

## ASSESSMENT OF THE ECONOMIC EFFICIENCY OF IT APPLICATION AT ENTERPRISES

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**Abstract.** The article covers theoretical aspects of the necessity of information technologies' introduction and development at the enterprise. There was substantiated the importance of the introduction of modern information technologies and their influence on the effective activity of the enterprise. There were generalized the conditions and consequences of technologies introduction, the main trends of IT development at enterprises, and possibilities of modern technologies use. The composite analysis of the methods for assessing the efficiency of information technology use conducted made it possible to compile the methods into three groups (methods of financial analysis, methods of qualitative analysis, methods of predictive analysis) and to distinguish their characteristics and possibilities of use. There were considered the most popular structural modules of the corporate information and technological system (CIS) in the world. There was the generalized structural composition of the ERP-system with MRP, SRM, CRM, and CSRM modules. There were determined the main characteristics of IT systems, advantages and disadvantages of integrated CRM modules – customer relationship management system, BI data analysis systems (SAP, Microsoft Dynamics AX, Oracle BI systems), communication management system with SRM providers; 1C: Enterprise 8 – system of bookkeeping and management accounting use and the possibility of their association in CIS as: CSRP Enterprise Resource Planning System (Customer Synchronized Resource Planning). Resource planning technologies are functionally related in such a system, modules of CRM strategies are integrated, interaction with buyers and customers and bookkeeping analysis and accounting are synchronized. The method of economic efficiency determination with the improvement of calculation algorithm is proposed. The main stages of assessing the effectiveness of IT introduction and application at the enterprise can be summarized in three stages: preparation – analysis and assessment of the technology selection; introduction – analysis and assessment of direct costs and substantiation of expediency; implementation – assessment of economic efficiency of application and calculation of intellectual depreciation and possible stepwise modernization of information technology in future. The multiplicity of introduction goals and sources of IT payback requires a differentiated approach to the determination of the criteria for their effectiveness assessment. There was developed an algorithm of determination of the economic efficiency of IT introduction in the activity of the enterprise. The traditional way of profit assessing from the IT introduction does not ensure full consideration of qualitative and strategic efficiency, therefore, it requires additional use of predictive methods that allow supplementing quantitative calculations. The author proposed to calculate the efficiency of introduction, modernization, and use of IT projects, use of scenarios analysis methods, which include the Black-Scholes model and the binomial model for calculating the effectiveness of real options. The author considers the application of the Black-Scholes-Merton model to be the most expedient because, in contrast to the binomial one, it is easier to use but allows obtaining a result with minimal errors, without significant time costs close to the definitions of the binomial model. The use of such a model has already proven effective not only when calculating the effectiveness of real options, but there are also positive results of the study when using them in other areas of analysis. We consider it economically feasible to use methods determined by the author to assess economic efficiency of IT use.

**Key words:** information technologies, CIS of the enterprise, IT development trends, problems of IT introduction, assessment of IT efficiency, assessment of costs, assessment of IT application, Black-Scholes-Merton model.

**JEL Classification:** C31, C58, G24, G35

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## 1. Introduction

In the current context, the development of the business environment, the trends of information, the impact of global innovation and technological standards of enterprises operation, effective business dealing in Ukraine becomes impossible without the introduction of information technologies that are able to ensure the integration and communication of enterprises at the modern business level.

Information technologies become an essential part of the business of each enterprise as it provide: automation of business processes of the enterprise, improvement of the quality of goods and services, accelerate transfer, analysis, and storage of a large amount of information, accelerate the speed of servicing and efficiency, improve the processes of customization, taking into account the individual needs of the clients. The introduction of information technologies at the enterprises objectively causes transformational changes in activities, changes the algorithms of interaction in structural units, changes the regulatory functionality of the enterprise, and increases the level of qualification competence.

Substantiation of the problems of IT introduction effectiveness at the enterprises was started both in studies of foreign scientists and in the works of Ukrainian scientists. The development of information technologies in the management of enterprises was studied by such scientists as: Arefieva I.Y., Ashvanden S., Batiuk A.Y., Karpenko S.H., Kanonenko I.V., Mykhailov P., Nefodova L.I., Novak V.O., Novakivskiy I.I., etc.

The following scientists, such as: Vendorov A.M., Vovk I., Zelynskyi S.E., Karpov D.V., Kalnytska I.V., Kravchenko V.H., Martyniuk O.A., Müller-Stevens G., Pleskach V.L., and many others paid special attention to the peculiarities of projects realization connected with the introduction of new information technologies or improvement of the existing information system at the enterprise.

Scientists' works highlight the relevance of information technologies introduction, their roles, prospects, and strategic priorities in details and widely. But not enough attention is paid to the problems of application of technologies, specific algorithms and the tactical decision of certain technologies definition necessary for the enterprise development.

