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# IMPACT OF CLOUD ASPECTS ON IT EFFECTIVENESS

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## ABSTRACT

Against the backdrop of new economic realities, one of the larger forces that is affecting businesses worldwide is cloud computing, whose benefits include agility, time to market, time to capability, reduced cost, etc. The intent of this research was to contribute to the body of knowledge that could be applied by researchers, businesses, and IT organizations alike to achieve optimal results by focusing on the key aspects of cloud based services and solutions. The study findings provided statistical evidence that cloud connectivity, software and application modularity within cloud, as well as software and systems compatibility within cloud have strong positive correlations on IT effectiveness. Also, having multiple interfaces for users to access applications on cloud, portability across multiple cloud providers, legacy systems not hampering development of new applications in cloud, and multi-protocol support are identified as the top four aspects which has much higher positive impact on IT effectiveness.

**Keywords:** cloud computing, information technology, IT, IT effectiveness

## INTRODUCTION AND BACKGROUND

Information technology (IT) is changing the way businesses operate, the process of creating products and services to their customers, and in the way they compete [2]. Today's IT challenges faced by Chief Information Officers (CIOs) include cost pressure, lack of agility, security, recovery from recession, and to enable new products & services [18]. Cloud computing can potentially transform a majority of the information technology industry into services oriented IT organizations or simply IT as a Service (ITaaS), changing the way software and hardware are designed and purchased. Cloud computing derives from a long history of research and development on various approaches to IT outsourcing, in which customers draw from a service provider's pool of capacity on a pay-as-you-go basis as an alternative to managing their own IT infrastructure [39, 57]. Cloud computing is an outcome from decades of research in various disciplines including virtualization, distributed computing [36], utility computing [21, 53], networking, and software services [62]. Some of the key attributes of cloud computing are service-based, scalable, shared, metered billing, elastic and incorporates advanced technologies like virtualization [50]. However, there are many challenges that come along with cloud concept, biggest of them being security, performance and availability although cost and speed of adoption remain the top benefits of cloud computing [25]. According to Gartner, cloud computing is the top strategic technology for 2010 [51].

There are three service models in cloud computing: (a) Software-as-a-Service (SaaS) (b) Platform-as-a-Service (PaaS) (c) Infrastructure-as-a-Service (IaaS). Effectiveness of IT is known as the degree to which IT can effectively and efficiently deliver and/or integrate with the technology based services and solutions. Strategic alignment with business stakeholders has traditionally been viewed as the means to achieve greater IT delivery capabilities, but recent trends seem to indicate higher cloud adoption (a combination of public and private clouds resulting in community and hybrid clouds) as a means of achieving IT effectiveness.

Pierce examined the relationships between business strategy, IT strategy, strategic alignment, return on IT investment, and corporate performance, and provided empirical evidence on the effect of alignment between business and IT strategies by measuring return on IT investment and corporate performance [52]. Tallon and Kraemer using the theory of dynamic capabilities examined the relationships between IT flexibility, strategic alignment and IT business value to assess whether capabilities around flexibility can enable corporations to realize greater payoffs from IT investment [59]. Ness examined the relationships between IT flexibility, strategic alignment and IT effectiveness to provide empirical evidence on the strength of these relationships and asserted with evidence that IT flexibility has greater influence on IT effectiveness than does strategic alignment on larger IT organizations [45]. Chebrolu examined the relationships between cloud adoption, strategic alignment, and IT effectiveness among all IT organizations irrespective of their type and size to provide empirical evidence that adoption of cloud technologies does positively impact IT effectiveness than does strategic alignment [11]. This study is an extension of Chebrolu's [11] research, drilling down to study the impact of cloud adoption's individual construct elements and sub-items (cloud aspects) and their measures on IT effectiveness. This study also measured the impact of each of the fifteen cloud aspects on their respective parent constructs as well as on IT effectiveness as a whole.

## Statement of the Problem

Increased competitive pressures upon businesses as a result of global competition [64], increased complexity and economic uncertainty [33] and more dynamism in the marketplace [8] are continuing to escalate, generating the need for higher efficiency and productivity among IT organizations. In preparation for economic recovery from the latest global recession which started in 2007, many IT organizations have been analyzing their management practices and sharpening their business models [31]. Information technology (IT) budgets will be leaner, management discipline tighter and business models more focused. The practice of removing extra expenses from the IT portfolio and determining areas of strategic investment is essential in a restricted economy [31]. Breakthroughs in technology based services and solutions are driving frequent, rapid, and unplanned changes in business strategies along with the resultant demand upon IT for its support required to achieve sustained competitive advantage [45]. While adoption of cloud computing provides lot of benefits including real time provisioning, pay-as-you-go billing which could align with business strategy in IT organizations, it has its own share of complexities in terms of security, performance, availability and integration challenges [41]. Spending in IT related to adoption of cloud based services and solutions in 2008 is \$16.3 B which is projected to reach \$42.2 B by 2012 as cloud-computing related spending will account for 25% of annual IT expenditure growth [24]. US government projects that between 2010 and 2015, it's spending alone on cloud computing will be at a 40% compound annual growth rate and will pass \$7 B by 2015 [34]. Providing a wide array of computing-related services on the fly on a pay-as-you-go basis opens up many opportunities for the cloud providers in that expanding market which is worth \$100B [9]. It is not clear how many of those IT organizations which adopted cloud based services and solutions are more effective than what they were before the cloud adoption and which aspects of cloud technologies and solutions or services really helped those IT organizations (as cloud consumers) the most. In particular, based on the literature reviewed, there was a lack of empirical evidence about the impact of each individual aspect of cloud technology on IT effectiveness. This study is an attempt to validate their relationships and to analyze which, if any, aspect of cloud has a higher correlation with IT effectiveness.

## Assumptions and Limitations

The assumptions of this study were that the participants would answer the survey questions based on their technical expertise in information technology. The participants' technical expertise must include knowledge pertaining to their firm's cloud adoption and how effective their IT organizations are. Also, it was assumed that the participants would answer all survey questions honestly. The limitations of this study were that the sampling population firms in the United States have one, or more, IT employees. The results from this study should not be generalized to non IT organizations. In addition, the results would represent participants from multiple business types, and therefore, the results should not be interpreted as representing any specific business sector, type or size.

# LITERATURE REVIEW

## Cloud Computing

From a technical perspective, cloud computing mainly focuses on service-oriented architecture (SOA) and virtualization of both hardware and software [34, 41]. Cloud computing offers reduced IT overhead for the customers, great flexibility, reduced TCO (Total Cost of Ownership), on-demand services, and improved productivity [65]. Economic benefits, simplification and convenience of the way computing services are delivered seem to be the key drivers to speed up the adoption of cloud computing [19]. Cloud adoption fast tracks the cost reduction, increases efficiency and ultimately creates a competitive advantage in any market [20].

There are lot of application types (reporting, transactional, data-interactive) where cloud computing has been adopted including higher education [57, 66, 56], solutions for human resources [20], software testing [4], data back-up or archive services [61], web 2.0 based collaborative applications [48], storage capacity on demand [35], and content distribution services [22]. New use cases and approaches, taking advantage of cloud computing are being actively proposed in the industry, for example, market oriented allocation of resources [9], hard discrete optimization problems [38], defending financial infrastructures against attacks and frauds using intelligence in the cloud [40], collaborative business intelligence [6], data mining algorithms and predictive analytics [68, 28], software testing as a service [13], e-government solutions [10], architecture and implementation courses at graduate level in the cloud [30]. Various cloud agnostic middleware is mushrooming up to augment the functionality provided by cloud providers [41]. Cloud brokers are helping to increase the adoption of cloud computing for various IT organizations by addressing secure and reliable integration needs. The evolving approach of using cloud adapters which use APIs targeting multiple clouds and hide the complexity could help cloud adoption further.

There are several research opportunities in cloud computing that are actively being pursued in the areas of cloud process and workflow management, meta-data management, security, service portability [62], enterprise grade cloud computing [44], efficient indexing for data management on cloud [69], various fee structures and classification and quantification of the execution costs on cloud [17]. Cloud computing poses tremendously interesting research questions and opportunities, especially in the areas of distributed systems, power management, inter-cloud communication protocols, virtualization architectures, service-oriented architectures and management technologies [6, 18] and automated control in terms of decoupling, feedback, and granularity [41].

There are some challenges of cloud computing like trust, privacy, data ownership and control, which trade-off with the cloud benefits like scalability, ease of deployment and ease of management [19]. Various aspects of security need to be addressed by cloud computing technology solutions and cloud computing service providers to increase the cloud adoption [12, 34, 43, 49, 63, 65]. However, some cloud providers argue that their security measures and processes are more mature than those of an average IT organization, which suggests that the security posture of applications or services will be improved with the adoption of cloud. Cellary and Strykowski [10] stated that the professional security staff employed at a cloud provider will be able to ensure higher security of hardware and software than the corresponding security personnel employed in multiple smaller IT organizations. The ability to get smarter through the use of cloud is the key differentiator that will sufficiently alleviate security concerns to ensure widespread adoption [11]. As the cryptographic techniques get more mature, like those which allow computations to be performed on cipher text, they may open up new possibilities for cloud computing security. Federated identity management needs to become a common architectural model to authenticate users on applications which are deployed at multiple cloud providers. Increasingly complex integration and the dynamics in cloud computing present significant challenges to timely diagnosis and resolution of incidents such as malware detection and immediate intrusion response to mitigate the impact [12]. Incidence management should be thought through and integrated into service life cycle management (design, deployment and maintenance of services) on the cloud.

US government launched a major cloud initiative to come up with useful minimal standardizations to promote interoperability and portability of services across cloud providers that will help large enterprises unlock the full potential of cloud computing [23]. Open source community in an effort to develop inter-operability frameworks and standards for cloud computing, created what is called open cloud consortium, which is being used by various organizations for information sharing on various aspects of cloud [28]. Vendor lock-in issues are discussed in greater detail by Brandel [7] who summarized both sides of the argument about the amount of risk associated for cloud based systems as against to on-premise systems. According to Brandel [7], the degree of vendor lock-in issue depends on the type of cloud deployment, use of proprietary user interfaces (UIs) and application programming interfaces (APIs). This implies that risk is more in case of SaaS and PaaS models than IaaS models due to the potential usage of APIs in SaaS and PaaS models. There are tools available in the market which creates an abstraction layer on top of the vendor services and interfaces and hence make the cloud based applications more portable across cloud providers. In some cases, vendor lock-in risk involved with cloud based systems is the same as the risk involved with data housed in traditional on-premise ERP systems, like Oracle, SAP [7].

