Information Technology and Management Science
doi: 10.2478/v10313-012-0013-8
2012 /15

Cloud Computing Evaluation Based on Financial Metrics

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***Abstract* – Interest in cloud computing is growing, and, as a result, there is much information about it – both positive and negative. On the one hand, cloud computing saves money because it does not require IT infrastructure, servers, and it is very scalable. On the other hand, it might lead to financial loss due to security risks, possible data access problems, data privacy policies, etc. Therefore, cloud computing evaluation based on financial metrics is proposed in this article. This paper consists of four major sections. The first section is a literature review of cloud computing and its types. The next section describes some common financial metrics such as CBA, ROI and TCO and describes how they might be applied to evaluate cloud computing. The third section proposes evaluation strategies, and the last section contains the evaluation of a series of cloud computing projects based on chosen evaluation strategies, and results are verified based on expert opinion.**

***Keywords* – cloud computing, CBA, ROI, TCO, ROC**

I. Introduction

Cloud computing seems to be one of the most promising sectors in the future of computing. The cloud model of providing information technology solutions as a service can greatly decrease the complication of IT management, therefore enabling more pervasive use of IT. It is an opportunity for small and medium enterprises to reduce initial investments, enabling them to use sophisticated business intelligence applications that only large enterprises could previously afford [1]. To evaluate how well cloud computing is suitable for enterprise, researchers recommend using financial metrics [2], [3]. Most commonly recommended metrics are CBA, ROI and TCO [4] – [10]. However, little information is available on the results of financial metrics comparing one with another and when comparing to other evaluation strategies. Therefore, this paper aims to investigate how cloud computing can be evaluated using several financial metrics and offering a decision model that would be beneficial for enterprises considering the use of cloud computing.

The rest of the paper is organized as follows: in Section 2, we provide a view of cloud computing with its characteristics and models. Section 3 gives the description of some financial metrics. Section 4 lists evaluation strategies; while, in Section 5 we apply evaluation strategies in case study. Finally, we conclude the paper in Section 6.

II. Cloud Computing

Cloud computing is becoming popular in the IT industry. In recent years, the supply-and-demand of this new area has been experiencing a large increase in infrastructure investment. The National Institute of Standards and Technology defines cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configuration computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction" [11] or in simple terms – "low cost flexible entry and exit".

According to Cisco IBSG research [12], in March 2011, at least 12 percent of all enterprise workloads will run on clouds (public, private, hybrid and community) with distribution based on different areas of enterprises shown in Fig. 1, and, as a result, the percentage of cloud users will grow.

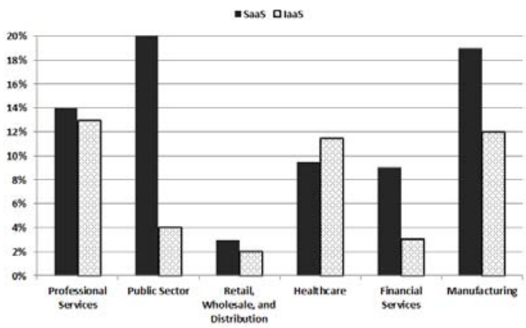

Fig. 1. Cloud workload shift in different business sectors

Reasons for popularity of cloud computing are its features. Cloud computing exhibits the following key characteristics:

- on demand self-service;
- rapid entry and easy exit;
- pay as you use (metered consumption);
- rapid elasticity, scale up/down, flex;
- shared pools, illusion of infinite resources;
- broad network access using standard internet protocols.

Based on computing infrastructure clouds can be divided into four fundamental service models:

Business Process as a Service (BPaaS) allows managing entire business process as a service in the cloud

Software as a Service (SaaS) allows users to use the applications of cloud computing providers through a thin client interface such as a web browser.

Platform as a Service (PaaS) allows users to deploy their own applications on the provider's cloud infrastructure under the provider's environment such as programming languages, libraries, and tools.

Infrastructure as a Service (IaaS) allows users to manage processing, storage, networks, and other fundamental computing resources so that they can deploy and run arbitrary software such as operating systems and applications.

Clouds can be divided into deployment models (see Fig. 2), which are based on access and security: 1) public clouds are made available to the general public by a service provider; 2) private clouds are operated solely for a single organisation, whether managed internally or by a third-party and hosted internally or externally; 3) community clouds are available for several enterprises (usually subsidiary companies); and 4) hybrid clouds allow for a composition of private and public clouds that remain unique entities but are bound together, offering the benefits of multiple deployment models.

