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Abstract

Cloud computing as an emerging high technology has been recognised by organisations and individuals for a wide range of potential applications. Since the concept’s first appearance in 2007, the authors found a dominant amount of studies in the non-technological domains, including attempts to define and categorise cloud computing and the challenges and issues of the technology’s adoption. Nonetheless, few researches are dedicated to determine the drivers of adopting cloud computing thus the literature is limited on this topic. As more adopters are becoming familiar with the technology and implementing cloud computing in their daily work, understanding of what drives their adoption decision is essential to create opportunities for future cloud technologies to be tailored and aligned with the consumer’s needs thus promoting exploitations of the technology’s promising applications. This research takes a quantitative approach by developing and validating a theory-based conceptual model. Among the theories that are commonly applied in Information Systems research, the authors found Technology-Organisation-Environment framework can encapsulate the adoption’s factors into one big picture. The authors conducted a secondary data analysis on the recent large-scale survey of IBM to investigate the drivers and barriers of cloud computing adoption. Structural Equation Modelling and Partial Least Square statistical methodologies provide rigid scientific procedures to validate the conceptual model. This study contributes a statistically validated conceptual model of the drivers and barriers of cloud computing adoption. In addition, the research provides a comparison between two different discussions (i.e., industry report and academic research) on the same topic and data. The findings benefits are twofold. First, it seeks to clarify the profound knowledge on the factors surrounding cloud adoption to better understanding cloud computing. Second, it also provides directions for future research by suggesting validations on the proposed model while discussing the limitations of analysing commercial survey.

Keywords: adoption, barriers, cloud computing, drivers, Technology-Organisation-Environment Framework
I. Introduction

Cloud computing offers numerous competitive advantages to today’s businesses. First and foremost, it offers the distributive IT hardware and software which saves the costs of the organisation’s IT infrastructure. This feature is especially beneficial for small and medium size business as they can adopt emerging software easily without requiring to make many purchasing, but rather one purchase and share it on the company’s cloud (Aljabre 2012). Likewise, managers do not need to invest much in high performance computers since cloud computing allows access to centralised applications which do not require to be installed locally. The low costs, minimum technical expertise requirements, flexible and dynamic applications of cloud computing makes it easier for technology adopters to make the switch to cloud computing. Businesses operations also become more agile and effective when they can scale their IT infrastructure which makes entering markets faster as well as meet customers’ demands. Finally, cloud computing offers opened environment which fosters distance online collaboration (e.g., Google Drive) as well as sharing repository (e.g., Dropbox) amongst the employees (Aljabre 2012).

While disputes on such benefits still leave rooms for future debates and corrections, the authors believe those advantages can partly explain why businesses chose to adopt cloud computing. More importantly, investigating this subject matter in detail can reveal the current concerns of businesses, including motivations and barriers, on the adoption of cloud computing. In the next section, the authors present the literature review of this study which includes discussions on both theoretical and conceptual backgrounds. After declaring the boundary and the relevant knowledge included in this research, Section 3 presents the hypotheses that are based on such backgrounds. Section 4 describes the selected research methodology – triangular approach of secondary data back with the IBM dataset. Section 5 provides the detailed data analysis and discussions of the validated hypotheses, followed by Section 6 – Limitations and Recommendations – which concludes the study.

II. Literature Review

Cloud computing adoption has great growth potential with the current and predicted total budget to be spent on its services. For example, Gartner reported significant amount of money spent on cloud computing (including Infrastructure-as-a-Service (IaaS), cloud management, security devices and Platform-as-a-Service (PaaS)) totalling $7.6 billion in 2011 worldwide and projected to be $35.5 billion in 2016 (Gartner 2012). Such enormous figures have been encouraging joint efforts from academia and industry to understand the reasons and contributing factors. Indeed, the authors found several relevant research articles that drew conclusions on the challenges and drivers of cloud computing adoption. Nonetheless, the found literature displays a lack of theories applied in overall when presenting their findings thus suggests gaps in the field.
The relevant literature reveals that most drivers of cloud computing adoption are benefits-driven. However, not all benefits of cloud computing could drive investment as such decision often requires careful cost-benefits analysis. In other words, organisations invest in cloud computing while expecting its business values in return – but only when they feel cloud computing is needed. This argument also clarifies the possible confusion between disadvantages and barriers of cloud adoption. In addition, it emphasises the necessary criteria of this study when selecting and reviewing literature: the authors are only interested in studies whose findings explicitly indicate factors as drivers or barriers of cloud adoption. Further, some drivers are consistent with those that were surveyed by IBM while some were regarded as challenges. Likewise, (Narasimhan and Nichols 2011) also asserts that cloud computing adopters have different perceptions regarding cloud computing. Table 1 below summarises the factors and their sources that indicate the factors’ roles; Section 3 will elaborate the details of the drivers.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Driver</th>
<th>Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business scalability</td>
<td>Carroll, Merwe, and Kotzé 2011; Wood and Anderson 2011; Chebrolu 2011; Pandey et al. 2010; Gupta 2010; Leavitt 2009</td>
<td></td>
</tr>
<tr>
<td>Cost flexibility – Allows “pay as and when needed” model</td>
<td>Carroll, Merwe, and Kotzé 2011; Sultan 2010; Leavitt 2009</td>
<td></td>
</tr>
<tr>
<td>Access to industry</td>
<td>Pandey et al. 2010</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Drivers and barriers of cloud computing adoption (adopted from IBM Center for Applied Insights 2012)

