Cloud computing and economic growth

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ABSTRACT

Cloud computing, is a rapidly evolving type of internet- based computing model that relies on sharing computing resources, rather than having local servers or personnel to handle them. It has already been adopted by a significant number of Small and Medium Enterprises (SMEs) as a business advantage able to improve their business environment and help them be more efficient and productive. Due to its beneficial characteristics, as flexibility of cost and scalability, cloud computing has the potential to transform the global ICT market techniques and contribute to the boost of economic growth. The provision of cloud computing services is a new and very promising business model and cloud service providers are already enjoying growing profits.

This paper seeks to highlight the economic benefits of cloud computing adoption, its impact on the economic growth of a country, and to explore its diffusion using evidence from the European area. Another main objective is the demonstration of the economic benefits an SME can achieve by adopting cloud services instead of proprietary infrastructures. A case study of a new company entering the market is considered and the corresponding calculations are based on a software tool developed by our research team for the calculation of the total cost of ownership (TCO). Results, will reveal the economic benefits of the cloud and its contribution to the economic growth.

General Terms

Management, Design, Economics

Keywords

Cloud computing, economic growth, cloud provider, total cost of ownership, ICT market

1. INTRODUCTION

Cloud Computing is a rapidly evolving paradigm that has succeeded in transforming the global ICT industry. It offers to numerous services businesses and it boosts them to be more productive, efficient and competitive, without investing a great amount from their capital budget [1].

Businesses vary in size and they are categorized into Small and Medium enterprises (SMEs) and Large sized enterprises. Businesses, independently of their size, aim to have maximum gains with minimum expenses, therefore they migrate to the cloud and become profitable and competitive.

Cloud Computing is a business model that it is highly popular among businesses and it is particularly adopted by SMEs, due to their limited budget. Small and Medium Enterprises that are willing to exploit the benefits of the cloud, are the pioneers in migrating to cloud computing. The cloud offers them numerous advantages, such as growth and cost savings.

SMEs are considered to be the backbone of the economy, thus many countries promote the adoption of the cloud, especially those currently facing the recession in their real economy. These countries are seeking for solutions in order to build more competitive and efficient economies.

The adoption of cloud computing is not only cost-effective and beneficial for the SMEs, but it is also profitable for cloud providers. The provision of cloud services is an innovative business with great prospects of growth and it presents constantly increasing profits. The gains of a cloud provider depend mainly on pricing methods. A pricing method is the process of determining the level of profits of a provider in exchange for its cloud services. The most important pricing factors considered in the pricing process are manufacturing cost, market place, competition, market competition, market conditions, brand and quality of products. These factors and the appropriate pricing strategy determines and estimates the costs and the profits of a provider.

This paper highlights the importance of cloud computing as an innovative business model. More specifically, Section 2 describes the architecture of the cloud computing, Section 3 highlights the economic benefits and the growth of the cloud and emphasizes on the importance of this business model. Section 4 presents the

diffusion of the cloud in Europe and the benefits that arise to the European economies. Section 5 analyzes a case study of a hypothetical startup company seeking to decide if it will adopt the cloud or it will maintain its own IT infrastructure and Section 6 concludes.

2. CLOUD COMPUTING BUSINESS MODEL

Cloud computing is a type of computing that relies on sharing computing resources rather than having local servers or personal to handle. The term “cloud” denotes "the Internet", therefore cloud computing refers to a type of Internet-based computing model, where different services - such as servers, storage and applications - are delivered to an organization's computers and devices through the Internet. In simple terms, cloud computing can be defined as the set of hardware, networks, storage, services and interfaces combined to deliver aspects of computing as a service based on user demand. It can also be perceived as the procedure of storing and accessing data and applications over the Internet, instead of the user’s computer hard drive.

2.1 Essential characteristics

- *On-demand self-service*. A consumer can unilaterally ask for the provision of computing capabilities as needed, such as server time and network storage, automatically, without requiring human interaction, or intervention of the service provider.
- *Broad network access*. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- *Resource pooling*. The provider’s computing resources (storage, processing, memory, and network bandwidth) are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources, dynamically assigned and reassigned according to the consumer’s demand.
- *Rapid elasticity*. Capabilities can be elastically and automatically provisioned and released, to scale rapidly outward and inward commensurate with demand.
- *Measured service*. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service [2].