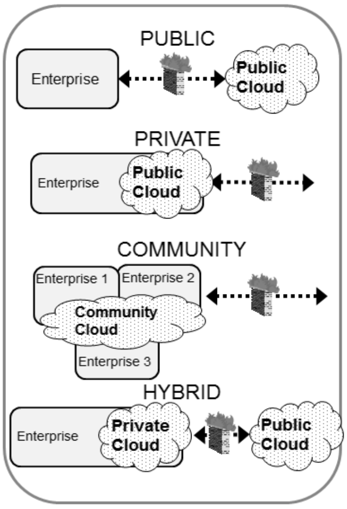

Fig. 2. Deployment models for cloud computing

III. Financial Metrics

The word 'metrics' refers to measurement, and financial metrics are used for financial measurement. Financial metrics say something about a body of financial data. In that way, they are like descriptive statistics that reveal some characteristic of the whole body of data that might not be obvious from reviewing the financial figures.

Since the purpose of every business is to be successful, it tries to minimise its expenses and expand its profits. Therefore, before implying cloud computing, an organisation should evaluate how effective this decision is. Some financial metrics can be applied in order to determine any potential benefit or expenses of this decision.

Three financial metrics are addressed in this paper: cost benefit analysis, return on investment and total cost of ownership.

A. Cost Benefit Analysis

Cost Benefit Analysis or CBA is a relatively simple and widely used technique for deciding whether or not to make a change. As its name suggests, the technique simply adds up the value of the benefits of a course of the action, and subtracts the costs associated with it.

Costs are either one-time, or may be ongoing. Benefits are most often received over time. This effect of time is built into the analysis by calculating a payback period. This is the time it takes for the benefits of a change to repay its costs. Many companies look for payback over a specified period of time – e.g. three years.

In its simple form, the cost-benefit analysis is carried out using only financial costs and financial benefits. For example, a simple cost/benefit analysis of cloud computing use would measure the economic benefit of using cloud computing. It also would subtract from this the cost of transition and its use. It would not measure either the cost of personnel work or the benefit of mobility of a system. A more sophisticated approach to cost benefit measurement models is to try to put a financial value on intangible costs and benefits.

Several variations of the cost benefit analysis can be used to compare the benefits and costs of cloud computing. The net present value (NPV) is used in this paper. Net benefits are simply the sum of benefits minus costs. The sum is discounted at the discount rate. Using this method, if the NPV is greater than zero at specified time moment T (the number of periods from the beginning of the project) then it appears to be a good decision for cloud computing implementation. The formula to calculate the NPV of the single project is:

$$NPV = \sum_{t=1}^{T} \frac{\left(Benefit_t - Cost_t\right)}{\left(1+r\right)^t} \qquad (1)$$

where $Benefit_t$ and $Cost_t$ are the values of the future amount in time t, r is the discount rate and t is the year.

Academics, cost benefit guides and textbooks give widely conflicting advice on discount rate selection, with recommended rates varying from 1 to 15 percent. The discount rate of 3 percent is used in the paper.

B. Return on Investment

Return on Investment (ROI) analysis is also one of several commonly used financial metrics for evaluating the financial consequences of business investments, decisions, or actions [13]. As a cash flow metric, ROI analysis compares the magnitude and timing of investment gains directly with the magnitude and timing of investment costs. A high ROI means that investment gains compare favourably to investment costs.

Most forms of ROI analysis compare investment returns and costs by constructing a ratio or percentage. In most ROI methods, an ROI ratio greater than 0.00 means the investment returns more than its cost. When potential investments compete for funds, and when other factors between the choices are truly equal, the investment – or action, or business case scenario – with the higher ROI is considered the better choice, or the better business decision. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio. The return on investment formula:

$$ROI = \frac{\left(Benefit - Cost\right)}{Cost} . \qquad (2)$$

In the above-mentioned formula "benefit" refers to the proceeds obtained from selling the investment of interest.

C. Total Cost of Ownership

Total cost of ownership (TCO) is a financial estimate whose purpose is to help consumers and enterprise managers determine direct and indirect costs of a product or system [14]. It is a management accounting concept that can be used in full cost accounting or even ecological economics where it includes social costs. For computer and software industries, TCO tries to quantify the financial impact of deploying an information technology product over its life cycle. These technologies include software and hardware, and training.

