ISSN: 2320-8848 (Online)
ISSN: 2321-0362 (Print)

International Journal for Management Science And Technology (IJMST)

Volume 1; Issue 9
Paper- 3

"Characterizing Diffusion patterns of Cloud Computing"

Shayan E

College of International Management
Ritsumeikan Asia Pacific University,
Japan

F. Ghotb

College of International Management
Ritsumeikan Asia Pacific University,
Japan

R S Suganda

College of International Management
Ritsumeikan Asia Pacific University,
Japan

Abstract
This paper reports an investigation on the status and the growth of cloud computing (CC) technology. It first provides some background knowledge on CC and its applications. It then reviews the concept of diffusion of innovation and the ways it can be modeled for cloud computing using proxy indicators. S curve model was assumed for prediction of the growth rate and behavior of CC adoption. Secondary data was used on some proxy indicators for adoption of CC due to the fact that the actual adoption figures are very small in number and not quite reliable. Two types of data were considered, the number of registered patents and the number of journal publications. The latter was obtained from two sources to ensure accuracy. The data was used to estimate the model parameters maximizing the coefficient of determination. The model identified the very likely pattern of behavior of growth of diffusion of CC. Both types of data confirmed the S-shaped behavior of the diffusion pattern and pointed to the same saturation time. Some conclusions were made on the basis of the findings indicating a positive sign for investment in this technology for some time.
Keywords: Diffusion of Technology, S-curve, Cloud Computing Trends

Introduction
Traditional information infrastructure or systems could no longer support the business operational or decision-making activities efficiently. The amount of information traffic needed, the increasing complexity, and even the assets needed to maintain the appropriate information architecture can be overwhelming for the company or corporation to handle.

Cloud computing technology provides an alternative innovation that changes, not what, but how of today's information and communication technology. According to Marston, Zhi, Bandyopadhyay, Juheng, & Ghalsasi (2010) cloud computing is a representation of a fundamental change of the way "information technology (IT) services are invented, developed, deployed, scaled, updated, maintained and paid for". The concept of "cloud" itself can be traced back to 1950s, where computers took huge spaces and were only available for experiments as a mainframe computer. The technology didn't allow for terminals or any internal computing or processing capability. Thus with physical networking, a mainframe will be connected to multiple clients or terminals to share computing capability with clients (Wikipedia, 2013). Even though the word "cloud" was not applied then, the concept of cloud as used today is rooted back to that time. As David Linthicum, senior Vice President for Cloud Technology Partners put it, "Cloud computing is nothing more than rethinking the way we consume the services and the delivery mode. However in the end we will still be dealing with the same things for over thirty years, such as storage, processors, application development, and so on", (Varett, 2013).

Korzeniowski (2013) named cloud computing as the "third platform" that shifts IT industry after mainframes followed by PCs, by which companies or organization can efficiently and flexibiliy manage their IT infrastructure according their needs. IDC even argued that from now on, cloud computing will drive around 90% of IT market growth (Korzeniowski, 2013). Equal Employment Opportunity Commission expects to save about 40% over the next five years by outsourcing its financial management application to a cloud computing service vendor (Marsan, 2011). Microsoft concluded that using 1000 servers through a cloud provider is 80% cheaper than owning 1000 server data centers (Mullins, 2011). Microsoft itself spent 90% of its $9.6 billion R&D budget on cloud strategy for the year 2011 (Bloomberg.com, 2011).

Despite such straight forward advantageous features there is still a great deal of uncertainties regarding the growth of this technology into its fullest potential because of the uncertainties in target consumer's mind. This paper attempts to shed some light on understanding of the growth of CC.

Nature and applications of Cloud Computing

Lack of one agreed definition of Cloud Computing may bring confusion. Some examples of these definitions can be seen in Investopedia.com, Geelan,(2009), Stavinoha, (2010). Internet services such as Google search engine, Gmail, Office 365, DropBox, and Youtube are actually cloud computing in action, (Nielsen,2013). This technology has three forms: *Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS),* and *Cloud Infrastructure as a Service (IaaS),* NIST (2012). The essential characteristics of Cloud Computing are, on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service (NIST, 2012).

Deployment of cloud can come in four models, *Private Cloud* where the cloud infrastructure is owned and operated exclusively for a single organization. *Community Cloud* shares the infrastructure between several organizations or entities that have the same concern or needs. *Public Cloud* refers to cases where the provider offers the applications, storage, and other services (or resources) for the public. *Hybrid Cloud* is using different cloud infrastructures bound together with standardized or proprietary technology that enables data and application portability.