2.2 Service Models

- *Software as a Service (SaaS).*The capability to use the provider’s applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser, or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities.
- *Platform as a Service (PaaS*).The capability to deploy onto the cloud infrastructure languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure but has control over the deployed applications and possibly configuration settings for the application-hosting environment.
- *Infrastructure as a Service (IaaS).* The capability to process, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components [2, 3].

2.3 Deployment Models

- *Private cloud*. The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
- *Community cloud.* The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
- *Public cloud.* .The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.
- *Hybrid cloud*. The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds [2, 3].

The above are graphically illustrated in Figure 1:

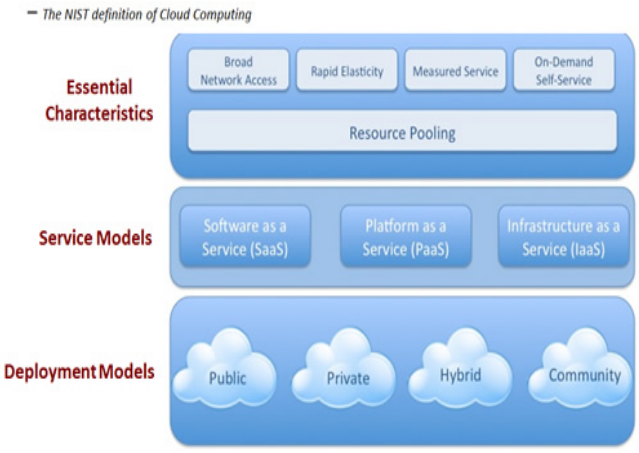

Figure 1. Cloud Computing Models.

3. ECONOMIC BENEFITS

Today, the cloud has become a very powerful computing tool for people and companies around the world. Sharing computing resources, delivering many different services, storing and accessing applications are only some clicks away. From a more business-oriented perspective, cloud computing is an indispensable business model, as well. It can help companies develop themselves, make cost savings, creating at the same time a competitive environment with more job opportunities and challenges not only in Europe but also worldwide [4].

With the advent of the cloud computing model, the business world has changed, as it has attained the form of a more global space than before, providing cost-saving benefits not only to ICT consumers, but also to SMEs. An enterprise that migrates its IT system and data to the cloud may hire the required resources as needed, instead of using proprietary infrastructures, reducing server and storage costs, software maintenance expenditures, network and energy expenses and costs associated with disaster recovery [5, 6]. Furthermore, cloud computing works, in general, on a "pay-as-you-go" basis, giving the option to the user to pay for what they use [7]. As a result, cloud computing adoption offers slow start-up costs to SMEs, which want to obtain a dominant ICT market share and creates an environment for rapid innovation and development for businesses that need to respond faster and cheaper to their constituents' demanding wills, based on different cost models than the traditional [3].

Consequently, a notable economic advantage of cloud computing is that it promises new development opportunities and job creation, contributing to the boost of economic growth of a state [4]. As a new business model, the provision of cloud computing services has tremendous potential and cloud service providers and small, upstart entrepreneurs have been some of the greatest beneficiaries from the cloud's empowering influence, since they have improved profitability and new revenue opportunities. In addition, the number of new SMEs is increasing, new job profiles are being derived from this necessity, more job positions are being created, resulting to multiplier benefits and growth of the society's economy and social surplus [3].

Due to all these operational and economic benefits of cloud computing, this innovative business model has already been adopted by a significant number of SMEs in the European area. There is evidence that some of the most important European economies have recognized and embraced the enormous opportunities the cloud can create, even as they work to address the risks to security and privacy it may bring [5, 6]. Findings indicate that the cloud computing business model should be also adopted by less developed countries, in order to boost growth and development [8].

4. CLOUD COMPUTING DIFFUSION

Cloud computing is continuously developed at a fast pace during the last years, as it is a business model that builds a competitive environment that benefits both suppliers and users and lets innovators and entrepreneurs thrive. It has already met explosive growth and this growth will increase to become the bulk of new IT spend [9]. As it is graphically shown in Figure 2, in 2008 the total cloud computing industry was estimated to be worth about $46 billion and by the end of the 2014 was predicted to be worth more than $150 billion. It is predicted that more than 50% of all information technology will be in the cloud within the next five to ten years [10].

