

A Conceptual Meta-Model for Representing Proxy-Based Measurement in Information Systems Research^{*}

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Abstract

Information Systems (IS) research increasingly relies on secondary data to study theoretical constructs that may not be directly represented in available datasets. When empirical measures are used as proxies, the reasoning linking them to theoretical constructs may remain implicit or fragmented across theory, data constraints, assumptions, and validation practices. This research investigates how a conceptual meta-model can make the key elements and assumptions underlying proxy-based measurement in secondary-data IS research explicit. It proposes a reusable representation of the construct-proxy relationship, including the empirical representation, selection rationale, assumptions, context, alternative explanations, and validation evidence. Using an iterative design science approach, initial requirements have been derived from relevant literature and a preliminary review of published IS studies; the meta-model will next be refined and evaluated through case-based application. The study is currently at an early design stage, with the preliminary review, research question, design requirements, and initial meta-model developed. The proposed artifact aims to improve measurement transparency by making proxy reasoning more explicit, traceable, and comparable.

Keywords

proxy measurement, conceptual modeling, meta-model, secondary data, construct validity

1. Introduction and Research Problem

Information Systems (IS) research increasingly relies on secondary data to investigate human and organizational phenomena. Although such data can provide rich records of behavior and organizational activity, the variables available in existing datasets do not necessarily correspond directly to the theoretical constructs that researchers seek to study [1, 2]. Many constructs central to IS research, including trust, engagement, influence, motivation, and organizational capability, are theoretical or latent and cannot be observed directly. Researchers must therefore operationalize these constructs by linking their theoretical meaning to observable empirical measures [3]. For example, secondary data may consist of behavioral traces already recorded in digital platforms. Jo et al. [1] derive LMS-log proxies for learners' time-management strategies, illustrating how observable measures can represent theoretical constructs that are not explicitly captured in the dataset.

When an available dataset does not contain a direct measure of a construct, researchers may rely on a proxy: an observable measure used as a stand-in for a theoretical concept that cannot be directly or reliably observed in the available data [1, 2]. Proxy-based measurement therefore involves more than selecting a technically usable variable. It entails a representational claim that an empirical measure can serve as evidence about an underlying theoretical construct [4, 5]. Such a claim may be imperfect because an operationalization can capture only part of the intended construct or may also reflect phenomena that are theoretically distinct from it [2, 5].

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The key issue is whether the reasoning through which an empirical variable is interpreted as evidence about a construct is sufficiently explicit to permit informed evaluation. Relevant elements may include the focal construct, the observable phenomenon, the dataset variable or variables involved, the empirical representation used as a proxy, the rationale for proxy selection, interpretive assumptions, plausible alternative explanations, and evidence bearing on the proposed relationship. A preliminary review of secondary-data IS studies conducted for this research suggests that these elements are not consistently articulated together: proxy relationships may remain implicit, rationales may be dispersed across an article, and empirical checks may emphasize the robustness of downstream results rather than directly examining the construct-proxy relationship.

Existing measurement research guides construct definition, empirical representation, and validity assessment [3]. Related work distinguishes theoretical concepts from their empirical proxies [4] and further decomposes measurement into relationships linking concepts, proxies, and empirical observations [6]. Conceptual modeling research emphasizes explicit and meaningful representation of domain concepts and relationships to support understanding and evaluation [7–10]. However, it remains unclear whether a single representation integrates the proxy claim with its rationale, assumptions, alternative explanations, validation evidence, and relevant data context.

This research treats proxy-based measurement as both a validity and conceptual representation problem. It proposes a meta-model that makes the reasoning connecting an empirical representation to a theoretical construct explicit, traceable, and comparable across studies. The artifact provides a reusable structure for examining construct-proxy relationships rather than determining proxy validity.

Accordingly, this research asks: How can a conceptual meta-model make explicit the key elements, relationships, and assumptions underlying proxy-based measurement in secondary-data IS research?

The research has four objectives: (1) to analyze how construct-proxy relationships are currently articulated and justified, and how their validity is addressed in secondary-data IS research; (2) to identify the concepts, relationships, and assumptions that should be represented in a conceptual meta-model of proxy-based measurement; (3) to develop a meta-model that makes these elements and their relationships explicit; and (4) to apply and evaluate the proposed meta-model using published IS studies, with particular attention to its clarity, representational coverage, application consistency, and usefulness.

2. Background and Related Work

2.1. Construct Measurement and Validity

Construct measurement connects theoretical concepts to empirical observations. Because many constructs are not directly observable, operationalization requires a clear conceptual definition, specification of how observable indicators relate to the construct, and evidence that the resulting measures adequately represent its intended meaning. Weaknesses in these steps can undermine construct validity and make findings across studies difficult to interpret or compare [3, 11].

