

A Proposed Framework for Examining Information Systems Security Research

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Abstract

As information security becomes increasingly important, more research is being conducted in this area. In an attempt to better understand current research activities in Information Systems Security (ISsec) and to guide future explorations, a number of authors have made tentative attempts to survey/review the existing literature. However, the criteria employed in these reviews are neither consistent nor complete, which weakens their validity. Drawing on previous research, we propose an improved examination framework for systematically investigating ISsec research. This framework will allow researchers to gain a more thorough understanding of what has been done so far and to target future research efforts more effectively.

Keywords: Information systems security, examining framework, paradigm, theory, method, analysis

1. Introduction

The last a few decades have witnessed the widespread adoption and development of Information Systems (IS), to the point where they are now deployed in almost every organization. Organizations of all kinds and sizes have adopted IS for administrative, managerial, marketing, communication and production purposes in an effort to adapt to a fast-changing world and enhance competitiveness. The wide use of IS has sparked a series of research activities in this area that aim at boosting efficiency and reliability. Methodology in this research area is continuously evolving, and this has had a clear and direct influence on the development of IS itself [12].

Information Systems security (ISsec), however, has received little attention compared to other IS issues [5]. According to a survey released by the UK's Department for Business, Innovation and Skills in 2013, 42% of large organizations do not provide any ongoing security awareness training to their staff, despite the fact that 78% of these organizations had been attacked by an unauthorized outsider in the previous year [4]. But safe, robust and reliable IS are crucial if an organization is to achieve its business goals [23].

The need to develop effective ISsec should be driving academic activity, but published anecdotal evidence and existing ISsec survey research suggest that research in ISsec lags behind the general advance in IS [19], and that it is often perceived as esoteric and inconclusive. The few existing studies are isolated rather than systematic, and ISsec research generally has been disjointed. Those studies that do contain in-depth analysis only concentrate on a small number of ISsec research outputs, while those that examine a large number of articles merely focus on certain criteria rather than taking an overall view. Thus, a comprehensive study of ISsec research is overdue.

The main purpose of this research, therefore, is to provide practical suggestions to refine the existing examining framework which will allow researchers to conduct in-depth, systematic

reviews/surveys of existing material, thereby facilitating reflection upon previous ISsec research and supporting future study.

We aim to briefly describe previous reviews of ISsec research, to analyse the criteria employed in this research and to offer suggestions for future activities. Thus, Section Two presents an overview of previous research efforts and the criteria they have adopted, while Section Three considers the components that should be taken into account in the examining framework. We set out a plan for future study in Section Four, while Section Five concludes the research by summarizing our findings.

2. Related Work

Mounting threats to IS security and the growing attention being paid to this issue have prompted a range of studies on ISsec. However, although a number of important threads have been developed in ISsec research, these threads have not been woven together into a cohesive fabric. To achieve a better understanding of current ISsec research activities, and to establish a clear research pattern, a number of authors have attempted to examine ISsec research.

Baskerville [2] pioneered exploration into ISsec research by detailing the mismatch between system development methods in general and security development methods in particular. He suggested that to survey and compare security analysis and design methods, the general characteristics of them are needed. The taxonomy, simple but useful, harbouring this feature, relates the evolution of information systems security methods to the perspective of the broader information systems development community, and thus is chosen as the criterion.

The study of ISsec research as a discipline in its own right did not emerge until the 2000s. Dhillon and Backhouse [9] analysed eleven ISsec studies, adopting sociological paradigms developed by Burrell and Morgan [6] to illustrate the need for understanding of the social as well as the technical aspects of ISsec. They posited that while IS research in general had moved away from a narrow technical viewpoint, ISsec research was still dominated by technical and functionalist preconceptions, and that the use of socio-organizational perspectives to understand ISsec was still at the theory-building stage.

Villarroel et al. [21] critically reviewed eleven secure system design methodologies, paying particular attention to their technological and practical implications. Others [19, 20] went further, undertaking relatively comprehensive comparisons of methodologies. These later studies were the first to adopt systematic criteria (i.e. theory, method and topic) to review existing research.