Problems in assessing the economic efficiency of IT use and managing information require further research and development of an economic mechanism for their introduction. Unfortunately, enough attention is not paid to the problems of information technology use as a means of the enterprises' efficiency increasing in Ukraine under objective conditions.

The main purpose of the paper is to generalize the methodological foundations and to deepen the methodological provisions for assessing the economic efficiency of IT introduction and use at the enterprises.

## 2. The methodology of research

The generally accepted approach to determine the effectiveness of the IT introduction is the ratio of profits and total costs of the enterprise. However, the efficiency assessment only on the basis of one indicator reduces the scope and gives a limited economic presentation. The problem is that the impact of information technology on the profitability of an enterprise is mediated and manifests through the improvement of business processes of the enterprise, increasing the efficiency of analytical data obtaining, managerial decision-making, etc. It is difficult to measure the actual profitability of IT introduction from the enterprise's overall profit.

Therefore, the value of the efficiency indicator will not be able to provide accurate information on the rationality of a particular information technology introduction to some extent. This is due to the problems of determining the results of automation since it is not enough to calculate the efficiency as the difference between the resources spent and the savings received in the present context. The effects become much more complex and should be evaluated in terms of the strategic goals of the entire enterprise development.

The information technology market is developing very dynamically, responding to the needs of the business environment, so there are new CSRP (Customer Synchronized Resource Planning), Enterprise Resource Planning that implement resource planning technologies, integrate client-oriented strategy modules, and synchronize interaction with buyers and customers. This is the information systems of the next generation, if MRP, MRPII, and ERP are focused on the internal organization of the enterprise, then CSRP systems contain a complete cycle of business technology from the design of future product, taking into account the customer's requirements to warranty and service maintenance (Kravchenko, 2008).

According to the world's consulting companies, stock reserves on the majority of enterprises, in which such systems had been introduced, decreased by an average of 11%, operating expenses decreased by 12%, administrative expenses – by 10%, timeliness of deliveries improved – by 13%, observance of production plans – by 12%; the production cycle decreased – by 14%. However, 27% of surveyed business heads have stated that they did not return the investments that were spent on information systems introduction, and 28% cannot assess the effects obtained. Only 35% of companies introduce integrated information systems without exceeding the budget and only a third of such projects is completed according to the calendar plan. As a result, a lot of enterprises do not receive the expected preferences: on average only 8% of them receive from 80 to 100% of the planned functions. The modern stage of enterprise management automation is also characterized by the growth of indirect effects:

standardization of processes, integration of various information products, flexibility and speed of response to the needs of consumers, which adds complexities to the assessment process (Algorithm, 2013; Vovk, Mykhailov, 2013).

The effectiveness of information systems using in the economic management of an enterprise directly depends on two main factors: the impact on improving the efficiency of management and reducing the cost of the enterprise that improves the profitability of the enterprise.

The processes of enterprise's information infrastructure management and, in particular, the processes of IT (information technology) introduction are associated with the well-grounded investment of resources for the acquisition of technology, development of projects, carrying out of preparatory works, development of new management technologies and personnel training.

The main stages of assessing the effectiveness of IT introduction and application at the enterprise can be summarized in 3 stages: preparation – analysis and assessment of technology selection; introduction – analysis and assessment of direct costs and substantiation of expediency; implementation – assessment of the economic efficiency of the application and calculation of intellectual depreciation and possible stepwise modernization of information technology in future.

Economic efficiency is calculated at all stages of IS design and introduction (Kanonenko, 2010; Kalnytska, 2010):

- 1) when surveying an enterprise to create an IS, a preliminary calculation of expected economic efficiency is performed;
- 2) at the stage of working technological design, a detailed calculation of expected economic efficiency is performed;
- 3) upon IS introduction into industrial operation, the actual economic efficiency is determined.

However, at the early stages of preparatory and design work, calculations are predictive. The calculations of economic efficiency after the introduction or modernization of the information system or individual information technologies are often considered under two methodological directions in the domestic economic literature, the first is based on calculations of the annual economic effect, the second one – on calculations of the integrated economic effect (Algorithm, 2013; Vendorov, 2006).

When calculating the annual economic effect, there is a comparison of the annual volume of sales, production costs, sales profits in the reporting period (after changes in the enterprise's information system) with similar indicators in the base period (before changes in the enterprise's IS). In the case of integral economic effect calculation, the comparison of the indices of the expenditure and revenue sides of the enterprise activity for the entire accounting period from the beginning of the introduction of changes to the enterprise's IS is carried out.

However, both methods for economic efficiency calculation cannot accurately assess the contribution of IS to the overall economic development of the enterprise. This is due to the multitude of factors that can affect the indexes being compared. For example, the annual volume of sales may change due to the introduction of new technological developments, changes in demand or advertising policies. Therefore, we believe that it is necessary to determine the economic effect of IT use based on all factors: economic, organizational, technical, and social at all stages of the IS application (Batiuk, 2004). For this purpose, a complex of various methods of analysis, which can be divided into three groups: methods of financial, qualitative and predictive analysis, is used (see: Table 1. Made by the author on the basis of (Boda Z, 2004; Karpenko, 2004; Martunyuk, 2012; Nefiodov, 2009)).

