TRANSACTION COST ECONOMICS OF CLOUD COMPUTING ADOPTION

Abstract: *Cloud computing is posited as a next major innovation in IT industry*. *But Cloud computing is in its infancy in terms of market adoption. Its adoption is impeded by issues of privacy, security, confidentiality, availability and performance. In this paper, we use the framework offered by transaction cost theory to explain the adoption of cloud technologies. We study the three phases of migration to cloud – information seeking, contract preparation and contract execution. For each of these phases we categorize the transaction costs resulting from uncertainty surrounding the transaction and asset specificity required to support the transaction. We propose a set of guidelines for adopting organizations and providers that can reduce the transaction costs of cloud adoption.*

Keywords: Cloud computing, Transaction Cost Economics

"*Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction.*" (NIST, August 2009)

Cloud computing enables convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services). These resources can be rapidly provisioned and released with minimal management effort or service-provider interaction (NIST, August 2009). It is a sharp departure from the current scenario where companies own their software and hardware and keep them on-premises in data centers and other specialized facilities. This new concept, promising substantial IT cost savings and innovation possibilities, has generated a lot of industry hype.

This novelty and the hype found in some media stories make it difficult for organizations to evaluate its potential, costs and risks (Harris & Alter, 2010). There are several concerns that the users have regarding the adoption of cloud computing. They include availability, security privacy, support, interoperability, and compliance. In this paper we examine the issues that inhibit cloud adoption.

Transaction Cost Economics (TCE) is a stream of organizational economics that recognizes the importance of transaction costs. Transaction costs refer to the costs of organizing information, coordinating behavior, safeguarding the interests of the transacting parties, monitoring the transactions, etc. TCE has been widely used in prior research to address the issues that concern the choice of outsourcing Information Systems activities versus keeping them in-house (Aubert, Rivard, & Party, 1996).

The objective of this paper is to understand the obstacles to cloud adoption with the help of the framework offered by Transaction Cost Theory and to come up with some guidelines to overcome these obstacles. We review the literature on cloud computing and TCE, to evaluate the costs of adopting and not adopting cloud technology and to design a framework to classify transaction costs involved with cloud technology adoption. We then identify underlying causes for each of the transaction costs and offer possible guidelines to mitigate these costs and promote cloud adoption.

Cloud Computing

Cloud computing is a phenomenon where software and computation is migrated to distant datacenters reached through the internet. "Cloud computing" refers to both the applications delivered as services over the internet, and the hardware and systems software that provide these services (Armbrust, et al., 2010). These services are generally referred to as "Software as a Service" (SaaS) and the hardware and software together are referred to as "cloud". For example, when we create a google spread sheet, major components of the software reside in unseen computers possibly scattered across continents (Hayes, 2008). A cloud made available in a pay-as-you-go manner to the public, is referred to as Public Cloud; and the services sold are referred to as Utility Computing. Current examples of public Utility Computing include AmazonWeb Services, Google AppEngine, and Microsoft Azure. The term Private Cloud refers to internal datacenters of business or other organizations that are not made available to the public. Figure1 depicts the relationships among cloud providers, cloud users and SaaS users. In this paper, we focus on the relationship between cloud providers and cloud users.

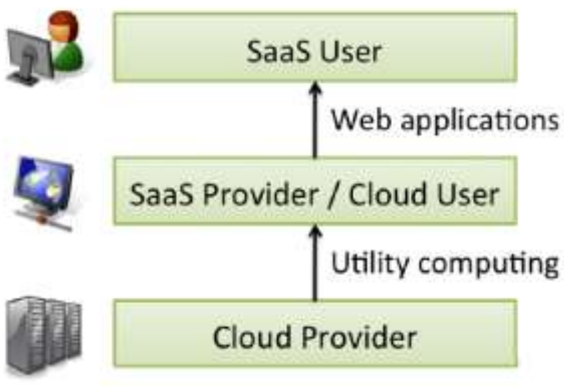

Figure 1 (Armbrust, et al., 2009)

