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Cost–benefit analysis – evaluation model of cloud computing deployment for use in companies

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ABSTRACT

The use of cloud computing services appears to offer significant cost advantages. The most frequently mentioned advantages include investment and operating costs saving, high elasticity of services as well as increased flexibility of certain business processes. On the other hand, the adoption of cloud computing in enterprise environments is non-trivial. Understanding the organizational benefits and drawbacks is far from straightforward. The adoption of cloud computing results in a considerable amount of organizational change that will affect employees. The aim of this contribution is to conduct and describe the evaluation model of cloud computing that would be applicable in business practice for evaluating the effectiveness of such investments. The target users of this model are primarily people in companies with decision-making power in the investment field. The appropriate starting point based on the multi-criteria evaluation was the cost–benefit analysis (CBA) approach for cloud computing (CC). A multi-method approach (systematic literature review, analysis of real cloud computing services, expert interview, case study) was applied in order to develop and evaluate the formal model. We found that our model fits the practical requirements and supports decision-making in cloud computing.

KEYWORDS

Cloud computing; costs; evaluation model; business; multi-criteria evaluation

JEL CLASSIFICATION

M15; M21

I. Introduction

International business in the twenty-first century and globalization go hand in hand (Kačerauskas 2015; Brunet-Thornton and Bureš 2012). In connection with the economic crunch, the emphasis is more than ever laid on improving work performance (Mohelska and Sokolova 2014), efficient functioning of processes in companies, well-incurred costs and the return on investment (ROI). Few doubt that it also applies to investments in information technologies (IT). Several surveys indicate that many organizations are concerned about the issue of measuring the benefits of IT investments. Measuring IT benefits and IT value is considered to be one of the most important issues for senior IT management (Brancheau, Janz, and Wetherbe 1987; Watson et al. 1997). This issue has been addressed for many years and still remains relevant in the context of new technologies in enterprises. In recent years, cloud computing has become one of the major trends. It shares its key problem with previous technologies, namely, the evaluation of returns on cloud computing investment (Dedrick, Gurbaxani, and Kraemer 2003). Another problem is the quantification of numerous highly qualitative variables (Svenningsen 1998).

Cloud computing is a model facilitating a comfortable access to a network of shared memory in configurable information sources including networks, servers, storage devices that can be quickly loaded and unloaded with minimal managerial effort or interaction with the service provider. The National Institute of Standards and Technology (NIST) determines five essential characteristics of cloud computing: on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service (Mell and Grance 2011).

Cloud computing differs from classic hosting by offering flexible services. According to the current needs of a customer, the parameters of the services used can be fully self-service changeable. The suitability of the resulting solution is closely related to both organizationally demanding changes as well as the complexity of calculating the costs of the actual

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migration to the cloud environment. With regards to the characteristics of cloud computing, according to Hosseini and Sommerville (2010), it is possible to distinguish between the cost and organizational aspects.

Cost aspects of the implementation of cloud computing services:

- the actual resources consumed by a system, which are determined by its load,
- the deployment option used by a system, which can affect its costs as resources such as bandwidth are more expensive between clouds compared with bandwidth within clouds,
- the cloud service provider's pricing scheme, which can change at any time. The consequence is that decision-makers are faced with much uncertainty regarding the best provider and whether cloud adoption is more cost-effective than other more traditional forms of IT provisioning such as co-location.

Organizational aspects of the transition of cloud computing services:

- Accounting: hardware and network infrastructure is not procured upfront. It may be consumed as a service and paid for just like a utility.
- Security: virtualization introduces new vulnerabilities, and there could be conflicts between customers and cloud providers who are both attempting to harden their security procedures.
- Compliance: the geographic location of data will not be known exactly in the cloud; this has long-term implications for enterprises concerned with data privacy.
- System support: will change because administrators will no longer have complete control of a system's infrastructure.

In 2010, the largest cloud-based technologies market was in the United States; European Union (EU) countries were in second place (FEEDIT.CZ 2013). The use of cloud computing in EU countries does not develop as fast as it does in the United States. In 2012, 4000 PC users across 9 EU countries were approached and asked about knowledge and use of cloud computing. This survey was realized by the Business Software Alliance Association (BSA) and they discovered that although cloud computing is one of the most rapidly developing technologies, cloud services are used by less than a quarter of computer users in the EU. The EU is therefore below the world average, which is 34%. The situation in the Czech Republic is even worse. According to the survey of Aspectio Research (September 2011), the use of cloud computing within the EU is below average; the survey from 2013 (University of Hradec Kralove and Datank s.r.o.) suggests that this technology is used by only 9% of small- and medium-sized enterprises in the Czech Republic (Maresova and Halek 2014).

The reasons for these causes are that company managers are not motivated to introduce new technologies. The concept of cloud computing is not fully understood and thus the efficiency of investment in it cannot be directly evaluated. In spite of the fact that there exist a lot of metrics evaluating the efficiency of technologies, they are rarely used in business practice. This fact may be due to several reasons:

- business executives lack the knowledge of metrics for evaluating IT,
- they lack motivation to apply these metrics,
- indicators are too technical and there is little connection with routine business evaluation of the effectiveness of investments,
- there is no comprehensive information for managers to make their decisions in this way,
- there is a lack of evaluation of the security risks for the case of migration of existing technologies to cloud,
- it solves IT problems only partially.