General costs can be calculated as

$$TCO_T = Initial \quad Costs + \sum_{t=1}^{T} (Direct \quad Costs + Indirect \quad Costs) \tag{3}$$

where TCO_T is a total cost of ownership for n years, initial costs include all costs that have to be paid in the beginning. Direct costs include expenses that are obvious and easy to manage such as software licence and maintenance fees, hardware infrastructure and personnel training. Indirect costs include expenses that are not obvious such as application maintenance and upgrading, data centre infrastructure, infrastructure administration, replacement, decommissioning and others. Indirect costs usually are equal or greater than direct costs and can be up to 70% of all expenses.

Speaking about cloud computing TCO, it is important to remember about costs such as cloud license fees (rental fees for using cloud services, and since with the growth, the amount of cloud space will be increasing too, TCO model needs to factor in a growth model that is realistic over the time horizon of analysis) or cloud integration cost. However, at the same time cloud computing eliminates software and hardware upgrade costs (include cost savings for not having racks, cooling, and switching hardware), and reduces labour cost as there is no need to perform IT testing, user acceptance testing, and IT development effort to re-apply past customizations.

Hence, cloud computing evaluation using TCO is performed by comparing TCO of the use of cloud solution and TCO of the use of traditional IT departments within enterprises.

IV. Evaluation Strategies

Cloud computing evaluation with financial metrics allows enterprises make proper decisions on the use of clouds. By observing financial metrics in the previous section, it is seen that metrics use different information and allow obtaining different information based on economic nature of an enterprise.

It is seen that cost benefit analysis and return on investment evaluate both benefits and cost of the proposed alternative and, as result, show how effective or non-effective a solution is. However, at the same time both metrics are not very detailed and thus might be not very exact. Total cost of ownership deals only with costs of the system so that TCO of only one alternative cannot show if it is sufficient or not – it serves only as a tool to compare two or more alternatives. However, this method is very detailed and allows evaluating both direct and indirect costs.

Hence, all metrics use information about costs and two of them use information about gains or benefits. To perform cloud computing evaluation, cloud computing criteria that influence costs or gains need to be determined.

Positive criteria of clouds are application programming interface (especially using SaaS model), device and location independence that allows accessing information from any PC or phone with internet access, virtualization that allows using more servers without interfering main functions, multitenancy that allows resource sharing, scalability and elasticity, reliability and easier maintenance. Additional benefit of using cloud is the use of best practices that enterprise usually does during its transition to cloud solution, thus leading to the increase in the utilization of work process that results in higher profits. All of these criteria are applied to all types of cloud models and turn a cloud into a tool to save money because it does not require IT infrastructure, servers and it is very scalable.

However, cloud computing has also negative aspects such as a communication control security (how hard it is to intercept communication process and make changes in the sent messages), access risks (what will happen if a user has no Internet access, how often back-up files are recorded, any possible conflicts of multiple use of the same data) and data privacy policies (government policies on data storage). The criteria listed here are not necessarily a result of cloud computing provider, but they can lead to extra expenses that could be avoided by using inner IT infrastructure.

There are 18 key performance indicators (KPI) of cloud computing that are evaluated as cost for each category:

- time related KPI – application releases frequently, speed of reduction, optimisation time ōf delivery, availability compared to current service levels, workload cost;
- cost related KPI – speed of reduction, optimisation cost of capacity, optimisation ownership use, utilisation;
- quality related KPI – nature of environment, supported application number, optimisation cost of delivery, green cost, experiential, intelligent automation;
- margin related KPI – number of servers, optimising margin, revenue efficiencies.

Based on the information necessary for financial metrics and cloud computing criteria, 3 evaluation strategies are proposed for the evaluation of several cloud computing projects from one of leading cloud solution providers.

The first strategy is based on 3 metrics to compare each project that uses cloud computing to a similar project that has its own IT structure. CBA and ROI metrics evaluate each project and determine it as being successful if metrics value exceeds 0; otherwise, the project is classified as unsuccessful. TCO is calculated for cloud implementation project, as well as for implementation of traditional IT departments, and when cloud computing has less TCO costs it is classified as successful. This strategy allows determining the efficiency of each financial metrics and its appropriateness for calculation of this type of tasks.

