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ABSTRACT
Information security incidents are serious threats for a modern business environment. Firms believe that an investment on information security contribute to firms avoiding security incidents. However, there is a little research on economic outcomes of information security investment. This research investigates the relationship between information security investments and the number of information security incidents. This study empirically investigates how the information security related investment could reduce the possibility of information security incidents. Based on survey data, this study explores an impact of information security investment on information security incidents. This research explores the factors; an investment on information security, top management support, and Employees’ information security awareness, contributing on firms’ information security breaches. Based on Poisson regression model, we expect to figure out a positive impact of firm’s information security investment on reducing the number of information security incidents. In addition, we expect to find out the impact of support of top management and employees’ information security awareness.

CCS Concepts
Security and privacy → Human and Societal aspects of security and privacy → Economics of security and privacy

Keywords
Information security incidents, Investment of information security, Poisson regression model, top management’s support, and Employees’ information security awareness

1. INTRODUCTION
As firms’ value of information has recently been increased tremendously, there are growing numbers of incidents and crimes targeting information systems in the business sectors. According to breach level index by Gemalto, the number of recorded information security breach was more than 70 million in 2015 [9]. When firms make investments on information security to reduce the risk of information security breaches, they want to have strong evidences on the positive results or return on investment of their investment decision. However, measuring the amount of return on information security is very challenging because it is impossible to precisely gauge the amount of loss from information security incidents. Due to these reasons there is little research providing empirical evidences on the value of information security investment.

There is some research finding investment outcomes through indirect measurement such as stock market reactions toward information system security investments. Research of Chai et al. tried to measure the return of information security investments through stock market reactions toward firms’ information security investments and discovered positive market reactions influencing the market value of an investing firm [5]. There is also several research measuring the market value of information security incidents [1,3,4,8]. This research find out that market investors consider negatively about information security incidents.

Based on extensive survey data from Korean organizations, this research are planning to explore an impact of information security investment on the number of information security incidents. In addition to the relationship, we will examine an organizational
factors related to decision making on information security. Our research objectives are first, finding out empirical evidence that information security investment could reduce the number of information security incidents. Second, investigating the relationship between top management’s support for information security and the number of incidents. Third objective is examining the relationship between employees’ information security awareness and incidents.

This research contributes to academia by adding to research body about economics of information security. This study suggests that the tangible outcomes could be facilitated from information security investment. This research also contributes to firms’ decision makers. The results of this study can provide them clear basis for information security investment decision by suggesting empirical evidences that the investment can results in reducing information security incidents. In the section 2, we explain research background and literature review. In the next section, we suggest a research model and hypotheses. In conclusion section, we explain data and methods planning to use in this research. In the final section, expected result of this research and contribution are suggested.

2. RESEARCH BACKGROUND

2.1 Information Security

Information security is defined as the protection of information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide confidentiality, integrity, and availability [15]. Information security measures include both of physical and logical methods to prevent breakdown of information system. It is necessary that sufficient investment need to be made for firms acquiring proper level of information security. As there are increasing threats in information security, firms are noting but to invest resources on information security. Firms invest to hardware, software, human resources, and policy to prevent security incidents. In this research, we define information security investment as firms’ resource allocation to acquire proper measure protecting information system. Information security incidents are incidents that caused by worms, hacking, virus and distributed denial-of-service attack (DDoS). In this research, we exclude failure of information system caused by natural disasters since natural disasters are unavoidable by human efforts.

2.2 Information Security Investment and Incidents

Researchers investigate information security in economic perspective. A study of Gordon and Loeb [10] is one of most well-known research. In their research, they tried to explain the relationship between information security investment and information security incidents theoretically. They insist that the number of security incident be decreased by increasing investment amount until the optimal level, around 36.7% of total expected loss from the incidents. However, there is no empirical research proving their theory because it is very difficult to measure the precise loss from information security incidents because calculating legal expenditure, loss of brand value and compensation are taking long time even more than 5 years. Therefore, there is some research investigating the value by indirect measurement such as stock market reactions. Bharadwaj and Keil found out that IT failures resulted in a 2% decrease in market value [1]. A study of Ettredge et al. [8] investigated that firms’ stock price decreased after the attacks. Internet firms’ stock price decreased more than non-Internet firms after the attacks [1]. A study conducted by Campbell et al. [3] only information security breaches violating confidentiality protocol causing 2% decrease of stock price of the firm [3]. Cavusoglu et al. confirmed that announcement of Internet security breach caused decrease of stock price [4]. Their study examined that type of firms, firm size, and the year of the breach occurred as factors affecting the decrease.

Even though there are continuous attempts measuring the value of information security investment. Little research directly measures the value of the investment before the actual incidents occurring to firms. Therefore, researchers indirectly measure the value of the investment in various ways. There are some studies conducted on indirect measuring of the value of the investment. A study of Chai et al. examined the market value of an investment in information security [5]. In this study, researcher found a support for the hypothesis that security investment cause increase of stock price of firms. A study of Shin et al. [16] used a survey to examine the causality between information security investment and the incidents. They could not find any substantial evidence prove a positive impact of information security investment on information security incidents. As discussed in this section, there are few literature discovered returns on the investment in the relationship with the incident number due to various difficulties.

