

Do Cloud Security Announcements Affect Firm Valuation?

Srikanth Parameswaran, Srikanth Venkatesan, and Manish Gupta

Abstract—Recent years have witnessed unprecedented growth in adoption and offerings of cloud computing services. Security and availability risks have risen to become one of the biggest challenges and concerns for not only businesses that are transitioning into the cloud but also companies offering the cloud services. The focus of this paper is to investigate how announcements in media about security of cloud computing affects the market valuation of firms involved in the announcement. The paper uses event study methodology to analyze impact of the media announcements about cloud security. The paper also examines the impact of these announcements on the market valuation of the competitors of the companies involved in the announcements.

Index Terms— Cloud Computing, Cloud Security, Firm Valuation, Information Security, Market Impact

I. INTRODUCTION

THE arrival of cloud computing has accelerated commoditization of computing power. It has ushered in an era of pay-as-you-go model in the computing environment of businesses. But, the risks stemming from ensuring availability are transferred to cloud service providers. The risks of additional exposure to entities outside the organization environment are still an unsettled issue. Amidst these issues, the question is “Does deploying cloud computing reduce costs?” Businesses, especially Small-to-Medium Businesses (SMBs), benefit from low cost of entry and reduced IT barriers in the adoption of cloud computing services [30]. Companies that use these services cite the potential reduction in costs and business agility as primary reasons for its success [14] [36]. Given the advantages offered by cloud computing, it is not surprising that the adoption of cloud computing has tremendously increased over the years.

A study from Ovum [33] has found that the uptake of cloud services among multi-national corporations (MNCs) has grown more than 60 percent since spring 2010; with 45 percent of the MNCs surveyed saying that they have used cloud sourcing for at least some elements of key IT services. Going with this upward trend in the adoption of cloud computing services, the future looks bright with Gartner predicting the cloud computing business to be worth \$150 billion by 2014. However, as the popularity of cloud computing has been increasing, concerns over the security and privacy of user data has emerged as one of the biggest obstacles in its adoption [24].

Cloud security has become a top concern for businesses transitioning into the cloud, especially the ones in the

healthcare and financial industries that store and use sensitive data. According to a survey conducted by Symantec [42] in 5300 organizations across 30 countries in 2011, organizations rated security as a top goal and a top concern when moving to the cloud. Though 87 percent of the respondents in the survey were confident that moving into the cloud will actually improve their security, they still felt that achieving security in a cloud environment was their topmost concern citing potential risks like malware, hacker-based theft and loss of confidential data [42]. A survey conducted by CSO magazine, along with CIO magazine, and PriceWaterhouseCoopers sums up the situation, with respondents expressing their concerns on inadequate training, IT auditing and their ability to enforce security policies at a provider site [5].

The focus of this paper is to investigate how announcements in media about security of cloud computing affects the market valuation of firms involved in the announcement. There are several other studies that have investigated impact of security breaches on stock performance (see for example, [2] [6] [16] [18] [22] [25] [29]). Since enterprises have already begun taking advantage of cloud services, the paper examines how announcements about cloud security or privacy impact the market valuation of the firms involved in the announcement. Though there are many studies that analyze information security announcements, there are not many studies studying the impact of cloud security announcements. This is the first study that analyses the impact of cloud security announcements on firm valuation.

Our study contributes to the extant literature by answering the following research questions:

- 1) How negative cloud security announcements affect market valuation of firms?
- 2) How positive cloud security announcements affect market valuation of firms?
- 3) How cloud security announcements affect the stock prices of competitors of the companies involved in the announcement?

The rest of the paper is organized as follows: Section II provides background and literature review in the area, Section III discusses the methodology of this research in detail, followed by presentation of the results in Section IV. Section V implications of findings, Section VI concludes the paper with limitations and directions for future research.

