

Daniel Dor
Senior SAS Consultant, SAS Software Distributor, Herzliya, Israel
Yuval Elovici
Director of Telekom Innovation Laboratories and Director of Cyber Security Labs at Ben-Gurion University, Beer Sheba, Israel

Abstract
Following recent developments in the information security threats landscape, the information security issue became a complex managerial problem. Using Grounded Theory and empirical analysis, we present a conceptual model that describes the decision making process regarding Information Security Investments in SMBs from several industries. The framework described in the article, generalize the decision making process under the understanding that organizations differentiates in plenty of factors such as: the organizational position that holds the information security budget, the CISO’s role in the organization, the interactions between the various parties in the organization, the organizations’ industry, the organizational structure, the type of information on which the organization trying to keep, the organizational awareness of information security, regulation in the industry and more. We further discuss the organizations’ capabilities to handle the information security investments decision process and how it can become better.

The purpose of the empirical analysis
In order to validate the grounded theory outcomes, we have decided to conduct an empirical analysis of 84 articles that dealt with information security investments and information security management. The empirical analysis was based upon empirical contextual analysis, that was used in order to examine whether the concepts and categories (and their associations) that appeared in the grounded theory research, also appears in the literature about information security investments and information security management.

A contextual analysis is defined as a phase of natural language processing, following semantic analysis, whose purpose is to elaborate the semantic representation of what has been made explicit in the utterance with what is implicit from context (McGraw-Hill, 2003). An empirical contextual analysis, takes identify all the concepts that appear in the dataset, and using statistical analysis in order to find patterns, correlations and other insights from the contextual analysis.

This empirical analysis was conducted in order to check whether the findings in the grounded theory process, also appears in the literature, but with more quantitative approach. In a matter of fact, this analysis enable us to validate the concepts, categories and propositions that emerged from the Grounded Theory part, and on the other side to enhance the findings with some more findings and conclusions.

One reservation to note is that the articles in the literature describe sometimes different or partial problems and processes from those we are trying to describe using the Grounded Theory. However, those articles can show us if the associations that was found in our research make sense, and backed up by at least 12 years of research.

How to empirical analysis related to the conceptual framework
During the empirical analysis, we’ve built a contextual analysis model, which got as input 84 articles that dealt with information Security Investments and IS management, and outputs for each document the list of categories and concepts that appears in this document. The list of categories and concepts were taken from the Grounded Theory research. Using the contextual analysis model we’ve built, we can see whether the associations that we’ve identified in the conceptual framework, are similar to those we found in the 84 articles.
The following is the complete research process that was carried out (5 phases): (1) in the 1st phase, we executed a machine learning process in order to find all the terms and topics that appeared in the 84 articles. The machine learning algorithms identified automatically 46,689 terms (Abbr., Adj., Adv., Noun groups, Nouns, Verbs, Numbers and prop.) and 12 topics. (2) In the 2nd phase, we've built rule based model, which extracted all the concepts, categories and associations in each article. The rule-base model was built using the machine learning outputs and the concepts and categories that were found during the Grounded Theory research process. (3) In the 3rd phase, an ETL process was executed on the data, and in the end of this process, we could have identified for each article whether it consists one of the 14 categories or one of the 16 concepts that were observed in the Grounded Theory process. (4) In the 4th phase, we’ve checked for empirical associations inside the articles, between those 14 categories and 16 concepts. (5) In the last phase, we’ve compared the associations we’ve found in the Grounded Theory section and the associations we’ve found in the empirical analysis section.

**Correlations between concepts and categories in the empirical analysis**

In order to find out the association between categories and concepts that were found inside the articles, we’ve done hypothesis testing using Pearson’s r testing. The process we’ve executed is as follows: (1) We first defined null and alternative hypotheses ($H_0; p = 0, H_1; p ≠ 0$), (2) we Stated ($\alpha = 0.1$) (3) we calculated degrees of freedom (84-2=82) (4) we stated decision rule (critical r) using the r-table (0.18) (5) we calculated r for each category-concept pair and then we found which r is significant.

Our findings shows that 34 out of 224 pairs (14 categories X 16 concepts) are significantly correlated, i.e. there is a connection between the appearances of some categories to the appearance of some concepts in the 84 articles. For example, we observed that the category (1) External Environments of Business is correlated with the concept (G) Information security compliance ($r=0.23862$, $p\text{-val}=0.0288$). This finding tells us, that whenever scholars write about external environments, there is moderate chance that they’ll write about information security compliance.

**Study’s limitations**

We identify several limitations of this study. First, the grounded theory based upon limited experience of limited subjects from limited industries in limited amount of locations. Therefore, there is probably more variations for the insights and findings we’ve found. Second, although we’ve used methodological and firm research processes, we are still talking about socio-technical research that might be biased in some cases. Finally, the empirical evaluation we did, is based upon contextual analysis and rule-based models, which both of them might be subjective from several perspectives.

**Summary, Discussion, and Conclusions**

In this research, we develop a conceptual model that describes the decision making process regarding Information security Investments from several industries. The model present different non-sequential phases (categories) that affect and affected by different concepts. The model tries to describe what actually happening in companies by using Grounded Theory methodology. Our empirical results, which based upon empirical contextual analysis of 84 articles in the information security investments and information security management domains, validate most of the phases (categories) and most of the concepts described by the conceptual model.