The reason that a business considers or decides to use cloud is mainly economical as cloud computing needs less initial investment, fewer skilled internal IT resources, and lower operating expenses (Stavinoha, 2010).

Cloud offers freedom to break away from the physical restriction on data storage, by offering cloud storage service. An example is Office 365 that allows operations on Office documents online and access to email and calendar integration, file sharing and project managing tools (Microsoft, 2012). For the user, the data is always couple of clicks away thus negating the need for up-front investment in user-owned resources Strickland(2013).

Marston, Zhi, Bandyopadhyay, Juheng, & Ghalsasi (2010), summarizes the key advantages of cloud computing to business in 5 points namely 1)lowering the cost, 2)quick access to needed resources with least investment, encouraging innovations, quick scaling of services according to the market demand and the possibility to new types of applications and delivery.

Application of public cloud services, mainly due to computing for supply chain management, has grown exponentially to reach $206.6 billion by 2016 from $109 billion in 2012, Dwight Klappich (2012). From 2011 to 2012, the number of companies that adopted the cloud computing technology has increased by about 40% and not slowed down, Pham (2013). Cloud-based Customer Relationship Management (CRM) applications has the highest penetration in Small and Medium Businesses (SMBs), according to a survey conducted in December 2011 on more than 400 U.S based companies (ITBusinessEdge.com). Putting the HR department 'on the cloud' facilitates a mobile workforce and should also allow flexibility as well as being more cost effective than traditional IT (Wootton, 2013).

Security in cloud computing is one of the biggest concerns, Furht & Escalante,(2010). Physical segmentation and hardware-based security is futile to resist attack from another virtual machine that uses the same server. Thus companies show negative feeling about how

someone else, the service providers, has control on their data or application (Furht & Escalante, 2010). This point was confirmed by a survey done by Microsoft using 1979 IT professionals.

The combination of the above knowledge has caused a pattern of progress in adaptation and adoption of this technology. Question is what should be expected of the future? This paper attempts to provide some insight into the diffusion of cloud computing technology by fitting an S curve to the data available in order to determine the progress of CC.

Due to lack of a concise definition, varied nature of the technology and lack of data over the short life of CC, we chose to use proxy data. It is safe to assume that number of publications and patents resemble the progress of CC as a substitute for the actual number of adoptions. Daim, Rueda, Martin, & Gerdsri (2006), concluded that patent data and bibliometrics, the measurement of texts and information that traditionally was being used only to trace academic journal citation, can provide the historical data in the case of emerging technologies to understand the past and forecast possible future. We therefore fit the well-known Gompertz's S curves into the proxy data while testing the statistical suitability of the model to the sample and the population. Conclusions will be drawn on the results.

Literature search on Diffusion of Technology

The concept of Innovation was popularized in a book titled "Diffusion of Innovation", by Rogers (2003), where he defined diffusion as a process an innovation is communicated through certain channels over time among the members of a social system" having *compatible values, beliefs, and past experiences, leading to* social change. He further identifies that individuals or social units are adopting new ideas in different ways and speed, called innovativeness. The innovators come first, among 2.5% of all, followed by early adopters (13.5%), early majority (34%), the late majority (34%), and the laggards (16%) roughly as parts of a normal distribution.

Hameed, Counsell, & Swift (2012) acceps Roger's theory of Diffusion of Innovation in explaining pre-adoption and adoption-decision stages. However argue that user acceptance model is needed to explain all pre-adoption, adoption-decision, and post-adoption stages, thus objecting to its adequacy for information technology (IT) adoption. They base their arguments on findings of Thong and Yap (1995) and (Lee & Cheung, 2004).

Using other research results such as Theory of Reasoned Action (TRA), Fishbein and Ajzen (1975), and Perceived Behavioral Control (PBC), (Ajzen, 1991), Technology-Organization-Environment (TOE) framework of Tornatzky and Fleisher reported in Brigham Young Universtiy, (2011), Hameed, Counsell, & Swift (2012) developed the Diffusion of Innovation Theory (DOI) to explain activities involved in pre-adoption and adoption-decision phase using 5 determinants of Innovation Characteristics (trial-ability, cost, security, advantage, etc.), Organizational Characteristics (top management support, readiness, size, etc.), Environmental Characteristics (uncertainty, government support, competitive pressure, etc.), CEO Characteristics (CEO's attitude, innovativeness, knowledge, etc.) and User Acceptance Attributes (attitude toward use, perceived ease of use, perceive usefulness, etc.). Given sufficient data one could use this type of models to determine the relationships between its constituents and to draw conclusions on how diffusion could be characterized.