Based on the type of offerings, Iyer et al. (2010) have classified cloud providers (also known as cloud vendors) into five levels of abstraction, similar to a software stack. The layered model has the following five layers as illustrated in Figure 2:

- Infrastructure Level: Vendors, such as Amazon, provide basic services like computer processing time to developers. These services function by providing dedicated servers with memory. Once a computer process is started, the user has complete control over its operations and must add necessary processes to it and terminate once done.
- Platform as a Service Level: This provides a higher level of abstraction that allows developers to build applications without worrying about computer processes. Typically, vendors such as Google and Salesforce.com provide a development environment with a programming language that can be used to create new applications.
- Application Level: Offerings at this level are the most popular in the cloud computing stack. Users access online services such as Google Maps, Salesforce.com, Google docs, so on, by paying based on usage.
- Collaboration Level: The collaboration level is comprised of a set of applications that focus exclusively on social network applications, such as Facebook, LinkedIn, and others that help build communities and support collaborative work.
- Service Level: This level includes companies that provide consulting and integration services, such as Appirio, Boomi, and Opsource.

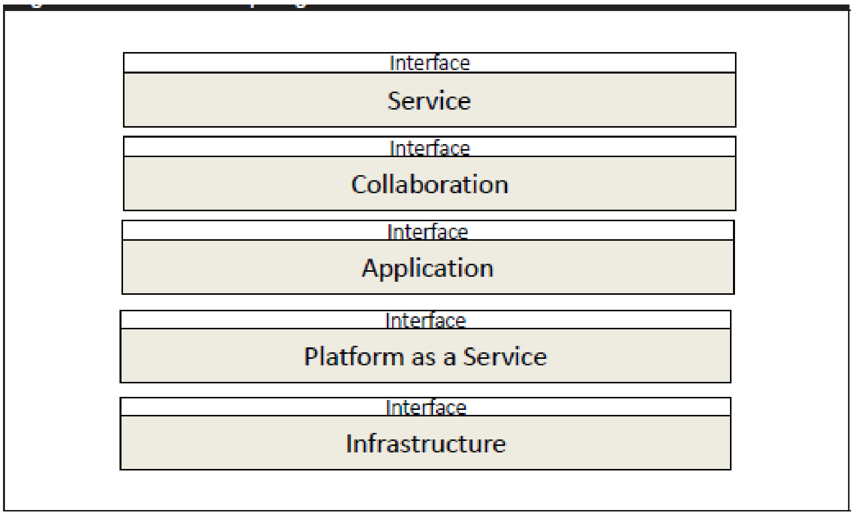

Figure 2 The Cloud Computing Stack (Iyer & Henderson, 2010)

From hardware provisioning and pricing point of view cloud computing offers the following advantages (Armbrust, et al., 2010):

- The virtual availability of ‘infinite’ computing resources, available on demand, rapidly enough to follow load surges, thereby eliminating the need to plan for provisioning of future needs.
- The elimination of an up-front commitment, thereby allowing companies to start small and increase hardware resources as and when there is an increase in their needs.
- The ability to pay per use of computing resources on a short-term basis as needed (for example, processors by the hour and storage by the day) and release them as needed. This is known as the advantage of “elasticity” provided by cloud computing.

Cloud computing offers numerous benefits to the adopting organizations and has the potential to become the next major driver of business innovation. It promises to enable new business models and services across many industries and provide access to new market segments (Porta, Karimi, & Botros, 2009).

Despite the number of advantages offered by cloud, adoption of this technology is impeded by issues of privacy, security, confidentiality, availability and performance (Harris & Alter, 2010). In the following sections of this paper, we will examine how these issues can be analyzed through the lens of transaction cost economics.