Although these studies cast some light on ISsec research, they are not without their limitations. Baskerville's [2] research was conducted in the early days of IS, before the development of appropriate research mechanisms and standards, while Villarroel et al. [21] concentrated only on the development of secure IS and system design methods and methodologies, which is only one of the three research tracks within the ISsec field. Furthermore, they listed but did not explain their chosen criteria.

Although Dhillon and Backhouse [9] tried to deepen the discussion, their arguments were not based on widely accepted theoretical paradigms and were bounded with the concept of development of secure IS, which weakens their applicability. Moreover, they adopted sociological theory but ignored the key influence of IS theoretical paradigms on ISsec research. Finally, they reviewed a limited number of articles, which raises questions about the generalizability of their criteria.

The research of Siponen et al. [19] was relatively systematic in that their choice of theory, method and topic as the three examining factors was consistent with the Reticulated Model of Science [16]. However, separating these factors out in this way is inconsistent with the integrated nature of the research process, and the set of criteria neglect the analysis stage altogether. Siponen's most recent research was conducted in 2008, but during the past few years, tremendous changes have taken place in ISsec and numerous advances have been made. Our research aims to reflect these changes and to incorporate more recent contributions.

In summary, previous ISsec studies have shortcomings which seriously impair their validity. In theoretical terms, they do not take the methodological perspective into consideration, meaning that their criteria are patchy and inconclusive.

3. A Proposed Examining Framework

The IS community's interest in methodological issues has grown considerably, as methodology is of great importance in directing research activities. These activities may include administering and analysing a survey, conducting controlled experiments, engaging in ethnography or participant observation, and developing root definitions and conceptual models. Research methodology may be described as a clearly defined sequence of operations [7, 13]. More generally, a methodology is a structured set of guidelines designed to assist the researcher in generating valid and reliable research results. This methodology will be built upon a set of assumptions, methods and techniques [17]. It is our view that the examining framework should reflect all these methodological components; in other words, that it should encompass paradigm, theory, method and analysis. Accordingly, the following sections draw on existing research to discuss how these four components should be incorporated into the framework.

3.1. Research Paradigm

All IS scholars take on their research holding a number of explicit and implicit philosophical assumptions about the nature of human organizations, the nature of their particular search/review and the expected results. These assumptions play a crucial role in guiding the IS research procedure and directly affect the likelihood they will get a result as well as the nature of these results; in other words, the assumptions that are adopted will determine the research approach and the potential research outcomes.

A number of theoretical perspectives have been employed in the IS domain. Orlikowski and Baroudi [18] were the first to identify the various paradigms employed in IS literature, which they did by surveying 155 research articles published between 1983 and 1988. Following Chua [8] classification of research epistemologies, they identified the positivist, interpretive and critical paradigms as the most widely used. The positivist paradigm aims to test theory to arrive at a better predictive understanding of a phenomenon. The paradigm is premised on the assumption that the phenomenon can be understood by objectively measuring a set of known fixed variables. By contrast, the interpretive paradigm assumes that scholars are able to create their own subjective understanding by interacting with the world around them; phenomena are understood by accessing the meanings that are assigned to them. Finally, the critical paradigm critiques deep-rooted contradictions within social systems with the aim of emancipating individuals from restrictive social conditions.

Since these three paradigms guide nearly all research in IS, they were adopted as the criterion for the philosophic assumption component.

Table 1. Three Types of Research Paradigm

Research Paradigm	
1	Positivist
2	Interpretive
3	Critical

3.2. Research Theory

Theory, illustrating the scholars' cognitive aim and facilitating intervention and action, is generally developed to describe, explain and enhance our understanding of the world and to predict what will happen in the future. Numerous theories have been adopted in ISsec research;

38 were identified by Siponen et al. [19]. It would be inefficient, if not impossible, to develop a framework that statistically examines the theoretical perspective of every piece of ISsec research – in any case, such attention to detail may blur the overall picture. It is therefore necessary to choose an alternative theory-related criterion. This criterion must be easy to manipulate while accurately reflecting the range of theoretical perspectives employed.

