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DEVELOPMENT OF METHODS AND TECHNOLOGIES OF INFORMATICS FOR PROCESS MODELING AND MANAGEMENT

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This book consists of papers describing applications of informatics in process modeling and management and in environmental engineering. Problems presented in the papers concern development of methods supporting process management, development of calculation methods for process modeling and development of technologies of informatics for solving some problems of environmental engineering. In several papers results of the research projects supported by the Polish Ministry of Science and Higher Education are presented.

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CHAPTER 1

Process management and management tools

SELECTED PROBLEMS OF THE ASSESSMENT OF ECONOMIC EFFECTIVENESS OF IT PROJECTS

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Abstract: *The paper presents selected problems of the assessment of economic effectiveness of IT projects. In the initial part the authors discussed briefly an idea of examining effectiveness of investments in IT technologies and justified why business entities should carry out comprehensive studies of effectiveness of IT projects. Next, selected methods of effectiveness assessment were presented with the emphasis placed on calculation of economic effectiveness and financial analysis. The selection of these very methods resulted from the fact that they are favored in business plans of projects financed with external funds (bank loans, supporting funds etc.). This has become particularly important after our accession to the European Union when the pool of funds allocated to innovative undertakings, among others for IT projects, has substantially increased. Nevertheless, an absorption of these funds is determined by an ability to make thorough appraisals of effectiveness of such projects.*

Keywords: IT projects, economic effectiveness, effectiveness assessment.

1. Introduction

Information technology is playing a more and more important role in business organizations. Enterprises perceive it as one of main factors of their competitive advantage. Development of information and communication technology is radically transforming their business activity, opening new business areas for companies and changing their business formats. Thus, more and more financial resources are assigned to informatization. This is – in simple words – how the "bright side" of IT investments looks. On the other hand, it is frequently claimed that heavy expenditure does not always bring about expected results. It is distinctive that, in principle, the described situation has not been changing for years[1].

It seems that the problem of such a considerable divergence of assessments results only in part from the specificity of IT projects which generate numerous effects of qualitative character – difficult to express in monetary units and some-

[1] A wide review – on the basis of abundant sources and own analyses – of the problem of the so-called paradox of productivity of information technology is presented in works of, among others (Osei-Bryson, Ko, 2004, pp. 1-13) and (Esker, 2005, pp. 789-798).

times simply impossible to be subjected to any measurement – what, beyond any doubts, poses obstacles to credibility of economic calculation. With regard to IT area at least the equal importance – according to the authors – should be assigned to decisions based on "premonition" of decision-makers, tendencies on a market or even fashion for certain solutions – without any analysis of profitability of such investments. Therefore, the authors decided to bring forward fundamentals of such an analysis in this work.

2. The essence of effectiveness assessment in IT projects

Before we move to an actual discussion on selected methods it is necessary to introduce briefly the essence of an assessment of economic effectiveness of IT projects.

Firstly, for the purpose of this study we can accept, that effectiveness (defined also as efficacy, efficiency, ability or performance) is an ability to realize an adopted strategy of an enterprise (also in the information technology area) and to achieve goals set in it[2]. In regard to innovative undertakings, as, for instance, IT projects, the concept of effectiveness is often perceived in respect to economic effectiveness and, consequently, to economic results of an undertaking, calculated as a relation of projected effects to expenditure incurred. In the sweep that implies the best results at the lowest cost. Thus, improvement of effectiveness involves streamlining of expenditure, on the one hand, and, on the other, achieving optimal effects – in certain conditions – both of functional and economic nature, what corresponds with the general model of improving any business activity.

Secondly, it should be noticed, that – having defined the concept of effectiveness this way – the process of assessment of economic effectiveness of IT projects consists of three fundamental phases, fully compatible in terms of methodology (Cypryjański, 2002, pp. 124-125), particularly in respect of:

a) identification – the essence of which is to determine all input and effects of a project assessed,

b) quantification – which consists in adopting methods of measurement and measuring identified input and effects,

c) calculation – which aims at selection of criteria and methods of appraisal and formulating an assessment itself.

[2]The definition of effectiveness is discussed at length by the authors in works (Dudycz, Dyczkowski 2001, pp. 111-112), (Dudycz, Dyczkowski 2003, pp. 175-185), (Dudycz, Dyczkowski 2005) and (Dudycz, Dyczkowski 2006). The exhaustive study on the category of effectiveness, explanation of its essence, dimensions, determinants as well as presentation of practicable measures and ratios of effectiveness assessment comprise the research program presented in paper (Krupa, Kulińska, 2003, pp. 670-679).