II. BACKGROUND AND MODEL

Cloud computing is a model for enabling network access on demand to a pool of computing resources like storage, applications and services which are remotely and conveniently configurable. The resources can be availed rapidly with a service provider interaction [32]. Since the concept of cloud computing has changed the way data is stored and shared across interconnected infrastructures, new kinds of security and privacy related issues such as loss of governance, isolation failure, compliance risks, under-provisioning, over-provisioning, distributed denial of service attack (DDoS), economic denial of service attack (EDoS), etc., have to be addressed [7]. For example, the concept of multi-tenancy, wherein a single instance of a software program may service multiple tenants or clients, demands for proper isolation of user's data. Therefore, a failure in the mechanism that separates the memory, storage and routing between different tenants may be considered a risk that is attributable to the cloud computing environment [7].

A. Research Model

Since many companies use cloud services expecting reduction in costs and increase in business agility, it is important to measure and identify if such security announcements on cloud computing really impact the market value of the firms [14]. Research has shown that cloud computing announcements do have a significant impact on the stock prices of the companies involved [34]. In order to measure the impact of such announcements, internal measures such as Return on investment or internal rate of return are difficult to apply to financial benefits obtained on IT investments as there is very little information available about the changes to cash flows due to an announcement [10]. Since there are multiple factors influencing the cloud computing services, we employ an external measure to find the impact of these announcements. Since the time frame within which the announcements may affect the respective firms may vary, the stock price would show the impact more appropriately since it takes future costs and benefits into account. It is also independent of the likelihood of occurrence of the event. Thus, market response could be a reliable and suitable indication of the effect of the announcements, which can be measured using event study. These announcements which are related to cloud security may have immediate or delayed impact. We therefore examine whether cloud security announcements affect the stock prices of various firms through three hypotheses (also shown in Fig. 1).

Researchers have widely studied impact of security breach on market valuations of companies that suffer the breach (See, for example, [1] [2] [6] [8] [13] [17] [18] [26] [44]. Garg et al. [16] estimate that on an average, breaches could lower annual sales of companies by 0.5 to 1 percent. A Ponemon study estimates that companies suffering from data breaches paid £47 per compromised record in 2007 and the average cost per reporting incident for the company is around £1.4m [37]. Extant studies have shown a significant negative impact due to information security breach (e.g., [1] [8] [13] [16]). Besides loss in stock value, there are long term costs associated with a security breach such as loss of trust, loss of

business, legal actions and negative reputation [8] [43]. Thus, we expect negative abnormal returns for cloud security breach announcements. Hence we hypothesize that:

H1a: *Cloud security breach announcements will have negative impact in market valuation of the involved companies*

Customers and stakeholders gain confidence about the company when announcements about a corrective action are made. These positive announcements help in restoring and uplifting the image that was damaged due to a crisis [39]. Several studies have reported the reputational capital effect on stock performance of companies [15] [19] [27]. The crisis response to a cloud security breach incident can take form of positive announcements regarding company's security initiatives to further strengthen the overall security posture. Hence we hypothesize that:

H1b: *Positive cloud security announcements will have positive impact in market valuation of the involved companies.*

Customers shifting to competitors for same products or services usually accounts for a change in profitability. Event studies can reveal the impact of any event on the stock price of a firm. An investors' perception about a company's profitability and efficiency results in abnormal changes in the stock price. Adverse announcements like a cloud security breach have potential to affect the stock prices of other companies in the industry. Studies have shown certain events can cause competitor's stock price to change. For example, Lang and Stulz [28] show that at the time of the bankruptcy announcement, stock price of the bankrupt firm's competitor's decreases by 1% and the decline is statistically significant. Eckel et al. [12] also showed statistically and economically significant impact on competitors' market value due to airline privatization announcement. Recent research has shown that stock prices of competitor companies in financial sector tend to react in same way as companies that have had an information security breach [21]. So, we expect a negative abnormal return for the competitors of the companies involved in a cloud security breach. Hence we hypothesize that:

H2a: *Cloud security breach announcements will negatively impact market valuation of competitors of Cloud companies involved*

Research has also showed that competitors do benefit from positive security announcements from the companies that had a breach, across industries, firm types and years [21]. We expect a positive abnormal return for the competitors of the companies involved in a positive cloud security announcement. Hence we hypothesize that:

H2b: *Positive cloud security announcements will positively impact market valuation of competitors of Cloud companies involved*

III. METHODOLOGY

In this section we present the data collection and the research methodology used for analysis.