Gregor [10] discerned five distinct theoretical approaches. Studies employing analysis theory, the most basic type, describe what has been found in previous research thereby classifying specific characteristics of research entity, such as individual, team or phenomenon. Studies employing explanation theory seek to explain how and why phenomena occur, while prediction theory's primary goal is to take these explanatory factors into account in order to make logical and testable predictions about the future. Studies combining explanation and prediction theory seek to demonstrate the existence of a phenomenon, how, why and when it occurs, and what will happen in the future. Finally, studies employing design and action theory seek to explain the principles by which systems are created and thus guide the development of IS.

This five-type typology of theory represents the theoretical foundation of IS and was therefore adopted as the criterion for categorizing theoretical approaches in ISsec research.

Table 2. Five Types of Research Theory

Research Theory	
1	Analysis
2	Explanation
3	Prediction
4	Explanation and prediction
5	Design and action

3.3. Research Method

Significant attention has been paid to the research methods that have been applied in IS research, as they reflect implicit or explicit assumptions on the part of the researcher about the nature of the world and of knowledge. The research method can be viewed as the operational dimension for provoking a response from the world. The nature of the response depends on both the world and the underlying assumptions. Different methods generate information about different aspects of the world. This information is used to construct theories about the world, which in turn condition our experience of the world.

It is commonly held that research methods are bound to particular paradigms and that as these paradigms are incommensurable, it is illogical to mix methods from different paradigms. However, Mingers [17] asserts that it is both desirable and feasible to combine different research methods to gain richer and more reliable research results.

In an effort to well situate the position of research methods and encourage the adoption of a wider range of methodological approaches, several authors have sought to classify existing studies by research method. This has been approached in various ways; Benbasat et al. [3], for example, compared studies employing qualitative research methods to those using experimental and survey-based research methods, while Alavi et al. [1] divided the empirical studies they looked at into eight categories according to whether they were based on laboratory experiments, field experiments, field studies, case studies, surveys, MIS instruments, ex-post descriptions or other methods. Similarly, Orlikowski and Baroudi [18] surveyed 155 articles, classifying studies according to whether they were based on surveys, laboratory experiments, case studies, mixed methods, instrument development, protocol analysis or action research.

Among these different taxonomies the most consistent comparisons are between empirical and non-empirical [1] and quantitative and qualitative [3] methods. However, both of these general classifications have limitations. Regarding the specific types of method taxonomy, it is again too detailed for researchers to see the whole picture. In fact, there are more than ten frequently used methods in current IS and most of them can be employed across the paradigms. With this classification, it is difficult to map out the general picture of the coherent research activities. As for the straightforward dichotomy of method taxonomy, in contrast, it is too simplistic for researchers to explore the in-depth implications stemming from the research activities. Klein and Myers [14] indicate that quantitative/qualitative research can be positivist, interpretive or critical. Moreover, some research methods can be used in the context of both quantitative and qualitative research. In other words, this classification is useful in understanding the research approaches that the researchers, but not efficient to determine the appropriateness of the paradigms and theories and the overall consistence of the whole research activities.

In this sense, method taxonomy should not only be concerned with method itself, but also with theoretical considerations – it needs to be abstract enough to categorize a range of research but concrete enough to render rich implications to the research activities.

We chose the taxonomy of method proposed by von Alan et al. [22]. These authors group methods under the explanation (behavioural) paradigm and the improvement paradigm. The behavioural paradigm seeks to develop and verify theories that explain or predict human or organizational behaviour, while the design paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts. Both paradigms are fundamental to the IS discipline, positioned as it is at the confluence of people, organizations and technology.