Due to the cost structure and pay-as-you-go flexibility promise, the adoption of cloud services may be more applicable for small and medium scale companies and cash-strapped educational establishments which are often used to similar outages caused by their own in-house IT systems in the past [57]. Among individual or end users, as of September 2008, about 69% of Americans use some form of cloud computing services, including webmail and online data backup services [34]. But, recent research suggest that even large companies are in fact already using certain types of cloud services like infrastructure and storage services and their cloud adoption is only going to increase in future [26]. Enterprises will start building private clouds to leverage existing infrastructure, thereby making cost-effective use of previous investment. Some other enterprises are adopting hybrid cloud models as they build private clouds while still using public clouds as a means to complement their internal capacity [5, 23]. The more and more the applications move onto the cloud, the more and more, the requirements come up to connect back to the systems (e.g., databases, email servers) that are remaining on-premise or located at other cloud providers [67]. Even though data security is a common concern for public cloud adoption, about 75 to 80 percent of intellectual breaches are a result of attacks originating inside the company, which would not impact a decision to use clouds one way or other [16].

## IT Effectiveness

Several studies have shown that effectiveness of IT investments lead towards favorable results in terms of firms' performance directly or indirectly across various business fields such as health care industry [29], rubber industry [32], supply chain management [27], and across various countries and transitional economies [54]. Research also indicates that firms with superior IT capability exhibit higher performance when compared to average industry performance [55]. Huang [32] found that several factors such as ease of use, frequency and length of use and company culture and attitudes of employees towards IT affects the company's performance in a positive manner, even though there is no direct impact of IT investment on performance. Motjolopane & Brown [42] recognized that by achieving strategic business-IT alignment, IT investments contribute immensely in improved organizational performance. Lee, Chu & Tseng [37] argued that strategic alignment between IT and business is required to use IT assets effectively to assist business management and practices and to functionally integrate with internal and external variables. González-Benito [27] found out that IT investment and its effectiveness is related to the degree of strategic integration with business and the performance improvement of business due to IT takes place in different ways and at different levels.

Over years, research has shown that the companies which spent more on IT upgrades increased in value and improved their earnings performance over time [29, 32]. Research has established that instead of simply adapting IT to existing processes, an effective use of IT which requires interpretation, analysis and redesign of information flows and finally business processes will provide expected competitive advantage [27]. Studies has shown that IT can enable the coordination of different but related resources to create new products and services which can enhance value to the customers [55]. Measurement of IT effectiveness to organizational performance provides a benchmark from which many IT processes can be evaluated and refined, without which IT may be undervalued by top executives with implications to future budget allocations [3].

# METHODOLOGY

## Research Design

The purpose of this quantitative correlational study was to examine the relationship between various elements of cloud adoption by IT organizations and their IT effectiveness which can be measured and published. The intent of this research was to contribute to the body of knowledge that could be applied by researchers, businesses, and IT organizations alike to achieve optimal results through adoption of cloud based services and solutions. The research was designed to study the degree to which elements of cloud correlates with IT effectiveness in terms of IT's ability to deliver solutions to the business in a dynamic marketplace. In addition, the research was intended to study how scale items of cloud construct elements impact IT effectiveness. The research questions were:

1. To what extent, if any, is “connectivity to cloud” related to IT effectiveness among all IT organizations, irrespective of their type and size?
2. To what extent, if any, is “software and application modularity within cloud” related to IT effectiveness among all IT organizations, irrespective of their type and size?
3. To what extent, if any, is “software and systems compatibility within cloud” related to IT effectiveness among all IT organizations, irrespective of their type and size?
4. To what extent, if any, was the relationship between “software and systems compatibility within cloud and IT effectiveness” stronger than that between” “connectivity to cloud and IT effectiveness” or “software and application modularity within cloud and IT effectiveness” among all IT organizations, irrespective of their type and size?

The research design was non-experimental and the research approach was quantitative correlational, which allows for some flexibility in assessing the relationships among the variables. In an effort to retain the identical validity and reliability from previous research methods and instrumentation by Ness [45], and Tallon and Kraemer [59], a 7-point Likert-type scale was used to represent ordinal data values. Prior research was used as the basis for certain construct elements, measures, as a means for measuring and determining construct’s reliability, validity, and correlation. The studies from Ness [45], Tallon and Kraemer [59] and Pierce [52], along with their survey formats, were used as a means to achieve construct measurement and instrumentation.

The analyses of ordinal data values were handled through chi-square testing followed by multiple regression tests and analysis. The use of regression analysis for ordinal data types was consistent with prior research by Ness [45], Tallon and Kraemer [59] and Pierce [52]. The survey questions on IT flexibility by Ness [45], with appropriate modifications to apply for cloud computing technologies and services were used as part of the total survey instrument in this study to achieve overall construct reliability, validity, and correlation among elements and measures of cloud adoption and IT effectiveness.

## Conceptual Model

This study’s conceptual model is shown in Figure 1. It is an extension of Chebrolu’s [11] research, drilling down to study the impact of cloud adoption’s construct elements and their individual measures on IT effectiveness.

## Operational Definition of Variables

The elements from prior research by Ness [45] and Tallon and Kraemer [59] were used to assess the construct of IT effectiveness, whereas the elements used to assess the construct of IT flexibility were used to assess the construct of cloud adoption. This method of measurement helped to ensure validity and reliability between this study and previous research. Cloud adoption had multiple survey questions that were used to measure each element’s strength towards IT effectiveness based on a 7-point Likert-type scale. The total strength of the overall construct on IT effectiveness was determined through an averaging of the means of each construct’s elements. The primary elements belonging to each of the three constructs on this study were as follows:

*Cloud Adoption Elements.* The three elements are connectivity (CON), modularity (MOD) and compatibility (CMP). The research instrument questions to assess IT flexibility used by Ness [45] and Tallon and Kraemer [59] were all based on a 7-point Likert-type scale, representing ordinal data.

*IT Effectiveness Elements.* The primary elements (or items) that were used to measure IT effectiveness construct were taken from prior research by Tallon, Kraemer, and Gurbaxani [60], which they used to assess the construct of strategic flexibility. Ness [45] asserted that elements used to measure strategic flexibility appeared to be closely aligned operationally and provided the best source to measure IT effectiveness. These elements are ‘overall quality of service’, ‘user satisfaction with IT’ and ‘helpfulness of IT staff to users’.

This study was consistent with the prior researchers in terms of methodology and hence a 7-point Likert-type scale was used as the basis for data collection and analysis. A 7-point Likert-type scale ordinal data represents data elements in an ordered measurement relative to size or quality [1]. In regression analysis, it is verified that independent variables in the collected data have a normal distribution prior to testing.