S-curve or sigmoid curves describe most technology adoption behavior. This curve has especially interesting characteristics reflecting the adoption process as it naturally occurs. It starts slowly, continued by a steep growth, changes direction at its inflection point, and then

slows down approaching the saturation level and eventaually dies down, Aravantinos & Fallah, (2006). Rojko, Lesjak, and Vehovar (2010) depict the present condition of IT evolution in term of Efficiency and Development as a combination of individual S-curves.

Fisher-Pry model is a symmetric S-curve, meaning that the inflection point occur in the middle range, ie, the peak of the diffusion rate will be achieved at half of the saturation level while in Gompertz model the saturation point is related to the time that the growth reaches 37% from its saturation level, (Christodoulos, Michalakelis, & Varoutas, 2010). Although Gompertz model was developed to estimate or calculate the mortality rates in 1825, it has been adopted in forecasting technology (Martino, 1993) mainly due to its unique asymmetric properties, (Trappey & Wu, 2008). CostQuest, (2011), summarized that Fisher-Pry can better forecast technology when substitution is driven by superior technology that would overwhelmingly hold advantage over the old ones and that Gompertz model is better when the substitution is driven by superior technology, but the consumer choice is a significant factor in the adoption process.

Given that adoption, personal or individual factors are significant determinants for adoption as argued earlier and summarized by Hameed, Counsell, & Swift, (2012), and the data available, Gompertz model will be used to model the indicators for diffusion of Cloud Computing data.

Data

For one indicator on diffusion of cloud computing, 44 cases of monthly registered patent data under cloud computing was acquired from United States Patent and Trademark Office (USPTO), from October 1st, 2009 to May 1st, 2013. The percentage of the possible unregistered inventions is assumed to be insignificant.

The second indicator used here is the number of research papers on cloud computing published in peer reviewed and academic journals between 2006 and 2013 were also collected in yearly time-series manner. The data was collected from 2 online academic journal databases EBSCO.com and ProQuest.com, Note that the term cloud computing was not used before 2006.

Model Development

The aim is to fit the Gompertz time series model given by $\hat{y}(t) = Se^{-e^{-a-b.t}}$ function into the available data points y, by determining the best values of its parameters S, a, b. Note that S is an asymptote at y=S. Inflection point is at a point with coordinates (t=a/b, $\hat{y}$ =S/e).

The function can be linearized to ln(ln (S/ $\hat{y}$))= (a-bt). Note that the growth rate dy/dt = b. $\hat{y}$. e $^{(a-bt)}$ = b. $\hat{y}$ ln S/ $\hat{y}$. This yields a relative growth 1/ $\hat{y}$. d $\hat{y}$ /dt = b.e $^{(a-bt)}$ and max growth rate of bS/e

Determination of the values of parameters for the best fit of the curve into data can be achieved in different ways. One way is by establishing a regression model that has the largest coefficient of determination, r^2. The other is to find the parameters to have the minimum total error of fit. The resulting model will then be used to forecast the future levels of diffusion of cloud computing.

Regression approach

Here we use a nonlinear regression analysis approach to fit a relationship that produces the maximum value of the coefficient of determination r^2 where

$$r^2 = 1 - \frac{\sum(y-\hat{y})^2}{\sum(y-\bar{y})^2} \qquad or \qquad r^2 = 1 - \frac{SSResid}{SSTo}$$

Where *SSResid* is the residual sum of squares (or error sum of squares) defined as, $\sum(y-\hat{y})2$, and *SSTo* is the total sum of squares, defined as $(y-\bar{y})2$.

Curve fitting Approach

Here the same curve $\hat{y}(t) = Se^{-e^{-a-b.t}}$ is fit into that data set y so that the parameters yield the minimum value of $e^2 = \sum(y-\hat{y})^2$.

Solution Approach

Solver, a handy tool add in tool of Excel was used to find values of parameters in both cases. We assume the reader is familiar with Solver. Otherwise please just follow the help menu to learn how to apply it.