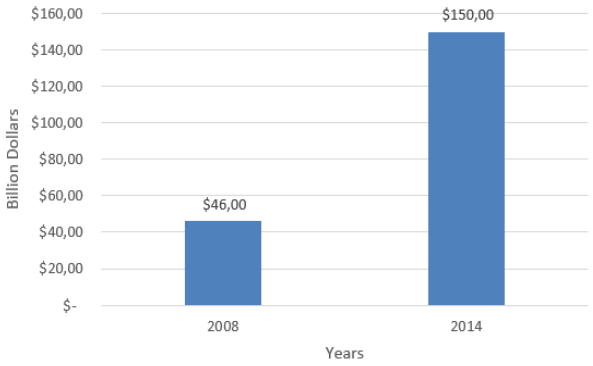

Figure 2. Value of Cloud computing industry (2008 - 2014).

Because of its beneficial characteristics, the cloud computing business model is well known and used in European countries that are trying to maximize its continued impact on economic growth and prosperity [4]. Exploring its diffusion across the European area, it has been found that cloud computing has contributed to economic growth, productivity, and employment of the countries that finally adopted it. The Centre for Economics and Business Research Ltd (Cebr) examined some of Europe's most important economies, the French, the German, the Italian, the Spanish and the English. It found that the cloud is estimated to account for a significant and growing portion of overall Gross domestic product (GDP) in the 5 nations studied, at an expected level of €763 billion from 2010 to 2015 [6].

The above countries have already achieved quite high average rates of cloud adoption, gaining at the same time substantial economic benefits especially at particular industry sectors, usually depending on the characteristics of each individual economy [3]. In Germany, the strongest of the five economies, the cloud is expected to account for 1.59% of GDP over the 5-year period from 2010 to 2015, whereas the banking, financial and business services sectors are predicted to be developed the most, resulting in a great amount of new business positions. The cumulative business creation benefit is predicted to be one of the greatest among the 5 nations, exceeding the level of 31% of the German cloud gain in total. In the rest of the considered countries the distribution, retail and hotel sectors are the ones that capture more of the benefits that cloud computing adoption may create. The highest cumulative cost savings are met in the UK and then in Spain, constituting the 22.2% and 19.9% of their aggregate cloud share respectively. The UK plays also a leading role in business development benefits, which are expected to account for 25% of its cumulative cloud dividend, due to the high productivity of English SMEs. Furthermore, France ranks as the fastest growing player in the cloud's business creation benefits with 31.6%, while Italy and Spain have also a significant percentage contribution, estimated at about 28% (see Figure 3) [5, 6].

All of these findings show that cloud computing is going to be a catalyst for generating jobs, as well. Many small and midsize enterprises have surveyed and are expected to be expanded, while new job positions and SMEs are being created in various industrial sectors in all the aforementioned countries, as shown in Table 1 [6].

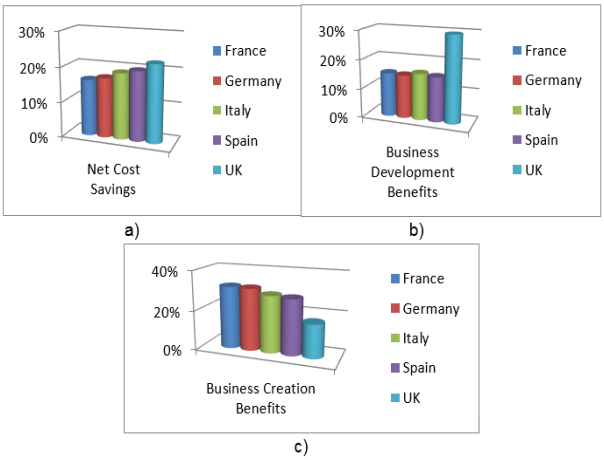

Figure 3. Percentage contribution of a) Net Cost Savings, b) Business Development Benefits, c) Business Creation Benefits of cloud adoption to total economic benefits of each country (2010-2015).

Table 1. Creation of new jobs and new business start-ups by 2015 (thousands)

Country	New jobs	New SMEs
United Kingdom	289	35
Germany	789	39
France	469	48
Italy	456	81
Spain	393	55

These findings suggest that developing countries, as well, will need to sharpen their focus on the benefits the cloud is likely to offer for the enhancement of their economic development and generation of new jobs. The Foundation for Economic and Industrial Research in Greece (IOBE) examined how cloud computing can be a driver for Greek economy competitiveness. As a result of cloud computing adoption, it is expected that savings in Greece can reach €4.8 billion over the decade, between years 2010 to 2020. Although there are many Greek established SMEs, cloud computing has not been yet quite popular among them. Governmental leaders and private-sector entrepreneurs should be encouraged to adopt this new business model, as its usage and expenditure are directly correlated with higher business development, creation and economic growth in GDP per capita. According to IOBE's macroeconomic study, these important direct economic output effects of cloud computing adoption, such as business development and creation benefits, are estimated to add an extra value of €5.1 billion for Greece over the 10-year period from 2010 to 2020 [8].