The above text suggests that the transfer of existing services to the cloud computing infrastructure is a complex process, which brings significant risks and potential savings that are difficult to grasp and quantify. Cloud computing is a broad term that requires an inter-connection of technological and economic-managerial perspective for successful implementation. A key issue is the under-pinning of quantitative and qualitative parameters affecting the actual process of implementation, including informatics and technical metrics. The aim of this article is therefore to propose an evaluation model of cloud computing

with regard to application in business practice in evaluating the effectiveness of investments. The target users of this model are primarily people in companies with decision-making powers in the investment area. Given the extent of the article, a general model of evaluation of the effectiveness of investments in cloud computing will be characterized. As part of an internal university project, six case studies have already been established, which describe the application of this method in a company.

II. Methods

In order to meet the objective and propose of an evaluation model of cloud computing, several methods, including the literature review, expert interviews and multi-criteria decision-making, were used. The literature review focused on methods used in the area of measuring the effectiveness of IT, especially in relation to cloud computing.

Multi-criteria decision-making is used for the purpose of selecting the initial methodological framework for evaluating the effectiveness of cloud computing. The multi-criteria decision-making theory deals with situations in which the decision-maker evaluates the consequences of their choice according to several criteria (Zavadskas and Turskis 2011). These are quantitative criteria, which are usually expressed in natural scales (also referred to as numerical criteria). Additionally, there exist qualitative criteria, where an appropriate scale is implemented. In the theory of decision-making processes, in principle, for example, we use the following procedure, which is also used in the context of selection of suitable default method for cloud computing: identification of alternatives, selection of criteria, assessing the impact of each alternatives in relation to each of the criteria, determining the importance of the criteria, evaluation of alternatives.

Interviews with experts were carried out with the aim to design the structure of the evaluation model of cloud computing that would correspond with the characteristics of this technology. Another aim was to verify that the selected indicators and metrics are suitable. Of course, it was taken into consideration whether or not it is applicable in business practice. Among the addressed experts were IT specialists and business economics experts.

III. Selecting a methodological framework for measuring the effectiveness of cloud computing

For the design of the evaluation model of investment in cloud computing, the key thing is to correctly obtain the quantitative and qualitative parameters affecting both the actual process of the implementation as well as the subsequent operation of technology in an enterprise. For this purpose, the costs and benefits of this technology were specified that have a quantitative and qualitative nature.

The most frequently mentioned benefits are (Linthicum 2009; Sarna 2011): qualitative: innovative approach, faster access to the market, support for business processes, elasticity and scalability; quantitative: reduced investment and operating costs, the lower number of IT staff or reduction of the cost of IT, energy saving, shorter delivery time.

In particular, the nature of benefits served as one of the bases for determining the cloud computing evaluation methods. It is possible to monitor the quantitative benefits, and also to a large extent the qualitative benefits, which are considered when compiling the model.

Cloud computing literature has so far examined the costs of using cloud via individual case studies (Mowbray 2009; Hosseini et al. 2010). On the basis of these studies, the costs are divided into various groups according to various criteria. For example, Maresova and Klimova (2015) distinguishes specific costs associated with cloud computing, such as the direct costs associated with the technology and services, and there will also be costs in terms of its impact on other technology systems that are already in place. Other costs and returns will be linked to the organisztion, for example through altered resource flows, performance changes, changes in work flows and internal relationships. Additional costs may be imposed on external persons or organizations by changes in the way that services are delivered or other business is conducted (Maresova and Halek 2014). Gabler (2004) defined three categories associated with:

- manpower resources,
- technology and infrastructure,
- processes.

Martens, Walterbusch, and Teuteberg (2012) specify different types of costs and assigns specific items to them such as: strategic decision, selection of cloud computing services and cloud types, evaluation and selection of service provider, service charge IaaS, SaaS, PaaS, implementation, configuration, migration and support.

In connection with specified costs and benefits of cloud computing, it is necessary to focus on appropriate methods of expressing the effectiveness of cloud computing. The methods that are most commonly used for evaluation of IT, also known in business practice, and they have also been used in cloud computing can be divided into two categories: economical methods by which we can obtain the output, if the cost and revenue side of cloud computing is available in monetary terms (ROI, net present value (NPV), the internal rate of return (IRR), economic value added (EVA), total cost of ownership (TCO) productivity of employees). The other group is of general methods within which all the effects of the introduction of this technology are first specified, focusing on qualitative aspects of the issue and they contain financial indicators only as a minor part in themselves (balanced scorecard (BSC), cost–benefit analysis (CBA), porter value chain model, total quality management (TQM), benchmarking) (Uzoka 2009; Hájek, Hynek, and Janecek 2005; Maresova 2012; Kornevs, Minkevica, and Holm 2013; Garga, Versteegb, and Buyyaa 2013; Sharma, Thulasiram, and Thulasiraman et al. 2012). According to the Microsoft AZURE cloud calculator, the calculation formula contains three levels, depending on the customer requirements. When particular parameter is set, the customer immediately sees the information about price. This application does not compare prices with alterative calculators, not even within the internal IT infrastructure. Adjustable parameters are listed in Table 1.

Another yet important cloud calculator is Amazon AWS TCO Comparison. The calculation formula consists of three steps. First, the main customer requirements are set. Consequently, the brief TCO calculation for AMAZON AWS is available. Finally, customers are able to download the complete report which contains detailed calculations along with other indicators. In this calculator, the client describes its physical and logical IT infrastructure needed for company operations. The calculator then compares AMAZON AWS variants and creates report. This output report provides interesting information about savings in particular areas such as: server, storage, networking, hardware equipment, infrastructure management, etc. This report is relatively complex and detailed, input parameters are listed in Table 2.

Table 1. Input parameters of Microsoft AZURE cloud platform.

Input parameters
Number and type of CPU cores
Operating system
Cache size
Storage size
Data import and export
Bandwidth
Data backup
Replication and recovery settings
Security level
Reporting
Infrastructure management
SQL database parameters
Other services (traffic manager, media services, service bus)

Source: Processing according to Windows (2014).