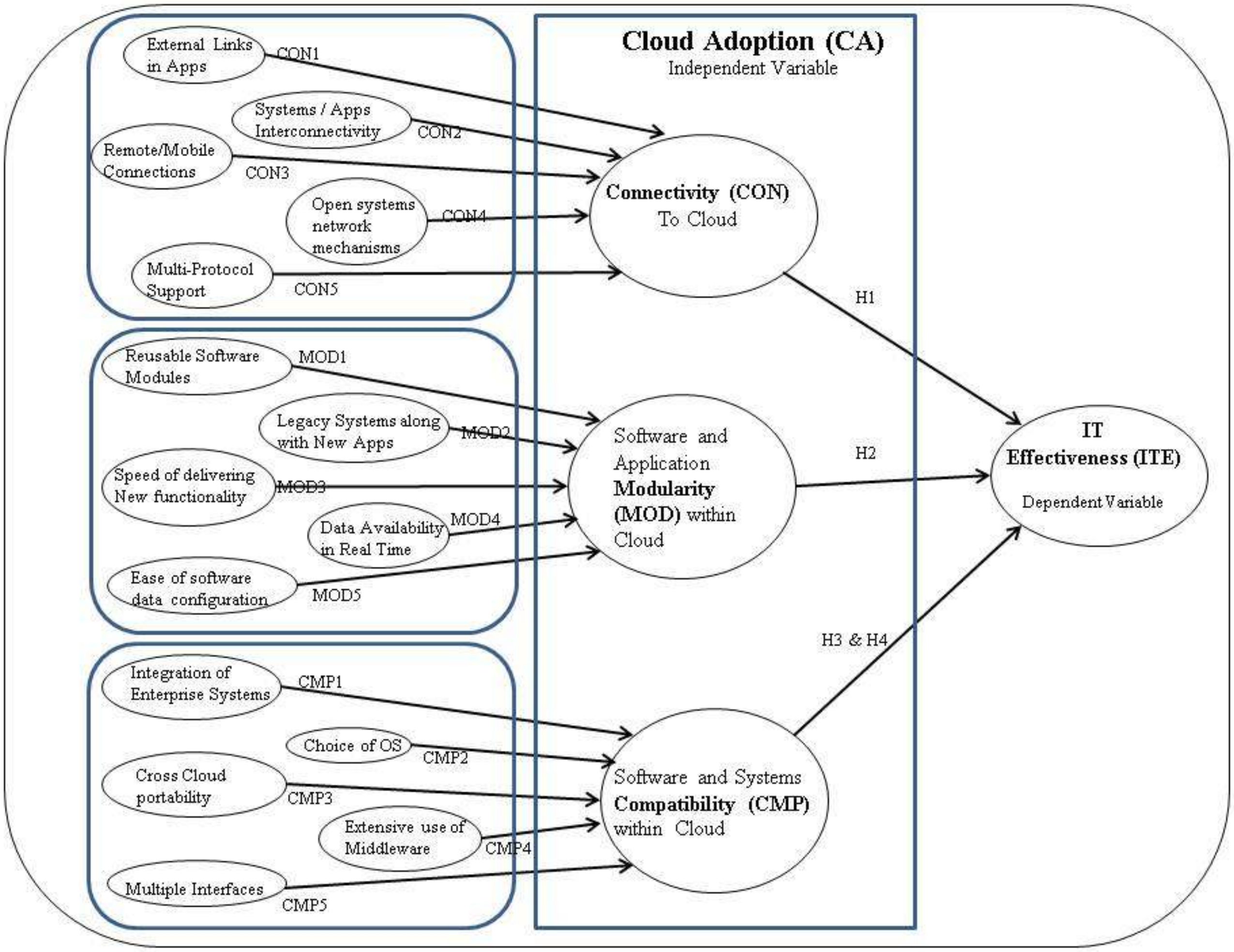


Figure 1: Conceptual Model

## Sample

The sampling methods used by prior researchers were followed as much as possible to replicate validity and reliability. The target population for this study needs to be those who had extensive knowledge of IT and its relationship to the business. In most cases, senior IT managers (including IT directors, IT VPs, IT SVPs) in the role of CIOs were identified to satisfy this population criterion. A list of 4,146 names and mailing addresses of top IT executives (CIOs - Chief Information Officers) were purchased from Applied Computer Research Inc. (http://www.itmarketintelligence.com). The above count of 4,146 was based on the contacts that were playing CIO role in various IT organizations with titles like CIO, Deputy CIO, Acting CIO, Co-CIO, Global CIO, Interim CIO, and Associate CIO out of a total of 30,466 contacts that were available in ACR database for IT executives based in United States. Unlike similar studies done by Ness [45], size and type of the IT organizations were not used to narrow down the contacts, as this study is focused on all IT organizations, and hence include all sizes (small, medium & large) and all types (for-profit, for-nonprofit, educational, corporate and government organizations). Out of 4,146 survey memos that were mailed, 71 were returned as undeliverable by the USPS. The eligible remaining participants were 4,075.

### Instrumentation / Measures

The survey instrument consisted of questions that were designed to collect information from the participants on cloud adoption and IT effectiveness. The source for this study's survey instrument was based on the research done by Ness [45] on IT flexibility, strategic alignment and IT effectiveness. The survey was a combination of the original survey questions that were created by Tallon, Kraemer, and Gurbaxani [60] and later used by Tallon and Kraemer [59] and Ness [45] for IT flexibility, strategic alignment and IT effectiveness. The survey questions for IT flexibility were modified minimally to apply for cloud adoption (which is a form of IT flexibility as mentioned earlier). In an attempt to replicate the original survey, the layout and format of the previous survey questionnaire was maintained for added validity and reliability. All questions maintained their original standardized 7-point Likert-type scale format for assessment.

### Data Collection and Analysis

Data was collected through an online survey instrument that was described earlier. Online survey link was distributed to the potential participants by sending an envelope by USPS regular mail, which pointed participants to the survey questionnaire hosted at SurveyMonkey's website (https://www.surveymonkey.com), a company specializing in online survey data collection and storage. The targeted participants in this survey were IT executives (whose titles include Director, VP, SVP) playing the role of CIOs for US based firms. A total of 148 participants had responded to the survey questionnaire within the timeframe allotted for statistical analysis from among 4,075 eligible participants, but only 143 participants provided answers to at least one question. The survey results in the form of a zip file containing Microsoft Excel© spreadsheet was downloaded from SurveyMonkey's Web site. The data was then imported into SPSS student version 20 software for the required statistical analysis and formatting. Multiple regression analysis were performed as confirmation to the chi-square results obtained. The strength of each relationship between ITE, CON, MOD, and CMP was evaluated based on the correlation coefficients and the statistical significance level calculated for each factor.

### Validity and Reliability

According to Swanson and Holton [58], there are three common types of validity: content validity, criterion validity and construct validity. A construct is something that cannot be directly measured or observed like job satisfaction and IT effectiveness. A construct can be measured quantitatively and analyzed statistically, which is what this study incorporated. According to Cooper & Schindler [15], a measure is reliable to the degree that it supplies consistent results. Reliability is a necessary contributor to validity but is not a sufficient condition for validity. The reliability of a study implies that the operations of the study can be repeated with the same results.

## FINDINGS

### Assessment of Scale Validity and Reliability

According to the G*Power 3 post hoc power analyses, a sample size of 118 was recommended to achieve the statistical power necessary to establish the validity of this study. The survey sample collected by SurveyMonkey.com totaled 143. In addition, an overall Cronbach's Alpha score of 0.805 was calculated from standardized items that substantiated the internal consistency for this study. Norusis [47] recommended a Cronbach's Alpha score of at least 0.5 to establish the reliability of a study's measures. These statistical tests have shown that the data used in this study are both valid and reliable. Only 118 participants answered all 18 questions as some participants chose to skip few questions. Norusis [46] recommended that before calculating a correlation coefficient, a screening for data outliners should be made to prevent misleading results. A box and whisker plot was completed using the entire 118 response dataset. The box and whisker plot identified one response dataset (92) for ITE outside of inter quartile range; whereas it identified three response datasets (45, 92, 110) for CON and MOD; however identified five response datasets (45, 50, 92, 107, 110) for CMP outside of inter quartile range as shown in Figure 2. Norusis [47] warned that any dataset outside the whisker range in the box and whisker plot is considered an extreme and should be removed from the full response dataset. Therefore, the datasets (45, 50, 92, 107, 110) were removed from this study leaving 113 responses for analysis.

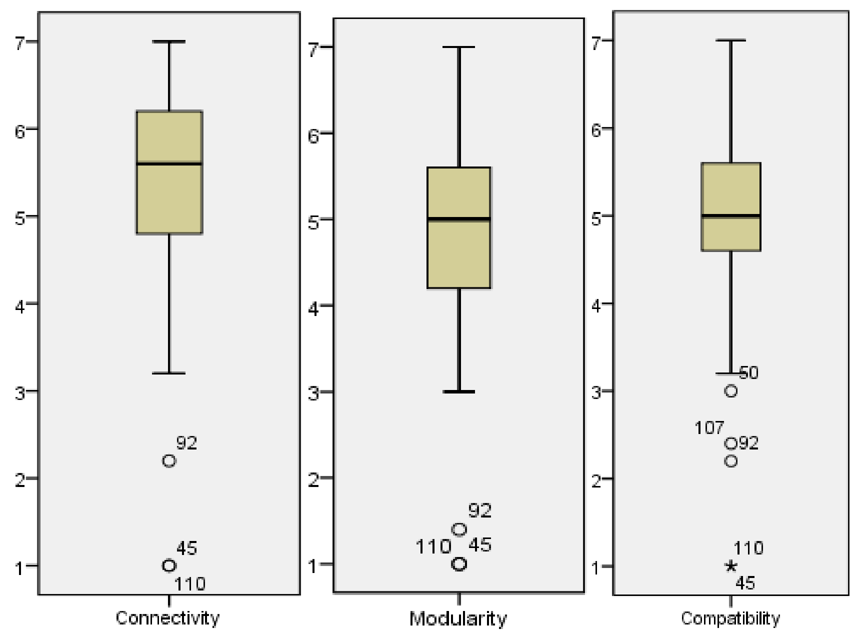


Figure 2: CON, MOD, and CMP Box and Whisker Plots (n=118)

## Analysis and Evaluation of the Research Data

**Bivariate Correlations and Linear Regression Analysis:** After adjusting the full response dataset to 113, an inter-scale correlation test was performed on all paired constructs such as ITE-CON, ITE-MOD, and ITE-CMP (see Table 1). The arrangement of variables in the bi-variate correlations test were that the ITE variable was the target (dependent) and the CON, MOD and CMP were the predictor (independent) variables. The results of the tests revealed that positive correlations existed between ITE-CON at r = .467 ($p < .001$, $r^2 = .218$), between ITE-MOD at r = .432 ($p < .001$, $r^2 = .187$), and between ITE-CMP at r = .524 ($p < .001$, $r^2 = .275$). The linear regression tests validated the bivariate correlation test results by producing the exact calculations. The Phi/Pearson's R value provided evidence that there are positive correlations between the paired constructs of ITE-CON (r = .467, p < .001), ITE-MOD (r = .432, p < .001), and ITE-CMP (r = .524, p < .001).

Table 1: Bivariate Correlation Results (n=113)

| | ITE-CON | ITE-MOD | ITE-CMP |
|---|---|---|---|
| Pearson's Correlation (r) | .467 | .432 | .524 |
| R-Square ($r^2$) | .218 | .187 | .275 |
| Sig. (2-tailed) (p) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

**Pearson's Chi-Square Test:** The Pearson's chi-squared test results with 113 response datasets are shown in Table 2. The Pearson's chi-squared results for ITE-CON were $\chi^2(1,N = 113) = 247.446$, p < .001; for ITE-MOD were $\chi^2(1,N = 113) = 203.607$, p < .001 and that for ITE-CMP were $\chi^2(1,N = 113) = 116.349$, p < .001. All the relationships between ITE and aspects of Cloud such as CON, MOD and CMP are statistically significant because p < .001 in case of each of them.

Table 2: Pearson's Chi-Square Crosstabs Analysis Results (n=113)

| | ITE-CON | ITE-MOD | ITE-CMP |
|---|---|---|---|
| Pearson's chi-square | 247.446 | 203.607 | 166.349 |
| Phi/Pearson's R | .467 | .432 | .524 |
| R-Square (calculated) | .218 | .187 | .274 |
| Approx. Sig. | .000 | .000 | .000 |

**Scatter Plot Analysis:** According to Norusis [47], the inequality of regressions or heteroscedasticity, represents a sequence of random variables with different variances and hence square-root transformations are commonly used for positive data when addressing the assumption of heteroscedasticity in linear regression analyses. The paired constructs of ITE-CON, ITE-MOD and ITE-CMP have positive slopes, but still the technique of square-root transformation for the ITE construct was used for further analysis. However, the same kinds of slopes with similar $r^2$ linear values are obtained as shown in Figure 3.