Statistical Tests

F test was also run on the results to establish the power of the fit where $F = \frac{r^2/k}{(1-r^2)/(n-(k+1))}$. Here ***k*** is the number of parameters to estimate, k=3 for Gompertz model, and ***n*** is the number of data observed and *df* = n-(k+1) = degrees of freedom, for further explanation see for example (Peck, Olsen, & Devore, 2008).

Results

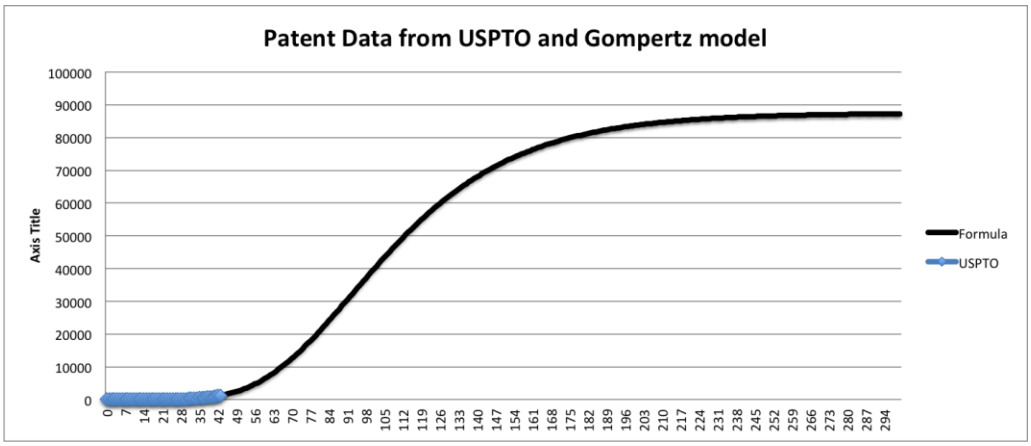
Solver is applied to maximize r^2 on both the patent data and the number of publications, each being presented separately.

Patent data

S	7450.0558696135	Saturation
b	0.0291988813417274	Growth Rate
a	15.0365220752906	
r^2	0.9991	

Table 1: Solver Result For Value Of Parameters Minimizing R^2 On Patent Data

The shape of the Gompertz curve for patent data for the optimum values of Fig 1, is given in Fig 2.



.

Figure 1: Shape Of Gompertz Curve For Patent Data, For Maximum R^2

The low growth rate b from Fig 1 is reflecting the fact that cloud computing is at its early stages of adoption. The high value of r^2 indicates that the curve well fits the existing data. However extension of the curve beyond the existing data is not very reliable. There may be many other S shaped curves fitting the initial data whose later behavior can be very different.

Number of Publications data

Figures 3, 4 show the results and the respective Gompertz curves for the two sets of data EBSCO and ProQuest which as expected show close results.

	EBSCO	ProQuest	
S	4630.599876	3784.834242	Saturation
b	0.326723293	0.379465229	Growth Rate
a	10.65616598	10.2965932	
r^2	0.9998	0.9999	

Table 2: Solver Result For Values Of Parameters Maximizing R^2 For Ebsco Data

Despite the slight differences both curves demonstrate that in terms of publications diffusion is at a more advanced stage as the growth rate is much higher than the patent data. This is understandable as patenting is a much longer and more costly process which is not taken up by many inventors. In fact study of diffusion based on number of publications seems to be more realistic.