Table 2. Input parameters for TCO calculation in Amazon AWS portal.

Server requirements	Database server	Physical storage
CPU/server amount	CPU/server amount	Number of requested torages
Server performance	Server performance	Cloud type (private × public)
RAM/server	RAM/server	Network bandwidth
HDD/server	HDD/server	ISP/peering number
CPU core/server	CPU core/server	Maintenance costs (% total HW costs)
Operating system selection	Operating system selection	Deprecation
Hardware/software	Hardware/software	Geographical location (country, continent)

Source: Own assessment according to Amazon (2014).

For selecting a methodological framework for measuring the effectiveness of cloud computing, an overview of general methods was done (Maresova and Halek 2014; Maresova and Klimova 2015), and a selection of one of them was conducted. It will serve as a basis for designing the method for assessing the effectiveness of cloud computing.

The selection of criteria and evaluation of the impact of various alternatives in relation to these criteria

In practice, there are several different ways to select the appropriate criteria and determine their importance. In

this case, to determine the importance of the criteria, and possibly also the selection of the criteria involved in an expert group, some of them were addressed through questionnaires sent to them to comment on the criteria and their importance. Criteria (K_1–K_6) are determined with regard to the needs of business sector in the Europe and they are based on the nature of the benefits of cloud computing.

K_1: Knowledge of the method in European business sector
K_2: Option to evaluate qualitative benefits
K_3: Option to evaluate quantitative benefits
K_4: Quantitative resulting expression
K_5: Availability of method characteristics
K_6: Availability of examples of the method's use

This is qualitative and maximization criteria. They all are rated on a five-point scale in which the maximum number of points represents the best rating.

Table 3 shows the valuation of the methods according to various criteria.

To determine the importance of the criteria for the selection of a method for assessing the benefits of knowledge management, the method of allocation of 100 points was chosen – the so-called Metfessel allocation (special case of pointing method) (Newman 1977). The importance expression of the criteria is shown in Table 4.

The highest importance was assigned to criterion K_4: 'Quantitative resulting expression'. It is because the problems in deciding on the deployment of cloud computing include unclear ROI and few tangible benefits. Twenty points were assigned to criterion K_3: 'The option to evaluate qualitative benefits'. As follows from the characteristics of the benefits, most of them are qualitative in nature, that is why it is very important that the method allows their evaluation. Criterion K_5: 'Availability of the method characteristics' was given 15 points. It is important that the given method is the best described in our or foreign literature for reasons of proper application of any eventual modification in cloud computing. The same number of points was given to criterion K_2: 'The option to evaluate the quantitative benefits'. It is necessary to allow the method to include such values in the final statement of all benefits. Criterion K_1: 'Knowledge of the method in Czech enterprises' and K_6: 'Availability of examples of the method's use' were evaluated with 10 points. It will be a great advantage if the resulting method will be similar to those existing in enterprises. This will allow easier use of the method in Czech enterprises. Moreover, if specific applications of this method will be available for investment projects, enterprises would gain a concrete idea about the use of the method, which is valuable information in the case of own use.

The actual calculation is implemented using MS Excel program for manual implementation of the scoring method and calculation tool multi-criterion analysis (MCA) Kosa for the method of linear partial utility functions (weighted sum), TOPSIS and ELECTRE I, AGREPREF, MAPPAC and PROMETHE. The overall evaluation of all the methods of multi-criteria evaluation of alternatives used a synoptic table, which captures the results of each method (Table 5).

The order of the advantages of the deciding alternatives established by one of the methods of multi-criteria evaluation of alternatives depends mainly on the importance of individual criteria and the method used. The table clearly shows that first position belongs to the first alternative, which is represented

Table 3. The decision matrix.

	K_1	K_2	K_3	K_4	K_5	K_6
CBA	3	5	5	5	4	5
BSC	2	5	5	2	5	4
Benchmarking	5	5	4	1	5	4
TQM	3	4	3	2	4	4

Table 4. Criteria importance.

	K_1	K_2	K_3	K_4	K_5	K_6
Importance	10	15	20	30	15	10
Normalised importance	0.1	0.15	0.2	0.3	0.15	0.1

Table 5. Total results.

		Method of weighted sum	Method TOPSIS
Alternative	ELECTRE	Rank	Distance from basal alternative
CBA	Effective	1	0.863558
BSC	Ineffective	2	0.31161
Benchmarking	Ineffective	3	0.208068
TQM	Ineffective	4	0.243957

	AGREPREF		MAPPAC		PROMETHEE
Alternative	Index Dh	Rank	Sigma	Class	Net flow
CBA	3	1	2.386545	1	0.080556
BSC	1	2	1.517532	2	0.025
Benchmarking	−1	3	0.77479	3	−0.025
	−3	4	0	4	−0.08056

by the CBA method. Second place most often belonged to the second alternative – BSC method, third position is taken by benchmarking, followed by TQM. The method, which will form the basis of the evaluating system of cloud computing effectiveness, is therefore, CBA.