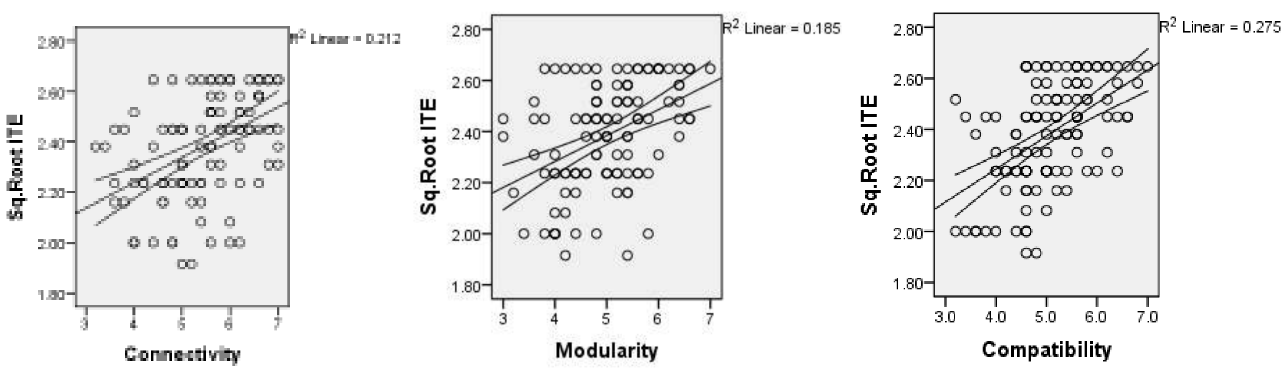


Figure 3: √ITE – CON, √ITE – MOD and √ITE - CMP Scatter Plots (n=113)

**Normal P-P Plot for √ITE, CON, MOD and CMP:** According to Norusis [46], an assumption of hypothesis testing is a normal distribution of values of the dependent variable. To demonstrate that √ITE had a normal distribution at the reduced response dataset of 113, the observed cumulative probability was plotted against the expected cumulative probability for √ITE. Figure 4 shows that the standardized values represent a normal distribution of the dependent variable and conformed to the assumption of homoscedasticity for regression analysis. Therefore, the 113 datasets represented in √ITE (IT effectiveness) for this study was valid for parametric regression testing. Similarly, the observed cumulative probability was plotted against the expected cumulative probability for CON, MOD and CMP to make sure that the 113 datasets represented in CON, MOD and CMP for this study were valid for regression testing.

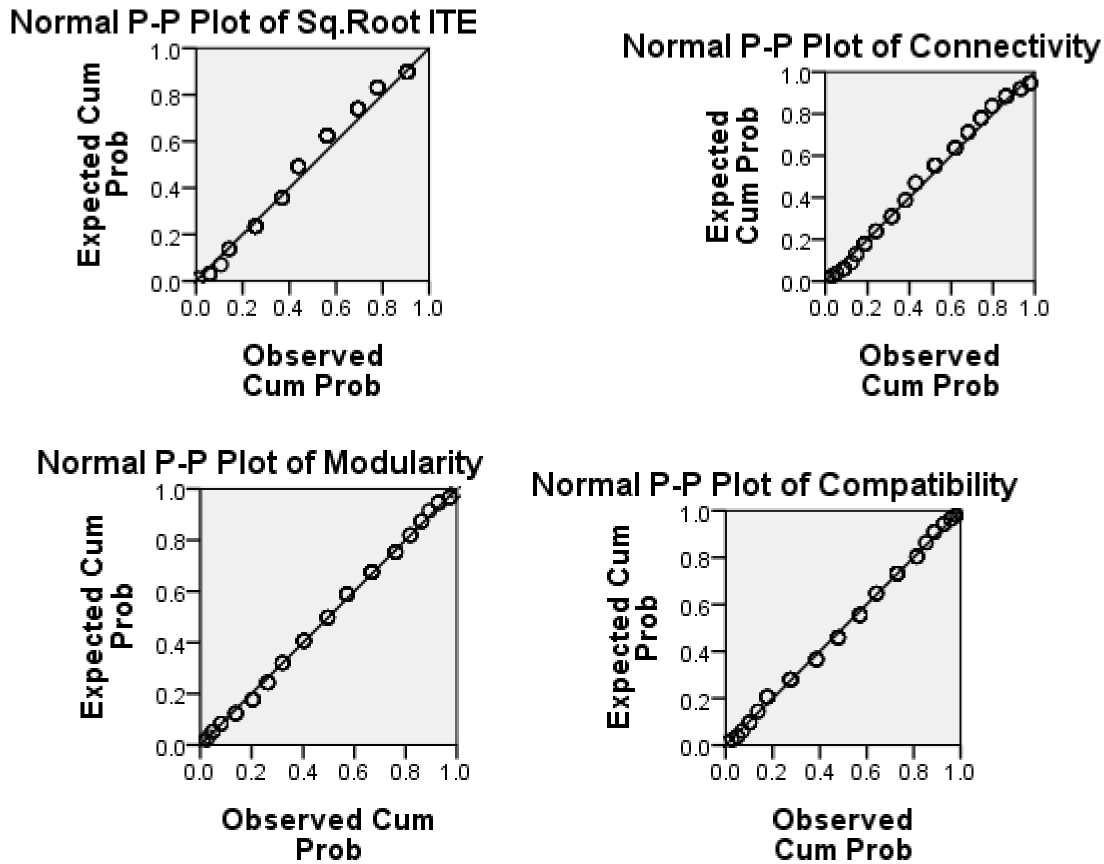


Figure 4: Normal P-P Plots for √ITE, CON, MOD and CMP (n=113)

**Bivariate Correlations and Linear Regression Analyses with √ITE:** The direction and strength of the relationships between the variables were determined by the $r^2$ values of each correlation calculation (see Table 3). The p-value was the basis for the rejection or not of each null hypothesis of this study. The bivariate correlations and linear regression analyses were performed using the √ITE transformation for all paired constructs. Table 3 shows that the paired construct of √ITE – CON ($r = .460$, $r^2 = .212$, $p <= .001$), √ITE – MOD ($r = .430$, $r^2 = .185$, $p <= .001$), and √ITE – CMP ($r = .525$, $r^2 = .275$, $p <= .001$) all had positive correlations.

The same method that was used to determine the correlations among the constructs in Table 3 was also used to determine the correlations among the individual scale elements within CON, MOD, and CMP. Table 4 shows the correlation and size of each scale element used within CON construct (External Links in Apps, Systems/Apps Interconnectivity, Remote/Mobile Connections, Open systems network mechanisms, and Multi-Protocol support) and √CON. Table 5 shows the correlation and size of each scale element used within MOD construct (Reusable software modules, Legacy systems, Speed of delivering new functionality, Data availability in real-time, and Ease of software configuration) and √MOD. Similarly, Table 6 shows the correlation and size of each scale element used within CMP construct (Integration of enterprise systems, OS choice, Cross cloud portability, Extensive use of middleware, and Multiple interfaces) and √CMP. The bivariate correlations test results in Table 4 provided evidence that there were positive correlations among the scale elements used within dimension of connectivity (√CON – CON1 at $r = .784$, $p < .001$; √CON – CON2 at $r = .796$, $p < .001$; √CON – CON3 at $r = .691$, $p < .001$; √CON – CON4 at $r = .736$, $p < .001$; and √CON – CON5 at $r = .848$, $p < .001$). Similarly, the bivariate correlations test results in Table 5 and Table 6 provided evidence that there were positive correlations among the scale elements used within dimension of modularity (√MOD – MOD1 at $r = .643$, $p < .001$; √MOD – MOD2 at $r = .679$, $p < .001$; √MOD – MOD3 at $r = .793$, $p < .001$; √MOD – MOD4 at $r = .619$, $p < .001$; and √MOD – MOD5 at $r = .631$, $p < .001$) and there were positive correlations among the scale elements used within dimension of compatibility (√CMP – CMP1 at $r = .221$, $p < .001$; √CMP – CMP2 at $r = .636$, $p < .001$; √CMP – CMP3 at $r = .794$, $p < .001$; √CMP – CMP4 at $r = .632$, $p < .001$; and √CMP – CMP5 at $r = .702$, $p < .001$). The effect sizes of each dimension and individual scale element within each dimension represent the $r^2$ value used in this study's conceptual model results as shown in Figure 5. Within the dimension of connectivity, the scale element CON5 (multi-protocol support) with ($r = .848$, $r^2 = .719$, $p <= .001$) seems to have maximum effect on cloud connectivity. Similarly, within the dimensions of modularity and compatibility within cloud, the scale elements MOD3 (speed of delivery new functionality) with ($r = .793$, $r^2 = .629$, $p <= .001$) and CMP3 (cross cloud portability) with ($r = .794$, $r^2 = .630$, $p <= .001$) seems to have maximum effect on modularity and compatibility respectively.