The second strategy implies the use of all formulas (1-3) in order to provide a combined metric for calculation. A formula of new metric is:

$$V_T = \left[\sum_{t=1}^{T} \frac{Benefit}{(1+r)^t} - Initial \quad Cost - \sum_{t=1}^{T}(Direct \quad Cost_t + \right.$$
$$+ Indirect \quad Cost_t)\Big]/[\sum_{t=1}^{T}(Direct \quad Cost_t + Indirect \quad Cost_t) \tag{4}$$
$$+ Initial \quad Cost\,]$$

where *VT* is the percentage of the return on investments at a specified time moment T. Metrics evaluate between two alternatives: cloud and tradition IT shop and suggest one with the higher percentage.

The third strategy creates a model that helps to determine the effectiveness of cloud computing based on the two previous results.

V. Case Study

The case study is performed to validate evaluation strategies. The private cloud model is selected for the case study because a private cloud has a higher risk of being unsuccessful from an economic point of view. The reason is the greater investment requirement. Thus, data are chosen from 1000 projects on private cloud implementation from America (67% of projects), Europe, Middle East, Africa, Russia (22%), and Asia Pacific (11%). 19% of projects were implemented at large enterprises with transaction size more than 1 million US dollars per year, 10% of all projects came from medium-sized enterprises with transaction size between 200k and $1M, and 3% of the data were from small enterprises with transaction size less than 200 000 dollars per year. All of these transactions were performed in 2009.

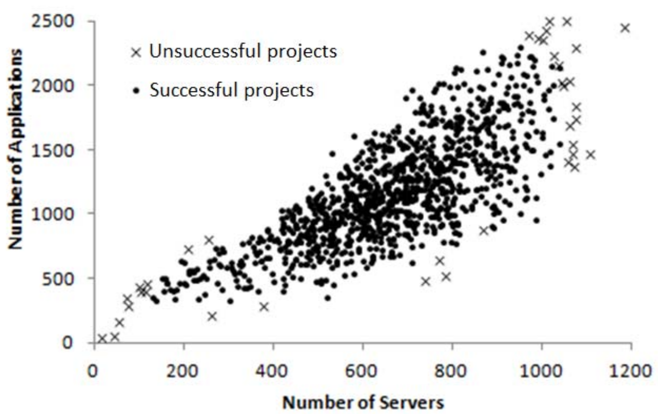

Fig. 3. Distribution of successful and unsuccessful projects based on the number of servers and number of supported applications

Each project has key indicators listed in the previous section and is evaluated by experts as economically successful or not after three years of its use. All of the projects are shown in Fig. 3, where each case is illustrated based on the number of servers and supported applications.

Each project has been evaluated based on financial metrics (CBA, ROI, TCO, combined) in order to determine if a project has been successful by its third year. Results of the classification are shown as a confusion matrix in Table I. It is a matrix showing the predicted and actual classifications in order to determine a classification error more accurately. Confusion matrix has four different possible outcomes: true positives (TP) when successful cloud implication is marked as successful, true negatives (TN) – unsuccessful implication is marked as unsuccessful, false positives (FP), where unsuccessful is marked as successful, and false negatives (FN) when successful implication is marked as unsuccessful.

TABLE I

Confusion Matrix with Results of the Metrics

			Predicted class	
			successful	unsuccessful
CBA	Actual class	successful	941	17
		unsuccessful	19	23
ROI	Actual class	successful	935	23
		unsuccessful	16	26
TCO	Actual class	successful	921	37
		unsuccessful	10	32
Combined	Actual class	successful	939	19
		unsuccessful	10	32

Receiver operating characteristic (ROC) graph is used in this paper as a way to examine the performance of classifiers [15]. The graph uses two standard rates that have been defined for the 2 class confusion matrix – the false positive rate (formula 5) and the true positive rate (formula 6):

$$false \quad positive \quad rate = FP/(TN + FP) \tag{5}$$

$$true \quad positive \quad rate = TP/(TP + FN) \tag{6}$$

ROC graph is a plot with the false positive rate on the X axis and the true positive rate on the Y axis [16]. The point (0;1) is the perfect classifier: it classifies all positive cases and negative cases correctly. It is (0;1) because the false positive rate is 0 (none), and the true positive rate is 1 (all). Results can be represented as single ROC point for non-parametric classifiers (as financial metrics) or ROC curve for classifiers that have parameters that can be adjusted. ROC graph with financial metrics is seen in Fig. 4.