A. Data Collection

In this research, we collected 214 cloud computing announcements related to information security. We used cloutage.org, a leading source of cloud security breaches to collect announcements on cloud computing information security. We also used keyword search to collect more announcements on cloud computing information security. The keywords we used for the search to collect cloud security breach announcements include “cloud security breach” OR “cloud security announcements” OR “cloud security news” OR “cloud security breach” OR “cloud security data loss”. Some examples of cloud security breaches include:

“Apple App Store Suffers Hack Attack” (7/6/2010)
“Salesforce.com crashes again” (1/31/2006)

In order to collect positive cloud security news announcements we used keywords including “cloud security technology” OR “cloud security fix” OR “cloud security investment” OR “cloud security improvement”. Some examples of positive cloud security news include:

“With encryption breakthrough IBM boost cloud computing” (7/5/2009)
“Amazon cloud-based database gains high-availability feature” (5/18/2010)

The announcements were also collected from press releases of the companies and popular news websites that release cloud computing news. The time period for data collection is four years – 2006 to 2010. We obtained historical stock price information for companies making the announcements from the Centre for Research in Security Prices (CRSP) at the University of Chicago. CRSP contains price information of stocks listed in the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and NASDAQ. We also recorded the number of employees for each company involved in these cloud security announcements, from finance.yahoo.com. Out of the 214 cloud computing announcements related to Information security, there are 37 distinct companies that were involved in these announcements, 32 companies are publicly traded in the US market. But the announcements that involved the 5 companies that are not publicly traded, involved another company that is publicly traded. We also collected stock price information of 3 publicly traded competitors of each companies involved in cloud security announcements. Competitor companies were identified from the “Hoovers” database as the source. In this analysis, the date of announcement has been used as the date to perform competitor analysis. Table I shows the sample size and brief description on data included for each hypothesis.

TABLE I
DATA DEFINITION SCHEME

#	Sample Size	Data
H1a	183	Includes all publicly traded companies involved in a cloud security breach
H1b	31	Includes the publicly traded companies involved in a positive cloud security news
H2a	397	Includes the competitors of the companies involved in a cloud security breach
H2b	103	Includes the competitors of the companies involved in a positive cloud security news

B. Event Study Methodology

Event Study’s popularity and relevance to IS research has gained tremendous attention and traction and such studies are becoming common in IS literature ([35] [3] [23] [38] [9] [11] [41] [8] [26] [6] [20] [40]) amongst others. In our research Abnormal stock returns serve as the metric of the economic impact of cloud computing announcements and cloud adoption announcements [3]. In an event study, abnormal returns are calculated for an event window. The most important choice in an event study is the choice of the length of the event window [3] [37]. Based on prior event studies in the field of information systems, we chose event windows of (-1, 0) (0,+1) (0,+2) (0,+3) in addition to taking the actual date of announcement or the zeroth day. We used the market adjusted returns model, for the computation of abnormal returns to compute the abnormal returns we used the Eventus software package. Given an event window and the model for abnormal returns calculation, the Eventus software computes the abnormal returns for firms for that window, by interfacing SAS and the CRSP database [3]. Based on the Market adjusted model, the abnormal returns for a firm i on day t is,

$$A_{it} = R_{it} - R_{mt} \quad (1)$$

Where R_{it} is the return of stock for firm i on day t ; and R_{mt} is the CSRP value weighted market return on the same day.