Transaction Cost Economics

Transaction cost economics (TCE) is a stream of organizational economics that focuses on the central question of "Why do organizations exist?" Ronald Coase in his book "The nature of the firm" (1937), gave a convincing answers to this question. He stated that organizations exist because, sometimes, the cost of managing economic exchanges across markets is greater than cost of managing economic exchanges within the boundaries of an organization. Oliver Williamson's extension to Coase's work is considered as the core of transaction cost economics.

TCE makes two basic assumptions about the human agents engaged in a transaction. First assumption is that, economic actors take decisions on the basis of limited knowledge. They cannot foresee all the possible outcomes in a transaction. This behavior is called "bounded rationality" and is a departure from rationality of homo economicus. It means that their behavior is "intendedly rational but only limitedly so". This implies that all complex contacts are unavoidably incomplete. Second assumption is that economic actors are opportunistic. They act with self-interest combined with guile. Opportunism may include lying, cheating, stealing etc., but generally refers to "incomplete or distorted disclosure of information" in order to confuse or mislead partners in an exchange (Williamson, 1975).

Williamson has defined markets and hierarchies as alternate modes of governance. Economic actors will choose that form of governance that reduces any problems in potential exchanges due to bounded rationality and opportunism. In hierarchical governance, a third party is delegated with the responsibility of managing economic exchanges in ways that minimize problems due to bounded rationality and opportunism. As markets and hierarchies are polar opposites in governance models, intermediate governance forms also gathered attention. These governance forms are labelled as hybrids and they have stronger incentives and adaptive capabilities than hierarchies and more administrative control than markets (Williamson, 1991). These governance models differ from one another on three dimensions of authority, incentives and ownership (Makadok & Coff, 2009).

Three attributes of commercial transactions: frequency with which the transactions occur, the uncertainty to which they are subject to and the conditions of asset specificity, may contribute to contractual hazards. Asset specificity implies transaction specific investment which is valuable in that particular transaction and has little or no value in further transactions. Under conditions of uncertainty, the difficulty of using contracts to manage a transaction increases and a third party may be required to resolve any problems that may arise. Williamson concluded that hierarchical governance arises to manage transactions when there is high asset specificity under conditions of uncertainty. At the same time, firms are prone to important incentive and bureaucratic disabilities that limit their size (Barney & Hesterly, 2006). According to Williamson (1975), “specific” assets lead to “lock-in” effect that causes hold-up problems. When asset specificity is low, organizations opt for market governance and when asset specificity is high, there is a necessity to build a safeguard. This safeguard can take the form of a formal contract as in the case of hybrid governance form or can take the form of total vertical integration (internalization). Similarly, when uncertainty is high, cost of writing contracts that cover changed circumstances is high and to economize such transaction costs, organizations use an internal governance structure (Klein, Frazier, & Roth, 1990).

The term transaction cost was coined by Williamson who defined it as “The ex ante costs of drafting, negotiating and safeguarding an agreement and, more especially, the ex post costs of maladaptation and adjustment that arise when contract execution is misaligned as a result of gaps, errors, omissions, and unanticipated disturbances; the costs of running the economic system" (Williamson, 1991).

Ojha (2004) provides an operational definition of transaction cost and defines it as the costs involved in each of three stages of transaction processing: first stage is the information seeking stage, second stage is the contract preparation stage and the third stage is contract monitoring. Thus transaction costs include, information costs, contracting costs and coordination costs each related to the three stages of transactions. Information costs are the costs related to search and information processing. Contracting costs are the costs related to negotiations and contract development. Coordination costs are the costs related to monitoring the contract.

Aubert et al. (1996) have used transaction cost framework to explain outsourcing behavior of firms at two levels. One concerns the choice of activities to outsource and of those to keep in-house. The other pertains to the management of the relationship created by outsourcing activities: the definition of the terms of the contract and the governance of this contract. Gurubaxani and Whang (1991) have utilized transaction cost theory to calculate the benefits in external coordination costs as a result of Information Technology adoption.