Table 3: Bivariate Correlation and Linear Regression Results with Transformation for ITE (n=113)

| | √ITE - CON | √ITE - MOD | √ITE – CMP |
|---|---|---|---|
| Pearson's Correlation (r) | .460 | .430 | .525 |
| R-Square ($r^2$) | .212 | .185 | .275 |
| Sig. (p) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

Table 4: Bivariate Correlation and Linear Regression Results with Transformation for CON (n=113)

| | √CON–CON1 | √CON–CON2 | √CON–CON3 | √CON–CON4 | √CON–CON5 |
|---|---|---|---|---|---|
| Pearson's Correlation (r) | .784 | .796 | .691 | .736 | .848 |
| R-Square ($r^2$) | .614 | .634 | .477 | .542 | .719 |
| Sig. (p) | .000 (<.001) | .000 (<.001) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

Table 5: Bivariate Correlation and Linear Regression Results with Transformation for MOD (n=113)

| | √MOD–MOD1 | √MOD–MOD2 | √MOD–MOD3 | √MOD–MOD4 | √MOD–MOD5 |
|---|---|---|---|---|---|
| Pearson's Correlation (r) | .643 | .679 | .793 | .619 | .631 |
| R-Square ($r^2$) | .413 | .460 | .629 | .383 | .398 |
| Sig. (p) | .000 (<.001) | .000 (<.001) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

Table 6: Bivariate Correlation and Linear Regression Results with Transformation for CMP (n=113)

| | √CMP–CMP1 | √CMP–CMP2 | √CMP–CMP3 | √CMP–CMP4 | √CMP–CMP5 |
|---|---|---|---|---|---|
| Pearson's Correlation (r) | .221 | .636 | .794 | .632 | .702 |
| R-Square ($r^2$) | .049 | .405 | .630 | .399 | .493 |
| Sig. (p) | .019 (<.05) | .000 (<.001) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

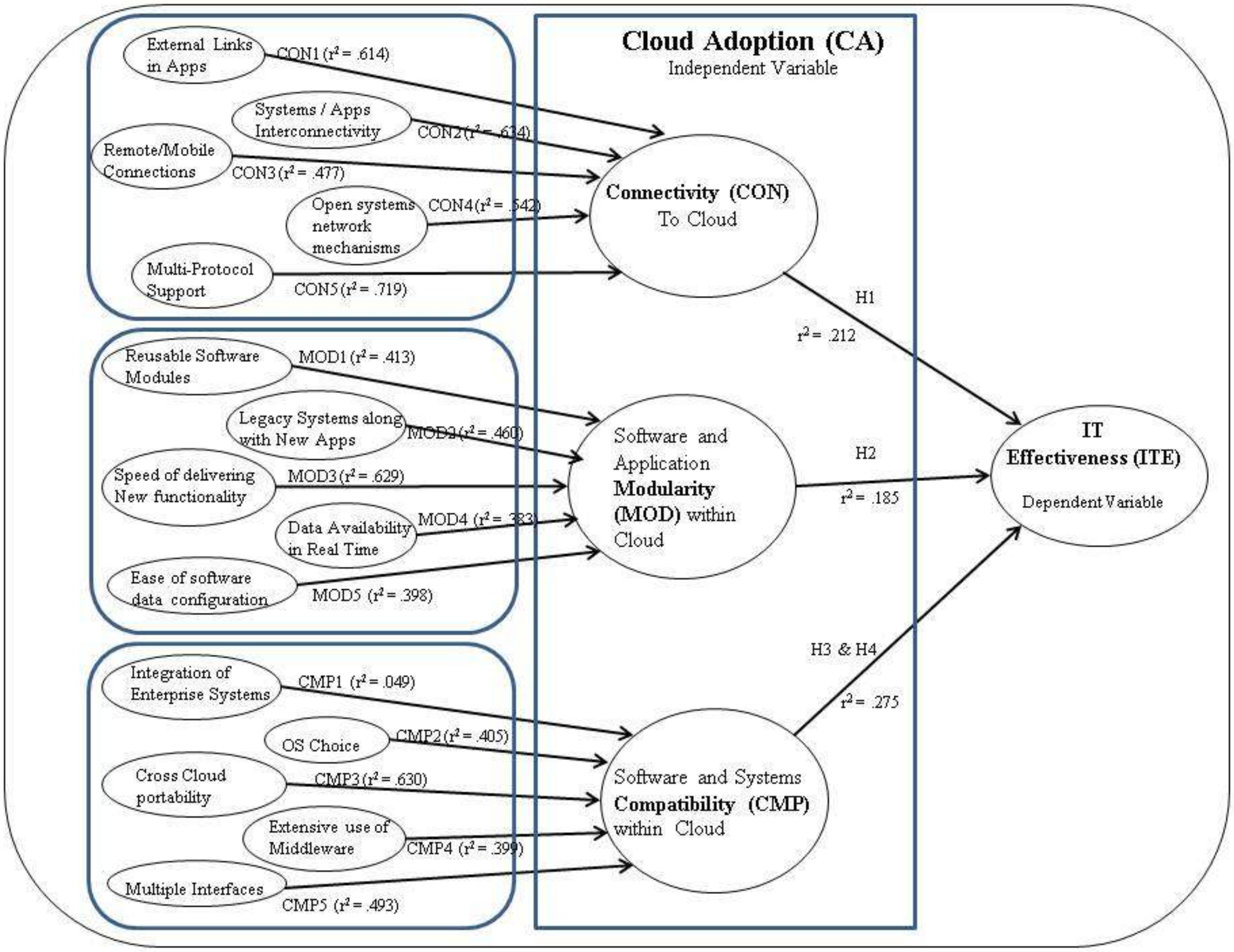


Figure 5: Conceptual Model Results

**Stepwise Regression Analysis:** A stepwise regression analysis was also performed on the paired constructs to analyze the dominance between CON-ITE, MOD-ITE, and CMP-ITE. Table 7 shows the summary model associated with the stepwise regression test. All stepwise regression tests were performed with ITE normalized through a square root transformation (√ITE). This test verified the dominant correlation between CMP-ITE over any other relationship of independent variables with ITE.

Table 7: Stepwise Regression Analysis Results - Model Summary[c] (n=113)

| Model | Phi/Pearson's R | R-Square ($r^{2)}$ | Sig. (p) |
|---|---|---|---|
| 1 | .525[a] | .275 | .000 |
| 2 | .557[b] | .310 | .021 |

a. Predictors: (Constant), CMP
b. Predictors: (Constant), CMP, CON
c. Dependent Variable: √ITE

The stepwise regression test results from Table 8 and Table 9 show that there are two models that represent predictors, as CON and MOD are excluded in first model and MOD is excluded in second model, when the analysis is performed with CON, MOD, and CMP as independent variables and √ITE as dependent variable. Applying Cohen's rule of thumb [14], the correlation of CON ($r^2$ = .212, p<.001) and CMP ($r^2$ = .275, p<.001) are considered medium to small as both of them have $r^2$ values higher than 0.2, whereas correlation of MOD ($r^2$ = .185, p<.001) is considered small as its $r^2$ value is lower than 0.2, but the variances were statistically significant at p<.05 and therefore valid. Due to the relatively weaker relationship of MOD on ITE ($r^2$ = .185) and better relationships of the four interaction terms, CONxMOD on ITE ($r^2$ = .249), MODxCMP on ITE ($r^2$ = .268), CONxCMP on ITE ($r^2$ = .312) and CONxMODxCMP on ITE ($r^2$ = .297) as shown in Table 10 warrants a revised conceptual model representing these findings. Figure 6 shows the revised conceptual model with the relationships among CON, MOD, CMP and their four possible interaction terms.

Table 8: CA, SA Stepwise Regression Analysis Results - Coefficients[a] (n=113)

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | 1.726 | .103 | | 16.808 | .000 | 1.523 | 1.930 |
| | Compatibility | .129 | .020 | .525 | 6.495 | .000 | .090 | .169 |
| 2 | (Constant) | 1.624 | .110 | | 14.783 | .000 | 1.406 | 1.841 |
| | Compatibility | .096 | .024 | .388 | 3.953 | .000 | .048 | .144 |
| | Connectivity | .050 | .021 | .230 | 2.344 | .021 | .008 | .092 |

a. Dependent Variable: √ITE

Table 9: Stepwise Regression Analysis Results - Excluded Variables[a] (n=113)

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | Connectivity | .230[b] | 2.344 | .021 | .218 | .650 |
| | Modularity | .107[b] | .918 | .361 | .087 | .479 |
| 2 | Modularity | -.028[c] | -.215 | .830 | -.021 | .369 |

a. Dependent Variable: Sq.Root ITE (√ITE)
b. Predictors: (Constant), CMP
c. Predictors: (Constant), CMP, CON

Table 10: Bivariate Correlation and Linear Regression Results of Interaction Terms with Transformation for ITE (n=113)

| | √ITE–CONxMOD | √ITE–MODxCMP | √ITE–CONxCMP | √ITE–CONxMODxCMP |
|---|---|---|---|---|
| Pearson's Correlation (r) | .499 | .517 | .559 | .545 |
| R-Square ($r^2$) | .249 | .268 | .312 | .297 |
| Sig. (p) | .000 (<.001) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

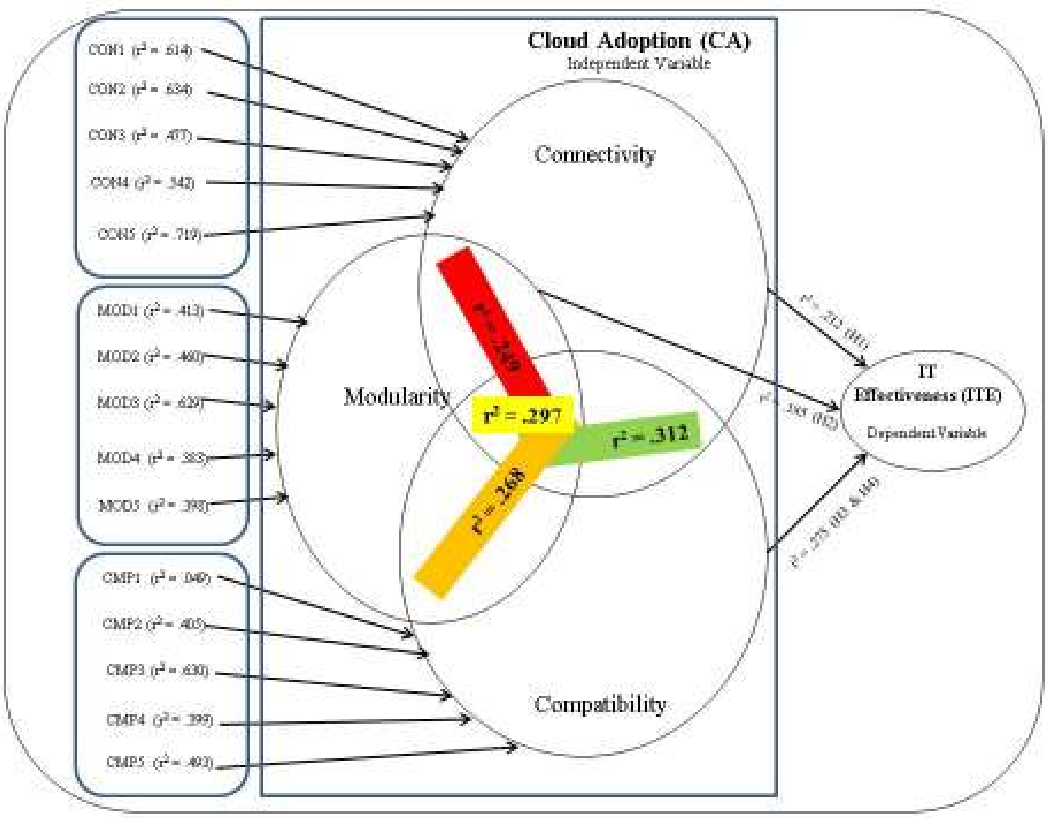


Figure 6: Revised Conceptual Model with CON, MOD, CMP, and their four interaction terms

## Examination of Hypotheses and other Findings

An examination of the research findings was performed to determine the rejection or not of the study's hypotheses. The values in Table 3 represent the inter-scale correlation results with transformation for the dependent variable (√ITE) which were used to reject, or accept first four null hypothesis and the values in Table 11 represent the inter-scale correlation results with transformation for the dependent variable (√ITE) which were used to reject, or accept next seven null hypothesis.