III. Hypotheses Development

Theoretical Background:

To add a profound theoretical stance to this investigation, the authors found the Technology-Organisation-Environment (TOE) framework (Tornatzky and Fleischer 1990) can encapsulate the adoption’s factors into one big picture. More important, the framework was originally developed to link Information
Systems innovation adoption decisions with contextual factors, thus it can be considered a fit with cloud computing as an emerging technology (Chau and Tam 1997). The TOE framework posits the influences of the factors from three contexts (Technology, Organisation and Environment) on the organisation’s adoption decision. The framework offers a holistic view on the multiple facets of an organisation rather than focuses on an individual’s viewpoint such as the Technology Acceptance Model.

**Conceptual Background:**

As the study attempts to conduct a secondary data analysis based on IBM data, this section identifies such factors and discusses their relevant to the study. Such discussions are crucial as they establish concrete concepts that are to be fitted in the theoretical background. Accordingly, the authors excluded the elaborations of Market adaptability, Hidden complexity and Inadequate IT skills as few evidences were found advocating their driver’s and barrier’s function. However, these factors are still included in the study’s hypotheses as well as the conceptual model to conform to IBM survey’s results.

**1) Drivers of Cloud Computing**

Business scalability can be one of the best reasons for organisations to consider cloud computing adoption (Phaphoom et al. 2012). This factor exploits the virtualising and leveraging capability of cloud computing that allow businesses to scale down its infrastructure to save costs (including hardware, software and labour etc.) while improving IT performance (Kim et al. 2009; Aljabre 2012). Further, organisations can enjoy the green benefits thanks to less power consumption from the scaled infrastructure (Marston et al. 2011; Sultan 2010; Pandey et al. 2010). On the other hand, scalability is desirable for continuous growth as the efficient environment of cloud can host very large volumes of data (Baars and Kemper 2011). At the same time it also supports the rapid deployment of computational tools which help businesses to be more responsive and proactive in operations (Marston et al. 2011).

Cost flexibility appears to be a desirable feature of cloud computing that allows businesses to “pay as and when needed”. Indeed, such ability to control costs is beneficial to small and medium businesses, especially those that are new (Leavitt 2009). Furthermore, (Sultan 2010) asserted that cloud computing's cost flexibility is also appealing to educational institutes. The author provided a case where the University of Westminster can literally utilise Google Mail for free instead of spending huge budget on equivalent data storage (Sultan 2010).

Access to industry expertise refers to the ability to share best practices using cloud computing’s communication capability. The authors found a dominant amount of literatures highlighting the capability to foster internal collaborations such as teleworking and external communications with customers; however only one of them mentioned organisations’ need to invest in cloud computing to share best practices within
the industry (Marston et al. 2011). Despite the lack of clarification on this factor, one study revealed that the need for growth in business collaboration was one of the top drivers of cloud adoption list with 54% consensus (Pandey et al. 2010).