Financial analysis is a generally accepted tool for justification of any business project. The methods of this analysis use traditional approaches to the financial calculation of economic efficiency taking into account the specifics of IT. The advantage of financial methods is in their basic principles, borrowed from the classical theory of the economic efficiency determination. Also, with the help of financial methods, it is possible to assess the economic parameters of introduction and application of ISs by analogy with the assessment of any other investment project.

The methods of qualitative analysis complement quantitative calculations that help to assess all the factors of IS effectiveness and match them with the overall strategy of the company. This group of methods allows professionals to choose the most important characteristics of systems for them independently depending on the specifics of products and activities of the enterprise and to change the correlation between the indicators using the coefficients of significance.

Predictive methods use statistical and mathematical models to assess the probability of risk occurrence. Such methods are used to assess the future effect of the information system; they are not common in practice, as the others (Novakivskyi, 2010).

All groups of methods for assessing the economic efficiency of the IS operation at the enterprise allow obtaining multi-faceted information on the use of IT and IS at all stages of the enterprise development. But despite the fact that in the present context any enterprise has a fairly large selection of different methods and methodologies for assessing the effectiveness of IS use, businessmen prefer analysis with two indicators: total cost of ownership (TCO) and return on investment (ROI). The Total Cost of Ownership Indicator (TCO) describes the full set of costs for the introduction and use of ISs, where, in addition to direct costs for IS development, introduction and operation, indirect costs associated with downtime and human factors are taken into account.

Table 1

**Composite analysis of methods for assessing the effectiveness of information technology use**

Name of the method	Characteristics of determination	Possibilities of use
<b>METHODS OF FINANCIAL ANALYSIS</b>		
Return on Investment, ROI	The determination of efficiency is carried out by calculating the ratio of the amount of profit or loss to the amount of investments.	Unambiguous interpretation; The indicator reflects the absolute benefit of the project. It does not take into account the difference in terms of project implementation; it is difficult to choose the year (period) specific to the project; as a rule, the net profit, not the cash flow, is taken into account; it is impossible to determine the best project with the same ROI, but different investments; absence of risk analysis.
Internal Rate of Return, IRR	The methodology assumes determination of the relative permissible rate of return of the project. To determine the profitability or unprofitability of a project being implemented, the IRR indicator is to be compared with the price of the financial resources involved.	Allows comparing projects with a completely different level of funding; takes into account risks; takes into account the discounted value of future cash flows; takes into account cash flows throughout the lifecycle of the project; has clear criteria for decision-making. Sometimes it calculates non-objective rates of return or gives an approximate result; the complexity of determining the revenues from the quality indicators improvement; does not show the amount of cash receipts.
Accounting Rate of Return, ARR	The ratio of net profit to the difference between investments and the liquidation value of assets is calculated.	The algorithm of calculation is simple, which determines the wide application in practice. It takes into account the income from the liquidation of assets, the useful life of which has expired. It is applicable only to assess the effectiveness of projects with a short payback period.
Rapid Economic Justification, REJ	The key idea of the methodology is to look at IT in terms of the company's business priorities, strategic plans for its development, and the main financial indicators (ROI, etc.). REJ methodology defines the potential revenue from achieving the set critical success factors and the cost of information technology introduction that is presented in the form of cash flows.	Reasonableness of results; taking into account both quantitative and qualitative effects from the IT introduction; taking into account risks; the possibility of comparing alternative projects; the speed and quality improvement of analysis and justification of investment attractiveness of projects. It is recognized as the most complex and comprehensive tool for assessing the IS introduction project; does not allow to assess the projects of modernization of IT infrastructure as a whole effectively.
<b>METHODS OF QUALITATIVE ANALYSIS</b>		
Total Cost of Ownership, TCO	A calculation methodology designed to help users and heads of the enterprise to determine the direct and indirect costs and benefits associated with any component of computer systems. The assessment of efficiency is carried out by comparing the TCO index of the enterprise with TCO indexes of other enterprises of the same profile.	It allows avoiding unprofitable and unnecessary costs and keeping the total amount of costs at a reasonable level and maximizing the benefits of information technology use, the cost for their support. It is associated with business tasks; is not useful for risk assessment and for determining the ways of IS compliance with strategic objectives of the company; significant time expenditures; the complexity of determining the value of indirect costs of the project.
Activity Based Costing, ABC	The methodology consists in the complex study of actions aimed at the object of information technologies at the introduction stage and the functions of the object in the process of use in order to identify the reserves of cost minimization at the stages of its design, introduction, and use while maintaining or improving its functions and increasing its usefulness for consumers.	It allows more precise definition of the product value, which makes it possible to make justified strategic decisions on the pricing of products, through which companies can pay more attention to improving the efficiency of high-priced transactions, etc.; allows pointing at the possible ways to improve value indicators; productivity increase, cost reduction, labour intensity, time and quality improvement; The process of functions describing may be too detailed; the model is quite complicated in application, it is difficult to maintain; for a high-quality realization of the method, special software is required; the method "goes out of date" due to organizational changes; most often the stage of collecting information about data sources by function is underestimated; insufficiently supported by operational management.
Net Present Value, NPV	The essence of the methodology is to carry out a comparative analysis of the amounts of initial investments and the current value of future cash flows.	Takes into account the time factor in calculations. The calculation of such an assessment will require detailed forecasting of cash flow receipts for the entire project lifecycle, not taking into account the risks of the project.

