумкових прогнозів. Запропоновано з метою врахування невизначеності вихідних даних при розробці фінансових моделей застосовувати математичний апарат інтервальної алгебри. Використання пропонованого підходу проілюстровано на прикладі задачі оцінки ефективності інвестиційного проекту. Показано прості методики оцінки невизначеності фінансового прогнозу й ризику інвестиційного проекту, які дозволяє здійснювати інтервальна модель.
Ключові слова: фінансова модель; інтервал; ризик; невизначеність.

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РАЗРАБОТКА ФИНАНСОВЫХ МОДЕЛЕЙ В УСЛОВИЯХ ЧАСТИЧНОЙ НЕОПРЕДЕЛЕННОСТИ
Аннотация. В статье рассмотрены проблемы учета частичной неопределенности исходных данных в задачах финансового моделирования. Показано, что используемые в настоящее время методы содержат в себе ряд противоречий с реальными экономическими процессами, что может служить причиной неадекватности получаемых итоговых прогнозов. Предложено с целью учета неопределенности исходных данных при разработке финансовых моделей применять математический аппарат интервальной алгебры. Использование предлагаемого подхода проиллюстрировано на примере задачи оценки эффективности инвестиционного проекта. Показаны простые методики оценки неопределенности финансового прогноза и риска инвестиционного проекта, которые позволяет осуществлять интервальная модель.
Ключевые слова: финансовая модель; интервал; риск; неопределенность.

Introduction. It is impossible for the present-day economy to assess and to take investment decisions without financial modeling tools which are used to predict results, analyze possible scenarios, conduct risk-testing, and eventually to conclude whether the entire project is efficient or not.

As practice shows, to construct the financial model which is properly adjusted for a number of different external factors and in-house business processes turns out to be quite challenging. This is due to the following facts:

- The overall uncertainty of socio-economic systems. As it is shown in the G. Tintner's study [1], in the socio-economic systems the vast majority of factors are characterized by a high degree of uncertainty and/or randomness.
- The sources which are used for the forecasting purposes often prove to be unreliable (e.g. statistical data can be incomplete, expert opinions may be contradictory, etc.) [2].
- Today changes in many macroeconomic measures fail to follow normal market cycles; volatility in factors which affect corporate business activities increases repeatedly, the changes are dramatic and poorly predictable.
- It can be extremely difficult and/or unprofitable in terms of time and money to make exact forecasts for a number of factors. Moreover, most often even very accurate and costly simulation methods provide rather approximate results in the long run [3].

However, if you choose not to use simulation tools, this often makes it absolutely impossible to have project performance evaluated and supported with sound figures, rather than with abstract arguments. This will further be accompanied by a number of mistakes in selecting optimum action strategy. To have investment decisions taken in practice, it is essential to use methods which enable to identify and filter out definitely unpromising and excessively risky areas directly at the initial stage of project development, which will result in a more efficient distribution of limited economic and human resources (A. Dyskina [4]).

Brief Literature Review. Economic aspects have been simulated very intensively over the past 30-40 years, however there is still debate going on in scientific literature between the experts who argue for the simulation as a framework for business management and the experts who dispute the feasibility of such approach. We may distinguish the work of such scientists and practitioners as: G. Zemitan (2014), R. Gessing (1985), E. Hansen (1993), N. Rosenberg (1982), G. Shackle (1961), I. Shvetsov, V. Kornienko and S. Preis (1997), G. Tintner (1991), V. Galasiuk (2008), A. Dyskina (2011).

The purpose of article is development of tools which enable to assess ongoing investment projects efficiency with due account for the existing uncertainty under scenario conditions.

The existing approaches to accounting of uncertainty in financial modeling

In practice, the following two approaches are generally used nowadays to account uncertainty: scenario and probabilistic ones [5]. Due to scenario approach, we develop and analyze a number of possible case scenarios (e.g. optimistic – medial – pessimistic) followed by model-to-new initial parameters sensitivity analysis. Within probabilistic approach we treat inexactly known values as random and legally-specified which are described in one manner or another (e.g. using mathematical expectation and mean root square deviation).

In my opinion, these approaches contain the basic contradiction – artificial substitution of inexact variables by their determinate values or mathematically-defined probabilistic estimates, thus, there is a contradiction between traditional mathematical tools gravitating towards certainty and actual economic situation which always contains considerable portion of the unknown.