Thirdly, the process of appraisal – understood that way – is always carried out in given contexts which determine its course, mode and a way of conducting. In order to identify these factors we will use characteristics introduced in the paper (Cypryjański, 2002, pp. 124-129). It is assumed, therefore, that in order to define methodology of assessment, it is necessary to analyze the following determinants: time of making an appraisal, its purpose, subject and object.

With regard to time of assessment we may distinguish two kinds of analysis:

a) *ex ante* – carried out during formulation of a strategy of informatization or at the stage of meeting decisions concerning scope and a way of realization of particular projects (such an analysis is based on planned expenditure and effects and it may refer to one or several scenarios of execution),

b) *ex post* – usually conducted once a project is completed and implemented solutions exploited for a certain period of time, and consists in comparison of actual expenditure incurred and effects produced with the planned ones.

Sometimes another type of analysis is distinguished i.e. current, usually fragmentary assessment of effectiveness carried out in the course of development of a project, for example, after reaching so-called milestones. For the purpose of this paper *ex ante* analyses – conducted mainly at a preinvestment phase of IT projects, when requirements and potentialities of a project have been identified, a preliminary selection of possible options of a project and scenarios of its realization made, formulation of technical and economical terms and conditions completed and, subsequently, an assessment of final operational version conducted as well as a decision on beginning of a project met – are of the greatest importance. This is what the detailed methods discussed in the later part of the paper will, therefore, focus on.

With regard to objectives of effectiveness assessment a certain level of diversity is observed[3]. From the methodological point of view they can be, as a rule, reduced to the problem of multicriterial selection of the best solution from several acceptable options. It should be emphasized that in reference to assessment of economic effectiveness and detailed methods described in the later part of study it would be ideal if particular options were comparable and criteria of selection could be described by attributes possible to express in monetary units.

However, looking at the essence of effectiveness assessment from a point of view of a business entity subjected to appraisal the attention should be paid to two aspects of such a perspective:

[3]This diversity can be depicted by a list of typical questions, which should be addressed while an assessment is carried out: Which solutions from IT area are the most suitable from a perspective of a business strategy of an enterprises? When, if at all, realization of particular project should be started? Which IT projects should be carried out and in what order? Which applications available on a market should be chosen when an integrated system is to be developed?

a) results of partial analyses carried out from the point of view of organizational microstructures or structures related to processes may differ radically from those oriented on macrostructures (enterprises, groups or networks of enterprises or the so-called extended logistic chain),

b) analyses of effectiveness should be conducted in a different way when they are carried out by subjects from areas of financial planning or accounting to when the analyses are located within a scope of managerial or controlling tasks.

The methods discussed hereafter can be applied both in the micro and macro scale, whereas so-called traditional methods of calculation of economic effectiveness as well as financial analysis are targeted on supporting financial decisions and the 'new methods' facilitate, above all, management processes in IT area and serve a purpose of management control function.

The last group of determinants of the assessment involve its subject which is also characterized by considerable diversity. While choosing the right method of assessment a specificity and genre of particular project are of primary importance. In addition, it should not be overlooked that apart from projects which, in principle, generate mainly costs (this is e.g. the case of investment in IT infrastructure), or those which produce notable direct or indirect benefits, there are also such which result from competitive pressure, have strategic or transformational character or are characterized by high potential, however, difficult to be estimated[4]. In the last case so-called traditional assessment methods, discussed in further part of the paper, are frequently replaced or supplemented by the new ones, some of which have been developed with investments on capital markets in mind (e.g. method of real options). Even though – according to the authors – there exists at present a shortage of appropriate experience in implementation of these solution in companies of the domestic IT sector as well as among enterprises investing in information technology, these methods ought to be presented in the following part of the study. It is quite likely, that once these methods are improved and popularized in future, they will become a part of procedures of effectiveness assessment used in practice.

3. Methods of effectiveness assessment

3.1. Calculation of economic effectiveness

The essence of calculation of economic effectiveness comprises: identification and comparison of quantified input and effects and assessment of effectiveness of planned investments.

[4]For an exhaustive discussion on influence of character of IT projects on reasons of taking investment decisions study the work (Lucas, 1999). See also (Cypryjański, 2002, pp. 127-128) where additionally usefulness of the method of technology portfolio management (analogous to well-known BCG matrix) in investment assessments related to IT projects is analyzed.