End of Table 1

Economic Value Added, EVA	EVA reflects the value creation process and is defined as the difference between the net operating income of the enterprise and all expenses incurred by the enterprise for the IT infrastructure.	It combines simplicity of calculations and possibility of determining the market value of an enterprise; provides a measurement of “surplus” value created by investments; is an indicator of the quality of managerial decisions that are made; allows assessing the effectiveness of individual divisions of the enterprise. There is a delay between the moment of introduction of one or another system or the moment of making changes in existing business processes and changes in EVA indicators; the complexity of future profits determination.
Total Economic Impact, TEI	It is a heterogeneous methodology, which allows assessing the introduction project of one or another component of the information system of the enterprise in terms of three indicators – “value”, “benefits” and “flexibility”.	Analysis of risks arising in the process of acquiring, introduction, and operation of a component of an information system that is being analysed. It has a narrow range of applications. It is used for the analysis of introduction options of a specific IT infrastructure component of the enterprise.
<b>METHODS OF PREDICTIVE ANALYSIS</b>		
Applied Information Economics, AIE	The AIE methodology involves increasing the accuracy of the “real economic value of investments in security technology by determining the return on investment” index before and after investing.	Provides an opportunity to assess the probability of risk emergence and the emergence of new opportunities through statistical and mathematical models; allows reducing the uncertainty of expenses, risks, including non-obvious ones. The need for statistical observations and a large amount of statistical data. The necessity of systemicity.
Real Options Valuation, ROV	The basis of the methodology is the key concept of building a model of “flexible company capabilities” in the future. The methodology considers security technologies as a set of capabilities with a high degree of detail. The correct decision is made after careful analysis of a wide range of indicators and consideration of the set of results or options for future scenarios that under the methodology terms are called a dynamic plan of management decisions or flexibility that will help organizations adapt better or to change their course in information security field.	It assumes an assessment of a wide range of indicators. The possibility of omitting other project risks from the field of view.
Economic Value Sourced, EVS	The methodology assumes expanding the use of such tools as EVA, Internal Rate of Return (IRR), and Return on Investment (ROI) for IT assessment; The EVS methodology goes a step further, trying to determine the parameters of time and risk and to add them into the equation. EVS is based on the risk management method.	It is possible to apply the probability of a timely and qualitative execution of the product development project. The necessity of systemicity; the impossibility to predict changes in the technical and economic performance of the enterprise under the modern economic conditions accurately.

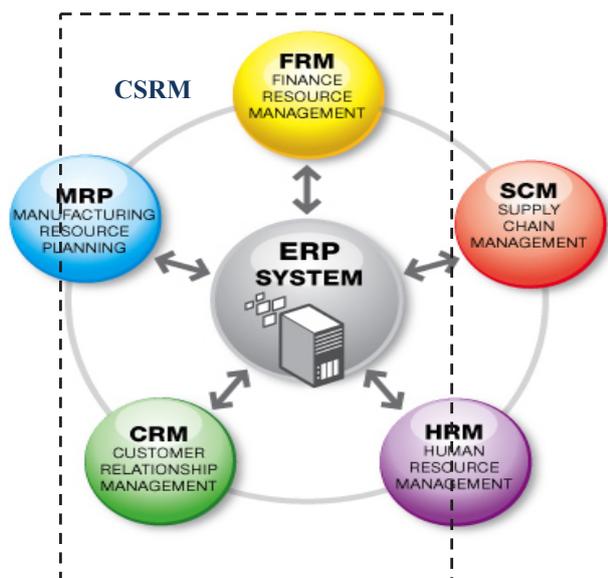
Source: drawn up by the author

### 3. Results and discussion

Since the 90s of the XX century, domestic enterprises have been making attempts to introduce integrated information systems and IT for automation of business processes. The first integrated management attempts were ERP (Enterprise Resources Planning System). Modern ERP systems incorporate large subsystems: financial management, MRP material management, production management, MPS (Master Production Schedule), project management, service maintenance management, Pond-Draining System PDS (SIC – Statistical Inventory Control), personnel management,

automation systems for design and development activity and engineering process (CAD / CAM - CAD / CAM / CAE / PDM) (Vovk, 2011). The last of the standards integrated into the ERP-II systems is the CSRP (Customer Synchronized Resource Planning) – resource planning, synchronized with customers, which embraces customer relationships either.