In this paper, we use the transaction cost framework is to explain the adoption of cloud technologies. We study the three phases of migrating to cloud – information seeking, contract preparation and contract execution. For each of these phases we categorize the transaction costs resulting from uncertainty surrounding the transaction and asset specificity required to support the transaction. Since it is a onetime transaction which supports cloud migration, frequency of transactions is not considered in evaluating the transaction costs. In the following section we analyze the transaction costs of cloud migration in detail.

Transaction Costs involved in adopting cloud technology

We analyze the costs incurred in adopting cloud technology through the lens of transaction cost theory and we categorize the costs of hosting service on the clouds under the costs of seeking information about cloud provider, the costs of drawing up a contract and the costs of monitoring the contract. We further examine the impact of uncertainty and asset specificity on each of these cost categories. Table 1 aids in understating the classification of various transaction costs involved.

	Uncertainity	Asset Specificity
Information Costs	1. Obscure operational information and more focus on pricing models	-
Contracting Costs	2. Issues of data Privacy, Security, auditability and compliance with laws 3. Reputation and Fate Sharing Issues	-
Coordination Costs	4. Issues of Availability of Service 5. Performance Unpredictability 6. Data transfer bottlenecks	7. Vendor Lock-in and interoperability issues

Table 1: Classification of Transaction Costs

Information Costs

As a first step in migrating to cloud, firms must evaluate the offerings of various cloud providers against their current and future requirements. The market place is saturated with cloud vendors and analyses of the market place indicate an inexperienced customer base. Such a customer base is not adept with vendor selection or determining the cost of service, which is further complicated by lack of benchmarking and reporting tools to evaluate the various commodities on cloud (Durkee, 2010). This implies that companies have to incur substantial information search costs in selecting vendors, products and service costs.

Uncertainty. Lack of information, on operational details of cloud provision, leads to uncertainty in vendor and product selection. Customers obscure to this information focus on just the costs of cloud provision and lose focus on expected performance and reliability. This leads to a situation of information asymmetry[1]. Cloud vendors, who have all the information about the internal operations and mechanisms of cloud provision, are unwilling to share this information with the enterprises adopting cloud. This information asymmetry leads to increased uncertainty in decision making for the cloud adopters.

Contracting Costs

After seeking information on various cloud providers and their offerings, the next step in adopting cloud technology is to enter into a contractual arrangement with the cloud provider. Pre-contract evaluation of cloud vendors is complex and different from traditional outsourcing contracts. Contract must protect the customer from any legal or regulatory issues that may arise as a result of the arrangement and encompass a wide range of aspects such as privacy, data security, regulatory requirements, intellectual property right, audit rights, etc. In addition, the contract gets further complicated with the commercial details of pricing models and licensing agreements.

Uncertainty. Uncertainty in preparing a contract arises due to the issues of data privacy, security, auditability and compliance with local laws. This uncertainty is furthered by the fact that all customers on the same cloud share the reputation and fate of the cloud provider.

[1] Information asymmetry is a situation in a transaction where some of the participants gain advantage from access to preferential information.

Data Privacy, Security, Auditability and Compliance. In the context of cloud computing, data resides in servers across the globe unknown to the customers and the control of the data remains with the cloud providers. This characteristic of cloud leads to confusion in several regulatory aspects. Data privacy, security, auditability and compliance with laws are some of the areas which require insights while preparing a contract.

Data in different locations is protected by local laws which vary in their intensity across countries. The "physical location" of data leads to the question of legal governance and uncertainty in the jurisdiction of conflict settlement in case of a dispute (Dlodlo, 2010). There is less privacy protection under the law with the cloud. This adds to the complexity of contracts that need to be drafted to safeguard the parties in transaction.