Initial parameters errors are generally accumulated. Accordingly, in any stable economic situation expert and statistical forecasts often have errors of up to 1%, which results in 3-6% error of simulation results, whereas under economic depression conditions the similar estimations may produce an error of 30-50% or more, which can lead to the total forecast depreciation. Also, it is often impossible to take into account all various incoming information (e.g. expert judgments) as far as information which is poorly related to other factors accounted by the model is usually disregarded.

It is not fairly correct to use laws of random distribution in order to estimate model parameters' probability. Back in the early 1960s, G. Shackle proved that in practice the definitions «inaccuracy» and «randomness» are not identical [6]. That is why the very idea of using any probabilistic law to describe parameter distribution is artificial in nature and, therefore, such a model will be basically in disagreement with the actual economic situation. Also, statistical data often appears to be just not enough to establish laws of criteria distribution.

As a result, numerous problem formulation conditions result in the fact that the only possible way to handle the problem is to sort out all possible values. Thus, in order to eliminate the risk and to ensure the guaranteed result, managers have to focus on the most unfavorable (extreme) combination of different factors.

The interval algebra mathematical tools usage in financial models

By analyzing various, practically relevant methods to determine parameter values for financial forecasts, we propose to classify them as follows (see Table 1).

Many initial parameters of financial model can be assessed only as certain interval (e.g. «the expected rate of inflation will be between 2% and 7%»). With such task assignment method, model parameters are defined as a range of possible values in which the upper and lower range limits correspond to estimated maximum and minimum possible values respectively. In this case, the final forecast for company expected performance should also represent a certain field of possible values.

It is important to note that any method used to model parameters can be eventually narrowed down to the single type – multi-interval, that is, to the following form: $A = ([a_1 \dots a_2]; [a_3 \dots a_4]; \dots)$. Such method of model parameters determination as «scalar» one can be also represented as an interval with a specified scalar value (that is $A = a = a \dots a$) being its start and end points. In its turn, the method of model parameters determination as «interval» is a degenerated case of multi-interval method (multi-interval with the single constituent interval).

This conclusion makes it possible to develop financial models of investment projects applying the principles of interval algebra with mathematical tools, which are substantially developed and examined in the scientific literature (see E. Hansen [7]). Currently, there is considerable experience accumulated in these tools usage to meet the global optimization challenges for the sake of resource allocation (see R. Gessing [8]). In addition, some practical aspects related to this experience utilization in relation to problems of planning have been examined by I. Shvetsov, V. Kornienko, and S. Preis in their study [9].

It is obvious that such an approach would require modifications in equations, which make up financial model. For example, one of the most well-known investment efficiency factors is Net Present Value (NPV) which is defined as:

$$NPV = \sum_{t=0}^{T} \frac{NCF_t}{(1+i)^t}, \qquad (1)$$

where t – target year sequence number; T – project duration in years; NCF_t – net cash flow value under the project in the t-th year (it is calculated as a sum of all incomes and expenses associated with project implementation); i – discount rate.

If such project indicators as project duration (T), cash flow for each year (CF_t) and discount rate (i) are given as intervals, the final estimated value of net cash flow will be also in the form of interval:

$$[NPV_1 \dots NPV_2] = \sum_{t=0}^{[T_1 \dots T_2]} \frac{[(NCF_t)_1 \dots (NCF_t)_2]}{(1+[i_1 \dots i_2])^t}. \qquad (2)$$

Any other financial model equations can be modifies in a similar way. Despite the fact that the formulas modified using the proposed method look cumbersome at first, they are easy to use and can be easily automated.

Account of interval-represented cash flow fluctuations

It is obvious that some financial model parameters can be subject to serious fluctuations. When considering company-level cash flow fluctuations, V. Galasiuk, a member of the Ukrainian Academy of Economics, proved that possible deviations «occur in some cash inflows and outflows, but not in net cash flows» [10].

However, as practice shows, in most cases it is quite a complicated task for an expert to select specific numeric value for event occurrence probability within financial model. A more simple approach is to divide events into three groups according to their degree of probability: «high – medium – low». For example, when drafting sales plan for finished products (operating income schedule) even for a period of one year, it appears to be extremely difficult for managers to evaluate in figures the conclusion probability for some or other contract but it turns out to be quite possible to perform assessment of this contract in terms of contingent groups.

To switch from conditional assessment to interval-based one, it is necessary to assign probability intervals for each of the contingent groups (see Table 2).