IV. Cost–benefit analysis for cloud computing

Cost–benefit analysis (CBA) is a systematic method that evaluates and compares costs and benefits of an investment. It analyses impacts of the investment on the involved sides, then it quantifies these impacts and translates them into a common (if possible, financial) unit. The costs are understood as negative impacts of the project, or a reduction in its utility. Every increase in its utility is then a benefit. CBA also counts opportunity costs with negative impact on utility. CBA is considered to be the most complex one-criterion method of evaluating an investment project. The basic CBA question is 'what and to whom does the investment project bring and what and from whom does it take?' (Sieber 2004). CBA aims to find out whether the means are used effectively, it determines and recommends the most suitable alternative of the project in question. It is also an advantage that time is considered as well and benefits are expressed in figures, that is in monetary units. As both inputs and outputs are evaluated in monetary units, prior to calculation it is necessary to decide whether to use nominal or permanent prices. A problem arises when it is also needed to evaluate non-financial effects by translating them into financial units. Once all effects are expressed in financial terms, decisive indicators are set to show whether or not the project is beneficial. If there are more variants of the project, it is easy to compare them in monetary units and choose the optimal variant. Discounted rate is a vital part of CBA. If discounted benefits exceed discounted costs, the project is economically favourable.

The application of CBA in deploying advanced technologies, information systems or new software (e.g. Harrigan et al. 2008) is quite common. The problems (costs) of the project include, among other things, software price, cost of consultants, installation and user training. Its advantages (benefits) include an improved business process, which leads to savings in production costs, better decision-making process and increased morale of employees, who feel good as they work with new technologies.

Based on interviews with IT experts, the general steps of the CBA method mentioned in Boardman et al. (2006) and Nas (1996) were modified for cloud computing purposes (Figure 1).

Given the scope of the article, in the description of the individual CBA steps, the attention focuses particularly on the determination of cloud computing costs and benefits, indicators and methods for their economic assessment.

Cloud computing: deployment specification

This step of analysis defines basic cloud computing requirements. Three essential groups of questions and criteria that help in cloud computing decision-making are specified (Figure 2).

Questions related to the strategic management of a company and economic criteria are meant to describe well the flexibility of the company's IT equipment in relation to the strategic objectives and their changes, particularly whether there is sufficient capacity. Companies should know whether their IT is flexible enough to react in the case of an accident, whether it is possible to increase the capacity of data storage, whether their IT sufficiently ensures the continuity of business. Providing there are any weaknesses, it is necessary to specify corresponding company processes and data and propose a solution related to the distribution model.

Concerning the operational criteria, several things are essential. Namely, company data use regulations, whether the company work with their clients' sensitive data, and consequently has to take into account legislation related of personal data protection in various countries (Steinberg 2006). All this leads to the problem of deployment specification. In the case of a large amount of sensitive data that cannot be located at the third party, it is recommended to use private cloud. Last but not least, if the company in question is characterized by the fluctuation of commissions, it is a good idea to use this technology. Different approaches (ITIL, TOGAF, FCAPS, IT Governance, etc.) address the problem of efficient design and operation of IT in organizations.

The last area is technical criteria aimed at the requirements like the server capacity, requirements to change the load and volume of data storage.

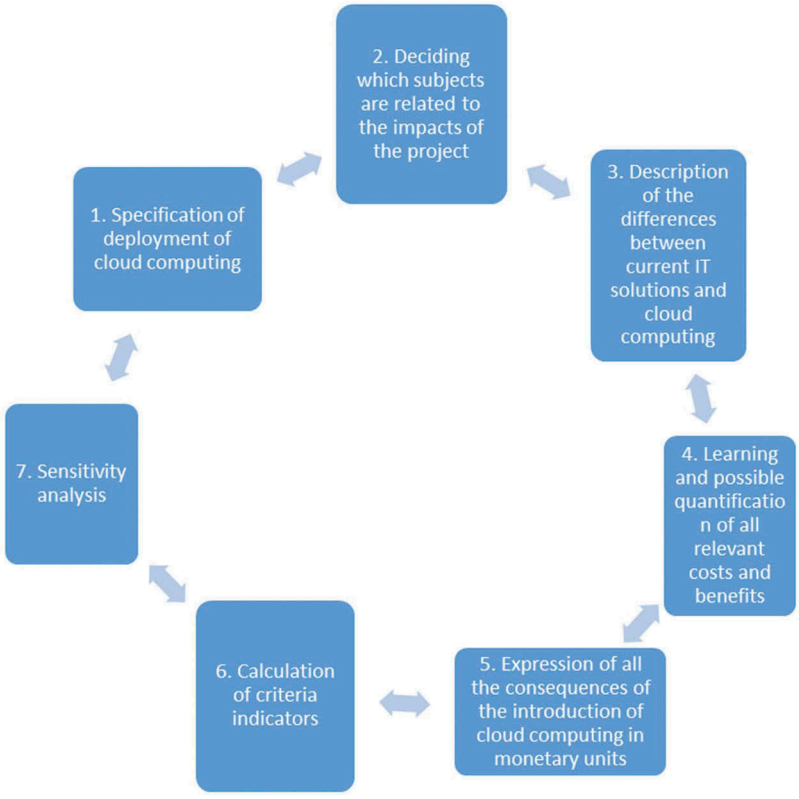

Figure 1. Steps of the CBA for cloud computing.

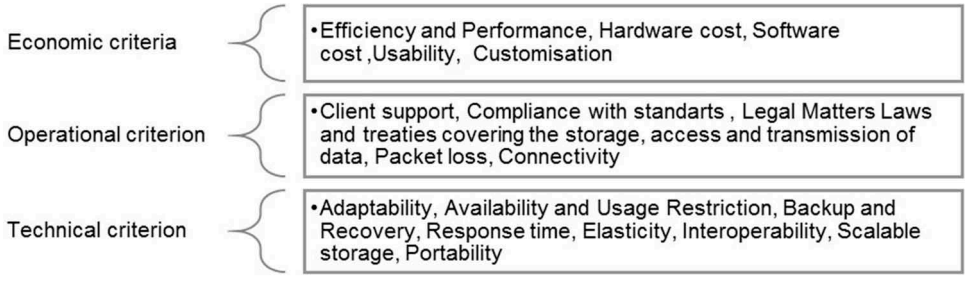

Figure 2. System of Criteria for Cloud Computing.
Source: Own processing according to Maresova, Sobeslav, and Klimova (2015).