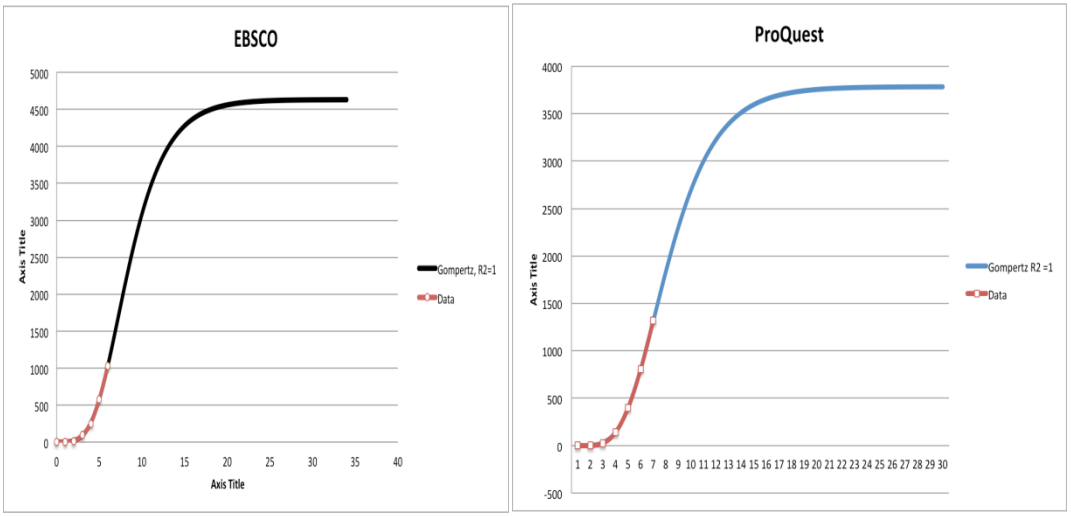


Figure 2: Shape Of Gompertz Curve For Max R^2 On Ebsco And Proquest Data

It confirms the S curve nature of the diffusion and heralds a period of high concentration of publications in the field as a reflection of a sharp increase in new developments and adoption of cloud computing. Adoption will be leading to new experiences with the technology with new impacts on the environment and other technologies, in turn needing further research and so more publications.

Due to space limitation and similarity we do not report the results of curve fitting with minimum error approach.

Discussion of outcomes and conclusions

For Patent Data the value of F statistic for n=44 and k=3 is F= 14801which is much greater than $F_{.01}$ indicating that the fit is significant. Similarly for both data sets on the number of research papers it is concluded that Gompertz model is a good fit.

Watts & Porter, (1997) proposed maximizing the coefficient of determination to 0.99 rather than 1 to find the range of the saturation level while keeping the other parameters (*a,b)* constant at their optimum level for r^2 =1. This is shown in Figure 3.

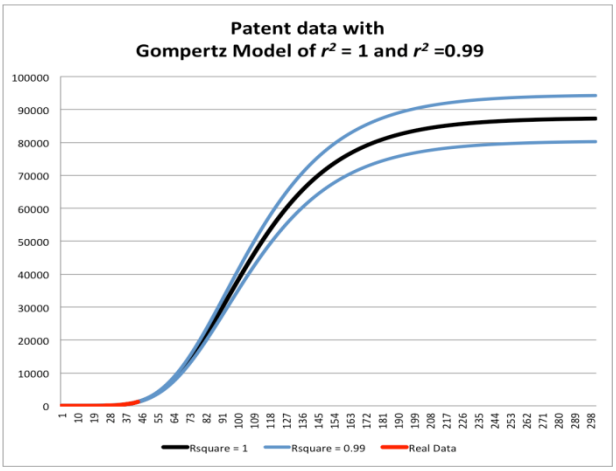


Figure 3: Three Gompertz Curve With $R_{squared}$=0.99 And $R_{squared}$=1

The range of saturation level of the Patents, Figure 2, turned out to be from 80,428 to 94,465 patens occurring around 190 month or 15 years from Oct 2009, ie about 2024. Note that saturation points for papers published would arrive much earlier in about 2020.

The highly possible saturation level is at 87,450 patents, where the current level is only 1,198 at May 1st, 2013, about 1.4% of the total saturation. The technology is still at the very beginning at the innovator category. On the other hand results show the current paper publication level at 1,032 or around 26% of the predicted saturation level 3,976 of EBSCO, and at 1,317 or 35% of ProQuest data with predicted saturation level of 3,784. The lag between saturation level of Patent and publications is mainly reflecting the fact that publishing is much simpler and more common than registering patents due to cost and time. One indication may be that perhaps now is a good time for investment in the technology that has the potential to be one of the standards of computing technology in the not a distant future.

This paper was based on a small sample size, thus the generated forecasts may be improved with more data. However even the current results demonstrate that the diffusion is most likely following the expected S curve and that diffusion of cloud computing is yet at its early stages. Experts' opinions from the media, the extent of popularity of the technology even among those non-adopters, the enormous amount of developments particularly in the social media such as Google, further strengthen the conclusions on the direction and speed of diffusion of cloud technology from this work. The authors would like to continue this investigation by some other methods of technological forecasting to gain more support for these assertions.