In case of an IT project identification and comparison of quantified expenditure and effects of an investment might not always be simple. While estimation of costs is relatively easy, difficulties appear when expected benefits, which may be expressed only partially in value terms (it may well happen that none effects can be subjected to quantification), should be assessed. Numerous benefits do not have a nature directly related to implementation of information technology (e.g. an increase in functionality, higher quality of products and services, better promotion of an enterprise or strengthening competitive position). In such a case it is necessary to carry out – beside (or instead of) formalized calculation of effectiveness an analysis – as extended as possible – of all unmeasurable effects of a project[5].

The analysis of expenditure incurred on application of information technology leads to distinguishing the following two types of input: quantified i.e. measurable (among which it is possible to identify one-off and current expenditure) and unquantified i.e. hardly measurable (resulting e.g. from organizational chaos or information noise in the first period of running a system). The effects may be distinguished alike: quantified i.e. measurable (among which there are one-off and current benefits) and unquantified i.e. hardly measurable (concerning e.g. streamlining an organizational or information structure, improving internal communication within an enterprise or overall strengthening of its image). In order to analyze and compare expenditure and effects of an IT project the following measures can be applied (Marcinkowska, 2000, p. 165):

a) traditional analysis of expenditure and effects – benefits resulting from applying information technology are compared with costs (in the extended version costs postponed or avoided are also taken into consideration),

b) linkage of values – taking into account benefits arising in different areas than these where the costs originate,

c) restructuring of values – using information technology to enable employees to carry out functions of higher value.

Having identified and compared input and effects we can proceed to effectiveness assessment of a planned undertaking. For this purpose two possible kinds of methods can be applied: traditional, where static (simple) and dynamic (discounted) methods can be distinguished, and so-called 'new' ones.

Traditional static methods are simple in application and recommended when a necessity of formulating a prompt assessment of a project and meeting a decision emerges. However, they should not constitute the basic criterion in case of long-term investments and in economies where considerable inflation appears, since they disregard an influence of a time factor on value of money – and, on the other hand, it is money that is a measure of both expenditure and effects. The following static meth-

[5] P. Jędrzejowicz recommends application of a cost-effects sheet for this purpose (Jędrzejowicz 2001, p. 203).

ods of assessment may be applied to IT projects: Payback Period (PB) and Accounting Rate of Return (ARR). The weaknesses of static methods (the time factor and inflation) can be eliminated by using traditional dynamic methods of assessing effectiveness of undertakings since they take into consideration time structure of both expected inflows and expenses connected with an examined investment. Using compound interest and discount techniques they enable to make expenditure incurred and effects attained in various periods comparable. Of all dynamic methods of appraisal of IT projects the methods of Net Present Value (NPV) and Internal Rate of Return (IRR) are applied the most frequently in practice. A wider description of traditional methods of assessing effectiveness of investments can be found in Table 1.

Table 1. Basic traditional methods of assessment of investments effectiveness.

name	algorithm	characteristics	advantages	disadvantages
TRADITIONAL STATIC METHODS				
Payback Period (PB)	$PB = \frac{IO}{NI + D}$ where: PB - payback period, IO - investment outlay, NI - net income, D - depreciation.	The method determines a period of time needed for net income to cover costs of an investment – this way, it determines an expected number of years necessary to regain the investment outlay. The shorter the Payback Period is, the better.	• Disregards both time value of money and cash flows appearing after the payback period. • It is improper for analyses of projects belonging to various risk classes. • Does not inform on profitability.	• Enables to assess liquidity of a project (projects of shorter Payback Period are characterized by higher liquidity). • Allows preliminary assessment of investment projects
Accounting Ratc of Return (ARR)	$ARR = \frac{NI_{at} + I}{IO_n}$ where: ARR - accounting rate of return, NI_{at} - net income after taxation I - interest on bank loans, IO_n - nominal investment outlay.	The method allows assessing an influence of an investment on a balance sheet of an enterprise and its profit and loss account – however, not its cash flow. The best undertaking is that, which is characterized by the highest Accounting Rate of Return.	• Subjective way of defining the limiting level of the rate of return. • Disregarding changes in value of money in time.	• Uses easily accessible input data, originating from typical financial statements. • Simplicity of calculations and clarity in interpretation of results.

