

Review Report for Chapter One of the Doctoral Dissertation

Submitted by Researcher: Abdulaziz Arfaj

Dissertation Title: Cybersecurity Governance in Modern Operational Technology Environments: A Risk Management Framework for Connecting Emerging Technologies Across IT/OT Boundaries

Below is a comprehensive evaluation of Chapter One in accordance with the Chapter One Writing Guidelines, including developmental notes and directions.

1. Introduction

The introduction begins with a broad context addressing the historical evolution of Operational Technology (OT) and the transition phase toward integration, convergence, and connectivity with Information Technology (IT). Recent and robust literature suited to the general framework of the topic has been cited, such as *Stouffer et al., 2023; Lee et al., 2016; Dragos, 2024*. Furthermore, the researcher progressively linked the topic to its direct applied environment through his role as a Cybersecurity Officer at the NEOM Green Hydrogen Company in the Kingdom of Saudi Arabia.

Guidance Notes

1. Despite the reference to the National Vision program and large-scale-projects like "NEOM," it is recommended to deepen the paragraph concerning the National Cybersecurity Authority (NCA). This will clarify how the infrastructure currently being built in the Kingdom is classified as "Modern OT" (Greenfield Projects), making it a unique global case study rather than just a local context.
2. Take into account when phrasing the introduction to avoid conceptual confusion. A precise distinction should be maintained between Artificial Intelligence as a general analytical tool (AI-driven analytics) and the role of governance in regulating the data flow of these tools across shared boundaries to maintain business continuity and the safety of critical operations.

2. Problem Statement

The problem is formulated in a highly rigorous and deep scientific manner. The structural and practical gap has been identified, demonstrating that current standards (such as *IEC 62443*, *NIST SP 800-82*, *NERC CIP*) were built for stable and isolated environments. Applying them to modern environments that incorporate 5G, AI, and cloud computing creates structural, rather than incidental, governance gaps. The problem is divided into 3 dimensions: the gap in architectural frameworks (The Purdue Model), the activity within the shared boundary environment (IT/OT Boundary), and the regulatory gap regarding the CISO's role.

Guidance Notes

It is recommended to introduce a prominent, independent subheading or paragraph explaining the research gap. While referencing the Operational Technology Cybersecurity Controls (OTCC-1:2022) issued by the National Cybersecurity Authority (NCA) is appropriate, the text should emphasize the lack of empirical or field studies measuring the adequacy of these national controls or their governance mechanisms in integrating emerging technologies.

3. Research Questions

The chapter includes an overarching primary question representing the core of the problem, from which four precise sub-questions branch out. These questions comprehensively cover the variables (Risk Profile, the impact of technology adoption, the shortcomings of current frameworks, and the proposed framework). All of them begin with proper research interrogatives (What, How) and avoid yes/ no questions.

Guidance Notes

1. Rephrase the Second Sub-Question to Reflect Governance: The second sub-question focuses on how emerging technologies introduce risks (at the technical and security level). It is suggested to slightly modify the phrasing to lean toward the administrative and governance aspect, becoming: "How does current governance at the shared boundary (IT/OT Boundary) affect the management or amplification of cyber risks resulting from the integration of emerging technologies...?" This aligns it fully with the thematic direction of the study.

4. Research Objectives

Current Evaluation

The objectives are formulated with high academic professionalism, matching the sub-questions and achieving comprehensive logical coherence. The researcher utilized measurable operational verbs such as: (*To conduct, To identify, To critically analyse, To develop, To validate*) and completely avoided vague verbs.

Guidance Notes

In the fourth objective (developing the original governance framework), it is recommended to append a phrase indicating "aligning it with national regulatory requirements in the Kingdom of Saudi Arabia (such as NCA controls)." This will ensure the objective reflects the practical added value of the study.

5. Significance of the Study

The significance context is currently integrated implicitly within the introduction of the proposal and the target scope of the research, identifying the beneficiary groups (modern operational organizations, national policymakers, and the academic community).

Guidance Notes

1. The chapter currently lacks the inclusion of "Significance of the Study" as an independent primary heading divided into (Theoretical Significance and Practical/Applied Significance), as stipulated by the guidelines.
2. **Required Phrasing for Theoretical Significance:** Clarify that the research provides an integrated theoretical foundation that addresses the severe shortage in Arabic and Gulf literature concerning modern OT governance. It should offer a model linking complex technical variables to administrative variables (such as operational complexity and governance effectiveness).
3. **Required Phrasing for Practical Significance:** Explicitly name the entities in alignment (e.g., the National Cybersecurity Authority (NCA) in the Kingdom, the Saudi

Ministry of Energy, and large-scale energy, water, and hydrogen corporations such as NEOM and its partners).