References

- Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes , 50 (2), 179-211.
- Aravantinos, E., & Fallah, M. H. (2006, April). A Methodology to Improve the Mobile Diffusion Forecasting: the Case of Greece . Retrieved July 10, 2013, from Social Science Research Network: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=981985&download=yes
- Bloomberg.com. (2011, April 8). Microsoft Says to Spend 90% of R&D on Cloud Strategy. Retrieved July 9, 2013, from Bloomberg: http://www.bloomberg.com/news/2011-04-06/microsoft-s-courtois-says-to-spend-90-of-r-d-on-cloud-strategy.html
- Brigham Young Universtiy. (2011, November 16). Technology-organization-environment framework - IS Theory. Retrieved July 10, 2013, from http://istheory.byu.edu/wiki/Technology-organization-environment_framework
- Christodoulos, C., Michalakelis, C., & Varoutas, D. (2010). Forecasting with limited data: Combining ARIMA and diffusion models . Technological Forecasting & Social Change , 558-565.
- CostQuest. (2010). BAM Attachment 9 - Gompertz Penetration Rate. Retrieved July 11, 2013, from Boradband.Gov: http://download.broadband.gov/plan/fcc-omnibus-broadband-initiative-%28obi%29-working-reports-series-technical-paper-bam-attachment-9-gompertz-penetration-rate-documentation.pdf
- Daim, T. U., Rueda, G., Martin, H., & Gerdsri, P. (2006). Forecasting emerging technologies: Use of bibliometrics and patent analysis. Technological Forecasting and Social Change , 73, 981-1012.

- EBSCO. (n.d.). EBSCOhost online research databases. Retrieved June 15, 2013, from EBSCO: http://www.ebscohost.com/
- Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research. Addison-Wesley Pub.
- Furht, B., & Escalante, A. (Eds.). (2010). Handbook of Cloud Computing. Springer.
- Geelan, J. (2009, January 24). Twenty-One Experts Define Cloud Computing. Retrieved July 25, 2012, from Cloud Computing Journal: http://cloudcomputing.sys-con.com/node/612375?page=0,2
- Hameed, M. A., Counsell, S., & Swift, S. (2012). A conceptual model for the process of IT innovation adoption in organizations. Journal of Engineering and Technology Management , 29 (3), 358-390.
- Investopedia.com. (n.d.). Cloud Computing Definition. Retrieved 7 25, 2012, from Investopedia.com: http://www.investopedia.com/terms/c/cloud-computing.asp - axzz21agUKHcW
- ITBusinessEdge.com. (n.d.). Five Cloud Application Adoption Trends. Retrieved July 4, 2013, from IT Business Edge: http://www.itbusinessedge.com/slideshows/show.aspx?c=94959
- Korzeniowski, P. (2013, April). Cloud computing continues to drive IT growth, shapes industry. Retrieved July 9, 2013, from Search Cloud Computing: http://searchcloudcomputing.techtarget.com/tip/Cloud-computing-continues-to-drive-IT-growth-shapes-industry?asrc=EM_ERU_22441234&utm_medium=EM&utm_source=ERU&utm_campaign=20130709_ERU Transmission for 07/09/2013 (UserUniverse: 607658)_myka-repor
- Lee, M., & Cheung, C. (2004). Internet retailing adoption by small-to-medium sized enterprises (SMEs): a multiple-case study. Information Systems Frontiers , 385-397.
- Marsan, C. D. (2011, 3 11). Federal agency predict 40% savings from move to cloud. Retrieved 7 25, 2012, from Network World: http://www.networkworld.com/news/2011/031111-eeoc-case-study.html
- Marston, S., Zhi, L., Bandyopadhyay, S., Juheng, Z., & Ghalsasi, A. (2010). Cloud Computing - The business perspective. Decision Support Systems .
- Martino, J. (1993). Technological Forecasting for Decision Making (3rd edition ed.). New York: McGraw-Hill.
- Microsoft. (n.d.). Cloud computing survey. Retrieved July 10, 2013, from Microsoft.com: https://www.google.co.jp/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CEIQFjAA&url=http%3A%2F%2Fdownload.microsoft.com%2Fdocuments%2Fuk%2Ftechnet%2Fcloud-power%2FITPro_survey_v5.pdf&ei=NWDjUa6kHNDDkAWth4CABg&usg=AFQjCNHUkmwyCAzv9g4rez-mxjtnCwk91A
- Microsoft. (2012). Office 365 is Secure, Anywhere Access to Your Online Office. Retrieved June 14, 2012, from Microsoft: http://www.microsoft.com/en-us/office365/what-is-office365.aspx - fbid=YhpFMlmlwod
- Mullins, R. (2011, 10 3). Microsoft Tech: Microsoft study shows 80% savings by using the cloud. Retrieved 7 25, 2012, from NetworkWorld: http://www.networkworld.com/community/node/72069
- Nielsen, K. (n.d.). Confused About the Cloud? Deciphering Cloud Services for Consumers. Retrieved July 8, 2013, from Top-ten-reviews.com: http://cloud-services-

review.toptenreviews.com/confused-about-the-cloud-deciphering-cloud-services-for-consumers.html