Thus, if MRR, MRRII, and FRR are oriented on the internal organization of the enterprise, CSRP contains a full cycle – starting from designing the future product of buyers, taking into account the customer’s requirements for warranty and after-sales service maintenance (Karpov, 2010).



**Figure 1. The complex structure of the modern ERP II-system with the CSRP block (Customer Synchronized Resource Planning)**

Source: grouped by the author

Undoubtedly, there are many problems in the selection, introduction, and operation of both complex information systems and separate IT. In our opinion, the problem of outdated IS existing at the enterprises is in the first flight among identified problems of inefficient IT use, that is why they are not able to perform their functions effectively and do not allow the integration of modern IT modules.

The informality and chaos of the internal principles of enterprise management hold the second place among the IT introduction problems, which lead to uncertainty in the tasks of information provision (Karpov, 2010), the current situation on the market for vendors and consulting is characterized by two peculiarities: there is a large number

of proposals for information systems development and introduction, on the one hand, and almost no experience of their successful implementation, on the other hand. At the same time, the price of one APM, for example, ERP-system fluctuates within 10-40 thousand US dollars, and the average lifetime is 15 years (Algorithm, 2013).

The next problem of IT application in enterprises is the lack of a substantiated process of business process planning and in general planning of economic activity, strategic directions of development, as a result of which there is no need for the introduction of modern complex CIS (Novak, 2006; Karpov, 2010).

Separately the problem of coordination of the strategic objectives of the enterprise with the possibilities of information technology use can be distinguished. Despite the fact that IT technology is a separate segment interacting with the implementation of strategies for goals achieving for the enterprise, the structure of information system can be changed under the influence of external environment and innovation development of the enterprise (Pleskach, 2004).

Summarizing the identified approaches to the assessment, we can propose a separation of the main important stages for the formation of a model for assessing the effectiveness of the information systems introduction at the enterprise:

Stage 1. Assessment of business environment of the enterprise. The study begins with the identification of issues important for the enterprise. This allows analysts to link the IT-structure with problems important to the success of the enterprise. Firstly, there should be determined the critical factors of the enterprise’s success, there should be made a plan for their achievement, and there should be determined the indicators of critical success factors achieving. The identification of work that is most relevant to achieve the identified success factors in accordance with the chosen strategy is provided below.

Table 2

**IT technologies used in the activities**

Name of IT technology	Characteristics of IT technology	Advantages of use	Disadvantages of use
CRM system – customer relationship management	Automated data collection on buyers and constant information communication with buyers	The availability of feedback from buyers, the ability to automate the distribution of information among buyers and information receiving from them	Limited usage due to a large number of buyers or lack of feedback communication with many of them
BI data analysis systems (SAP, Microsoft Dynamics AX, Oracle BI systems)	Processing of a large amount of information at a high rate	Allows receiving and analysing data on the performance of the enterprise in a quick manner, generating reports much faster than in ERP systems	Not adapted to the activity features of many enterprises or (networks)
Supplier Relationship Management, SRM	The automated system of supplier relationship management	SRM integrates with other SAP Business Suite modules, supports data exchange with ERP and SCM systems. Optimization of purchasing activity	Limited use only in relationships with suppliers. Transferring sales risks to suppliers
Software product 1C: Enterprise 8	The automated system of bookkeeping and management accounting analysis	Integrates with other software products, automates management of sales, reserves, purchases, financial accounting and bookkeeping	It considers only buyers and suppliers among contracting parties (it is officially forbidden in Ukraine since 2017)

Source: drawn up by the author

Stage 2. Selection of business project. It is necessary to find information technology for each work defined in the first stage, with which it is possible to improve its efficiency. At this stage, a heuristic-functional analysis is made, which identifies bottlenecks in each of the selected business processes and chooses such a solution that allows eliminating the identified shortcomings and obtaining a qualitative result from the IS introduction.

Stage 3. Identification of the risks network. At this stage of research, various types of risks that may exist or already exist in the enterprise business environment and inherent to IT-projects, as well as uncertainties that arise directly at the assessment stage, are determined and measured.

Stage 4. Assessment of costs for information technology or general IS. At this stage, the volume of investments necessary for information technologies introduction is determined.

At the first stage, it is necessary to assess the cost for IT project introduction, to determine the amount of investment necessary to achieve the goal. Assessment of the cost for the introduction of information technology or CIS (complex information system), consists of two stages: assessment of total capital and current costs associated with the introduction and use of IT; and assessment of the reasonableness of a certain amount of costs. Let's consider such a scheme in more details (Algorithm, 2013; Vendorov, 2006; Kalnytska, 2009).