Construct validity cannot be established solely through reliability, statistical association, or predictive performance. Operationalization involves assumptions about how observable properties represent an underlying construct, creating the possibility of a mismatch between theoretical meaning and empirical representation. Making these assumptions explicit is therefore important for evaluating what a measure represents and how findings based on it should be interpreted [5].

2.2. Proxy-Based Measurement in Secondary-Data Research

Proxy-based measurement uses available observations to represent constructs that cannot be measured directly in the available data. Proxies may include individual variables, composite indices, multiple indicators, or computationally generated measures, and require substantive justification for why they provide evidence about the intended construct. Proxies may also contain noise or information associated with other concepts [2].

Research further indicates that proxy adequacy cannot be inferred from availability or statistical association alone. Proxies have been assessed through comparison with fuller measures, multiple-indicator approaches, reliability or agreement analysis, and sensitivity tests. Their adequacy may also depend on context and research purpose: a measure may be informative for one analytical objective while representing only part of a broader theoretical construct [12–15].

Some work structures the progression from conceptual definitions and relevant observables to empirical measures or proxies [16, 17], improving transparency but not necessarily providing a common representation of the assumptions, alternative interpretations, and evidence surrounding an individual proxy claim.

2.3. Conceptual Representation and Related Artifacts

Conceptual modeling makes domain concepts and relationships explicit for communication, understanding, and evaluation [9], while representational quality concerns whether relevant phenomena are represented clearly and sufficiently completely [7, 8, 10]. A meta-model provides a reusable type-level structure for representing multiple model instances [18]. From this perspective, proxy-based measurement can also be viewed as a problem of representing the reasoning connecting empirical variables to theoretical constructs.

Several existing artifacts address parts of this problem. Rigdon’s [4] Concept Proxy Framework explicitly distinguishes the theoretical concept from the empirical proxy constructed to represent it and locates the central validity problem in the relationship between the two. Zwanenburg and Qureshi [6] provide a broader representation of measurement reasoning by distinguishing conceptual, operational, and inferential relationships and showing that these can be decomposed into elementary logical links, including concept-to-proxy relationships.

Ontological approaches address related semantic issues. Weber [19] provides an ontological analysis of constructs and indicators and clarifies possible relationships between them. The Indicator Terminology for Explanation and Measurement (ITEM) Ontology provides a more granular representation of psychometric indicators through categories such as Objects, Measurables, Qualifiers, and Response Sets and their relationships [20]. Its primary focus, however, is the semantic and ontological structure of psychometric indicators rather than proxy-based measurement using secondary data.

Other semantic frameworks focus on variables and empirical observations. The Interoperable Descriptions of Observable Property Terminology (I-ADOPT) framework represents variable descriptions through Variable, Property, Entity, and Constraint, and the relationships among them [21]. The Sensor, Observation, Sample, and Actuator (SOSA) ontology similarly provides a lightweight representation of observations and related elements, including observable properties, features of interest, procedures, and results [22]. These frameworks provide structured semantics for what was observed or measured and how, but their primary focus is on variables and observations rather than on the reasoning by which an empirical representation is justified as evidence for a theoretical construct.

Taken together, these artifacts address complementary aspects of construct, proxy, indicator, variable, and observation representation. Among the artifacts examined to date, however, it remains unclear whether a single representation integrates the theoretical construct, empirical representation, and underlying data layer around an explicit proxy claim, together with its selection rationale, interpretive assumptions and context, plausible alternative explanations, and

validation evidence. The proposed research examines how these elements can be organized within a common conceptual meta-model for proxy-based measurement in secondary-data IS research.

3. Preliminary Review Findings

To examine whether the measurement issues discussed above are reflected in current IS research practice, a preliminary structured review was conducted of empirical studies published in MIS Quarterly in 2024 and 2025. The review focused on studies relying exclusively on secondary or archival data and operationalizing theoretical constructs in human or organizational contexts. An initial set of 88 research articles was retrieved from Web of Science. Screening based on data source, research design, domain, and empirical operationalization resulted in a preliminary sample of 20 studies.

For each study, the coding captured theoretical constructs, the variables used in empirical analysis, and the overall measurement strategy. Proxy-based operationalizations were further coded for whether the proxy relationship was explicit or implicit, the reported rationale for proxy selection, validation-related practices, and acknowledged measurement limitations. Coding was based on information reported in the published articles, with interpretive judgment used where necessary.

Operationalized constructs were classified as directly measured, proxy-based, or model-based according to the relationship between the theoretical construct and its empirical representation. Model-based operationalizations referred to constructs represented through elements of the empirical specification or estimation process rather than through an explicit observed variable. Proxy-based operationalizations were identified when an observable measure functioned as an approximation or substitute for a construct not directly represented in the available data. Proxy relationships were coded as explicit when authors identified the relationship as a proxy or indicator and as implicit when identified through systematic comparison of construct definitions and empirical measures but not explicitly articulated by the authors.