2.3 Top Management Support and Employees’ Awareness

2.3.1 Top management support

A critical success factor for implementing information security is management commitment on information security [7]. There are several studies examining an impact of top management’s support on information security effectiveness. A study of Kankanhalli et al. [11] investigates the influence of organizational factors on information system security effectiveness. Their research suggests that organizations with stronger top management support have more tendencies to actively allocate their resource on information security investment than the organization without it [11]. Previous studies investigated the role of top management support on organizational culture or level of security policy enforcement [12]. As top managements support information security investment to reduce the incidents, it is important that examining the actual relationship between the investment and the incidents.

2.3.2 Employees’ awareness

A study are growing importance of people factors in information security, many organizations provide education programs to their employees for increasing their awareness of information security. Information security education enhances employees’ awareness on information security protocol so that they could comply with security protocol well. A study of Bulgurcu et al. [2] examines an employee’s information security awareness has a direct influence on attitude toward compliance. As people have more awareness on information security, they show more protection behaviors so that the security breaches stem from human can be reduced [2, 13].
3. RESEARCH MODEL AND HYPOTHESES

3.1 Information Security Incidents
Firms make an information security investment to acquire stability of information systems by avoiding information security incidents. Firms invest on implementing new firewalls and vaccines, hiring system security professional and conducting information security educations for employees to protect information systems. If firms invest more resources on information systems protections, they have tendency to acquire advanced protective security system and high level of physical security that are considered as factors improving the security effectiveness [11]. The research of Gordon and Loeb, there is positive relationship between investment amount and the level of information security [10]. In this research, we assume that a firm can prevent loss from various information security threats through by increasing amount of investments on it. Based on the discussion, we posit following hypothesis:

H1: Information security investments have negative relationship with information security incidents.

3.2 Top Management Support for Information Security
For Information security, the support of top management is paramount to the success of an organization’s information security efforts [14]. If top managements strongly support for information security, they invest more financial and technical resource on information security [11]. Firms invest on protect systems like advanced security software and hardware. Strong preventive efforts can be carried out by increased investment. Therefore, firms could protect their information systems from information security incidents more effectively. Thus we suggest following hypothesis.

H2: Top management’s support for information security has negative relationship with information security incidents.

3.3 Employees’ Information Security Awareness
Information security education helps employees to be more aware of information security. As employees become aware of security policy, they become more careful on information system policy compliance [2, 13]. In this research, we assume that compliance behaviors of employees’ helps reducing information security incidents come from malpractices, failures and incidents caused by employees. Thus, we hypothesis;

H3: Employees’ information security awareness has negative relationship with information security incidents.

4. CONCLUSION

4.1 Data and Methods
We are planning to conduct a survey for firms in Korea. We expect to collect actual financial investment data and reported number of information security incidents from chief information officer (CIO) and chief security officer (CSO) in organizations. After acquiring survey data, we will test our hypothesis. In this research, the number of information security breach is countable variable so that it is suitable option for adopting Poisson regression [6]. In addition to the hypothesis, we added size of firms and business category as control variables in our model [5]. Before we adopt Poisson regression to test hypotheses, we will use Probit regression as a pilot test to find out variables affecting number of incidents. After applying Probit regression, we will test our model with Poisson regression for test our hypotheses. For this research, we posit a following model;

\[
E(y|x_1, x_2, x_3, x_4) = g(x) = \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 D_1)
\]

\[x_1 = \text{Information Security Investment}\]
\[x_2 = \text{Top management’s support on Information Security}\]
\[x_3 = \text{Employees Information Security awareness}\]
\[x_4 = \text{Size of firms}\]
\[D_1 = \text{Dummy variable of business category}\]

To make the model easily understandable, we apply a log of equation so that the log of the expected value becomes linear [17].

\[
\log[E(y|x_1, x_2, x_3)] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 D_1
\]

4.2 Research Model
For this research, we suggest this research model.

4.3 Expected Result and Contribution
In previous research, researchers could not find out the evidence that information security investment has negative relationship with the incidents. This study is conducted to investigate how investment of information security could reduce the possibility of information security incidents. By applying Poisson regression, we expect to find out a support that the security investment have positive impact on the incident.
In this study, we explore 3 factors which have relationship with the incidents; an information security investment, support of top management, and employees’ information security awareness. We expect to find out that investment of information security have positive impact on reducing information security incidents. We also could show evidences on the positive results in the impact of top management support on the reducing incident. Lastly, we are expecting to find out negative relationship between employees’ awareness and the incidents.

This research’s contribution is adding a new research about the economics of information security to academia. This study provide strong basis that could be facilitated from information security investment. This research also contributes to top management in business and organizations. The results of this study could present grounds for the investment decision by suggesting empirical evidences that the investment could have positive impact on reducing the number of the security incidents.

In addition to this research, we have a plan to conduct further research comparing relationships between information security investment and information security incidents in other countries. We will compare cases of Korea and other country. Therefore, we can generalize our model as a universal explaining power.

5. REFERENCES