1) Assessment of direct costs for information technology introduction is calculated by the formula:

$$Z_{II}^{IT} = Z_{T3} + Z_{II3} + Z_{OII} + Z_{HII} + Z_{C3} + Z_I \quad (1)$$

where:  $Z_{II}^{IT}$  means direct costs for IT introduction,  $Z_{T3}$  means the costs for the acquisition of technical support;  $Z_{II3}$  means the cost for the acquisition of software;  $Z_{OII}$  means labour costs for project participants;  $Z_{HII}$  means the costs for personnel training;  $Z_{C3}$  means deductions for social actions;  $Z_I$  means other direct costs for introduction.

2) The estimation of indirect costs for introduction ( $Z_{II}^{IT}$ ) is carried out according to a similar scheme, according to the specification of arising derived costs.

3) Let us analyse the assessment of costs for IT maintenance and use during its lifecycle. The second stage assumes forecasting of the annual costs for information technology maintenance during the cycle of their useful application.

Annual costs are determined by the formula (2):

$$Z_{YT}^{IT} = Z_{OII} + Z_P + Z_{C3} + Z_I \quad (2)$$

where:  $Z_{YT}^{IT}$  means costs of annual information technology use;  $Z_{OII}$  means labour costs to maintain and improve technological competence;  $Z_P$  means costs for third-party services;  $Z_{C3}$  means costs for social activity;  $Z_I$  means other costs for IT use.

4) The next stage of the analysis assumes identification of downtime losses (PIT) associated with the planned or unplanned termination of information technology using, costs associated with the elimination of system crashes

and other possible losses. Determination of the magnitude of potential losses that arise while using such information technologies is based on statistical data of other enterprises or accumulated at this enterprise (Algorithm, 2013; Kalnytska, 2009). Summarizing, we can determine the aggregate value of costs by the formula (3):

$$Z_{3az}^{IT} = Z_{II}^{IT} + Z_{HI}^{IT} + Z_{YT}^{IT} + P^{IT} \quad (3)$$

$Z_{3az}^{IT}$  – means total costs for IT introduction and use.

But the calculation of TCO only does not provide a reasonable assessment with regard to the feasibility of the information system use. In fact, it is necessary to consider not only the costs but also the benefits of the IS introduction, which are determined according to the return on investment index (Rd). This method allows assessing the profitability of investments in purchase and introduction of IS and is calculated by the formula (4) (Vendorov, 2006):

$$ROI = (\text{Payback-TCO}) / \text{TCO} * 100\%, \quad (4)$$

where: Payback means the benefits of system introduction.

As a rule, the benefits or the main effect of the introduction of information systems is the increase in labour productivity:

1. Saving of working time of employees of the enterprise.

2. Efficient use of human resources at the enterprise.

3. Reduction of cost for carrying out one or another transaction at the enterprise.

Upon calculation of direct and indirect costs of IT introduction, let's assess the reasonableness of estimated costs, by their comparison with the average indexes of enterprises of the same business sector and by cost-effectiveness determination.

The second stage assumes the calculation and assessment of the enterprise's profit from the information technology introduction. The choice of the method for IT effectiveness assessment depends on organizational efficiency and material profit, the receipt of which provides the introduction of information technology. There are three types of efficiency from the introduction of information technology distinguished in the scientific literature, namely: direct efficiency, qualitative efficiency, and strategic efficiency (Algorithm, 2013; Vendorov, 2006; Kalnytska 2009; Martunyuk, 2012; Nefiodov, 2009).

Direct efficiency is defined as direct financial profitability resulting from the application of IT. Qualitative efficiency affects the enterprise's profit indirectly, by improving the characteristics of processes, and improving the quality factors of production development. Strategic efficiency means profitability that is displayed in the long run. For example, competitiveness increase, expansion of the market of goods, QMS introduction, etc.

The multiplicity of introduction goals and sources of information technologies payback requires a differentiated approach to determine the criteria for their effectiveness assessment. In order to carry out a

comprehensive assessment of the effectiveness of IT use, it is also necessary to take into account the influence of external and internal factors of the enterprise operation.

The assessment of current performance should include comparing the results obtained with the average profit margins in the branch; with indicators of market leaders or desirable indicators.

The assessment of proceeds from IT introduction begins with the determination of the sources of economic efficiency of IT use, which depends on the functionality of the chosen system.

