FORECASTING THE ECONOMIC EFFICIENCY OF CLOUD INFRASTRUCTURE MIGRATION USING TCO AND ROI IN THE DIGITAL ECONOMY

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Abstract: *This article proposes a TCO- and ROI-based algorithm for forecasting the economic efficiency of enterprise migration to cloud infrastructure in the digital economy. The study compares traditional IT infrastructure with cloud scenarios based on IaaS, PaaS, SaaS and hybrid deployment models. The algorithm considers capital expenditure, operational expenditure, migration costs, staff training, information security, network reliability, service-level agreement indicators and the risk of vendor lock-in. A mathematical model, a decision workflow and a scenario-based comparison table are presented. The analytical evaluation shows that a planned transition to cloud services can reduce total cost of ownership, improve resource elasticity and support faster managerial decision-making. The proposed approach can be used by enterprises and public organizations before adopting cloud services to forecast financial benefits and manage implementation risks.*

Keywords: *cloud computing, digital economy, cloud migration, TCO, ROI, CAPEX, OPEX, hybrid cloud, cost optimization, decision model.*

INTRODUCTION

The development of the digital economy requires enterprises to use flexible, scalable and cost-effective information infrastructure. Traditional IT infrastructure usually depends on physical servers, software licenses, local data centers, technical maintenance, electricity consumption, backup systems and permanent technical staff. Such a model gives the organization full control over resources, but it often increases capital expenditure and limits the speed of digital transformation.

Cloud computing provides a different approach. Instead of purchasing and maintaining all infrastructure components, an enterprise can receive computing power, storage, development platforms and software services through the internet. This makes it possible to move from a capital expenditure model (CAPEX) to a more flexible operational expenditure model (OPEX). For this reason, cloud computing has become an important technological basis for e-commerce, online education, digital banking, health information systems, remote work, data analytics and artificial intelligence services.

However, cloud migration should not be treated only as a technical modernization project. The main question for managers is whether migration will create real economic value. A cloud solution can be efficient when subscription costs,

migration costs, security requirements, training expenses and risks are evaluated together. Therefore, enterprises need a clear model that compares traditional IT and cloud infrastructure before the migration begins.

The purpose of this article is to develop an algorithm for forecasting the economic efficiency of cloud infrastructure migration using Total Cost of Ownership (TCO) and Return on Investment (ROI). The article also proposes an integrated efficiency index that combines savings, service availability, resource utilization, security readiness and migration risk.

2. Related Work and Research Gap

Cloud computing research usually discusses three main service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). IaaS provides virtual servers, storage and network resources; PaaS supports application development and deployment; SaaS provides ready-to-use software through the internet. In addition, cloud deployment models are commonly divided into public, private and hybrid cloud models. Each model has different economic, technical and security characteristics.

From the economic point of view, cloud computing is attractive because it can reduce the need for large initial investments in servers and data centers. It also allows resources to be scaled according to demand. Nevertheless, cloud adoption may create new risks: dependence on the service provider, uncontrolled resource consumption, data protection challenges, network dependency and hidden operational costs. These factors show that a simple comparison of monthly subscription prices is not sufficient.

The research gap addressed in this article is the lack of a compact decision-oriented model that connects technical cloud migration scenarios with economic indicators such as TCO, ROI and payback period. The proposed approach treats cloud migration as a combined economic, technical and organizational decision rather than as a purely technological replacement.

3. Proposed TCO-ROI Cloud Migration Algorithm

The proposed algorithm begins with the identification of the existing IT cost structure. At this stage, an enterprise calculates hardware costs, software licenses, energy consumption, technical maintenance, staff expenses, security tools, backup systems and downtime losses. These indicators form the baseline for comparing traditional IT infrastructure with cloud alternatives.

The second stage is the selection of a cloud model. If the enterprise needs flexible computing capacity and full system control, the IaaS model may be appropriate. If the organization develops software products, PaaS can reduce development and deployment time. If the main task is to use ready-made digital

services, SaaS can be the most convenient option. In cases where sensitive data must remain under stronger organizational control, a hybrid cloud model can provide a balance between flexibility and security.

The third stage is the calculation of cloud TCO. This includes subscription fees, migration costs, network expenses, staff training, security configuration, data transfer, integration work and possible overuse of cloud resources. The fourth stage calculates expected savings and ROI. The fifth stage evaluates service-level agreement (SLA) indicators, data protection requirements and migration risks. Finally, the algorithm compares several scenarios and recommends whether to migrate, postpone migration or choose a gradual hybrid strategy.