Table 11: Bivariate Correlation and Linear Regression Results of Individual Scale Elements with Transformation for ITE-113

| | √ITE–CON1 | √ITE–CON2 | √ITE–CON3 | √ITE–CON4 | √ITE–CON5 | √ITE–MOD1 | √ITE–MOD2 | √ITE–MOD3 | √ITE–MOD4 | √ITE–MOD5 | √ITE–CMP1 | √ITE–CMP2 | √ITE–CMP3 | √ITE–CMP4 | √ITE–CMP5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pearson's Correlation (r) | .395 | .295 | .369 | .319 | .400 | .260 | .424 | .319 | .324 | .119 | .070 | .310 | .457 | .362 | .570 |
| R-Square ($r^2$) | .156 | .087 | .136 | .102 | .160 | .067 | .180 | .102 | .105 | .014 | .005 | .096 | .209 | .131 | .325 |
| Sig. (p) | .000 (<.001) | .002 (<.05) | .000 (<.001) | .001 (<.05) | .000 (<.001) | .005 (<.05) | .000 (<.001) | .001 (<.05) | .000 (<.001) | .208 (>.05) | .463 (>.05) | .001 (<.05) | .000 (<.001) | .000 (<.001) | .000 (<.001) |

## Hypothesis 1: CON correlated with ITE

$H1_0$: Connectivity to cloud was not positively correlated with IT effectiveness, irrespective of the type and size of the IT organization.

$H1_a$: Connectivity to cloud was positively correlated with IT effectiveness, irrespective of the type and size of the IT organization.

## Finding 1: $H1_0$ Rejected

Connectivity to cloud did positively correlate with IT effectiveness. The null hypothesis was rejected because the p-value of .000 was less than the significance level of .05 for testing [46]. The values for CON in Table 3 confirmed positive correlation between cloud connectivity and IT effectiveness. The values for CON were r = .460, $r^2$ = .212, $p < .001$, therefore, the findings established a positive correlation (medium to small) with IT effectiveness. This finding is consistent with prior research done by Chebrolu [11] which established a positive correlation of Cloud Adoption with IT effectiveness.

## Hypothesis 2: MOD correlated with ITE

$H2_0$: Software and application modularity within cloud was not positively correlated with IT effectiveness, irrespective of the type and size of the IT organization.

$H2_a$: Software and application modularity within cloud was positively correlated with IT effectiveness, irrespective of the type and size of the IT organization.

## Finding 2: $H2_0$ Rejected

Software and application modularity within cloud did positively correlate with IT effectiveness. The null hypothesis was rejected because the p-value of .000 was less than the significance level of .05 for testing [46]. The values for MOD in Table 3 confirmed positive correlation between cloud modularity and IT effectiveness. The values for MOD were r = .430, $r^2$ = .185, $p < .001$, therefore, the findings established a positive correlation (small) with IT effectiveness. This finding is consistent with prior research done by Chebrolu [11] which established a positive correlation of Cloud Adoption with IT effectiveness.

## Hypothesis 3: CMP correlated with ITE

$H3_0$: Software and systems compatibility within cloud was not positively correlated with IT effectiveness, irrespective of the type and size of the IT organization.

$H3_a$: Software and systems compatibility within cloud was positively correlated with IT effectiveness, irrespective of the type and size of the IT organization.

## Finding 3: $H3_0$ Rejected

Software and systems compatibility within cloud did positively correlate with IT effectiveness. The null hypothesis was rejected because the p-value of .000 was less than the significance level of .05 for testing [46]. The values for CMP in Table 3 confirmed positive correlation between cloud compatibility and IT effectiveness. The values for CMP were r = .525, $r^2$ = .275, $p < .001$, therefore, the findings established a positive correlation (medium to small) with IT effectiveness. This finding is consistent with prior research done by Chebrolu [11] which established a positive correlation of Cloud Adoption with IT effectiveness.

## Hypothesis 4: CMP was correlated at a higher level with ITE than does MOD or CON

$H4_0$: Software and systems compatibility within cloud has a lower correlation to IT effectiveness than does connectivity to cloud or software and application modularity within cloud, irrespective of the type and size of the IT organization.

$H4_a$: Software and systems compatibility within cloud has a higher correlation to IT effectiveness than does connectivity to cloud or software and application modularity within cloud, irrespective of the type and size of the IT organization.

### Finding 4: $H4_0$ Rejected

Software and systems compatibility within cloud is strongly correlated with IT effectiveness than cloud connectivity and cloud modularity. The null hypothesis was rejected because the p-value of .000 was less than the significance level of .05 for testing [46]. The values for CON, MOD, and CMP in Table 3 confirmed and established that cloud compatibility ($r = .525$, $r^2 = .275$, $p < .001$) has higher correlation with IT effectiveness followed by cloud connectivity ($r = .460$, $r^2 = .212$, $p < .001$) and cloud modularity ($r = .430$, $r^2 = .185$, $p < .001$).

### Finding 5: CON5 has the highest impact on cloud connectivity among all CONs

Based on the values from Table 4, CON1 (flexibility to incorporate external links in apps deployed on cloud) has the third highest impact on CON dimension among the five individual scale items (CON1 to CON5). The values for CON5 were $r = .848$, $r^2 = .719$, $p < .001$, therefore, the findings established that multi-protocol support for the apps and databases deployed in cloud (CON5) has the highest impact on cloud connectivity.

### Finding 6: MOD3 has the highest impact on cloud modularity among all MODs

Based on the values from Table 5, MOD1 (extensive usage of reusable software modules in apps deployed on cloud) has the third highest impact on MOD dimension among the five individual scale items (MOD1 to MOD5). The values for MOD3 were $r = .793$, $r^2 = .629$, $p < .001$, therefore, the findings established that speed of delivering new functionality within apps deployed on cloud based on end-user requests (MOD3) has the highest impact on cloud modularity.

### Finding 7: CMP3 has the highest impact on cloud compatibility among all CMPs

Based on the values from Table 6, CMP1 (cloud based IT applications using enterprise systems to achieve integration) has the lowest impact on CMP dimension among the five individual scale items (CMP1 to CMP5). The values for CMP3 were $r = .794$, $r^2 = .630$, $p < .001$, therefore, the findings established that cross cloud portability of software applications (CMP3) has the highest impact on cloud compatibility.

### Finding 8: CON5 has the highest impact on IT effectiveness among all CONs

Based on the values from Table 11, CON1 (flexibility to incorporate external links in apps deployed on cloud) within cloud connectivity dimension has the second highest impact on ITE. The values for CON5 were $r = .400$, $r^2 = .160$, $p < .001$, therefore, the findings established that multi-protocol support for the apps and databases deployed in cloud (CON5) has the highest impact on IT effectiveness.

### Finding 9: MOD2 has the highest impact on IT effectiveness among all MODs

Based on the values from Table 11, MOD1 (extensive usage of reusable software modules in apps deployed on cloud) within cloud modularity dimension has the fourth highest impact on ITE. The values for MOD2 were $r = .424$, $r^2 = .180$, $p < .001$, therefore, the findings established that co-existence of legacy systems and new applications in cloud (MOD2) has the highest impact on IT effectiveness.

### Finding 10: CMP5 has the highest impact on IT effectiveness among all CMPs

Based on the values from Table 6, CMP1 (cloud based IT applications using enterprise systems to achieve integration) do not seem to have any correlation with ITE due to its p-value. The values for CMP5 were $r = .570$, $r^2 = .325$, $p < .001$, therefore, the findings established that multiple interfaces or entry points for external users to access apps deployed in cloud (CMP5) has the highest impact on IT effectiveness.

### Finding 11: CMP5 has the highest and CMP1 has the lowest impact on IT effectiveness among all 15 cloud aspects

Based on the values from Table 11, CMP5 among all 15 cloud aspects used in this study have the highest impact on ITE. The values for CMP5 were $r = .570$, $r^2 = .325$, $p < .001$, therefore, the findings established that multiple interfaces or entry points for external users to access apps deployed in cloud (CMP5) has the highest impact on IT effectiveness, followed by CMP3, MOD2, CON5, CON1, CON3, CMP4, MOD4, CON4, MOD3, CMP2, CON2, MOD1, MOD5 and CMP1 in that decreasing order. This means MOD5 (ease of software data configuration) and CMP1 (cloud based IT applications using enterprise systems to achieve integration) ranked among the lowest, infact, these two do not seem to have any correlation with ITE due to their p-value (>.05). Every other cloud aspect used in this study, thirteen of them, seems to have positive correlation with ITE and as their p-values are low (<.05), the relationships are valid.

# SUMMARY, IMPLICATIONS, RECOMMENDATIONS

## Summary

This research study provided new empirical evidence that cloud compatibility has higher correlation ($r = .525$, $r^2 = .275$, $p < .001$) followed by cloud connectivity ($r = .460$, $r^2 = .212$, $p < .001$) and cloud modularity ($r = .430$, $r^2 = .185$, $p < .001$) with IT effectiveness regardless of type and size of IT organizations (hypotheses one, two, three and four). These findings are consistent with Chebrolu's [11] research which established that cloud adoption as a whole is positively correlated to IT effectiveness. Moreover, this study provided new evidence that some aspects of three cloud adoption constructs used in this study has much higher impact on IT effectiveness than others have, while establishing that 2 of the cloud aspects used in the study do not have any impact on IT effectiveness. Many authors have researched the impact of various constructs on IT effectiveness for large, for-profit IT organizations, either as a singled or as paired factors to determine business value through competitive advantage. However, this study filled in information gap in the literature because it focused on the impact of fifteen various aspects of cloud and included small, medium, large, for-profit, for-nonprofit, educational, corporate, and government IT organizations.