5. CASE STUDY

In this section a case study is presented and analyzed, aiming to show the economic benefits of a company that proceeds in adopting cloud computing services, instead of maintaining its own infrastructure. The study focuses on HuaNews a hypothetical new company which is about to enter the market engaging into the translation and display of foreign news from all around the world. Since HuaNews is startup company there are no switching costs but the management has to decide whether it will support its own computing infrastructures or go to the cloud. Calculations were based on a software tool that calculates the Total Cost of Ownership (TCO) of any given ICT infrastructure. The development of the software was based on a detailed methodology which incorporates all the appropriate parameters as inputs and makes the necessary calculations in order to estimate the initial investment and the Total Cost of Ownership (TCO) of an ICT infrastructure. Examples of inputs are:

- Design of the system architecture requirements
- Parameterization of the system. (Infrastructure, storage, hardware, software, networking requirements, component life cycles, the costs of each of the combined elements necessary in a solution including the cost of software licenses, upgrades, and expansions, power consumption)
- Economic inputs (Assets, Depreciation, Costing and Pricing details, component price evolution, cost of capital etc.).

After performing the appropriate calculations provides important outputs related to the investment:

- Values of a number of economic indices, in both the short and the long-term, such as: Initial investment, CapEx, OpEx, Cash flows, Payback period, Net present value (NPV), Internal Rate of Return (IRR), Return on investment (ROI).

The TCO is the sum of all costs categorized into capital expenditures (CapEx) and operating expenditures (OpEx) over an n-year period. Capital expenditures are the sum of the depreciated costs for purchasing servers, software licensing, networking, storage, power and cooling equipment as well as facilities (KMV, Cables etc.). Operational expenditures are the sum of: Real estate cost, power cost, cooling cost, support and maintenance costs as well as the administrator and the personnel costs.

According to the assumptions, HuaNews will create 50 job opportunities including reporters, journalists, translators, administrators and management staff. At the same time the company needs to ensure an adequate IT infrastructure that will facilitate the communication of its employees and the collaboration with news agencies, as well as the timely information of the public. The IT department will provide the following services: email, calendar, blog, web hosting, storage services, backups and VPN.

In this case study the costs of two options are examined and compared: the option of creating a proprietary IT infrastructure by purchasing the IT equipment (servers, storage, networking etc.) and the option of adopting cloud computing services,. The assumption made is that the needed software is free (OSS) and maintenance and support costs are the same for both cases. The TCO for both cases was calculated for three years in both cases, since three years are an adequate time period to valuate such a kind of investment.

Considering the first scenario, according to which HuaNews creates the IT department by purchasing and maintaining the equipment, the IT infrastructure is assumed to include 5 Servers (Intel® Xeon® E5-2640 v2 (8 core, 2 GHz, 20MB, 95W)[11], each one having the following characteristics: 2 processors with 8 cores per processor; 16GB of RAM memory; 4 NICs; 4 ports per controller; size U; 460W power supply and a total storage of 5TB SAS. TCO results are shown in Table 2 and Table 3. According to them, the initial investment (Table 2) will reach a level of 68.824 €

and the Operational Expenditures – OPEX (Table 3) will be 20.891 € for 3 years. Thus, the estimated TCO for the required infrastructure will reach a total of 89.715 €.

Table 2. Capital Expenditures of the IT Infrastructure

Initial Cost of Infrastructure	Quantity	Three Year Cost
Servers	5	17.500 €
Total Storage (SAN)	5TB	35.000 €
Networking (Switch)	4	14.710 €
Faclities (PDU,KVM etc.) per rack	1	897,00 €
Cooling equipment per rack	1	717,00 €
Capital Expenditures		**68.824€**

Table 3. Operational Expenditures (OPEX) of the IT Infrastructure

OpEx (3 years)		Price	Annual Cost	Three Year Cost
Actual Operating Power [12]	308 Watts per server	0,22€/kwh	2.962 €	8.885 €
Actual Cooling Power	385 Watts per server	0,22€/kwh	3.702 €	11.106 €
Real Estate Rent	5 sq.m	5€/sq.m	300 €	900 €
Operating Expenditures			**6.964 €**	**20.891 €**