Determination of entities affected by the project

The result of this step should be a list of entities that will be monitored as for the impact of the launch of cloud computing. The stakeholder model may be used to do it. The stakeholder approach sees the firm as a network of its mutual relationships with groups of other entities – owners, employees, creditors, suppliers, customers and the state – known as stakeholders.

There are the following essential points:

- identification of key stakeholders and their interests;
- evaluation of the stakeholders' needs, importance and influence;
- use of acquired information and its integration into the process of company strategy development.

Differences between current IT and cloud computing

This step aims at a more precise determination of the IT system's functionality. The table below is designed to help describe both the current and desired state. It

Table 6. IT parameters for specification of current state and desired state.

Hardware	Software	Safety
Physical servers	OS	Support and update
	Databases	Authorization
RAM	**Human resources**	Authentication
HDD	Number of full-time IT employees	Registration rights
CPU	Number of other employees involved in IT administration/IT strategy	Physical safety
UPS, cooling	**IT renewal**	Proactive approach
Structured cabling	Investment into HW renewal per year	
Network components	Investment SW licences per year	
Software	Failures per year	
OS		
Databases		

is divided into five parts: hardware, software, human resources, IT renewal and safety (Table 6).

The price will be calculated for both the current state and the cloud computing solution. Obviously, the price will be only indicative. Another step of practical implementation lies in a more precise determination of the IT system's functionality, where there belong following specifications: I/O operations, network speed, network latency, processing and latency, accessibility requirements.

Identification and quantification of all relevant costs and benefits

In this stage, a structured list of costs and benefits should be compiled. This step is crucial. It is facilitated by former precise specification of the zero and investment variants, as well as the list of entities impacted by the implementation of new technology. For illustration, some impacts are listed in Figure 3.

Expression of consequences of cloud computing implementation in monetary units

Another step in making of the CBA is the transfer of all impacts of the project into cash flows, on which investment indicators will be applied. Valuation methods, which enable the transfer of qualitative benefits and costs to quantitative ones, are divided according to the data that the valuation is based on. The data are collected either directly or from the market or from surveying individual people's preferences. It can also be based on expert estimates or other approaches. In general, approaches based on market data are considered to be more precise. It is suitable to substitute them by preferential methods if the market in question is considerably imperfect, or

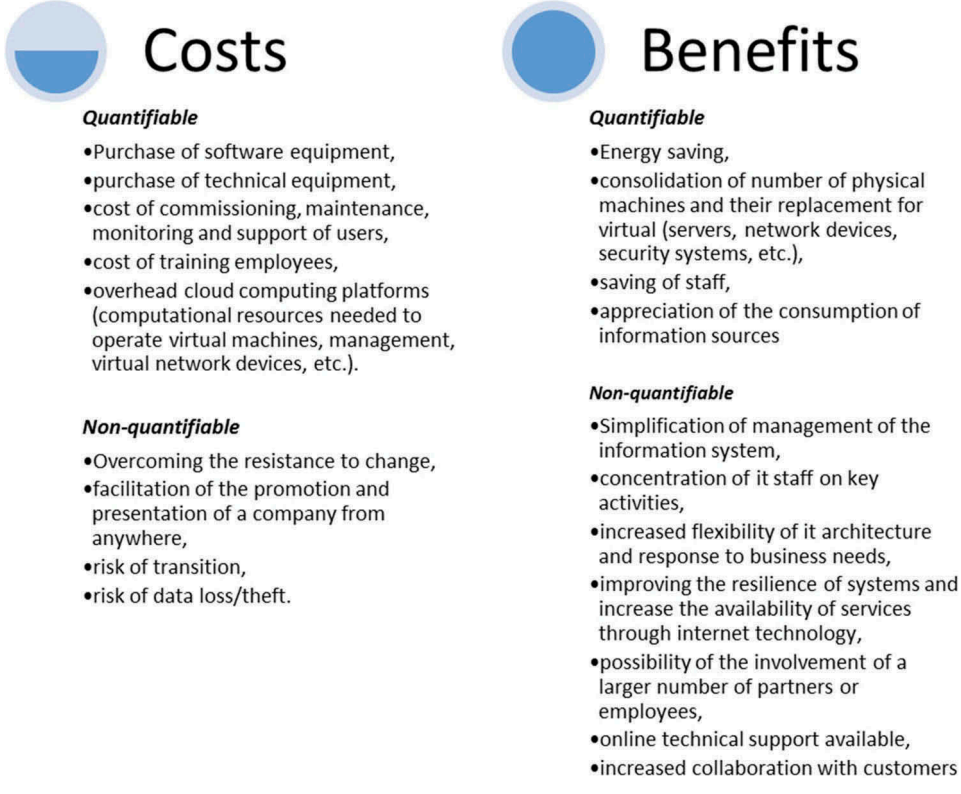

Figure 3. Costs and benefits of cloud computing.

Table 7. Principals, presuppositions, advantages and drawbacks of valuation methods.