Since we are looking at N firms, we need to aggregate the abnormal returns for each day for the period t ; therefore we formulate Mean Abnormal Return (MAR_t),

$$MAR_t = \sum_{i=1}^N AR_{it} \quad (2)$$

Cumulative Abnormal Return (CAR) is used to measure the change in firm value. The CAR for the cloud computing announcements for the firm i for the period $t1$ to $t2$ is given by,

$$CAR_i(t1,t2) = \sum_{t=t1}^{t=t2} A_{it} \quad (3)$$

In our research, since we are looking at the CAR for many firms, we need to compute the Mean Cumulative Abnormal Return (ACAR). For an event window T , the ACAR for N firms is given by,

$$mCAR_i(t1,t2) = \frac{1}{n} \sum A_{it} \quad (4)$$

Then we use Patell Z test statistic (a standardized parameteric test) to check if the MCAR are significantly (statistically) different from zero. If the significance is found in this test, we can say that the cloud computing announcements made an impact on the stock market. The magnitude of the impact can also be inferred based on the level of significance [3] [4] [18] [31].

IV. RESULTS

We investigated nine event windows for evaluating impact of cloud security announcements on the companies involved and on different stakeholder companies such as competitors. We discuss the results we obtained of these groups of companies next. We had nine event windows for each hypothesis and in this section; we present the ones we selected based on prior research and relevance to our research. For each hypothesis, we have omitted event windows that report inconclusive results. A summary of results for all the hypotheses is shown below, in Table II:

Hypothesis	Effect	Support
H1a	-	Supported.
H1b	-	Not supported. Negative abnormal returns.
H2a	-	Supported
H2b	-	Not Supported. Negative abnormal returns.

Table III shows the Average Cumulative abnormal returns for the companies involved in the cloud security breach

(negative) announcements from 2006 to 2010. The results for observed windows do not show any significance for abnormal returns. However, it does show some significance (Patell Z at 10% level) for (0, +1) window with an ACAR of -0.29%, which is consistent with other research that show negative reaction to negative information security announcements [1] [8] [16] [18] [21].

TABLE III
WINDOW BASED RESULTS OF NEGATIVE SECURITY ANNOUNCEMENTS

Window	ACAR	Positive: Negative	Patell Z	Generalized Sign Z
(-1,0)	-0.03%	86:97	-0.529	-0.235
(0,+1)	-0.29%	79:104	-1.619\$	-1.271
(0,+2)	0.05%	86:97	-0.397	-0.235
(0,+3)	0.09%	81:102	-0.233	-0.975

Table IV shows the Average Cumulative abnormal returns for the companies involved in the positive cloud security announcements from 2006 to 2010. The result is negative for windows (-1, 0) at 5% level of significance with ACAR as -0.54% for the generalized test. The windows (0, +1) and (0, +2) show negative abnormal returns with 10% level of significance. This shows that there was a negative impact of a positive cloud security announcement on the respective companies. This shows that even positive cloud security announcements yield negative market reaction.

TABLE IV
WINDOW BASED RESULTS OF POSITIVE SECURITY ANNOUNCEMENTS

Window	ACAR	Positive: Negative	Patell Z	Generalized Sign Z
(-1,0)	-0.54%	10:21<	-0.788	-1.705*
(0,+1)	-0.33%	11:20(-0.706	-1.345\$
(0,+2)	-0.78%	11:20(-0.673	-1.345\$
(0,+3)	-0.43%	14:17	0.574	-0.266

Table V shows the Average Cumulative abnormal returns for the competitors of companies involved in a cloud security breach announcement from 2006 to 2010. The result is negative for window (-1, 0) at 5% level of significance with ACAR as -0.09% for the generalized test. The window (0, +3) shows negative abnormal returns with 10% level of significance. This shows that there was a negative impact of a negative cloud security announcement on the competitors of the companies in the announcement. However the effect was delayed as shown by the impact on the third day after the announcement.