According to the second scenario, comparable resources come from the cloud and especially from the Amazon Web Service (AWS)[13] provider in the European zone. The corresponding Infrastructure will require five Virtual Machines, each one consisting of one large instanceEC2 m2.xlarge and 1 TB SSD EBS (17.1 GB RAM, 1 TB HDD, 2 vCPU ~ 6.5 ECU). As shown in Table 3 the total cost per month for the five VMs would be 455€, but by using the option of subscription for 3 years, the cost will be reduced to 323€ per month. Prices from other providers are of the same magnitude. For the above calculations it is assumed that each Amazon's VM is running on Linux, 24/7 for three years continuously; 50TB data transfer in ; 500GB data transfer out; 1 TB EBS storage; 10 million GET requests; 10 million PUT requests; Load Balancer 500GB for processed data. (source: Cloudorado [14]). The total cost of using Amazon's cloud instances and services for 3 years, with the assumption that the price will not change, will be 58.093€ according to the current Amazon's pricing policy.

Table 4. AWS Virtual Machine Cost

AWS VM (24/7)	Cost per month	Three Years
EC2 m2.xlarge + 1 TB SSD EBS	145 €	5.398 €
Transfer	75 €	2.707 €
Load balancer:	22 €	780 €
Cloud Object Storage capacity	28 €	991 €
Cloud Object Storage requests	48 €	1.743 €
Total	**323 €**	**11.619 €**

Table 5 and the Figure 4 show the annual comparison between the infrastructure cost and the cost of Amazon's cloud services. The comparison of these two scenarios, seeking to determine the less expensive, is also accomplished by calculating the present value (PV) [15] for each option, taking into account the monthly discount rate 10%/12. PV_(Internal Infrastructure)=86.808€ and PV_(AWS Cloud)=50.011€.

The above results reveal the economic benefits from adopting the cloud (AWS) instead of initial IT infrastructure for this case study of a new company in the media industry. As observed, there is a substantial cost difference between the two considered scenarios, leading to the proposal of adopting cloud services to maintain the organization, instead of supporting a self owned infrastructure.

Table 5. Comparison of the Investment in the Internal Infrastructure and the Cost of AWS Cloud

Period	Initial Investment+OpEx	AWS Cost
Start	68.824 €	0 €
1st Year	6.964 €	19.364 €
2nd Year	6.964 €	19.364 €
3rd Year	6.964 €	19.364 €
Total	**89.715 €**	**58.093 €**

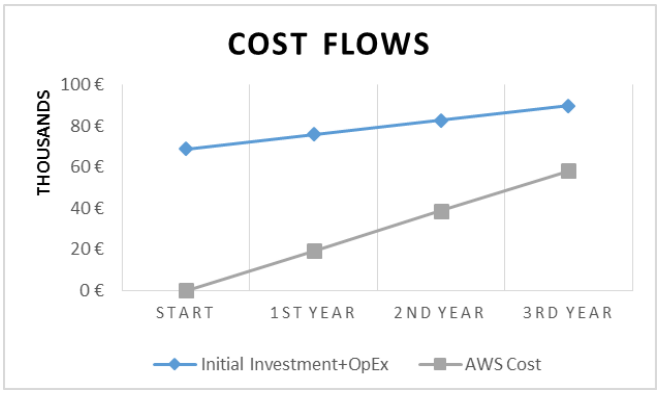

Figure 4 Cost flows - Comparison

6. CONCLUSIONS

In the context of this paper the contribution of the cloud computing into the economic growth is presented, highlighting the importance of this innovative business model.

According to the findings and the review of literature, cloud computing services are already adopted by a significant number of Small and Medium Enterprises (SMEs), since they can benefit by improving their business environment, being more efficient and productive. A case study of a new hypothetical company entering the market is considered as a case study, calculating the total Cost of Ownership for the two options of supporting self-owned IT infrastructure, or leasing cloud resources. Calculations were based on a software tool developed by our research team. Results, revealed the level of the economic benefits of the cloud and highlight the consequences on the economic growth.

Future work can focus on the more-in-depth analysis of the cloud computing business model and extend it to the other models, SaaS and PaaS, which are also expected to dominate the ICT market in the coming years.

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