Method	Basic principle	Preconditions to application
Method of convergent valuation	Direct survey of individual people's preferences (questionnaire, interview) related to changes in the quality of the goods	Representative sample of respondents, preliminary testing of the questionnaire, adequate knowledge of the situation
Method of substitute market	Valuation of the goods with respect to similar (ideally identical) goods traded in the market	A comparable substitute with similar qualities on the market
Method of shadow price	Items are valued in shadow prices; shadow price of the goods is the price for which it is sold and bought on the market; it is based on the cash flow of the project, which are not influenced by any financial decision	A comparable substitute with similar qualities on the market
Method of property valuation	Different prices of the goods if different qualities are used and their comparison determines the value of individual influences (goods)	A comparable substitute with various qualities on the market, knowledge of prices, assessed characteristics are reflected in the price of the goods
Hedonic price method	It is presupposed that the price of the private goods is a function of its utility characteristics and that the impact of these characteristics on the price can be measured	Expressing the relation of individual components to the price, determining the demand curve

Source: Own processing by Birol et al. (2006), Boardman et al. (2006).

when particular or related goods are not on the market. Market methods include yield, cost and comparative ones. Yield methods are based on a presupposition that the goods generate income in time and that it will generate income until the goods is changed. The goods are then evaluated by the current value of future incomes. Cost methods are related to necessary costs of prevention that are used to prevent any damage to the goods, those of renewal that are needed to restore the goods and travel costs that enable the entity to utilize the goods.

Expert and other methods are marginal. These methods utilize scientific approaches and expert estimates that are not connected with market principles. Their utility and reliability is questionable. More detailed characteristics of these methods can be found in Table 7.

The aforementioned sources provide a more detailed procedure for using these methods.

Calculation of criteria indicators

Assessment of economic efficiency of projects provides vital information for assessing the feasibility of the project and making decisions about its implementation. Commonly used methods either reflect or do not take into account time. Static methods do not reflect the factor of time and can consequently be used only in case time does not significantly influence the decision-making process about the investment. For instance, a one-time purchase of fixed property and a short lifespan of thus purchased property (maximum 2 years). Although in theory it is not correct to abstract from time, in most cases it cannot significantly influence the assessment and the choice of a suitable investment variant. Nevertheless, this rarely happens in practice. These methods are used only infrequently, usually as the first estimate of investment because they are easy to do.

Dynamic methods respect the factor of time. They are therefore applied for investment property acquisitions with a long-term economic lifespan. The factor of time significantly influences whether the project is accepted and it is vital for specifying the income and expenditure of an investment.

The most frequently used methods of assessing investment variants are the following ones:

- average annual costs,
- discounted costs,
- NPV and rate of return index,
- internal rate of return
- average rate of return,
- payback time.

The most frequently used methods in the area of cloud computing are rate of return indicators, NPV, TCO and productivity per employee. At this stage, companies themselves can decide what economic indicators to use. All necessary inputs are at their disposal.

Sensitivity analysis

In the area of cloud computing, determining all input parameters related to the investment cost depend on the project leader. As this is subjective and susceptible to error, it is suitable to do sensitivity analysis. Sensitivity analysis is mathematical modelling that determines risks related to changes of vital variables

in order to determine effects of these changes on the planned result. Most attention is paid to the most significant variables. The procedure is as follows:

- determining factors that influence cash flows,
- change of every factor by certain percentage, and a calculation of a new value of the indicator for each of these changes,
- a calculation of the change of the resulting criteria indicator.

In the final stage of project analysis, projects are assessed according to the values of decisive indicators (NPV, TCO, ROI). Organizations decide on their own how many criteria and which ones they choose to use. If financial cash flows and the resulting calculated indicators are set well, they provide valuable information for planning the investor's financial situation and about the impact of their investment intentions on their economic situation. The values of indicators show whether or not the project should be realized.

V. Discussion – differences of the proposed approach in comparison with other methods of investment assessment

Table 8 compares classical methods of investment decision-making in the field of business administration and the proposed method CBA CC (cloud computing). There is also a comparison with the original CBA (Table 8).

The essential benefits of CBA CC method in relation to common methods of business investment assessment for the area of IT are

- versatility,
- possibility to use both static and dynamic methods,
- respect to the character of both business and its activity,
- accessible applications of this method in other areas,
- possibility to transfer qualitative variables into quantitative ones,
- unlike methods used directly for investments into IT, it is better known more frequently used in Czech business environment
- on the other hand, its implementation requires an IT expert from the organization.

Table 8. Traditional methods of investment assessment and CBA CC.

	Traditional approach to investment assessment	CBA CC (cloud computing)
Type of method	• Static (rate of return indicators, payback time, indicators based on revenue) • Dynamic (net present value, IRR – internal rate of return, EVA – economic value added) • indicators for IT area (TCO – total cost of ownership, ITIL – Information Technology Infrastructure Library, IT scorecard)	• Analysis comparing benefits and costs of project with respect to qualitative variables expressed in quantitiesQualitative variables will finally be included into standard of investment assessment.
Advantages	• Most of the methods are not time-consuming • Low costs of these methods • They are well-known among Czech businesspeople • More methods combined have high information value	• Qualitative factors are taken into account by introducing CC (cloud computing) • Complex method solving the problem according to the type of company • Partial awareness about the method in Czech business environment
Drawbacks	• Suitable interpretation of results in the context of other company processes • Combination of more indicators is needed • The method depends on exact inputs	• It is time-consuming • High costs of the method • It is not commonly used in Czech business organizations

The main advantages and benefits of CBA CC in comparison with the original CBA method are the following ones:

- different number and structure of CBA steps so that they correspond with cloud computing implementation,
- the first three steps of the method correspond to the needs of cloud computing implementation,
- newly compiled list of critical questions for cloud computing decision-making,
- a proposed scheme of item specification for the current and required state of IT,
- a structure of entities influenced by the implementation of the technology,
- within the step named calculation of criteria indicators, the attention is focused on those that are used in both Czech business environment and cloud computing area.