name	algorithm	characteristics	advantages	disadvantages
TRADITIONAL DYNAMIC METHODS				
Net Present Value (NPV)	$NPV = \sum_{t=0}^{n} NCF_t \times (1+r)^{-t}$ where: NPV- net present value, NCF_t - net cash flows of consecutive years of a calculation period, r - discount rate, N - consecutive year of a calculation period.	This method enables to determine real (current) value of expenditure and effects related to a certain project. A scenario of realization of IT project should be accepted when NPV of it is higher or equal to zero.	• It does not contain information on risk margin. • Fixed discount rate for the whole investment period.	• Takes changeable value of money in time into consideration. • Enables to compare various projects (of various risk classes).
Internal Rate of Return (IRR)	The procedure of calculation of IRR is laborious and allows only approximate estimation of its value (except for the situation, when a length of the life cycle of a project is equal to one or two years). This measure is calculated with a help of computer (using e.g. spreadsheets) or a financial calculator.	The method is based on an interest rate, at which present (discounted) value of cash outflows equals present value of cash inflows, it is, therefore, a rate, for which NPV=0. An investment is profitable when IRR is higher than the limiting (discount) rate.	• Does not find application for mixed undertakings. • Fixed discount rate for the whole investment period. • Assumes that the reinvestment rate is equal to the discount one.	• Takes time value of money into consideration. • Contains information on risk margin. • Directly demonstrates the rate of return of examined projects.

Beside traditional methods of assessing effectiveness of planned investments mentioned above, more and more frequently the new methods find application in practice – especially in the area of management of informatization processes or in IT controlling. Their essence lies in taking into account specificity of information technology and relying on contemporary conceptions of measuring economic values. In the literature of the subject – see, among others, works (Dudycz, Dyczkowski, 2005 and 2006) and the sources to which they refer – the following methods are distinguished:

a) Total Cost of Ownership (TCO) enables to estimate total costs of running existing IT systems and to simulate changes in costs and expenses with regard to modifications in current solutions. TCO consists in measuring and simulating an influence of information technology on direct costs (recorded, concerning e.g. software, hardware, resources management or development of a system), indirect (unrecorded, associated with a final user or downtimes of a system) and deferred (e.g. costs of development of an infrastructure over a longer period of time);

b) Total Economic Impact (TEI) is an extension of traditional financial methods. TEI consists in analyzing, beside costs (direct and indirect) and benefits resulting from them, flexibility of new solutions and inherent risk. All these elements are

analyzed and reduced to a common, financial denominator. The result is a traditional rate of return on investment, however, taking also into account an influence of risk;

c) Real Options Valuation (ROV) is based on the financial theory of options. In ROV it is assumed that current investments in IT systems will allow new, potentially profitable investments in future. These investments have their value and this what we call a real option. The method, apart from taking into consideration the value resulting from calculation of costs and revenue, takes into account value of subsequent investments and value connected with flexibility i.e. a possibility of changing investment scenario in the course of its realization. Taking into consideration sequential character of realized IT projects and possibility of abandoning implementation at each stage ROV extends analysis of profitability carried out with traditional methods;

d) Information Technology Scorecard (ITSC) derives from Balanced ScoreCard of Kaplan and Norton. It also comprises four perspectives, for which objectives and measures, that can be e.g. quantitative, qualitative, resulting (referring to what has already happened) or forecasting, are set. There has been no common standard developed here, at the same time, the ITSC designed for a particular enterprise depends much on chosen approach and its specificity;

e) Information Economics (IE) is a method of assessment of IT investments taking into consideration all costs/input and benefits/effects. It enables to carry out a relative assessment of value of a project in two domains: business and technological. This becomes possible as a result of distinguishing seven categories, constituting objects of analysis, amongst which both measurable and unmeasurable can be found. By assessment of a projects each category is assigned a definite number of points (so-called rank) within a range from 0 to 5. Thus, all ratios, measurable and unmeasurable, are reduced to the common abstract number. The measure has a relative character and its values are restricted to the interval between 0 and 100, where 0 denotes a worthless project, whereas 100 a project of the highest importance for the business entity;

f) Applied Information Economics (AIE) is based on Bayesian algorithm of calculating information value which can be applied both as a detailed research method (analysis of information value) and a general procedure of examination. The method is qualified as *ex-ante* procedure of investment assessment, minimizing expenditure associated with acquiring information on NPV distribution. AIE can be distinguished amongst other methods due to its entirely objective, scientific concluding.

The limited scope of this paper does not allow further discussion on the above-mentioned methods, therefore, all interested are referred to other works of the authors.

3.2. Financial analysis

As it has already been mentioned, the complementary part of assessment of investments associated with IT projects, along with calculation of economic effectiveness, is the financial analysis. The basic objective of this approach – generally speaking – is to demonstrate whether there are sufficient financial resources available both for realization of a project and later – for financing of its day-to-day exploitation as well as how the future profitability of investment is going to develop[6].