The distributed nature of data in cloud raises questions on data security and confidentiality. Cloud infrastructure is shared across organizations and sensitive data moves in and out of cloud. Cloud adopters face security threats from both inside and outside the cloud. Thus legal compliance and protection therefore has to be guaranteed by the contracts. Issues of security and lack of auditability have been rated as some of the major obstacles to cloud adoption (Armbrust, et al., 2009). "A complete understanding of the data and document retention and destruction policies of the cloud computing provider, both at the time of contracting and during the term of the agreement, is also critical to understanding the information that may be available to an adversary during the litigation process." (Ryan & Loeffler, 2010)

Reputation and Fate Sharing. One of the major obstacles to adoption of cloud computing is - reputation and fate sharing (Armbrust, et al., 2010). Inappropriate behaviour of other customers sharing the cloud can impact the reputation of all the members of the cloud. For instance, blacklisting of EC2 IP addresses by spam-prevention services may limit which applications can be effectively hosted (Krebs, July 2008). There are no known legal contractual arrangements that can shield customers against this.

Coordinating Costs

After entering a contractual arrangement with the cloud provider, monitoring this contract to ensure that the cloud provider's service, cloud technology performance, data transfer mechanisms and compatibility of technologies on a particular cloud with applications and technologies of other clouds are as per the requirements of the cloud adopters is a difficult task involving substantial coordination costs. These costs are influenced by the uncertainty and asset specificity of the transaction. The classification of these coordination costs of adopting cloud are as follows:

Uncertainty. Uncertainties in monitoring the contract arise from service availability issues, performance unpredictability and data transfer bottlenecks. There is a certain uncertainty about adequate availability of service that may be because of either technical or non-technical reasons. Similarly there is uncertainty associated with cloud provider's performance predictability which is furthered by bugs that may come up in large scale distributed systems. Similarly there is also uncertainty from the transferability of data across the clouds.

Issues of availability of service. Organizations worry about adequate availability of utility computing service when adopting cloud. They are wary about the financial losses and loss of existing customers when there is an outage of their service. This is a major concern when the cloud provider goes out of business (Suwon, 2009) and this may also happen due to other non-technical reasons such as cloud provider being a target of regulatory action. This issue has been rated as a top obstacle to adopting cloud by armbrust et al. (2010). In the survey conducted by Baseline in 2011, they have discovered that risk of occasional unavailability of service is still one of the challenges for organizations using cloud technologies (Currier, 2011). The risk of unavailability of cloud also arises from the Distributed Denial of Service (DDoS) attacks from criminals who cut off SaaS services threatening by making services unavailable and extorting huge payments (Armbrust, et al., 2009).

Performance unpredictability. While multiple virtual machines can share CPUs and main memory well, Input / Output sharing on cloud is problematic (Armbrust, et al., 2009). Also cloud computing is yet to prove its performance suitability for High Performance Computing (HPC) (Bechtolsheim, 2008). In very large scale distributed systems, bugs that do not generally occur in smaller configurations may show up. This may add up to the problems of performance predictability on cloud.

Data Transfer Bottlenecks. Applications worldwide are becoming more and more data intensive. Applications are distributed across the boundaries of the cloud and so are the data that the applications generate. Also cloud could potentially become a preferred medium of file and archival storage particularly when they need not be accessed on a regular basis (Porta, Karimi, & Botros, 2009). Cloud adopters are worried about the transfer of this data over internet. Traffic over the internet due to these data transfers and the charges associated with these are causes for concern for both cloud providers and cloud adopters.

Asset Specificity. Adopting cloud technology would mean having the organization’s data under third party control. This would lead to data lock-in to a particular vendor’s cloud which indirectly leads to vendor lock-in. Also due to the lack of standardization of APIs (Application Programming Interfaces), interoperability across various cloud providers and across different cloud offerings is a problem. These two aspects of vendor lock in and interoperability issues lead to increased transaction costs as a result of transaction specific investment on the part of cloud adopters.