- NIST. (2012, May 29). NIST Manuscript Publication Serach - Cloud Computing Synopsis and Recommendations. Retrieved June 13, 2012, from National Institute of Standards and Technology: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=911075
- Peck, R., Olsen, C., & Devore, J. (2008). Introduction to Statistics & Data Analysis (3rd Edition ed.). Duxbury: Thomson Brooks/Cole.
- Pham, T. (2013, January 25). Cloud Computing Use Increases Among Supply Chains. Retrieved February 13, 2013, from SmartData Collective: http://smartdatacollective.com/onlinetech/99516/cloud-computing-use-increases-among-supply-chains
- ProQuest. (n.d.). Search ProQuest. Retrieved june 8, 2013, from ProQuest: search.proquest.com
- Rogers, E. M. (2003). Diffusion of Innovation (5th edition ed.). Free Press.
- Rojko, K., Lesjak, D., & Vehovar, V. (2011). Information communication technology spending in (2008-) economic crisis. Industrial Management & Data Systems , 111, 341-409.
- Stavinoha, K. E. (2010). What Is Cloud Computing and Why Do We Need It.
- Strickland, J. (n.d.). How Cloud Computing Works. Retrieved July 10, 2013, from HowStuffWorks: http://www.howstuffworks.com/cloud-computing/cloud-computing.htm
- Thong, J., & Yap, C. (1995). CEO characteristics, organizational characteristics and information technology adoption in small businesses. Omega , 429-442.
- Trappey, C. V., & Wu, H.-Y. (2008). An Evaluation of the Extended Logistic, Simple Logistic, and Gompertz Models for Forecasting Short Lifecycle Products and Services. Advanced Engineering Informatics , 22 (4), 421-430.
- USPTO. (n.d.). United States Patent and Trademark Office. Retrieved june 10, 2013, from United States Patent and Trademark Office: http://www.uspto.gov
- Varett, A. (2013, May). Cloud computing practices represent a fundamental shift in IT. Retrieved July 10, 2013, from Techtarget: http://searchcloudcomputing.techtarget.com/feature/Cloud-computing-practices-represent-a-fundamental-shift-in-IT?asrc=EM_ERU_22440451&utm_medium=EM&utm_source=ERU&utm_campaign=20130709_ERU Transmission for 07/09/2013 (UserUniverse: 607658)_myka-
- Watts, R. J., & Porter, A. L. (1997). Innovation Forecasting. Technological Forecasting and Social Change , 56 (1), 25-47.
- Wikipedia. (2013, July 9). Cloud Computing. Retrieved July 10, 2013 , from Wikipedia: https://en.wikipedia.org/wiki/Cloud_computing
- Wootton, P. (2013). The Uses of Cloud Computing in Human Resource. Retrieved July 5, 2013, from ShiftiQ.com: http://www.shiftiq.com/articles/the-uses-of-cloud-computing-in-human-resources.html

Appendix A:
Patent Data And Solver Result

USPTO					
("cloud computing" AND ISD/19800101->20130101)				= search term	
	by the first day of the month				
Date	T	No. of patents	Date	T	No. of Patents
10/1/2009	0	2	9/1/2011	23	48
11/1/2009	1	2	10/1/2011	24	55
12/1/2009	2	2	11/1/2011	25	66
1/1/2010	3	3	12/1/2011	26	84
2/1/2010	4	3	1/1/2012	27	95
3/1/2010	5	3	2/1/2012	28	120
4/1/2010	6	3	3/1/2012	29	137
5/1/2010	7	4	4/1/2012	30	163
6/1/2010	8	5	5/1/2012	31	187
7/1/2010	9	5	6/1/2012	32	213
8/1/2010	10	5	7/1/2012	33	250
9/1/2010	11	6	8/1/2012	34	325
10/1/2010	12	6	9/1/2012	35	396
11/1/2010	13	7	10/1/2012	36	458
12/1/2010	14	7	11/1/2012	37	541
1/1/2011	15	9	12/1/2012	38	627
2/1/2011	16	13	1/1/2013	39	731
3/1/2011	17	16	2/1/2013	40	811
4/1/2011	18	25	3/1/2013	41	939
5/1/2011	19	26	4/1/2013	42	1053
6/1/2011	20	31	5/1/2013	43	1198

upper asymptote	s	87450.0559	**Coefficient of Determination (r^2)**	0.9990699
growth rate	b	−0.0291989		
	a	−15.036522		
	t	0		

t	Yhat	SSResid	SSTo
0	0.0257918	3.897498046	38853.7856
1	0.0397559	3.842556971	38853.7856
2	0.0605221	3.761574674	38853.7856
3	0.0910278	8.462119509	38460.5584