TABLE V
WINDOW BASED RESULTS OF COMPETITORS OF COMPANIES WITH BREACH
ANNOUNCEMENTS

Window	ACAR	Positive: Negative	Patell Z	Generalized Sign Z
(-1,0)	-0.09%	167:230<	-1.051	-1.730*
(0,+1)	-0.16%	175:222	-0.792	-0.925
(0, +2)	-0.13%	186:211	-0.895	0.182
(0, +3)	-0.22%	174:223	-1.354\$	-1.025

Table VI shows the Average Cumulative abnormal returns for the competitors of companies involved in the positive cloud security announcements from 2006 to 2010. The result is negative for window (0, +1) at 1% level of significance with ACAR as -0.32% for the generalized test. This shows that there was a negative impact of positive cloud security announcement on the competitors of the respective companies.

TABLE VI
WINDOW BASED RESULTS OF COMPETITORS OF COMPANIES WITH POSITIVE
ANNOUNCEMENTS

Window	ACAR	Positive: Negative	Patell Z	Generalized Sign Z
(-1,0)	-0.25%	48:55	-0.686	-0.009
(0,+1)	-0.32%	36:67<<	-0.823	-2.379**
(0, +2)	-0.51%	42:61	-1.252	-1.194
(0, +3)	-0.34%	47:56	-0.641	-0.206

Next, we present implications of our findings to practice and research.

V. IMPLICATIONS AND CONCLUSION

Research shows that information security events in general have had significant impact on the stock value of the firms and their competitors [18] [21]. Our research shows that information security breaches related cloud computing has significant negative impact on the stock value of the firms on the day of announcement. We also show that the competitors of the companies involved in a cloud security breach have a significant negative impact on the firm valuation. Contrary to research on the effect of positive information security news on the companies and competitors [21], our research shows that positive cloud security news has significant negative impact on the firm valuation involved companies and their competitors. Thus we can conclude that given the uncertainty attributed to security in the cloud the stock market treats both positive and negative cloud security announcements as

negative information.

The Gartner Hype cycle for 2011 has positioned cloud security at the Peak of Inflated Expectations, a phase that is characterized by huge publicity eventually generating over-enthusiasm and unrealistic expectations. Any announcement regarding a firm's cloud security breach or a positive cloud security initiative would be subject to interest of the customers or the key stakeholders of the company. As the adoption of cloud computing has started increasing [33], cloud security has emerged as a top area of concern over the years [42]. The issue of cloud security has reached a point where, investors have started to take cloud security announcements more seriously by perceiving a cloud security announcement as a negative information about the company.

VI. LIMITATIONS AND FUTURE STUDY

We have analyzed the market impact of cloud security breaches and positive cloud security news on firm valuation of the companies involved. However, there are few limitations to our study. Firstly, our study is limited to publicly traded companies listed in the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and NASDAQ whose price information is listed in the CRSP database. Secondly, adverse events like a cloud security breach could be subjected to confounding effects of other adverse events in the same time period. In future work we would explore the confounding effects of other events on cloud security breaches and positive cloud security news. Thirdly, since we have collected data from press releases of the companies and popular news websites that release cloud computing news, we have not accounted for any leakages in the news prior to the release. Finally, as is the case with any other event study our research makes the assumption of market efficiency and that news media announcement about a firm will be reflected immediately in the stock price. Since, we have analyzed cloud security breaches on a whole, future research can be done on the impact of the types of cloud security breaches like data-losses, hacks and outages on the market valuation of the firms. Research can be done by analyzing the market impact of cloud security announcements individually and determine the framing effects of the top performing and bottom performing announcements. We can then determine the keywords that can be used to frame an announcement to get better impact on the market. We hope that more research is done in this area of cloud security breaches and investigate how important is cloud security in the adoption of cloud computing.

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