## Implications

By determining the dominance and prioritization of cloud compatibility over cloud connectivity and modularity for IT effectiveness, IT executives and IT managers could more effectively decide where, how and which aspects of cloud technologies to allocate financial resources for the implementation, deployment and maintenance of their complex IT systems in their respective organizations. The regression testing in this study showed that cloud compatibility is more dominant than cloud connectivity which in turn is more dominant than cloud modularity for IT effectiveness. In addition, some aspects of cloud compatibility do not have any impact on IT effectiveness while some aspects have much higher impact. The implication of this research finding is that IT executives and IT managers should allocate more financial resources towards software and systems compatibility within cloud than resources to cloud connectivity or software and application modularity within cloud in order to improve their IT effectiveness. Narrowing down further, IT executives and IT managers should allocate more financial resources towards CMP5 (multiple interfaces for external users to access cloud apps), CMP3 (portability across multiple cloud providers), MOD2 (legacy systems not hampering development of new apps in cloud), CON5 (multi-protocol support), and CON1 (apps on cloud are flexible enough to incorporate electronic links to external parties) which are the top five identified cloud computing aspects which has much higher positive impact on IT effectiveness.

The findings from this study represented only firms in US that were from multiple business types, sizes and therefore, the results should not be interpreted as representing any specific business sector type or size. Finally, since the participants were all top IT executives that are playing CIO (Chief Information Officer) role in various IT organizations the findings did not reflect any information that could have been obtained from lower managers or end-users. The research findings in this study have advanced the current knowledge of the relationships among cloud connectivity, cloud modularity, cloud compatibility, and IT effectiveness for IT organizations. The findings addressed the benefits of adoption of cloud computing and the impact of its individual aspects on IT effectiveness and would enhance the decision-making process for IT managers when considering the adoption of cloud technologies and its business models.

## Recommendations

The study's recommendations are that IT executives and IT managers should allocate more financial resources towards software and systems compatibility within cloud than resources to cloud connectivity or software and application modularity within cloud in order to improve their IT effectiveness.

**Recommendations for Further Research:** The authors recommend that this study be repeated with a case-study using qualitative approach on popular cloud providers and platforms like Amazon's EC2, Google's AppEngine, Microsoft's Azure, Cisco's WebEx and Salesforce.com etc about how their cloud based solutions impact IT effectiveness. This study could be repeated with a quantitative approach with the same variables by narrowing down on how a specific type of cloud service model (IaaS/PaaS/SaaS) or how a specific type of deployment model (public/private/hybrid/community) would impact IT effectiveness. In addition, the authors recommend that this research be repeated with a similar quantitative correlative study to analyze the same variables by narrowing down to either just small IT organizations or medium IT organizations or for-nonprofit or government organizations only or educational or corporations only. Authors hope that IT executives use this new knowledge when allocating their human and financial resources towards improving their IT effectiveness and deliver solutions to the business in a dynamic marketplace.

# REFERENCES


[1] Aczel, A. D., & Sounderpandian, J. (2002). *Complete business statistics* (5th ed.). New York: McGraw-Hill.

[2] Armbrust, M., Fox, A., Griffith, R., Joseph, A.D., Katz, R., Konwinski, A.,…Zaharia, M. (2009). Above the clouds: A Berkeley view of cloud computing. Retrieved from December 14, 2009, from http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf

[3] Avila, O., Goepp, V., & Kiefer, F. (2009). Understanding and classifying information system alignment approaches. *The Journal of Computer Information Systems, 50*(1), 2. Retrieved December 20, 2009, from ABI/INFORM Global.

[4] Babcock, C. (2009a, November). Ready for this? *InformationWeek,* (1250), 22-30. Retrieved December 20, 2009, from ABI/INFORM Global.

[5] Babcock, C. (2009b, September). Hybrid Clouds. *InformationWeek*, (1240), 15-19. Retrieved December 20, 2009, from ABI/INFORM Global.

[6] Birman, K., Chockler, G., & van Renesse, R. (2009). Toward a cloud computing research agenda. *SIGACT News, 40*(2), 68-80. doi: 10.1145/1556154.1556172

[7] Brandel, M. (2009, March). Exit Strategy. *Computerworld*, *43*(13), 23-24, 26. Retrieved December 20, 2009, from ABI/INFORM Global.

[8] Brown, D.H. (2004, April). *Websphere business integration server foundation v5.1: Building and deploying service-oriented applications that extend and integrate existing IT assets.* A D.H. Brown Associates white paper prepared for IBM.

[9] Buyya, R., Yeo, C.S., & Venugopal, S. (2009). Market-oriented cloud computing: Vision, hype, and reality of delivering IT services as computing utilities. Paper presented at the *10th IEEE International Conference on High Performance Computing and Communications,* 5-13.

[10] Cellary, W., & Strykowski, S. (2009). e-government based on cloud computing and service-oriented architecture. Paper presented at the *ICEGOV '09: Proceedings of the 3rd International Conference on Theory and Practice of Electronic Governance,* Bogota, Colombia. 5-10. doi: 10.1145/1693042.1693045

[11] Chebrolu, S. B. (2010). *Assessing the relationships among cloud adoption, strategic alignment and information technology effectiveness.* From ProQuest Dissertations & Theses database. (No. AAT 3426510)

[12] Christodorescu, M., Sailer, R., Schales, D. L., Sgandurra, D., & Zamboni, D. (2009). Cloud security is not (just) virtualization security: A short paper. Paper presented at the *CCSW '09: Proceedings of the 2009 ACM Workshop on Cloud Computing Security,* Chicago, Illinois, USA. 97-102. doi: 10.1145/1655008.1655022

[13] Ciortea, L., Zamfir, C., Bucur, S., Chipounov, V., & Candea, G. (2009). Cloud9: A software testing service. *SIGOPS Oper.Syst.Rev., 43*(4), 5-10. doi: 10.1145/1713254.1713257

[14] Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. 2nd Ed., Hillsdale, NJ: Erlbaum.

[15] Cooper, C. R., & Schindler, P. S. (2008). *Business research methods* (10th ed.). Boston: McGraw-Hill.

[16] Creeger, M. (2009). Cloud computing: An overview. ACM *Queue, 7*(5), 3-4. doi: 10.1145/1538947.1554608

[17] Deelman, E., Singh, G., Livny, M., Berriman, B., & Good, J. (2008). The cost of doing science on the cloud: The montage example. Paper presented at the *SC '08: Proceedings of the 2008 ACM/IEEE Conference on Supercomputing,* Austin, Texas. 1-12.

[18] Demirkan, H., Kauffman, R. J., Vayghan, J. A., Fill, H., Karagiannis, D., & Maglio, P. P. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade. *Electron.Commer.Rec.Appl., 7*(4), 356-376. doi: 10.1016/j.elerap.2008.07.002

[19] Erdogmus, H. (2009). Cloud computing: Does Nirvana hide behind the Nebula. *IEEE Software, 26*(11), 4-6. Retrieved from IEEE database.

[20] Farah, S. (2010). Cloud computing or software as a service-which makes the most sense for HR? *Employment Relations Today, 36*(4), 31. Retrieved May 3, 2010, from ABI/INFORM Global.

[21] Feeney, G. J., Hilton, R. D., Johnson, R. L., O'Rourke, T. J., & Kurtz, T. E. (1974). Utility computing: A superior alternative? Paper presented at the *AFIPS '74: Proceedings of the may 6-10, 1974, National Computer Conference and Exposition,* Chicago, Illinois. 1003-1003. doi: 10.1145/1500175.1500370

[22] Fortino, G., Mastroianni, C., Pathan, M., & Vakali, A. (2009). Next generation content networks: Trends and challenges. Paper presented at the *UPGRADE-CN '09: Proceedings of the 4th Edition*

*of the UPGRADE-CN Workshop on use of P2P, GRID and Agents for the Development of Content Networks,* Garching, Germany. 49-49. doi: 10.1145/1552486.1552516

[23] Fraser, S., Biddle, R., Jordan, S., Keahey, K., Marcus, B., Maximilien, E. M., & Thomas, D. (2009). Cloud computing beyond objects: Seeding the cloud. Paper presented at the *OOPSLA '09: Proceeding of the 24th ACM SIGPLAN Conference Companion on Object Oriented Programming Systems Languages and Applications,* Orlando, Florida, USA. 847-850. doi: 10.1145/1639950.1640043

[24] Gens, F. (2008, October 8). IT Cloud services forecast – 2008, 2012: A key driver of new growth [Web log message]. Retrieved from http://blogs.idc.com/ie/?p=224

[25] Gens, F. (2009, December 15). New IDC IT cloud services survey: Top benefits and challenges [Web log message]. Retrieved from http://blogs.idc.com/ie/?p=730

[26] Golden, B. (2009). Forrester bucks conventional wisdom on cloud computing. *CIO*. Retrieved from http://www.cio.com/article/496213/Forrester_Bucks_Conventional_Wisdom_on_Cloud_Computing

[27] González-Benito, J. (2007). Information technology investment and operational performance in purchasing. *Industrial Management + Data Systems, 107*(2), 201. Retrieved December 21, 2009, from ABI/INFORM Global.

[28] Guazzelli, A., Stathatos, K., & Zeller, M. (2009). Efficient deployment of predictive analytics through open standards and cloud computing. *SIGKDD Explor.Newsl., 11*(1), 32-38. doi: 10.1145/1656274.1656281

[29] Halamka, J. (2009). Making smart investments in health information technology: Core principles. *Health Affairs,* , W385. Retrieved from Retrieved December 21, 2009, from ABI/INFORM Global.