4	0.135311	8.206443234	38460.5584
5	0.1988557	7.846409498	38460.5584
6	0.2890223	7.349399977	38460.5584
7	0.4155771	12.84808746	38069.3311
8	0.5913345	19.43633191	37680.1038
9	0.8329265	17.36450146	37680.1038
10	1.1617133	14.7324445	37680.1038
11	1.6048456	19.31738231	37292.8765
12	2.1964897	14.46669063	37292.8765
13	2.9792225	16.16665169	36907.6493
14	4.0055986	8.966439729	36907.6493
15	5.3398893	13.39641061	36143.1947
16	7.0599866	35.2837594	34638.2856
17	9.2594609	45.43486747	33530.6038
18	12.049753	167.7088907	30315.5584
19	15.562479	108.9418528	29968.3311
20	19.951809	122.0625326	28262.1947
21	25.396897	158.8381937	25957.6038
22	32.104308	118.7161142	24371.4675
23	40.310388	59.13013218	22835.3311
24	50.283554	22.24486168	20768.7402
25	62.326413	13.49524302	17719.2402
26	76.777679	52.16192252	13251.1493
27	94.013825	0.972540419	10839.6493
28	114.45041	30.79791665	6258.96746
29	138.54305	2.380993666	3858.10382
30	166.78791	14.34829217	1304.19473
31	199.72186	161.8456561	146.740186
32	237.92196	621.1038706	192.831095
33	282.00458	1024.293003	2589.422
34	332.6239	58.12385703	15847.3765
35	390.46987	30.5822881	38764.2402
36	456.26565	3.007970653	67022.1493
37	530.76447	104.7661757	116886.286
38	614.74603	150.1597911	183086.74
39	709.01243	483.4533496	282903.104
40	814.38359	11.44865062	374404.922
41	931.69236	53.40166584	547431.831
42	1061.7793	77.07551575	729121.922
43	1205.487	56.05525331	997773.967
44	1363.6547		
45	1537.1121	**3967.896103**	**4266108.43**
46	1726.6736	SSResid	SSTo

Appendix B:
The Research Paper Data And The Solver Result

EBSCO HOST				
Search phrase: "cloud computing"				
limiters: Peer reviewed journals **Source type: academic journals**				
Year	total	Yhat	SSresid	SSTo
2006	0	0.1090745	0.01189724	162711.391
2007	2	2.1261804	0.0159215	161101.891
2008	13	18.112017	26.1327152	152392.641
2009	94	84.922891	82.3938992	95712.8906
2010	251	258.8497	61.6178617	23218.1406
2011	582	578.31613	13.5708663	31906.8906
2012	1032	1032.7092	0.50290605	395169.391
			184.24607	1022213.2

EBSCO HOST			
			Excel model for t(0)
Gompertz=	y(t) = ae^be^ct		D57*EXP(D59*EXP(D58*B65))
	upper asymptote	a	4630.59988
	growth rate	c	-0.3267233
		b	-10.656166
		t	0
		rsquared	0.99981976

ProQuest				
Phrase: "cloud computing				
advance search =				
peer reviewed scholarly journals				
Year	total	Yhat	SSResid	SST0
2006	1	0.1277301	0.76085478	161905.641
2007	1	3.2987647	5.28431918	162711.391
2008	25	30.515459	30.4202918	143925.391
2009	140	139.82948	0.02907684	83160.1406

2010	401	396.21132	22.9314996	20270.6406
2011	804	808.01996	16.1601184	0.140625
2012	1317	1315.7917	1.45998768	12017.6406
			77.046148	583990.98

PROQUEST			
			Excel Model for t(0)
Gompertz=	y(t) = ae^be^ct		K57*EXP(K59*EXP(K58*H65))
	upper asymptote	a	3784.83424
	growth rate	c	-0.3794652
		b	-10.296593
		t	0
		rsquared	0.99986807