Problems of CBA CC use

The utilization of CBA CC method involves certain risks. The method, if applied properly, enables to make a high-quality analysis. There are only problems linked to technical limits, which may make it impossible to quantify and transform into financial means important impacts of the project (lack of financial data, limited accessibility of methods suitable for transforming causes of effects into financial flows, and so on). Another problem is related to precise determination of discounted rate. The choice of discounted rate, or required rate of return, may significantly influence the resulting calculation and the resulting net present value or another criterion. It is therefore necessary to pay utmost attention to the determination of interest rate. Another factor that may distort the results of CBA CC is sudden changes of IT prices. Recent years have witnessed significant lowering of IT prices and a rapid onslaught of new technologies. It may play a significant role should the net present value for the period of 10 years be calculated. The forecast development of prices in ICT sector would mean to predict this development and, for instance, in the form of adjusting discounted rate to include into calculations.

Another factor that may decrease the information value of CBA is errors in individual steps of CBA. These errors may include unequal monitoring of different entities within the project. For example, income of some entities should not be monitored at the cost of others. If entities are included into the analysis, impacts on all of them should be monitored as closely as possible. Another problem is to omit that some benefit of an entity may be to the detriment of another one.

Double inclusion of some impacts of the project is another indicator distorting the output. It is not possible to count as a benefit, for instance, an increase of the revenue of a business organization and at the same time a growth of its employee's salary based on this higher revenue.

Negative effects resulting from investments should not include costs spent till the moment of decision-making on investments. These costs cannot be the subject of decision-making, as they have already been spent and the decision about the investment cannot influence them anymore. A typical example is costs spent on studies needed for the decision-making on the investment (costs of making CBA and so forth).

A significant factor for making CBA are people who look for positive and negative impacts. It is vital for the people who should specify impacts of the project to be cloud computing experts. This is important to eliminate errors in specifying positive or negative impacts. It can also happen that some effect cannot be transformed into financial flows. If these effects are not essential, they do not distort the result of the analysis. Nevertheless, they should be sufficiently described.

In order to make the method exploitable in practice, it is necessary for companies to devote enough time at the beginning to entering parameters. The application of the method should be as easy as possible and among outputs there should also be comments to data.

VI. Conclusion

Current business environment is characterized by growing competition boosted by globalization and spreading free market. Another essential factor is the economic crisis that influenced all business areas. In this environment it is increasingly important to use all sources efficiently and to focus on the main processes bringing added value to the business and exploit them to the full. Cloud computing is the technology that can help achieve these objectives. This article proposed a model of assessing cloud computing with respect to its utilization in business practice for assessing the efficiency of investments.

Multiple-criteria analysis of variants was used as a suitable starting point for assessing the efficiency of cloud computing. As a result, the CBA method, which is the basis of the system of assessing cloud computing benefits, was chosen. It was, however, significantly adjusted to the needs of decision-making about cloud computing, particularly in the first three steps. Compared with the CBA method, the essential benefit of the adjusted method lies in the following areas:

- a list of criteria questions concerning decision-making about cloud computing has been compiled,

- a scheme of specified items of both current and required state of IT was proposed,
- a structure of entities influenced by the implementation of the technology was created,
- within the step named calculation of criteria indicators are used those indicators which were labelled as suitable for the IT area by experts.

All aforementioned changes result from a detailed analysis of cloud computing deployment and facts that cause its implementation in the companies. In this way, it was possible to eliminate some problem areas of previously used methods; the proposed method also contributes to the development of business administration. CBA CC brings the following advantages:

- it solves the problem of expressing qualitative benefits in monetary units,
- this method can be utilized for indicators that are used in companies,
- this method assesses the utilization of cloud computing for the organization in question in relation to its characteristics, including its business activities, size, geographical position, etc.

In utilizing CBA CC, it is necessary to pay attention to the existing risk areas of the method. Among them belongs technical limits. They may make quantification of essential impacts of the project impossible. Consequently, these impacts cannot be transformed into financial means (because of the lack of inputs, difficult accessibility of methods suitable for transforming the effects into financial flows, etc.). The problem is also related to precise determining the discounted rate and double inclusion of some impacts of the project.

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References

Amazon. 2014. "Web Services." AWS Total Cost of Ownership (TCO) Calculator [online]. Accessed 10. September 2013. http://aws.amazon.com/tco-calculator/

Birol, E., K. Karousakis, and P. Koundouri. 2006. *Using Economic Valuation Techniques to Inform Water Resources Management: A Survey and Critical Appraisal of Available Techniques and an Application*, 126–140. Springer.

Boardman, A. E., D. H. Greenberg, A. R. Vining, and D. L. Weimer. 2006. *Cost-Benefit Analysis: Concepts and Practice*. 3rd ed., 493. New Jersy: Prentice Hall.

Brancheau, J. C., B. D. Janz, and J. C. Wetherbe. 1987. "Key IS Issues in Information Systems Management: 1994-95 SIM Delphi Results." *MIS Quarterly* 20 (2): 225–242.

Brunet-Thornton, R., and V. Bureš. 2012. "The Cross-Cultural Management: Establishing a Czech Benchmark." *E+M Ekonomie a Management* 15 (3): 46–62.

Dedrick, J., V. Gurbaxani, and K. L. Kraemer. 2003. "Information Technology and Economic Performance: A Critical Review of the Empirical Evidence." *ACM Computing Surveys* 35 (1): 1–28. doi:10.1145/641865.

Feedit.Cz: Průzkum Epicor: 2013 will bring a boom cloud and mobile solutions [online]. 2013. http://www.feedit.cz/wordpress/2013/01/10/pruzkum-epicor-rok-2013-prinese-rozmach-cloudu-a-mobilnich-reseni/

Gabler, E. 2004. "Economics of an Investments: Analysis Helps Agencies Target Limited Transportation Recources to Thein Best Uses, Innovationns and Techonology." *Roads & Bridges* 4:63–66.