[30] Holden, E. P., Kang, J. W., Bills, D. P., & Ilyassov, M. (2009). Databases in the cloud: A work in progress. Paper presented at the *SIGITE '09: Proceedings of the 10th ACM Conference on SIG-Information Technology Education,* Fairfax, Virginia, USA. 138-143. doi: 10.1145/1631728.1631765

[31] Howard, C. (2009, December). Q4 Executive Brief 2010 Trends. *Burton Group Confluence, 3*(6), 1-4.

[32] Huang, C. (2007). The effect of investment in information technology on the performance of firms in the rubber industry. *International Journal of Management, 24*(3), 463. Retrieved December 21, 2009, from ABI/INFORM Global.

[33] Kanungo, S., Duda, S., & Srinivas, Y. (1999, Nov/Dec). A structured model for evaluating information systems effectiveness. *Systems Research and Behavioral Science, 16*(6), 495-518.

[34] Kaufman, L. M. (2009). Data security in the world of cloud computing. *IEEE Security & Privacy, 7*(4), 61-64. doi: 10.1109/MSP.2009.87

[35] Kraska, T., Hentschel, M., Alonso, G., & Kossmann, D. (2009). Consistency rationing in the cloud: Pay only when it matters. *Proc.VLDB Endow., 2*(1), 253-264.

[36] Kroeker, K. L. (2009). The evolution of virtualization. *Communications of the ACM, 52*(3), 18-20. doi: 10.1145/1467247.1467253

[37] Lee, Y., Chu, P., & Tseng, H. (2009). Exploring the relationships between information technology adoption and business process reengineering. *Journal of Management and Organization, 15*(2), 170. Retrieved December 21, 2009, from ABI/INFORM Global.

[38] Li, Z., Wang, Y., Olivier, K. K. S., Chen, J., & Li, K. (2009). The cloud-based framework for ant colony optimization. Paper presented at the *GEC '09: Proceedings of the First ACM/SIGEVO Summit on Genetic and Evolutionary Computation,* Shanghai, China. 279-286. doi: 10.1145/1543834.1543872

[39] Lim, H. C., Babu, S., Chase, J. S., & Parekh, S. S. (2009). Automated control in cloud computing: Challenges and opportunities. Paper presented at the *ACDC '09: Proceedings of the 1st Workshop on Automated Control for Datacenters and Clouds,* Barcelona, Spain. 13-18. doi: 10.1145/1555271.1555275

[40] Lodi, G., Querzoni, L., Baldoni, R., Marchetti, M., Colajanni, M., Bortnikov, V., Chockler, G., Dekel, E., Laventman, G., & Roytman, A. (2009). Defending financial infrastructures through early warning systems: The intelligence cloud approach. Paper presented at the *CSIIRW '09: Proceedings of the 5th Annual Workshop on Cyber Security and Information Intelligence Research,* Oak Ridge, Tennessee. 1-4. doi: 10.1145/1558607.1558628

[41] Maximilien, E. M., Ranabahu, A., Engehausen, R., & Anderson, L. C. (2009). Toward cloud-agnostic middlewares. Paper presented at the *OOPSLA '09: Proceeding of the 24th ACM SIGPLAN Conference Companion on Object Oriented Programming Systems Languages and Applications,* Orlando, Florida, USA. 619-626. doi: 10.1145/1639950.1639957

[42] Motjolopane, I., & Brown, I. (2004). Strategic business-IT alignment, and factors of influence: A

case study in a public tertiary education institution. Paper presented at the *SAICSIT '04: Proceedings of the 2004 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on IT Research in Developing Countries,* Stellenbosch, Western Cape, South Africa. 147-156.

[43] Mowbray, M., & Pearson, S. (2009). A client-based privacy manager for cloud computing. Paper presented at the *COMSWARE '09: Proceedings of the Fourth International ICST Conference on COMmunication System softWAre and middlewaRE,* Dublin, Ireland. 1-8. doi: 10.1145/1621890.1621897

[44] Murray, P. (2009). Enterprise grade cloud computing. Paper presented at the *WDDM '09: Proceedings of the Third Workshop on Dependable Distributed Data Management,* Nuremberg, Germany. 1-1. doi: 10.1145/1518691.1518692

[45] Ness, L. R. (2005). *Assessing the relationships among information technology flexibility, strategic alignment, and information technology effectiveness*. From ProQuest Dissertations & Theses database. (No. AAT 3178531).

[46] Norusis, M. (2008a). *SPSS 16.0 Guide to Data Analysis*. Upper Saddle-River, N.J.: Prentice Hall.

[47] Norusis, M. (2008b). *SPSS Statistics 17.0 Statistical Procedures Companion*. Upper Saddle-River, N.J.: Prentice Hall.

[48] Orr, B. (2008). Will IT of the future have its feet firmly planted in the "cloud"? *American Bankers Association. ABA Banking Journal, 100*(9), 50. Retrieved December 20, 2009, from ABI/INFORM Global.

[49] Pearson, S. (2009). Taking account of privacy when designing cloud computing services. Paper presented at the *CLOUD '09: Proceedings of the 2009 ICSE Workshop on Software Engineering Challenges of Cloud Computing,* 44-52. doi: 10.1109/CLOUD.2009.5071532

[50] Perez, J., Germain-Renaud, C., Kegl, B., & Loomis, C. (2009). Responsive elastic computing. Paper presented at the *GMAC '09: Proceedings of the 6th International Conference Industry Session on Grids Meets Autonomic Computing,* Barcelona, Spain. 55-64. doi: 10.1145/1555301.1555311

[51] Pettey, C. (2009, October). *Gartner identifies the top 10 strategic technologies for 2010.* Retrieved from http://www.gartner.com/it/page.jsp?id=1210613

[52] Pierce, A.C. (2002). *The effect of business and information technology strategic alignment on information technology investment returns and corporate performance.* From ProQuest Dissertations & Theses database. (No. AAT 3058558)

[53] Ross, J. W., & Westerman, G. (2004). Preparing for utility computing: The role of IT architecture and relationship management. *IBM Systems Journal, 43*(1), 5. Retrieved December 20, 2009, from ABI/INFORM Global.

[54] Samoilenko, S. (2006). *Impact of the investments in information and communication technologies on total factor productivity in the context of the economies in transition.* From ProQuest Dissertations & Theses database. (No. AAT 3225834).

[55] Santhanam, R., & Hartono, E. (2003). Issues in linking information technology capability to firm performance. *MIS Quarterly, 27*(1), 125. Retrieved December 20, 2009, from ABI/INFORM Global

[56] Suess, J., & Morooney, K. (2009). Identity management & trust services: Foundations for cloud computing. *EDUCAUSE Review, 44*(5), 24. Retrieved December 20, 2009, from ABI/INFORM Global. (Document ID: 1865415041).

[57] Sultan, N. (2010). Cloud computing for education: A new dawn? *International Journal of Information Management, 30*(2), 109. Retrieved from ABI/INFORM Global.

[58] Swanson, R. A., & Holton, E. F., III. (Eds.). (2005). *Research in organizations: Foundations and methods of inquiry*. San Francisco: Berrett-Koehler.

[59] Tallon, P. P., & Kraemer, K. L. (2003). Using flexibility to enhance the alignment between information systems and business strategy: Implications for IT business value. Center for Research on Information Technology and Organizations (CRITO), University of California, Irvine. Retrieved May 31, 2010, from http://misrc.umn.edu/workshops/2003/spring/Tallon_042503.pdf

[60] Tallon, P. P., Kraemer, K. L., & Gurbaxani, V. (2000). Executives' perceptions of the business value of information technology: A process-oriented approach. *Journal of Management Information Systems, 16*(4), 145. Retrieved from ABI/Inform Global database.

[61] Treese, W. (2008). Movin' to the cloud. *NetWorker, 12*(4), 13-15. doi:10.1145/1461981.1461985

[62] Vouk, M.A. (2008). Cloud computing – Issues, Research and Implementations. Paper presented at the *ITI 2008: Proceedings of the 30th International Conference on Information Technology Interfaces,* Cavtat, Croatia. 31-40.

[63] Wang, W., Li, Z., Owens, R., & Bhargava, B.

(2009). Secure and efficient access to outsourced data. Paper presented at the *CCSW '09: Proceedings of the 2009 ACM Workshop on Cloud Computing Security,* Chicago, Illinois, USA. 55-66. doi: 10.1145/1655008.1655016

[64] Watson, R.T., Kelly, G.G., Galliers, R.D., & Brancheau, J.C. (1997, Spring). Key issues in information systems management: An international perspective. *Journal of Management Information Systems, 13*(4)*,* 91-115.

[65] Wei, J., Zhang, X., Ammons, G., Bala, V., & Ning, P. (2009). Managing security of virtual machine images in a cloud environment. Paper presented at the *CCSW '09: Proceedings of the 2009 ACM Workshop on Cloud Computing Security,* Chicago, Illinois, USA. 91-96. doi: 10.1145/1655008.1655021

[66] Wheeler, B., & Waggener, S. (2009). Above campus services: Shaping the promise of cloud computing for higher education. *EDUCAUSE Review, 44*(6), 52. Retrieved December 20, 2009, from ABI/INFORM Global.

[67] Woods, D., & Pattabhiram, C. (2009, June). Integration: The critical path to cloud computing. *Cast Iron Systems white paper on Cloud Integration.* Retrieved on March 29, 2010, from http://www.castiron.com/docs/whitepaper/Cloud_Integration.pdf

[68] Zeller, M., Grossman, R., Lingenfelder, C., Berthold, M. R., Marcade, E., Pechter, R., Hoskins, M., Thompson, W., & Holada, R. (2009). Open standards and cloud computing: KDD-2009 panel report. Paper presented at the *KDD '09: Proceedings of the 15th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining,* Paris, France. 11-18. doi: 10.1145/1557019.1557027

[69] Zhang, X., Ai, J., Wang, Z., Lu, J., & Meng, X. (2009). An efficient multi-dimensional index for cloud data management. Paper presented at the *CloudDB '09: Proceeding of the First International Workshop on Cloud Data Management,* Hong Kong, China. 17-24. doi: 10.1145/1651263.1651267

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