6. Research Hypotheses

The formulation of the hypotheses is highly precise, constructed within a null hypothesis (H0) framework suitable for rigorous statistical testing. An advanced mediation chain model has been built to link the variables (environment type, adoption of emerging technologies, operational complexity, and cybersecurity governance effectiveness) based on well-established scientific frameworks such as (*Baron & Kenny, 1986*).

Guidance Notes

- The hypotheses are well written and grounded statistically and methodologically. The sole direction is to ensure the use of Structural Equation Modeling (SEM) or Path Analysis in Chapter Three to be able to reject or accept the third hypothesis (H0(3)) regarding the mediating effect of operational complexity.

7. Definitions of Key Terms

A comprehensive and excellent table containing 12 core terms of the study has been prepared. The definitions are characterized by a professional and successful blend of the theoretical/conceptual dimension supported by references (such as relying on *Stouffer* for the OT section and *Dragos* for the Modern OT environment) and the operational/measurable dimension.

Guidance Notes

1. **Deepening Mathematical/Quantitative Precision for Operational Definitions:** Some operational definitions need to specify "how measurement occurs within the research" with greater precision. For example:
 - **Cybersecurity Governance Effectiveness:** The phrase: "and is operationally measured by the total score obtained by the respondent via the five-point Likert scale in the developed questionnaire, and the maturity level according to the Capability Maturity Model Integration (CMMI) modified in this study" should be added.

- **Emerging Technology Adoption Level:** Clarify how the scale (Low/Medium/High) will be transformed into quantitative or ordinal values suitable for statistical analysis.

8. Research Scope

The researcher covered the scope across its four required dimensions with excellent clarity:

1. **Thematic** (focusing on governance rather than purely technical design, and focusing on the shared boundary),
2. **Geographical** (the Kingdom of Saudi Arabia and the Gulf, extending to an international scope),
3. **Temporal** (from 2025 onwards to ensure keeping pace with rapid technological booms), and
4. **Population and Target Population** (OT security practitioners, policymakers, 50 to 100 respondents for the quantitative survey and 8–12 experts for the Delphi validation panel).

Guidance Notes

The scope is excellent and logically and scientifically justified; particularly the justification of the temporal scope, which coincides with the acceleration of AI and 5G technologies after 2020 to ensure hypotheses are not built on outdated literature that does not apply to current realities.

9. Research Methodology

The chapter provided an excellent, rapid overview indicating reliance on a mixed/multi-method approach (Quantitative Survey, Expert Interviews, and Embedded Case Study, and Delphi expert panel). The study population, sample, data collection methods, and tools were explicitly referenced.

Guidance Notes

It is recommended to allocate an independent heading named "Research Methodology" to be 100% compliant in form with item nine of the guidelines, summarizing the methodology there in a few dense lines before moving to the references.

10. Conceptual Model

The relationships are structured logically and theoretically in a highly robust manner within the text, and there is complete logical consistency linking the (Title ← Problem ← Questions ← Objectives ← Hypotheses ← Variables).

Guidance Notes

1. **Explicitly Inserting the Graphical Diagram:** Insert an "illustrative diagram that summarizes the study's relationships." Ensure the structural diagram is inserted, showing boxes for the independent variables (*Environment Type, Emerging Tech Integration*), the mediating variable (*Operational Complexity*), and the dependent variables (*Governance Effectiveness, Framework Adequacy Score*), while illustrating the direction of the hypothesized arrows and contextual derivations (*CISO Mandate, National Regulation*).

11. References

The reference list is sufficient, recent, robust, and cited with high precision according to the American Psychological Association system (*APA 7th Edition*).

Guidance Notes

1. Ensure the Digital Object Identifier (DOI) or URL is included for all references without exception in the final list to enhance the quality and reliability of the academic documentation of the thesis.

Overall Evaluation Summary of the Chapter:

The chapter is very good, and written in high-level academic English suitable for a doctoral dissertation and a proficient researcher who is a practitioner in his vital field. Responding to the minor structural notes (such as separating the significance and methodology into independent headings and explicitly inserting the graphical diagram of the conceptual model) will render this chapter complete, exemplary, and 100% compliant with all academic and research requirements.