Tab. 1: **Methods to determine financial model parameters**

Method	Designation	Practical examples
Scalar	$A = a$	Consumption rates of raw materials for production purposes, fixed part of remuneration, etc.
Multi-Scalar	$A = (a_1;\ a_2;\ a_3; \dots)$	Quantity of raw materials purchased in fixed batches, etc.
Interval	$A = [a_1 \dots a_2]$	Rate of inflation, price range for raw materials to be purchased, prices for products to be shipped, etc.
Multi-Interval	$A = ([a_1 \dots a_2];\ [a_3 \dots a_4]; \dots)$	Utilization of production capacities to maintain simultaneous and multi-line release of products, macroeconomic figures for several possible scenarios, etc.
Mixed	$A = (a_1;\ [a_2 \dots a_3]; \dots)$	Volume of sales if any part of products is to be shipped under pre-paid contract while the other part is to be freely marketed, etc.

Source: Compiled by the author

Tab. 2: **Groups of contract probability**

Probability	Interval
High	[1…0.7]
Medium	[0.7…0.3]
Low	[0.3…0]

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Then, it happens to be possible to obtain interval assessment for estimated aggregate value as well:

$$[A_1 \dots A_2] = \sum X_i \cdot [p_1 \dots p_2]_i \,, \quad (3)$$

where p_i – i-th event probability; X_i – i-th parameter value (in this case model parameter values X_i can be specified both in interval and scalar representation).

Example of interval-based financial model used to assess investment project efficiency

Let us consider the investment project assessment problem using modified measure – net present value from formula (2).

The key factor which is used to calculate net present value is net cash flow *(NCF)* as a sum of all receipts and expenditures related to the project implementation:

$$NCF = \sum CF_i^{IN} - \sum CF_j^{OUT} \,, \quad (4)$$

where CF_i^{IN} – amount of i-th cash inflow; CF_j^{OUT} – amount of j-th cash outflow.

Then, if there is an expert appraisal available in relation to the probability of receipts and payments, it appears to be possible to have interval assessment of NCF:

$$\begin{cases} NCF_{min} = \sum CF_i^{IN}(p_i)_{min} - \sum CF_j^{OUT}(p_j)_{max} \\ NCF_{max} = \sum CF_i^{IN}(p_i)_{max} - \sum CF_j^{OUT}(p_j)_{min} \end{cases} . \quad (5)$$

Let us explore the concrete project of new hardware and software platform to be developed and further introduced in a number of industrial enterprises for the purposes of computer-aided manufacturing. The project implementation period is seven years (T = 7). The initial investment costs are estimated at 1.5 million EUR.

The figure (see Figure) shows data calculation for such project performance factors as net present value *(NPV)* and payback period *(PBP)* computed using both traditional method and proposed approach.

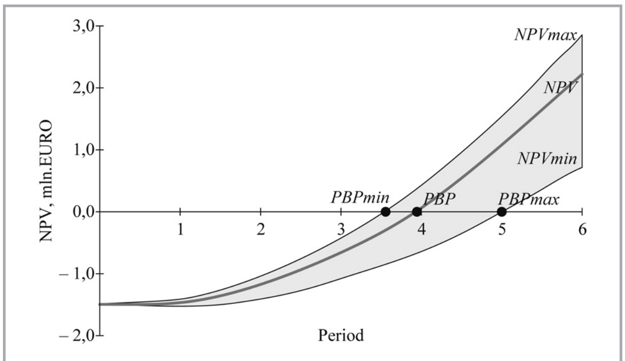

Figure: **Comparison of methods used to calculate project performance factors**
Source: Created by the author

The solid line in the graph means NPV resultant data calculated by the traditional method, the shaded area means the resultant data calculated by the proposed method.

It is obvious that in comparison with the traditional evaluation methods, the interval model makes it possible to have more detailed assessment of project profitability trends and gives more complete understanding of possible variations in cash flow amount.

The project looks quite efficient from the point of view of the traditional approach. However, interval records show that in case of certain values of initial parameters, the project may appear not to be as profitable as expected by investors (minimum projected NPV is three times less than the one predicted by the traditional model).

In addition, it is not least important to note that the interval model shows the scope and spread of critical values, which can be an important argument in the process of investment decision-making. Thus, if investors have free cash of 1.5 million EUR only, then, if they have to pay 1.6 million EUR due to negative situation and the high price of lending resources, this may further reduce the project profitability.