Total profit from IT introduction is determined by the formula (5):

$$\Delta S_{IT} = \Delta S_{na} + \Delta S_a + \Delta S_{np} \tag{5}$$

where:  $\Delta S_{IT}$  means total profit from IT introduction;  $\Delta S_{na}$  means profit related to the improvement of planning efficiency;

$\Delta S_a$  means profit related to the improvement of efficiency of procurement management and supply logistics;  $\Delta S_{np}$  means profit associated with the improvement of efficiency of the sales management process at the points of sale. However, we believe that the given method of assessment of profit from information technology introduction does not ensure full consideration of qualitative and strategic efficiency,

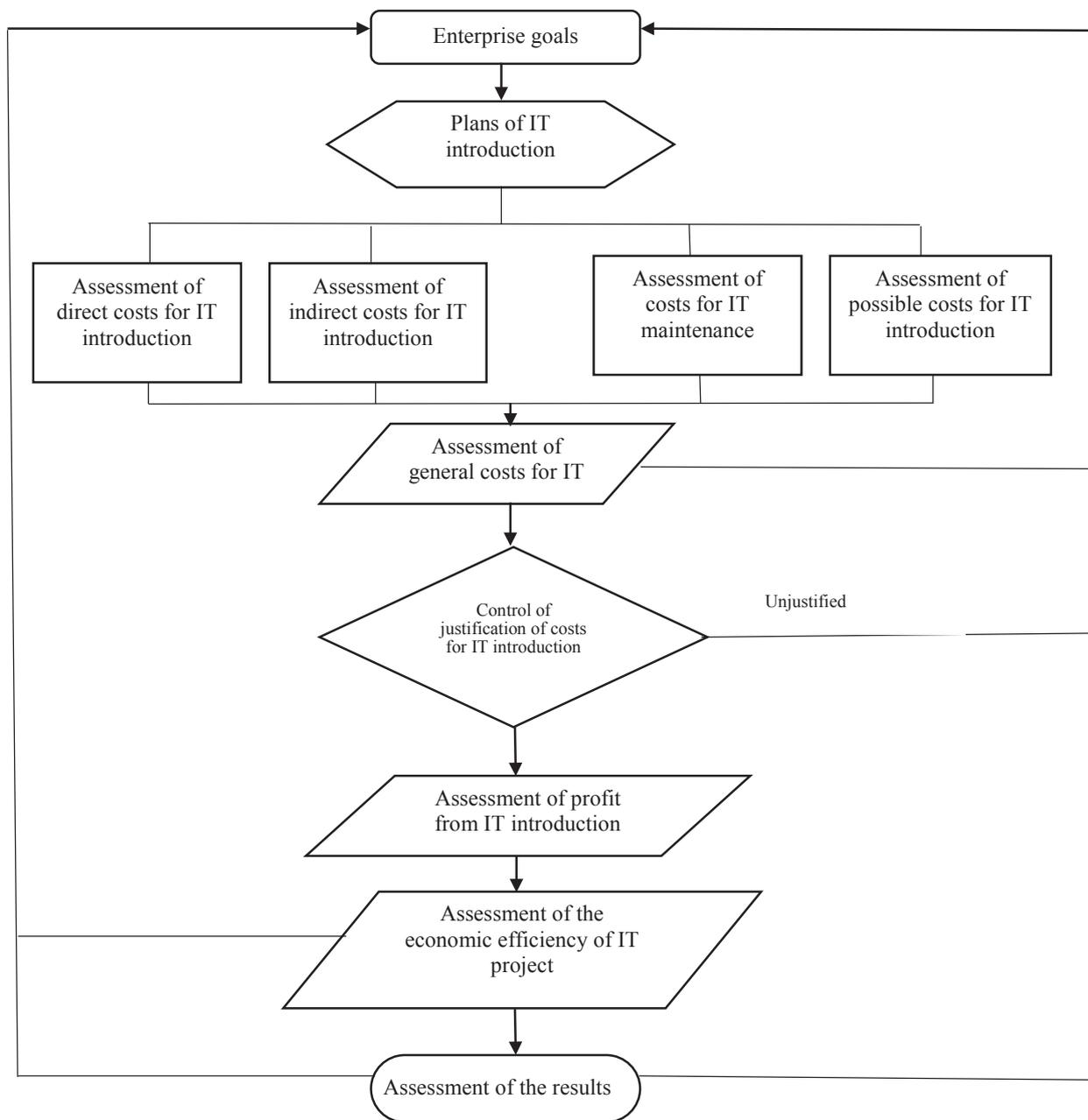


Figure 2. The algorithm to determine the economic efficiency of information technology introduction at the enterprise

therefore, requires additional use of qualitative methods that allow supplementing quantitative calculations.

Among the various methods for assessing the effectiveness of information systems introduction, the most important are those methods that allow assessing the effectiveness prior to implementation of the project, at the stage of feasibility study. They include: Internal Rate of Return (IRR), ROI (Return on Investment), TEI (Total Economic Impact), NPV (Net Present Value), EVA (Economic Value Added) (Table 1). It should be noted that the key point in these methods' use is to assess the predicted effect of the IT system introduction. Taking into account that predictive values are used in these methods, the validity of numerical estimates of the direct benefit from the system introduction may not be sufficiently reliable and may reduce the probability of resulting quality (Kanonenko, 2010; Body, 2004).