Vendor lock-in and Interoperability Issues. Another major challenge to adopting cloud computing is that, once data is generated and placed on a cloud, it is not an easy task to extract it and run on another cloud. Cloud adopters would like to move their data and applications across multiple cloud providers. This vendor lock-in makes cloud adopters vulnerable to price increases, reliability problems and providers going out of business (Zhang, Cheng, & Boutaba, 2010). Interoperability would mean that data and application can easily be integrated across the offerings of various cloud providers. Also adopters would like to integrate between the private and public clouds. Lack of interoperability results in specialized machine or application language learning pertaining to a particular cloud provider which would not help cloud adopter when he moves on to a different cloud offering. Most of the APIs are proprietary. Organizations would need to master multiple languages and operating environments (Gurav & Shaikh, 2010).

In summary, we have identified the transaction costs that result from uncertainty and asset specificity associated with migration to cloud technologies (Table 2 summarizes the transaction costs and underlying causes). On the other hand, organizations incur substantial costs when they have to manage the applications and data stores in-house. In the next section we examine the costs of hosting applications and managing data on-premises.

	Transaction Cost Elements	Causes
1	Obscure operational information and more focus on pricing models	Information asymmetry that causes uncertainty in vendor and product selection
2	Issues of data Privacy, Security, auditability and compliance with laws	Physical location of data causing uncertainty in legal governance and shared data centers causing uncertainty in privacy and security of data
3	Reputation and Fate Sharing Issues	Multiple adopters sharing a common cloud increases uncertainty as inappropriate behavior of one customer can disrupt the entire cloud
4	Issues of Availability of Service	Problems of DDoS attacks and dependence on a single cloud vendor that cause uncertainty in service availability
5	Performance Unpredictability	Bugs that show up in larger distributed systems and problematic input / output sharing on cloud
6	Data transfer bottlenecks	Traffic on internet and huge data transfer charges on internet that lead to uncertainty in data transfer mechanisms causing uncertainty of performance
7	Vendor Lock-in and interoperability issues	Data lockin and proprietary APIs that cause interoperability issues and asset specificity

Table 2: Transaction Costs and their causes

Costs of not adopting cloud technology

When organizations make a decision to move their existing service to the cloud or host a new service on the cloud, they have to compare the costs of hosting on-premise versus the costs of hosting on cloud. Key characteristics of the firms' resources to be considered for determining suitability for cloud computing include size of the IT resources and the utilization pattern for these resources (Misra & Mondal, 2010). Costs of not adopting cloud include costs of resource underutilization and saturation of resources, and operations costs of providing these services in-house.

Cloud computing offers the benefits of elasticity and transfers the risks of under provisioning and over provisioning of resources to the cloud provider. When one hosts these services in-house, they have to provide for resources capable of handling peak load, which leads to under utilization of these resources during off-load times. Greater the variation between peak and non-peak utilization, greater is the under utilization of resources, when provided for peak-load (DeCandia, et al., 2007). In real world, server utilization in databases is usually as low as 5% to 20% (Rangan, 2008).

Apart from this aspect of underutilization there is another reason for unequal utilization of resources. Software applications usually require a model of storage, a model of computation and a model of communication and most applications do not make equal use of computation, storage, and network bandwidth (Armbrust, et al., 2009). Cloud computing provides an option of paying separately for each of these resources depending on usage. But if one has to provide these resources in-house, they incur costs due to the in-elasticity of provisioning.

The costs of power, cooling and physical plan costs remain in-house and they have to be accounted for while comparing costs of hosting a service in-house versus hosting on cloud (Hamilton, 2008). Though hardware operating costs are low and minimally trained personnel can manage hardware, software management costs will have to be accounted for. Software must be installed and configured, then updated with each new release. The computational infrastructure of operating systems and low-level utilities must be maintained. Every update to the operating system sets off a cascade of subsequent revisions to other programs (Hayes, 2008).

We can thus conclude that operations cost of under-utilized resources is a major expense in hosting the service in-house.