Table 3. Two Main Types of Research Method

Research Method		
1	Explanation paradigm (Behavioural paradigm)	Quantitative method
		Qualitative method
2	Improvement paradigm	Design science method

3.4. Research Analysis

Analysis is an indispensable part of most IS research articles, as this is where the preliminary research results are positioned within a broader context. The analysis presents the research outcomes, summarizing the outputs from theoretical exploration and connecting theory with practice by explaining how the research applies to a real social setting. The fact that this essential stage has always been ignored in previous reviews of ISsec research reduces their value of these reviews. In this research, we endeavour to incorporate this component into the examining framework.

IS research mainly deals with the relationship between information technology and organizations, and ISsec is no exception. By their very nature, organizations are multi-level; individuals work in groups, and teams interact with each other and with outside organizations [15]. Every construct is tied to one or more organizational levels. To examine organizational phenomena is thus to encounter level issues, which is why level analysis has been chosen as another criterion for the examining framework.

Management research has generally adopted four levels of analysis – these have been adapted for ISsec research [11]. At the individual level, ISsec has generally been studied in terms of the factors that affect individuals, while at the level of groups/teams, ISsec has been studied in terms of the factors that foster or curb the security of a certain group. Research at the organizational level has focused on the impact technology and new products/business/structures

have on various types of organization. Finally, research at the societal level has focused on the management of ISsec and the emergence of new threats.

Table 4. Four Levels of Research Analysis

Research Analysis	
1	Individual level
2	Group/team level
3	Organizational level
4	Societal level

3.5. Examining Framework

To sum up, the theoretical framework consists of four components: research paradigm, research theory, research method and research analysis. Together, these cover the whole research procedure and address the practical concerns from the theoretical and methodological perspectives.

Table 5. Framework for Examining Information Systems Security Research

Objective	Philosophical Assumption	Cognitive Aim	Operational Dimension	Interpretive Level
Procedure	Research Paradigm	Research Theory	Research Method	Research Analysis
Criteria	Positivist	Analysis	Explanation/Behavioural	Individual level
	Interpretive	Explanation	Improvement	Group/team level
	Critical	Prediction		Organizational level
		Explanation and prediction		Societal level
		Design and action		

The advantages of this comprehensive framework for examining ISsec research are twofold. Firstly, distinct from the previous frameworks that either focused on certain component(s) of ISsec research or were based on some less accepted paradigms, our framework, adapted from widely-recognised and well-established research, takes into account all necessary components of the ISsec research activity. This is able to facilitate the possibility of obtaining a more thorough and profound understanding of the ISsec research by examining its integrated procedure with four objectives. Secondly, the previous studies that examined the theory and/or method predominately focused on the specific type of theory or method employed. One unavoidable problem stemming from that notion is that it is difficult if not impossible to work out the latent connection between a certain set of theory and method given the fact that there are at least dozens of different theories and methods. However, our framework is the first attempt, as far as we know, to map out an examining framework that closely combines each component by integrating their underlying assumptions, thereby enabling us to seek the possible relationship from a coherent and interconnected perspective.

4. Limitations and Future Work

There are some limitations to the research at this stage. Firstly, there was only a limited number of reviews/surveys of ISsec research to draw on. Similarly, the fact that there are only a few typology studies on ISsec made the selection of criteria more difficult. Three of the four

components (research paradigm being the exception) do not possess generally recognized typology, and potential criteria had to be selected from a comparatively small pool. Thirdly, the concept of level analysis has been borrowed from the discipline of management and adjusted to fit the context of ISsec. In addition, we have not yet conducted an empirical review/survey using this framework.

Further research is planned to fully tailor the concept of level analysis to the context of ISsec, and the framework will be applied to a comprehensive survey of ISsec literature. By drawing on this proposed framework, the data surrounding the research methodology of ISsec literature will be collected for the first time to shed light on the understudied area of the current ISsec research typology based on the paradigm, theory, method, and analysis. The results of this work will also be used to further refine the framework.

5. Conclusion

The growing interest in ISsec has prompted numerous research activities, but so far, these have been piecemeal and sporadic. Researchers have endeavoured to identify patterns or specific indications in the existing research by conducting literature reviews and surveys, but the lack of a systematic and coherent framework for examining previous research has so far hampered their efforts.