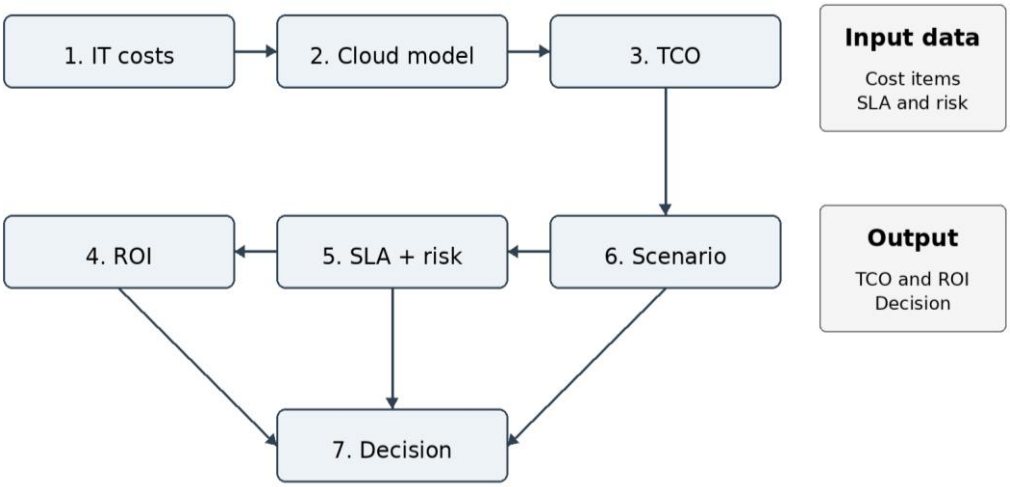

Figure 1. TCO-ROI based decision workflow for cloud infrastructure migration

4. Mathematical and Economic Model

The total cost of ownership of traditional IT infrastructure can be represented as follows:

$$TCO_{trad} = C_{server} + C_{license} + C_{energy} + C_{staff} + C_{maintenance} + C_{security} + C_{backup} + C_{downtime} \quad (1)$$

Here, C_{server} is the cost of hardware and servers, $C_{license}$ is the cost of software licenses, C_{energy} is energy consumption, C_{staff} is staff cost, $C_{maintenance}$ is maintenance cost, $C_{security}$ is security cost, C_{backup} is backup cost and $C_{downtime}$ is the economic loss caused by service interruptions.

For cloud infrastructure, total cost of ownership is defined as:

$$TCO_{cloud} = C_{subscription} + C_{network} + C_{migration} + C_{training} + C_{security} + C_{integration} + C_{overuse} \quad (2)$$

In this expression, $C_{subscription}$ is the cloud service fee, $C_{network}$ is internet and connectivity cost, $C_{migration}$ is the cost of data and application migration, $C_{training}$ is staff training cost, $C_{integration}$ is integration with existing information systems and $C_{overuse}$ is the additional cost caused by uncontrolled resource consumption.

The relative saving from migration is calculated by the following formula:

S = ((TCOtrad - TCOcloud) / TCOtrad) * 100% (3)

Return on investment is calculated as:

ROI = ((Bcloud - Cmigration) / Cmigration) * 100% (4)

In Eq. (4), Bcloud represents the expected economic benefit of cloud adoption, including cost reduction, productivity growth, faster service deployment and reduced downtime. To support final decision-making, an integrated efficiency index is proposed:

Ecloud = w1*Ssaving + w2*Aavailability + w3*Uresource + w4*Sec - w5*Rrisk (5)

Here, Ssaving is the normalized saving indicator, Aavailability is service availability, Uresource is resource utilization efficiency, Sec is security readiness, Rrisk is migration and vendor lock-in risk, and w1...w5 are weighting coefficients. A higher value of Ecloud indicates that cloud migration is economically and technically more justified.

5. Scenario-Based Analytical Evaluation

A scenario-based evaluation was prepared to demonstrate how the proposed model can be used before the real migration process. Four scenarios were compared: traditional IT infrastructure, hybrid cloud, SaaS-oriented model and optimized cloud architecture. The values in the table are relative indicators designed to show the logic of decision-making and can be adapted to real enterprise data.