Guidelines

So far we have discussed the transaction costs of cloud adoption and the costs of not migrating to cloud. Potential cloud adopters evaluate both these costs to take a decision about migrating to cloud. Despite many advantages provided by cloud technologies and the costs of hosting the services in-house, we posit that transaction costs inhibit adoption of cloud computing. We propose a set of guidelines for cloud adopting organizations and cloud providers that can reduce the transaction costs of cloud adoption. The following sections describe these guidelines in detail. Table 3 provides the classification of these guidelines.

	Transaction Cost Elements	Causes	Guidelines for Cloud Adopters	Guidelines for Cloud Providers
1	Obscure operational information and more focus on pricing models	Information asymmetry that causes uncertainty in vendor and product selection	-	Internal monitoring mechanisms and transparency
2	Issues of data Privacy, Security, auditability and compliance with laws	Physical location of data causing uncertainty in legal governance and shared data centers causing uncertainty in privacy and security of data	Adopt encrypted storage; seek legal advice on compliance to local regulationsccess	Make use of latest tools and technologies; protect harware facilities by restricting access
3	Reputation and Fate Sharing Issues	Multiple adopters sharing a common cloud increases uncertainty as inappropriate behavior of one customer can disrupt the entire cloud	Subscribe to reputation-guarding services	-
4	Issues of Availability of Service	Problems of DDoS attacks and dependence on a single cloud vendor that cause uncertainty in service availability	Work with multiple vendors; Use elasticity of cloud to fight DDoS attacks	-
5	Performance Unpredictability	Bugs that show up in larger distributed systems and problematic input / output sharing on cloud	Development of applications on virtual machines	Experiment with efficient architectures and flash memory; Use "gang scheduling" for HPC
6	Data transfer bottlenecks	Traffic on internet and huge data transfer charges on internet that lead to uncertainty in data transfer mechanisms causing uncertainty of performance	-	Shipping hard disks ; data archival procedures
7	Vendor Lock-in and interoperability issues	Data lockin and proprietary APIs that cause interoperability issues and asset specificity	-	Adopt open standards and collaborate with other vendors

Table 3: Guidelines for Cloud Adopters and Cloud Providers

Information Costs

Information costs, incurred by cloud adopters, are a result of information asymmetry that exists in the transaction. Transparency on the part of cloud vendors is a solution to reduce uncertainties involved in information gathering and decision making.

Uncertainty. To reduce the transaction costs for cloud adopters that may be incurred in information search about cloud providers and their offerings, cloud providers may put in place internal mechanism to monitor their performance and be very transparent about their performance measures and billing models and operational details. Transparency allows the customer to gain a level of trust as to the expected performance of the infrastructure and the vendor (Durkee, 2010).

Contracting Costs

Transaction costs involved in preparing a contract can be reduced by taking appropriate measures to safeguard against the uncertainties associated with data privacy, security, auditability, etc. Both cloud vendors and adopters have a role to play in reducing these uncertainties. There is a possibility of utilizing up-to-date tools, data security technologies and stringent practices to ensure data privacy and security. Contractual safeguards are a good means of ensuring auditability and compliance.

Uncertainty.

Data Privacy, Security, Auditability and Compliance. To reduce any uncertainty that may stem from privacy and security issues, cloud adopters can deploy well understood data security technologies such as encrypted storage (Armbrust, et al., 2009).To ensure cloud provider's compliance to regulatory aspects of cloud data, it is critical to obtain proper legal advice to ensure that the contract specifies the areas where the cloud provider is responsible and liable for ramifications arising from potential issues (Dlodlo, 2010). Cloud computing vendors can utilize the most sophisticated and up-to-date tools and procedures, and strive to provide better security and privacy than is available for on-premises computing (Suwon, 2009). They can restrict access to hardware facilities, adopt stringent accountability and auditing procedures, and minimise the number of staff who have access to critical components of the infrastructure (Dlodlo, 2010).