In light of this need, we propose a refined framework for examining ISsec research. The proposed framework draws on previous studies for its four components: it adopts different typologies for research theory and method as the new criteria and incorporates research analysis, which was previously overlooked. We believe that the proposed framework will provide effective support for future ISsec research, better guide the related research activities, and lay down the underpinnings of the exploration into the ISsec research typology.

References

- [1] Alavi, M., Carlson, P., & Brooke, G. 1989. The ecology of MIS research: a twenty year status review. Paper presented at the Proceedings of the Tenth International Conference on Information Systems.
- [2] Baskerville, R. 1993. Information systems security design methods: implications for information systems development. *ACM Computing Surveys (CSUR)*, 25(4), 375-414.
- [3] Benbasat, I., Cash, J. I., & Nunamaker, J. 1989. The information systems research challenge: Harvard Business School.
- [4] BIS. 2013. 2013 Information security breaches survey. Retrieved May 1, 2015, from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191671/bis-13-p184es-2013-information-security-breaches-survey-executive-summary.pdf
- [5] Brancheau, J. C., Janz, B. D., & Wetherbe, J. C. 1996. Key issues in information systems management: 1994-95 SIM Delphi results. *MIS Quarterly*, 225-242.
- [6] Burrell, G., & Morgan, G. 1994. *Sociological paradigms and organisational analysis*: Heinemann.
- [7] Checkland, P. 1981. *Systems thinking, system practice*. New York; John Wiley & Sons.
- [8] Chua, W. F. 1986. Radical developments in accounting thought. *Accounting Review*, 601-632.
- [9] Dhillon, G., & Backhouse, J. 2001. Current directions in IS security research: towards socio - organizational perspectives. *Information Systems Journal*, 11(2), 127-153.
- [10] Gregor, S. 2006. The nature of theory in information systems. *MIS Quarterly*, 611-642.
- [11] Gupta, A. K., Tesluk, P. E., & Taylor, M. S. 2007. Innovation at and across multiple levels of analysis. *Organization Science*, 18(6), 885-897.
- [12] Hirschheim, R. 1985. Information systems epistemology: an historical perspective. *Research Methods in Information Systems*, 13-35.

- [13] Iivari, J., Hirschheim, R., & Klein, H. K. 1998. A paradigmatic analysis contrasting information systems development approaches and methodologies. *Information Systems Research*, 9(2), 164-193.
- [14] Klein, H. K., & Myers, M. D. 1999. A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, 67-93.
- [15] Klein, K. J., Dansereau, F., & Hall, R. J. 1994. Levels issues in theory development, data collection, and analysis. *Academy of Management Review*, 19(2), 195-229.
- [16] Laudan, L. 1984. *Science and values*: Cambridge University Press.
- [17] Mingers, J. 2001. Combining IS research methods: towards a pluralist methodology. *Information Systems Research*, 12(3), 240-259.
- [18] Orlikowski, W. J., & Baroudi, J. J. 1991. Studying information technology in organizations: research approaches and assumptions. *Information Systems Research*, 2(1), 1-28.
- [19] Siponen, M., Willison, R., & Baskerville, R. 2008. Power and practice in information systems security research. *ICIS 2008 Proceedings*, 26.
- [20] Siponen, M. T. 2005. Analysis of modern IS security development approaches: towards the next generation of social and adaptable ISS methods. *Information and Organization*, 15(4), 339-375.
- [21] Villarroel, R., Fernández-Medina, E., & Piattini, M. 2005. Secure information systems development – a survey and comparison. *Computers & Security*, 24(4), 308-321.
- [22] von Alan, R. H., March, S. T., Park, J., & Ram, S. 2004. Design science in information systems research. *MIS Quarterly*, 28(1), 75-105.
- [23] Yeh, Q.-J., & Chang, A. J.-T. 2007. Threats and countermeasures for information system security: a cross-industry study. *Information & Management*, 44(5), 480-491.