Table 1
Preliminary Overview of Reviewed Studies and Extracted Constructs

Category	Item	Count
Sample	Articles reviewed	20
Constructs	Total Number of Theoretical Constructs	83
Analytical Status	Operationalized Constructs	70
	Non-operationalized Constructs	13
Measurement Approach	Directly Measured Constructs	22
	Proxy-based	42
	Model-based operationalizations	6

Note: Counts reflect the current preliminary coding and may be revised following further review.

The preliminary review identified 83 theoretical constructs, of which 70 were operationalized. Proxy-based measurement was the most common operationalization approach, accounting for 42 of the 70 operationalized constructs.

The 42 proxy-based constructs yielded 51 proxy operationalizations because some constructs used more than one proxy. Of these, 9 were explicit and 42 implicit. Table 2 summarizes proxy explicitness, selection logic, and validation-related practices.

Table 2
Preliminary Patterns in Proxy Selection and Validation

Dimension	Category	Brief Description	Count
Proxy explicitness	Explicit	Authors explicitly identify the proxy relationship	9
	Implicit	The authors do not explicitly identify the proxy relationship	42
Selection logic	Theory-driven	Justified primarily through conceptual or theoretical reasoning	4
	Literature-driven	Justified primarily through prior studies or established practice	6
	Data-driven	Shaped primarily by variables available in the dataset	10
	Mixed	Combines theory, literature, and/or data considerations	31
Validation-related practice	Construct-level support	Conceptual or literature-based support for the construct–proxy link	9
	Result-level checks	Robustness, sensitivity, or alternative empirical specifications	45
	No validation reported	No identified discussion supporting proxy validity	5
Validation explicitness	Explicit	Evidence or analysis is directly framed as proxy validation	10
	Implicit	Relevant reasoning or checks are present but not framed as validation	41

Note: The unit of analysis is the proxy operationalization (N = 51). Validation-related practice categories are not mutually exclusive. Counts reflect the current preliminary coding.

The review points to three recurring patterns: most proxy relationships are implicit; proxy selection commonly combines theoretical, prior-literature, and data considerations; and validation-related practices are dominated by robustness, sensitivity, or alternative-specification checks rather

than direct examination of the construct–proxy relationship. These patterns suggest that proxy reasoning is often distributed across theory, prior literature, data constraints, and empirical checks, motivating a representation that brings the construct–proxy relationship, its rationale, assumptions, context, alternative interpretations, and supporting evidence together.

Two cases illustrate this variation. Saldanha et al. [23] use stock-price variation to operationalize firm-specific uncertainty without explicitly framing the construct–measure relationship as a proxy. In contrast, Matherly and Greenwood [24] explicitly describe federal prosecution records as proxies for corruption and discuss their rationale, alternative measures, and limitations. Representing these cases with the proposed meta-model would clarify which parts of the measurement argument are explicit, implicit, or absent and support systematic comparison across cases.

The review is preliminary and limited to one leading IS journal and a two-year period. Because identifying implicit proxies and classifying selection and validation-related practices involve interpretive judgment, the review documents reported practices rather than determining the substantive validity of individual proxies. Current classifications therefore remain provisional.

4. Proposed Research and Meta-Model Direction

Building on the measurement and representational foundations discussed in Section 2, this research proposes a conceptual meta-model for representing proxy-based measurement in secondary-data IS research. Existing work distinguishes theoretical concepts from their empirical proxies, decomposes measurement into conceptual and empirical relationships, and formalizes aspects of constructs, indicators, variables, and observations [4, 6, 19–22]. The proposed meta-model focuses specifically on making explicit and traceable the reasoning through which an empirical representation is interpreted as a proxy for a theoretical construct, without determining proxy validity or prescribing a single operationalization [5].

The current formulation contains several provisional elements. A Construct represents the theoretical concept of interest; an Observable Phenomenon is a behavior, event, property, or state potentially informative about it; a Dataset Variable records information about that phenomenon; and an Empirical Representation is the measure actually used as a potential proxy, whether based on a single variable or constructed through aggregation, transformation, indexing, or computational modeling. Maintaining these levels separately is consistent with prior measurement work that distinguishes theoretical concepts from their empirical proxies and decomposes measurement into distinct conceptual and empirical relationships [4, 6]. I-ADOPT similarly distinguishes a variable from the properties, entities, and contextual constraints involved in describing what has been observed or measured [21].