To compare ROC points it is necessary to equate accuracy with the Euclidian distance from the perfect classifier, point (0;1) on the graph. The best result (distance = 0.37) is obtained using a combined method because it includes all benefits of each method. Distance from the best point can be explained with the fact that original classification was performed by owners of cloud solution and their result might be influenced by some other factors such as business sectors, made decisions, economic situations in different areas of the world etc.

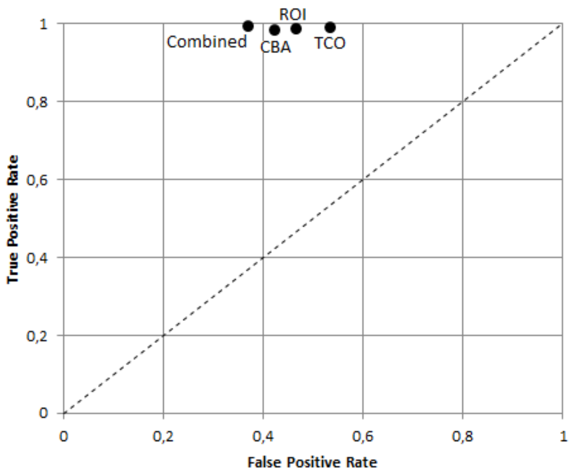

Fig. 4. ROC graph with financial metric results

A classification model that determines if a project will be successful in 3 years is presented by classical decision-tree classifiers, which is visualized as a set of the decision rules. The classification model constructed for the combined metric is shown in Fig. 5.

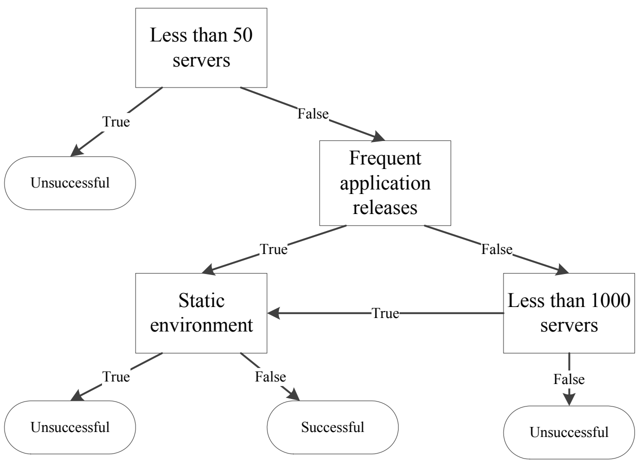

Fig. 5. The decision tree based on combined financial metric and expert opinion

VI. Conclusions

With the pervasive discussions of cloud looming all around, there is much debate about its actual efficacy. Many experts believe that cloud computing leads to greater efficiency and lower costs, while others consider that it is simply a trendy buzzword that provides little more than upfront expenditures and operational headaches.

As in the case with any solution – there is no one size fits all.

For the majority of Small/Medium Businesses and even small to mid-market commercial organizations (50 physical servers or less), a private cloud may not be of immediate relevance. Given the lower transaction volumes and typically small data centres these organizations cannot justify heavy investment in tools like automated provisioning, process orchestration and chargeback. Though small companies aspire to these things they do not typically produce the volume necessary to justify upfront investment in enterprise software/scripting and training to build end-to-end automation like Amazon would. Additionally they lack the headcount to embark down such an ambitious path.

For the large-sized commercial organizations (50+ physical servers), a cloud certainly maintains its allure. For these IT shops process is a real problem. They typically face bottlenecks at every step of the process – ranging from the approval of supported platforms to the actual procurement process. Change Advisory Board (CAB) meetings are getting old in such environments – they are ready for a paradigm shift to IT-as-a-Service rather than the traditional 2-3 month order fulfilment process.

Thus, organizations need to carefully evaluate their end state objectives and determine whether the adaptation of cloud technologies will help them get there while adhering to time and budget constraints. Certain industries are more compelled to explore cloud solutions in an attempt to lower lead times and maximize margins. The critical issue of this exploration is the understanding of the financial metrics and their interpretation.