Considering the TOE framework, the authors incorporated the discussed drivers into the construct “Perceived Benefit” as they reflect well organisational needs as a whole. This led to the hypothesis:

**H1.** Perceived Benefit (PB) has positive impact on Intention to adopt (ITA) cloud computing.

### 2) Barriers of Cloud Computing

Cloud security has always been widely discussed as the main barrier that prevents businesses from adopting cloud computing. Indeed, insecure cloud infrastructure could lead to problems between the adopter and the major stakeholders such as customers, partners, providers or even the government. One common security concern is the organisation’s data ownership and control when leveraging the provider’s cloud services (Chebrolu 2011). By doing so, businesses often feel insecure as they have to entrust their confidential data to the provider’s protection against the emerging cyber-threats. In particular, privacy of employees’ data, consistency and integrity of retrieved data (especially when multiple providers are involved in the process) are the top reasons that make organisations feel reluctant to migrate to the cloud (Sengupta, Kaulgud, and Sharma 2011; Motta, Sfondrini, and Sacco 2012).

Compatibility with existing applications (and extendibility of existing applications to the cloud) is also an issue when businesses consider adopting cloud technology (Heinle and Strebel 2010; Dargha 2012). This issue occurs when cloud adopters have little controls over the pre-designed computing platform by the provider, thus are required to compromise on flexibility. In addition, the vendor can also change the platform as they feel necessary but without the customer’s consent (Leavitt 2009). As organisations are operating well with their current infrastructure, any changes required by cloud integration can be a daunting task.

Reliability and availability are important features of cloud computing that organisations expect to have once they adopted the technology. These features are crucial as businesses often utilise cloud as a platform that supports daily operations and interact with customers and suppliers. As a consequence, any errors or delays that affect reliability and availability can jeopardise the whole process as well. However, the provider may fail to scale up their infrastructure or maintain high uptime and bandwidth to meet customer’s demand in terms of usage, thus affects the stability of the cloud services at some point in time (Kim et al. 2009; Marston et al. 2011; Heinle and Strebel 2010; Leavitt 2009).

Regulatory, governance and compliance policies can make businesses feel reluctant to adopt cloud computing due to the lack of regulations governing data ownership and privacy as well as data audit (access) and reporting rights (Kim et al. 2009; Marston et al. 2011; Motta,
Sfondrini, and Sacco 2012). In addition, cloud adopters are also concerned about whether they would receive support and protection from the government in case a breach occurred. Proprietary vendor platforms/lack of IT standards is the specific barrier that leads to the issues of Cloud security and Compatibility as discussed above. Likewise, Table 1 displayed that these three barriers share the same literatures.

Given the discussed barriers of cloud computing adoption and the remaining components of TOE framework (i.e., Technology and Environment), the authors developed two constructs. Specifically, Regulatory and Vendor appear to be outside of the business and its controls, thus formed the construct “Perceived Environment Barriers”. On the other hand, the remaining barriers fit into “Perceived Technology Barriers”. As a consequence, the authors proposed the following hypotheses:

H2. Perceived Environment Barriers (PEB) has negative impact on Intention to adopt (ITA) cloud computing.

H3. Perceived Technology Barriers (PTB) has negative impact on Intention to adopt (ITA) cloud computing.

In addition to the main components of TOE framework, the authors also utilise data from the IBM survey that describes companies’ adopting style towards cloud computing. Specifically, the surveyed questions include measurement of new technologies’ importance within the organisation’s body, pace and predominant approach of adoption. These questions together indicate the adopter’s styles that are introduced in the IBM report, namely Pacesetter, Follower and Dabbler (IBM Center for Applied Insights 2012). Accordingly, Pacesetters are found to be more proactive at adopting cloud computing while the other two appear to have less intention. In accordance to that finding, we proposed the following hypotheses representing the Follower’s and Dabbler’s styles:

H4. Adopter’s style (AS) has negative impact on Intention to adopt (ITA) cloud computing.

H5. Adopter’s style (AS) has positive moderating impact on Perceived Technology Barriers (PTB).

H6. Adopter’s style (AS) has positive moderating impact on Perceived Environment Barriers (PEB).

H7. Adopter’s style (AS) has positive moderating impact on Perceived Benefits (PB).

The conceptual model (Fig. 1) illustrates the proposed hypotheses and contributing factors mapping:
IV. Research Methodology

The authors performed a secondary data analysis using Structural Equation Modelling (SEM) methodology. The data source comes from a survey of 1,200 technology decision-makers conducted in 16 different industries and 13 countries, released in 2012 by IBM. The questionnaire was designed to capture insights about adoption of emerging technologies (e.g., cloud computing, social business, business analytics), particularly about the drivers and barriers surrounding the adoption as well as its current stage within each firm. Furthermore, the questionnaire contributes to this research its variables in terms of drivers and challenges which were crucial for the authors to conceptualise the research model. These variables were grouped and organised within the TOE framework so that the study can be coherent to a profound theory. To validate the model, the authors employed SEM statistical techniques to examine the correlations between the surveyed variables and their respective constructs indicated by the TOE framework.