Reputation and Fate Sharing. To address this issue, cloud adopters could subscribe to reputation-guarding services similar to "trusted email" services that are currently being offered (Armbrust, et al., 2009).

Coordination Costs

Similar to the contracting costs, transaction costs related to uncertainty and asset specificity involved in migrating to cloud can be reduced by appropriate contractual agreements and standardization of services. One can experiment with efficient architectures and alternate mechanisms for reducing performance unpredictability, resolving issues of unavailability and working around data transfer bottle necks.

Uncertainty.

Issues of availability of service. To overcome the uncertainty associated with the availability of cloud services and the transaction costs that follow, cloud adopters can choose viable vendors and as a contingent plan depend on multiple vendors for their requirements. They must seek service level agreements (SLAs) that motivate vendors to ensure desired level of availability. They can also take up precautionary measures such as having on premises back up and deciding not to store critical data on cloud (Suwon, 2009). To protect themselves from DDOS attacks, they can take the advantage of elasticity provided by cloud computing. Elasticity provided by Cloud shifts the risks of DDoS attacks to cloud providers (Armbrust, et al., 2009).

Performance unpredictability. To reduce the uncertainty in performance of applications on cloud, cloud providers can explore more efficient architectures to virtualize input / output channels and can experiment with flash memory. They can also come up with new ways of running parallel programs on simultaneous threads which enable faster processing of batch operations such as gang scheduling (Armbrust, et al., 2009). In reducing the costs that have to be incurred on discovering and correcting bugs that appear on large scale distribution over the cloud, cloud adopters can develop their applications on virtual machines (Armbrust, et al., 2009). They can ensure that the Service Level Agreements specify the performance requirements of the adopters. Before adopting cloud services, organizations can assess the communication bandwidth requirements, and evaluate the performance behavior of the applications with respect to transfer of large amounts of data (Kim, Kim, Lee, & Lee, 2009).

Data Transfer Bottlenecks. To reduce data transfer bottlenecks and the related transaction costs, cloud vendors can provide data shipping facilities via hard disks (Armbrust, et al., 2009; Currier, 2011). It is also beneficial to have data archival procedures in place to gain the trust and confidence of cloud adopters.

Asset Specificity.

Vendor lock-in and Interoperability Issues. To address the transaction costs related to asset specificity that arises from vendor lock-in, cloud vendors may target standardizing their application programming interfaces which will enable cloud adopters to work with multiple cloud vendors and they can also integrate their public and private clouds. Providers can collaborate with one another and support open standards that will simplify adoption of multiple cloud technologies for the enterprises adopting cloud. Cloud schemes adopting standards enables splicing multiple clouds and non-cloud offerings to create custom suites and integration that is most relevant to the needs of enterprises (Currier, 2011). “Providers who encourage open standards, non-legacy technologies, easy migration and collaboration are likely to gain the most credibility.” (Porta, Karimi, & Botros, 2009).

Conclusion

Cloud computing with its chief selling points of flexibility and versatility has immense potential to transform IT industry. Benefits of Elasticity from cloud computing could bring to the IT infrastructure what Henry Ford brought to the automotive industry with assembly lines and mass production: affordability and substantial improvements on time to market (Owens, 2010). In this paper we have looked into the costs of hosting applications and data centers on-premises and identified critical obstacles to growth of Cloud Computing from the lens of transaction cost economics. We have also come up with guidelines for both cloud adopters and providers to reduce the transaction costs involved with migration to cloud. These guidelines can mitigate the inhibitions to cloud adoption.

This paper on the whole establishes the suitability of Transaction Cost theory in taking make/buy decisions. We have used transaction costs theory to explain decisions to migrate to cloud. This paper could benefit from integrating agency theory and transaction cost theory to evaluate the choice between market and hierarchy. We intend to take this thought forward in our future studies.

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