The methods of scenario analysis proved itself to be most effective in calculating the effectiveness of real options; however, there are positive results of their use in other areas of analysis in the scientific literature. We consider it economically feasible to apply such methods to assess the economic efficiency of IT use. The most well-known is the scenario analysis method, the Black-Scholes model, and the binomial model (Body, 2004).

The method of scenario analysis allows obtaining approximate results, therefore, the use of this methodology is relevant if the use of IT does not significantly affect the implementation of the enterprise's strategy or if the assessment of the effectiveness of information technology is implemented in the regime of resource saving.

The Black-Scholes and binomial models, by contrast, allow determining assessment results in a fairly precise manner. In our opinion, the Black-Scholes-Merton model is most relevant, since in contrast to the binomial it is easier to use, however, it allows obtaining the result with minimal errors, without significant time costs, close to the definitions of the binomial model.

$$C = S_0 N(d_1) - Ke^{-rt} N(d_2), \quad (6)$$

$$P = Ke^{-rt} N(-d_2) - S_0 N(-d_1), \quad (7)$$

where:

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r^2 + \frac{\tilde{A}^2}{2}\right)T}{\tilde{A}\sqrt{T}},$$

$$d_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r^2 - \frac{\tilde{A}^2}{2}\right)T}{\tilde{A}\sqrt{T}} = d_1 - \tilde{A}\sqrt{T},$$

$N(x)$  – is the integral function of standard normal distribution, determines the probability whether the variable with a standard normal distribution is less than  $x$  value.

$S_0$  means the initial stock price

$K$  means the price of the option execution

$r$  means the risk-free interest rate

$T$  means the term before the option expiration (in years)

$\sigma$  – standard deviation of continuously accrued profitability per share

Assessment of the effectiveness of information technology use by the real options method should be considered not as an alternative to the Net Present Value method (NPV) but as a method of supplementation and refinement of the assessment obtained during calculations of the traditional discounted cash flow.

At the final stage, the economic efficiency of the introduction and application of information technology is calculated. As a criterion for the indicator of economic efficiency, we will use a general indicator that determines the value generated by the effect of IT introduction, that is, the quantitative indicator of capital gains from the use of information technology or information system. Such an indicator is calculated as the net present value (NPV), calculated on the basis of cash flow discounting method, and takes into account the value of IT acquired by the enterprise.

#### 4. Conclusions

Modern information technologies are able not only to satisfy the requirements of production systems to the fullest extent but also act as an important prerequisite for their adaptive development. World experience in the field of computer technology and information technology in recent years indicates a significant increase in the rate of scientific-and-technological advance. The high rate of information technology introduction contributes to the increase in the number of information and software technologies and technical devices used in the production and economic activities of enterprises of all sectors.

Technologies allow raising the methods of management to a qualitatively new level and using the management information of the enterprise not only for internal purposes but also for the development of cooperation relations with contractors and increase of the customers' loyalty. Modern information systems enable the implementation of such opportunities as: long-term and operational planning; development of new types of products; formation of production plans in accordance with sales plans; production management; planning of raw materials and materials flow; planning and accounting of finished goods flow; planning the resource requirements for rhythmic production; processing, analysis, and approval of applications from the enterprise subdivisions for the necessary materials; provision of a continuous production cycle; optimization of materials disposition; construction of databases and classifiers of enterprise materials; providing a deep level of details of cost elements.

There was carried out the analysis of selection, introduction, and use of IT in the activities of enterprises, and there was revealed a number of problems and specifics of their application. The main ways of these problems solving should be the following: change of the traditional outdated information system at the enterprise; management's belief in the need to invest in modern IT systems of strategic potential management of the enterprise, by way of economical substantiation of their expediency; clear definition of strategic goals and tasks of the enterprise's IT system; development of an effective system of the strategic potential management of the enterprise.

But modern information technologies that implement these functions require significant financial and resource investments, therefore, the relevance of determination of the economic efficiency of their introduction and subsequent use prompts the search for new methods of calculation.

Along with traditional and classical methods of financial, qualitative, and predictive analysis, there was proposed an improved methodology for economic efficiency calculation. The proposed methodology is based on the use of the Black-Scholes-Merton model of real options calculation, combined with the traditional algorithm for calculation of feasibility of introduction and efficiency of information technology using at the enterprise on the basis of the net present value NPV and direct costs, which will create an effective tool for measuring qualitative and quantitative effects and risks. In our opinion, this will allow making the right managerial decisions regarding the choice and application of IT systems. Further perspectives of scientific direction will be related to the research of the effectiveness of individual components and an integral indicator of determination of economic efficiency and validity.

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