Data Analysis and Discussion:

The research model was assessed by using Partial Least Squares (PLS) technique. SmartPLS 2.0 (Ringle, C.M., Wende, S. and Will 2005) was used to assess the research model. PLS is a least squares regression-based technique that can analyse structural models with multiple-item constructs and direct, indirect, and mediating paths. In addition, PLS is considered as a robust estimation method with respect to the distributional assumptions regarding

the underlying data and tests of normality. Bootstrapping procedure with the resample of 200 was applied to provide the standard error and the t-statistics of the path coefficients.

Measurement model in PLS is assessed in terms of item loadings, internal consistency, and discriminant validity. For construct validity, item loadings and internal consistencies greater than 0.7 (in some cases 0.5 for item loadings) are considered as adequate (Fornell and Larcker 1981; Hair et al. 2006). For discriminant validity, item loadings on their own construct should be higher than on other constructs, and the average variance shared between each construct and its measures should be greater than the average variance shared between the construct and other construct (the squared root of AVE of each construct is greater than all the correlation coefficients with other constructs). The structural model and hypotheses are tested by examining the standardized path coefficients. The explained variance in the dependent constructs (R² values) is assessed as an indication of the overall predictive power of the model.

Measurement Model:

It is required that the measurement model is checked for reliability and validity before the structural model is estimated. The test of measurement model includes the estimation of internal consistency and the convergent and discriminant validity of the instrument items. Cronbach’s alpha coefficient, whose value ranges from zero (unreliable) to one (perfect reliable), is used to examine the
reliability of survey instrument. A value of greater than 0.7 is optimum. However a value of greater than 0.5 is acceptable, but lower than 0.35 must be rejected (Hair et al. 2006). Constructs that have Cronbach’s alpha being greater than 0.7 are interaction constructs, i.e. PB*AS (0.76), PEB*AS (0.752), and PTB*AS (0.783) indicating their good reliability in the model. At a lesser extent, Adopter’s style (0.659) and intention to adopt cloud computing (0.502) have lower Cronbach’s alpha but both are above 0.5 which are acceptable to be included in the model. In contrast, three main variables in the model have very low Cronbach’s alpha that are Perceived Benefit (0.211), Perceived Technology Barriers (-0.072), and Perceived Environment Barriers (-0.04). Such results indicated that these constructs are not adequate reliable in the model. However we still keep these constructs in the model for the purpose of illustration.

Convergent validity is adequate when constructs have an average variance extracted (AVE) of at least 0.5. For discriminant validity, the square root of AVE for each construct should be greater than the correlation coefficients between the particular constructs and any other constructs (Chin 1998). Table 2 lists the correlations of the latent variables and the square root of AVE on the diagonal. In all cases, the square root of AVE for each construct is greater than 0.5, indicating sufficient convergent validity of the constructs. In most cases, the square root of AVE is larger than correlation of one construct with all others in the model, except the interaction terms between Perceived Benefit and Adopter’s style (PB*AS) and between Perceived Technology Barriers and Adopter’s style (PTB*AS). Construct validity is further examined by using factor loading analysis. First, items with factor loadings below 0.3 among all factors are to be deleted. Second, items with factor loadings of greater than 0.3 and which appear for more than one factor are also deleted. As the results, eleven items were deleted from the following analysis. These items are AS4, PTB3, PTB4, PTB5, PB1, PB2, ITA2, ITA3, ITA4, ITA5, ITA7, ITA8, ITA14, ITA15, ITA16 and ITA17.

<table>
<thead>
<tr>
<th>AS</th>
<th>ITA</th>
<th>PB</th>
<th>PTB*AS</th>
<th>ITA</th>
<th>PB</th>
<th>PTB</th>
<th>ITA</th>
<th>PB</th>
<th>PTB</th>
<th>AS</th>
<th>ITA</th>
<th>PB</th>
<th>PTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
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<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
<td>0.770</td>
</tr>
</tbody>
</table>

Table 2: Correlations of Latent Variables and Square Root of AVE
Figure 2: Structural model results

Structural Model:

The estimation of the structural model includes the estimation of the path coefficients and the $R^2$ values. Path coefficients indicate the impacts of the independent variables on the dependent variable, while $R^2$ values represent the amount of variance explained by the independent variables or the overall explanatory power of the model. Together, the $R^2$ and the path coefficients (loadings and significance) indicate how well the data support the hypothesised model. The path coefficients from the PLS analysis are shown in Figure 2. Overall, the estimated model explained for only about 23.3% of the variance in intention to adopt cloud computing. This is considered as quite low explanatory power of the estimated model.