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Maksims Korņevs, Vineta Minkēviča, Markuss Holms. Mākoņskaitļošanas novērtēšana, pamatojoties uz ekonomiskajiem rādītājiem
Palielinās interese par mākoņskaitļošanu, tāpēc ir daudz pozitīvas un negatīvas informācijas par šo tehnoloģiju. No vienas puses, mākoņskaitļošana var palīdzēt samazināt izdevumus, jo tā neprasa IT infrastruktūru un serverus un ir ļoti elastīga. No otras puses, mākoņskaitļošana var novest pie finanšu zaudējumiem vairāku faktoru dēļ: pastāv drošības risks, iespējamās datu pieejamības problēmas, datu konfidencialitātes noteikumi utt. Līdz ar to ir nepieciešams veids mākoņu novērtēšanai. Tāpēc darbā ir piedāvāts izmantot ekonomiskos rādītājus: izmaksu un ieguvumu analīze (CBA), investīciju ienesīgums (ROI) un īpašuma kopējās izmaksas (TCO). Papildus tiek izmantots kompleksais rādītājs, kas ir veidots, apvienojot šos trīs rādītājus. Gadījuma izpēte ir veikta, lai pārbaudītu novērtēšanas stratēģijas. Izpētei ir izvēlēti privātie mākoņi, jo privātajam mākonim ir vislielākais risks būt neefektīvam no ekonomiskā viedokļa - tas pieprasa lielākas sākotnējās investīcijas. Tāpēc ir izpētīti 1000 privāto mākoņu izmantošanas projekti, un katrs projekts ar ekonomisko rādītāju palīdzību tika klasificēts kā veiksmīgs vai neveiksmīgs. Vislabākais rezultāts ir iegūts ar komplekso rādītāju, kas ir veidots, apvienojot trīs iepriekšminētos ekonomiskos rādītājus. Gadījuma izpētes rezultāts rāda, ka maziem un vidējiem uzņēmumiem (līdz 50 fiziskiem serveriem) privātais mākoņskaitļošanas risinājums nav izdevīgs. Savukārt lielajiem uzņēmumiem mākoņskaitļošana var nodrošināt ekonomiskus ieguvumus. Tādējādi organizācijām rūpīgi jāizvērtē savus mērķus un jānosaka, vai mākoņskaitļošanas tehnoloģija palīdzēs īstenot šos mērķus, ievērojot laika un budžeta ierobežojumus. Ir svarīgi atcerēties, ka dažādās biznesa nozarēs var dažādi piemērot dažādus mākoņa risinājumus, tādējādi ir kritiski svarīgi izprast ekonomiskos rādītājus un veikt mākoņskaitļošanas novērtēšanu, pamatojoties uz tiem.

Максим Корнев, Винета Минкевича, Маркус Холм. Оценивание облачных вычислений на основании экономических показателей
Интерес к облачным вычислениям постоянно возрастает, и, как результат, появляется много положительной и отрицательной информации об этой технологии. С одной стороны, облачные вычисления позволяют экономить средства, так как дают возможность избавиться от собственной ИТ инфраструктуры и серверов, и являются очень эластичным решением. С другой стороны, облака могут привести к финансовым потерям из-за риска снижения безопасности, возможных проблем с доступом к данным, политики конфиденциальности данных и по другим причинам. В связи с этим необходим способ оценивания облачных вычислений. В работе для оценивания предлагается использование экономических показателей: анализ издержки-выгоды BCA, рентабельность инвестиций ROI и общая стоимость владения TCO. Дополнительно используется комплексный показатель, который основан на объединении перечисленных трёх показателей. С целью проверить стратегии оценивания произведено исследование. Для исследования были выбраны частные облака, так как частные облака больше всего подвержены риску быть экономически неэффективными из-за больших начальных инвестиций. В исследовании использованы данные 1000 проектов по внедрению облачных вычислений, и каждый проект классифицирован с помощью экономических показателей как эффективный или нет. Самый лучший результат получен с помощью комплексного показателя, основанного на трёх вышеперечисленных показателях. Исследование показало, что для малых и средних предприятий (до 50 физических серверов) частные облачные вычисления невыгодны. Однако для больших предприятий облачные вычисления могут принести экономическую прибыль. В связи с этим организациям необходимо внимательно оценить цели и определить, смогут ли облачные вычисления достичь этой цели, соблюдая ограничения по времени и бюджету. Важно помнить, что в разных сферах бизнеса облачные решения могут быть использованы по-разному, и поэтому критически важно понимать экономические показатели и производить оценивание облачных вычислений на их основании.