Garga, S. K., S. Versteegb, and R. Buyyaa. 2013. "A Framework for Ranking of Cloud Computing Services." *Future Generation Computer Systems* 29 (4): 1012–1023. doi:10.1016/j.future.2012.06.006.

Hajek, L., J. Hynek, and V. Janecek. 2005. *Evaluating Investments in Advanced Technologies*, 291. Hradec Králové: Gaudeamus.

Harrigan, P. O., M. M. Boyd, E. Ramsey, P. Ibbotson, and M. Bright. 2008. "The Development of E-Procurement within the ICT Manufacturing Industry in Ireland." *Management Decision* 46 (3): 481–500. doi:10.1108/00251740810863906.

Hosseini, I. K., and S. I. Sommerville. 2010. "Research Challenges for Enterprise Cloud Computing." LSCITS Technical Report. New York.

Kačerauskas, T. 2015. "Technologies in Creative Economy and Creative Society." *Technological and Economic Development of Economy* 21 (6): 855–868. doi:10.3846/20294913.2015.1036325.

Kornevs, M., V. Minkevica, and M. Holm. 2013. "Cloud Computing Evaluation Based on Financial Metrics." *Information Technology and Management Science* 15 (1): 87–92.

Linthicum, D. S. 2009. *Cloud Computing and SOA Convergence in Your Enterprise*, 264. New York: Addison-Wesley.

Maresova, P. 2012. *Measurements in Knowledge Management - Application Methods Cost Benefit Analysis*, 126. Hradec Králové: Gaudeamus.

Maresova, P., and V. Halek. 2014. "Deployment Of Cloud Computing in Small And Medium Sized Enterprises in the Czech Republic." *E+M. Economics and Management* 17 (4): 159–173. doi:10.15240/tul/001/2014-4-012.

Maresova, P., and B. Klimova. 2015. "Investment Evaluation of Cloud Computing in the European Business Sector." *Applied Economics* 47 (36): 3907–3920. doi:10.1080/00036846.2015.1019041.

Maresova, P., V. Sobeslav, and B. Klimova. 2015. "Methodological Approach to Efficient Cloud Computing Migration." In Dariusz Barbucha, Ngoc Thanh Nguyen, John Batubara (Eds.) *Intelligent Information and Database Systems (ACIIDS 2015)*, 199–208. Berlin: Springer.

Martens, B., M. Walterbusch, and F. Teuteberg. 2012. "Costing of Cloud Computing Services: A Total Cost of Ownership Approach." In *Proceedings of the 45th Hawaii International Conference on System Sciences*, Maui, Hawaii, USA, 1563–1572.

Mell, P., and T. Grance. 2011. "The NIST Definition of Cloud Computing (Draft): Recommendations of the National Institute of Standards and Technology [online]." Accessed 25 May 2014. http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

Mohelska, H., and M. Sokolova. 2014. "Effectiveness of Using E-Learning for Business Disciplines: The Case of Introductory Management Course E+M." *Economics and Management* 17 (1): 82–92.

Mowbray, M. 2009. "The Fog over the Grimpen Mire: Cloud Computing and the Law." *SCRIPTed Journal of Law, Technology and Society* 6: 132–146.

Nas, T. F. 1996. *Cost-Benefit Analysis. Theory and Application*, 220. Thousand Oaks, CA: Sage.

Newman, J. R. 1977. "Differential Weighting in Multiattribute Utility Measurement: When it Should not and When it Does Make a Difference." *Organizational Behavior and Human Decision Processes* 54: 456–476.

Sarna, D. E. Y. 2011. *Implementing and Developing Cloud Computing Applications*, 334. New York: CRC Press.

Sharma B, Thulasiram R. K, Thulasiraman P., Garg, S. K., Buyya, R. 2012. "Pricing Cloud Compute Commodities: A Novel Financial Economic Model." In *CCGRID '12 Proceedings of the 2012 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (ccgrid 2012) IEEE Computer Society*, Washington, DC, USA, 451–457. Ottawa, ON: IEEE.

Sieber, P. 2004. "Cost-benefit analysis methodological guide, the Ministry for Regional Development [online]." Accessed 25 May 2014. http://ww.strukturalni-fondy.cz/uploads/old/1083945131cba_1.4.pdf

Steinberg, R. A. 2006. *Measuring ITIL: Measuring, Reporting and Modeling the IT Service Management Metrics that Matter Most to IT Senior Executives*. 1st ed., 154. Victoria: Trafford.

Svenningsen, K. 1998. "An Evaluation Model for Electronic Resources Utilizing Cost Analysis, the Bottom Line." *Managing Finances* 11 (1): 18–23.

Uzoka, F. M. E. 2009. "Fuzzy- Expert System for Cost Benefit Analysis of Enterprise Information Systems: A Framework." *International Journal on Computer Science and Engineering* 1 (3): 254–262.

Watson, R. T., G. G. Kelly, R. D. Galliers, and J. C. Brancheau. 1997. "Key Issues in Information Systems Management: An International Perspective." *Journal of Management Information Systems* 13 (4): 91–115. doi:10.1080/07421222.1997.11518144.

Windows. 2014. "Windows." Calculator Windows Azure [online]. Accessed 24 March 2014. http://www.windowsazure.com/en-us/pricing/calculator/

Zavadskas, E. K., and Z. Turskis. 2011. "Multiple Criteria Decision Making (MCDM) Methods in Economics: An Overview." *Technological and Economic Development of Economy* 17 (2): 397–427. doi:10.3846/20294913.2011.593291.