Assessment of financial forecast uncertainty and risk

One of the most pressing challenges of financial modeling is to assess the level of uncertainty contained in company's business forecasts. Currently, to meet this challenge, expert methods are mostly often used when the judgment on the degree of forecast reliability is based on the aggregated of the experts' opinions [5, 7].

The interval model makes it possible without any additional techniques, to estimate the uncertainty contained in financial forecast. Its predictive interval width acts as an indicator of forecasting error risk.

Let us define interval limits as X_{min} and X_{max}, which will be understood by us as minimum and maximum projected value of company's financial performance, or, regarding a particular project, as minimum and maximum NPV.

The mean value of predictable result can be defined as forecast interval mid-point: $\overline{X} = (X_{max} + X_{min})/2$. Then, the spread of predicted value about its mean value which is expressed in fractions (percent) of this mean value can be found as: $Var(X) = |(X_{max} - \overline{X})/\overline{X}| = |(X_{min} - \overline{X})/\overline{X}|$. Or, if you incorporate this formula with an expression for calculation of interval mean value:

$$Var(X) = \left|\frac{2 \cdot X_{max}}{X_{max} + X_{min}} - 1\right| = \left|\frac{2 \cdot X_{min}}{X_{max} + X_{min}} - 1\right| . \quad (6)$$

Consequently, in the example analyzed above the spread of NPV predictable value about its mean value shall be according to expression (6) as follows:

$$Var(NPV) = \left|\frac{2 \cdot NPV_{max}}{NPV_{max} + NPV_{min}} - 1\right| = \left|\frac{2 \cdot 2.9}{2.9 + 0.8} - 1\right| = 0.57 \,, \quad (7)$$

in other words, the uncertainty of project results is about 57%, hence, the project is characterized by significant degree of uncertainty.

Project risk can be estimated as the probability of an event at which the financial result of the project appears to be lower than its target value. If we denote the target value as X_{target}, then by analogy with the formula for the calculation of $Var(X)$ we obtain:

$$R(X) = \left|\frac{X_{target} - X_{min}}{X_{max} - X_{min}}\right| . \quad (8)$$

It should be noted that in this particular case the risk level corresponds to the amount of maximum loss per unit of uncertainty.

Let us take the target net present value being equal to 2.5 million EUR (NPV_{target} =2.5) in the example above. Then, the risk of value non-achievement shall be found according to expression (8) as below:

$$R(NPV) = \left|\frac{NPV_{target} - NPV_{min}}{NPV_{max} - NPV_{min}}\right| = \left|\frac{2.5 - 0.8}{2.9 - 0.8}\right| = 0.81 \,, \quad (9)$$

in other words, the risk of value non-achievement of project targeted financial result is about 81%, which means that the project is characterized by significant degree of risk.

Conclusion

The proposed approach is universal and suitable to accommodate every assessment of the spread of every model parameters. It removes contradiction between formal certainty and actual uncertainty, which gives methodical advantage when making calculations.

The result is a high level of forecast validity, reliability and quality, which often fails to be achieved with conventional mathematical methods. The proposed approach will make it possible:

- to improve forecast accuracy in general. Interval values will significantly increase the probability that actual value is within the forecasting limits, because in the model interval values both for forecast and incoming data analysis are used;

- to take account of possible market fluctuations, seasonal and other variations, lack of information, etc., in other words, to consider all possible scenarios;
- to obtain a complete picture of the process to be predicted. Interval forecast results can generally give more complete picture of the projected process since they outline all areas of possible profits, losses and other important factors and indicators;
- to identify critical situation threats (e. g. lack of funding). So, the project, which proves to be effective for deterministic calculation, may show significant probability of inefficiency under the conditions of uncertainty.

Besides, such approach significantly simplifies plan adjustments in future. For instance, business operational plans made with the usage of conventional methods need to be constantly reviewed and re-approved if there are any actual deviations from the target values. In practice, we repeatedly had to face the situation, when companies established artificial range of values (e.g. ±10%), compliance with which provides to plan revision absence. In case of interval model, actual parameters will generally result only in correction (reduction) of the range of projected parameters, which means that plans will have to be re-approved only if actual deviations are very significant.