According to the statistical results only Adopter’s style (AS) has a significant negative direct impact on the Intention to adopt cloud computing (-0.48). This negative sign is indeed strange in common sense. However, this is reasonable in our analysis due to the way how the values of the Adopter’s style items were defined. In our dataset, the values of the items are defined from the most (IT) professional to the least (IT) professional, with the corresponding values varied from 1 to 5. As the result, when the adopter style went from more professional to less professional (from 1 to 5), the adopters are less willing to adopt the cloud computing. The remaining variables in the model show no significant impact on intention to adopt cloud computing although all the coefficients have expected signs.

Specifically, Perceived Technology Barriers (PTB) and Perceived Environment Barrier (PEB) showed no statistically significant impacts on Intention but both showed negative impacts on Intention as expected. The more the users perceived about the technology and the environment barriers, the lesser extend the users are willing to adopt cloud computing. In contrast, Perceived Benefit (PB) increases the Intention to adopt, though the impact is also not statistically significant. In our model, Adopter’s style was hypothesised to have moderating effects on the impacts on PTB, PEB, and
PB. However, unfortunately, statistical results showed that all of these moderating impacts were not statistically significant, i.e. all the slope coefficients of the interaction term are not statistically different from zero. The hypothesis testing result can be summarised as Table 3 below:

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1. Perceived Benefit (PB) has positive impact on Intention to adopt (ITA) cloud computing</td>
<td>Not supported</td>
</tr>
<tr>
<td>H2. Perceived Environment Barriers (PEB) has negative impact on Intention to adopt (ITA) cloud computing</td>
<td>Not supported</td>
</tr>
<tr>
<td>H3. Perceived Technology Barriers (PTB) has negative impact on Intention to adopt (ITA) cloud computing</td>
<td>Not supported</td>
</tr>
<tr>
<td>H4. Adopter’s style (AS) has negative impact on Intention to adopt (ITA) cloud computing</td>
<td>Supported</td>
</tr>
<tr>
<td>H5. Adopter’s style (AS) has positive moderating impact on Perceived Technology Barriers (PTB).</td>
<td>Not supported</td>
</tr>
<tr>
<td>H6. Adopter’s style (AS) has positive moderating impact on Perceived Environment Barriers (PEB).</td>
<td>Not supported</td>
</tr>
<tr>
<td>H7. Adopter’s style (AS) has positive moderating impact on Perceived Benefits (PB).</td>
<td>Not supported</td>
</tr>
</tbody>
</table>

Table 3: Hypothesis testing result

V. Limitations and Recommendations

Having presented the scientific analyses on the commercial dataset, we were with regrets for not being able to achieve much significant inferences on the factors surrounding intention to adopt cloud computing. As the reviewed theories shared consensus on the driver and barrier roles of the factors while statistical results displayed otherwise, it suggests that the data’s quality is our most challenging limitation. To produce quality results, we encourage future researches may design better instrument and perform analysis on this study’s proposed model.

We reflected this study’s results against the findings from IBM’s Tech Trends report (IBM Center for Applied Insights 2012). The report asserted that information security is a major challenge that organisations need to overcome to adopt cloud computing and the other technologies. Although our hypothesis did not support that finding, information security (as item PTB1) played significant role in the construct Perceived Technology Barriers thus indicated its affection. Similarly, the positive impact of Market adaptability as driver of intention to adopt cloud computing was also consistent with the report albeit its hypothesis was rejected due to low significance level. The most consistent finding from this research to IBM’s report was the negative influence of Adopter’s style on intention to adopt cloud. The supported hypothesis implied that adopters with lower IT are less willing to adopt cloud and vice versa for those with better technological ability. Likewise, IBM reported that more than 70% of Pacesetters, who are more strategic and proactive in exploiting technologies, have been conducting professional training to meet cloud implementation’s requirements. As a consequence, this resulted in their leading position in adopting cloud (34%) in comparison to Dabblers (5%) and Followers (15%). The rest of this paper’s findings slightly confirmed the factors’ relationships with intention to adopt cloud computing thus suggest future empirical studies to re-validate the hypothesised model and clarify our results.
References