Table 1. Comparison of cloud migration scenarios based on TCO and ROI

Scenario	Relative TCO	Expected saving	Main advantage	Main limitation
Traditional IT	100%	0%	Full internal control	High CAPEX and maintenance burden
Hybrid cloud	82%	18%	Balance between security and flexibility	More complex architecture
SaaS-oriented model	72%	28%	Fast implementation and simple management	Provider dependency
Optimized cloud	63%	37%	Elastic resource management	Requires continuous

			and lower TCO	cost monitoring

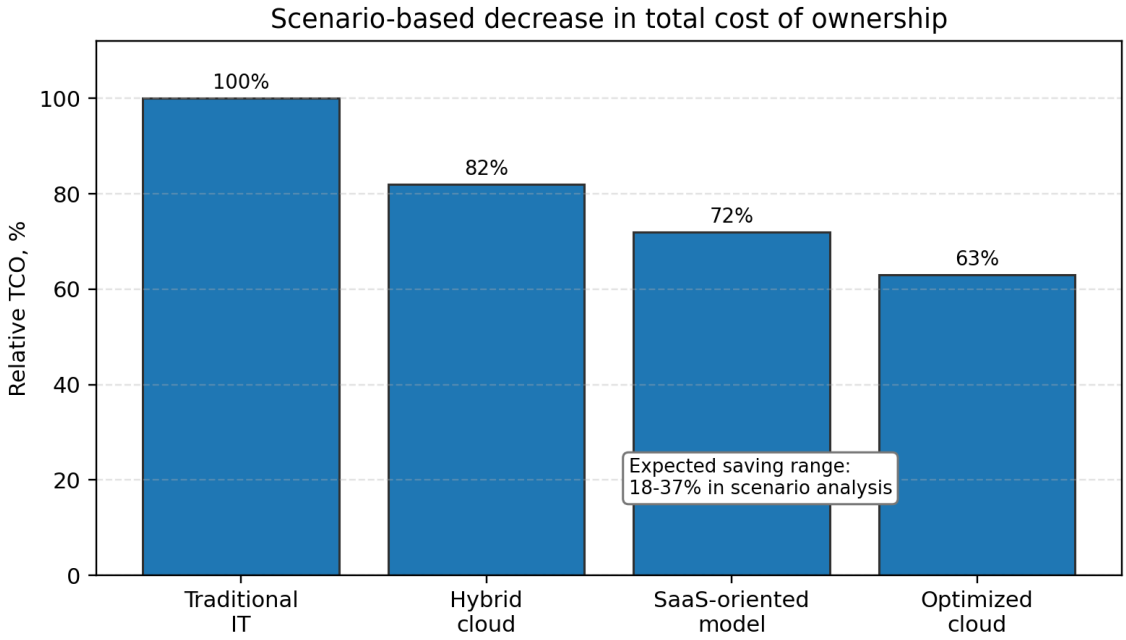

Figure 2. Scenario-based decrease in relative total cost of ownership

The scenario analysis indicates that cloud adoption can significantly reduce total ownership cost when migration is planned and controlled. However, the lowest subscription price does not always mean the best economic result. A solution becomes efficient only when performance, availability, security, staff readiness and resource consumption are managed as a single system. For organizations with sensitive data, the hybrid model may be preferable because it allows critical data to remain under stronger control while less sensitive services are moved to the public cloud.

The optimized cloud scenario demonstrates the highest potential saving because it combines resource elasticity, continuous monitoring and workload-based cost control. At the same time, this scenario requires mature governance. Without monitoring, auto-scaling policies and clear responsibility for resource consumption, cloud expenses may increase unexpectedly. Therefore, cloud migration must be supported by financial control mechanisms and technical monitoring tools.

6. Scientific Novelty and Practical Value

The scientific novelty of the article is the integration of TCO, ROI, SLA, security readiness and migration risk into one decision-oriented model. The proposed algorithm does not evaluate cloud computing only by its technical advantages. It connects infrastructure modernization with measurable economic indicators and converts them into a practical decision workflow.

The practical value of the model is that it can be used by medium and large enterprises, educational institutions, medical organizations, e-commerce platforms

and public information systems. It helps decision-makers answer four important questions: whether cloud migration is economically justified, which cloud model is most appropriate, which costs will decrease and which risks must be managed before implementation. The approach is especially useful for organizations that plan to move from traditional server-based infrastructure to a hybrid or service-based cloud environment.

7. Conclusion

This article proposed a TCO- and ROI-based algorithm for forecasting the economic efficiency of cloud infrastructure migration in the digital economy. The model compares traditional IT infrastructure with cloud alternatives and includes migration costs, training expenses, network requirements, security readiness, service availability and risk factors. A workflow diagram, mathematical formulas and scenario-based comparison were presented.

The analytical evaluation shows that a well-planned cloud migration strategy can reduce total cost of ownership, increase flexibility and accelerate managerial decision-making. However, cloud adoption must be supported by careful financial planning, security policy, staff training and continuous cost monitoring. Future research should test the proposed model using real enterprise datasets, develop a software module for automated TCO-ROI calculation and include energy efficiency and carbon footprint indicators in the assessment model.

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