References

1. Tintner, G. (1991). The Theory of Choice under Subjunctive Risk and Uncertainty. *Econometrica, 9,* 298–304.
2. Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics.* New York: Cambridge University Press.
3. Zemitan, G. (2014). *Methods of prediction of the organization's financial condition.* Retrieved from http://www.iteam.ru/publications/finances/section_29/ article_408/ (in Russ.)
4. Dyskina, A. A. (2011). An integrated approach to the evaluation of investment attractiveness of the industrial enterprises. *Proceedings of the Odessa Polytechnic University, 2,* 320-324 (in Russ.).
5. European Commission (2008). *Guide to cost-benefit analysis of investment projects.* Evaluation Unit DG Regional Policy EC (Structural Fund ERDF and Cohesion Fund ISPA).
6. Shackle, G. L. (1961). *Decision, Order and Time in Human Affairs.* Cambridge University Press.
7. Hansen, E. R. (1993). Computing zeros of functions using generalized interval arithmetic. *Interval Computations, 3,* 3-28.
8. Gessing, R. (1985). Two-level hierarchical control for stochastic optimal resource allocation. *International Journal of Controlling, 1,* 161-175.
9. Shvetsov, I., Kornienko, V., & Preis, S. (1997, April). *Interval spreadsheet for problems of financial planning (PACT'97).* London, England, pp. 373-385.
10. Galasiuk, Valeriy, & Galasiuk, Viktor (2008). Consideration of economic risks in a valuation practice: journey from the kingdom of tradition to the kingdom of common sense. *ICFAI Journal of Applied Finance, 14*(6), 18-33.

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ОСНОВНІ ШЛЯХИ ТА МЕХАНІЗМИ ПОДОЛАННЯ ЕКОНОМІКО-ПРАВОВИХ ПРОБЛЕМ У ГАЛУЗІ М'ЯСО-МОЛОЧНОГО СКОТАРСТВА

Анотація. У статті розглянуто основні напрями регулювання галузі м'ясо-молочного скотарства в економіко-правовому аспекті, що повинні поєднувати в собі методи ринкового саморегулювання та державної підтримки. Для цього проаналізовано обсяги і структуру державної підтримки в контексті вступу України до СОТ, які забезпечують протекціоністський ефект для товаровиробників; визначено основні шляхи підвищення ефективності економічно-правової політики на основі світової правотворчої діяльності; проведено оцінку ефективності чинних державних програм розвитку м'ясо-молочного скотарства.
Ключові слова: м'ясо-молочне скотарство; державна підтримка; економіко-правове регулювання.

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BASIC WAYS AND MECHANISMS TO OVERCOME ECONOMIC AND LEGAL PROBLEMS IN MEAT AND DAIRY SECTORS

Abstract. *Purpose.* Ukraine has a large number of legal acts regulating production of meat and dairy products, provision and management of investment, labour, material and technical resources, innovations, land. However, this number of constituent and regulatory documentation does not help, but creates additional difficulties in economic activity. The main key to revival of the meat industry and the dairy cattle producers, as well as efficiency of agricultural enterprises improvement is creation of regulatory framework through the clever combination of market self-regulation and government support.
Discussion. In today's realities, market cannot ensure food security, parity prices of industrial and agricultural products, export promotion, ecologization of production, preservation and improvement of breeding potential, development of the rural areas. Hence, the mechanism of state support for the compensation of market inability is a common phenomenon around the world.
Results. Equally important for Ukraine are the problems of economic and legal mechanism and the corresponding financial basis for the implementation of certain provisions of legal acts, as well as inconsistency of many legal acts of agricultural legislation with the norms and standards of the European Union and the World Trade Organization. The quality of legislation is one of the most important factors of national security, protection of the national interests of Ukraine, the rights and interests of legal subjects. Current regulations provide satisfactory conditions for the investment climate improving. Experts note that most of the investors' risk are associated with unpredictable changes in legislation, and about 50% of the risk are caused by the state policy imperfection in the field of agriculture and cattle breeding, if the actions are inadequate in conditions of the market and do not allow agricultural producers to predict the future conduct of its own economic activity, and investors – to be sure about return on investment.
Conclusion. To bring the legal framework of Ukraine's agriculture on a new, global level and make it more effective, we must use a global law-making experience. In addition, approval of the Agrarian Code of Ukraine will help to avoid many problems, for example, by improving the mechanism of calculation and payment of subsidies to the producers of milk and meat cattle.
Today, in dairy cattle industry 3 state programs are being implemented, and in the area of beef cattle – a national project «Renewed cattle», the implementation of which will make it possible to stabilize and build up cattle herds, to raise the level of consumption of animal products per person, increase volume of production, and improve the financial and economic situation of farmers.
Keywords: government support; meat and dairy cattle; regulation; legal framework for development industry.
JEL Classification: H80, K39, Q18