The financial analysis uses many detailed measures, enabling to assess an undertaking from different points of view. Ratio analysis is a basic perspective used while examining effectiveness. It consists in calculation of appropriate ratios and subjecting them to comparative evaluation in space and time. In practice, while considering effectiveness of IT projects two basic measures are used the most frequently: Return On Investments (ROI) and Return On Equity (ROE). They are believed to be the most synthetic ratios. They are built in a shape of a pyramid, on the top of which ROI (or ROE) is placed. On the lower levels the parameters – presented in the form of economic ratios or measures – influencing the ratios placed higher are located. This way a network of relations between basic factors and the ultimate one emerges. Such a decomposition of these ratios, by expressing them as a combination of other ones, allows analysis of reasons for all divergences in their level that may appear. Thus, a comparison of realization a IT project both in space and time is possible. The more detailed description of discussed ratios is contained in table 2.

Table 2. Basic ratios of assessment of investment effectiveness.

name of the method	algorithm	brief characteristics
Return On Investments (ROI)	$ROI = \frac{NI}{TC}$ where: ROI- return on investments, NI - net income, TC - total capital	Expresses effectiveness understood as the effectiveness of expenditure incurred on realization of a given project. In a narrower meaning the method is used for determining a percentage profit from investment.
Return On Equity (ROE)	$ROE = \frac{NI}{E}$ where: ROE - return on equity, NI - net income, E - equity	It represents a relation of profit (in particular of net income) to an average level of equity.

[6]Some authors maintain that limitation of financial analysis only to financial effects is reducing its usefulness for investments in the area of IT technologies and their applications (Jędrzejowicz, 2002, p. 405).

To sum up the review of methods of effectiveness assessment it should be emphasized that both the calculation of economic effectiveness and the economic/financial analysis should constitute the base of taking investment decisions associated with IT projects. These are two complementary elements, which allow to conduct an analysis and assessment of effectiveness of any investment. Thanks to application of discussed methods in appraisal of planned IT projects, it is possible, among others, to: express expenditure and anticipated effects quantitatively, select the optimal scenario of realization and control implementation of projects both in time and with regard to arrangement of elements they are composed of.

4. Conclusion

The authors are fully aware that they have not exhausted the subject but only brought up limited number of problems comprising broad and complex issue of assessing effectiveness of IT projects. In order to conclude the presentation they – once more – want to stress two – in their opinion – essential aspects comprising the discussed problem:

a) despite certain methodological and tool gaps all participants of IT projects must apply – in the course of planning and realization – methods which already exist and which are successfully used for improving investment and operating processes, especially those which in widely understood innovation management are regarded as standards – and no disquisition about the "specificity" of information technology exempt us from requirement of applying methods of economic calculation, financial analysis or finally – more widely understood – analysis of rationality of activities,

b) there exist a need to conduct intense, interdisciplinary research in this field, oriented on improving existing methods (among others those introduced in this paper) and, on the other hand, on developing and implementing new methods of assessment of effectiveness or operational management of the economic aspect of IT projects that will be more efficient with reference to IT area, and, at the same time, ready to be applied in practice (also in development and more extended application of the methods presented in this study).

We should bear in mind, however, what constitutes the essence of actions oriented on effectiveness and assume that Bartczak and Szafrański are right while noticing that "thanks to information technology it is possible to gain a lot of benefits but it is essential to be able to distinguish situations when one should make an accurate economic calculation in order to decide to begin a project, from such when it is simply a case of logical reasoning about the mutual influence of information technology and effectiveness of business, and finally those, when implementing an IT solution is indispensable in order to survive on the market" (Bartczak, Szafrański, 2000, p. 10).

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Jan Studzinski, Olgierd Hryniewicz (Editors)

DEVELOPMENT OF METHODS AND TECHNOLOGIES OF INFORMATICS FOR PROCESS MODELING AND MANAGEMENT

The purpose of this publication is to popularize application of informatics in process modeling and management and in environmental engineering. The papers published are thematically selected from the works presented during the conference '*Multi-accessible Computer Systems*' organized by the Systems Research Institute and the University of Technology and Agriculture in Bydgoszcz for several years already in Ciechocinek. Problems presented in the papers concern: development of quality and quantity methods supporting the process management, development of quantity methods for process modeling and simulation, development of technologies of informatics for solving problems of environmental engineering. In several papers results of research projects supported by the Polish Ministry of Science and Higher Education are presented.

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