At the center of the model is a Proxy Claim, which asserts that a particular Empirical Representation can serve as evidence about a Construct for a specified research purpose. This formulation builds on the distinction between a theoretical concept and the empirical proxy used to represent it [4]. A Selection Rationale explains why that representation was chosen, for example, based on theory, prior literature, established empirical practice, or characteristics of the available data. An Assumption represents a proposition that must hold, or be considered sufficiently plausible, for the Empirical Representation to be interpreted as evidence about the Construct. The importance of making such assumptions explicit is consistent with measurement-modeling research emphasizing that operationalization necessarily rests on assumptions linking observable properties to theoretical constructs [5]. An Alternative Explanation represents a plausible competing interpretation of what the Empirical Representation may capture; such alternatives are relevant because observed information may reflect factors other than the focal construct [6]. Validation Evidence represents evidence used to evaluate or inform the adequacy of the construct–proxy relationship, distinct from both the rationale for selecting the proxy and robustness or sensitivity checks concerned primarily with downstream empirical results. Context specifies the

boundary conditions of the Proxy Claim, including the research purpose, population, setting, time period, or data-generating environment in which the interpretation is intended to apply.

Together, these elements form a traceable measurement argument in which Dataset Variables provide the basis for an Empirical Representation, and a Proxy Claim links that representation to a Construct for a specified purpose. The claim is further characterized by its Selection Rationale, Assumptions, Context, Alternative Explanations, and Validation Evidence. The structure also allows multiple empirical representations and interpretations to be compared [4, 6].

Drawing on these foundations and the preliminary findings in Section 3, five initial design requirements follow from this formulation. DR1 – Conceptual separation: the model should distinguish the theoretical construct, observable phenomenon, dataset variable(s), and empirical representation used as a potential proxy. DR2 – Explicit proxy claim: the claim that an empirical representation can serve as evidence about a construct should be explicitly identifiable. DR3 – Reasoning transparency: the selection rationale, assumptions, context, and plausible alternative explanations underlying the claim should be traceable. DR4 – Evidence differentiation: evidence concerning the construct-proxy relationship should be distinguishable from robustness or sensitivity checks concerned primarily with downstream empirical results. DR5 – Comparative representation: multiple proxies and interpretations should be representable and comparable without the model itself determining which is valid or preferable.

A preliminary representation of this structure is shown in Figure 1.

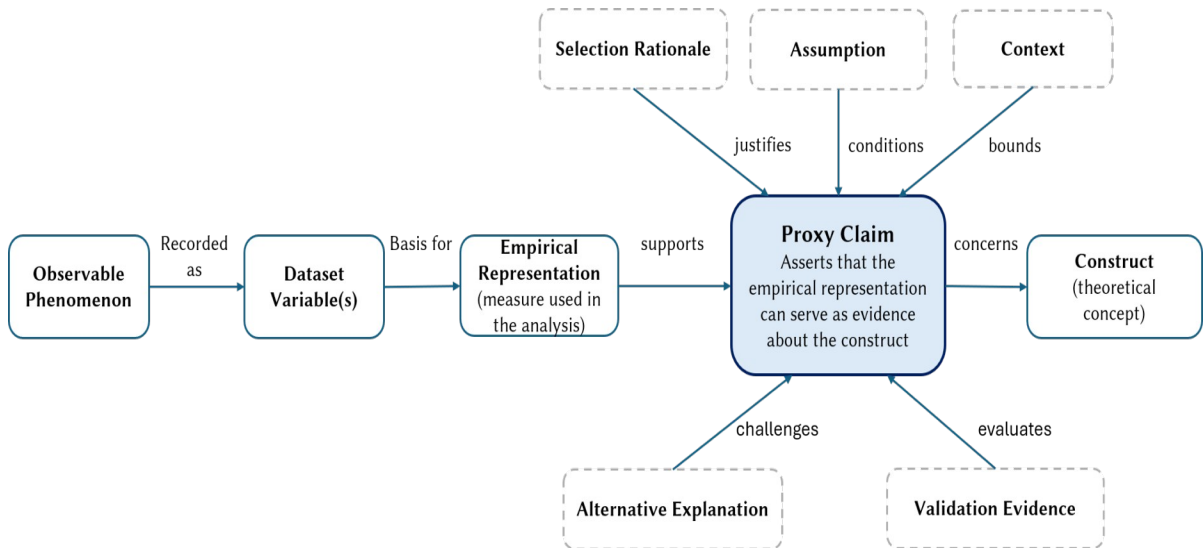


Figure 1. Preliminary conceptual meta-model for proxy-based measurement.

The structure remains provisional. Its concepts, relationships, and terminology will be refined through comparison with related artifacts and application to published secondary-data IS studies. The resulting meta-model will subsequently be evaluated for its clarity, representational coverage, application consistency, and usefulness in examining proxy-based measurement decisions.

5. Research Method and Evaluation Plan

The research will follow an iterative design science approach using the Design Science Research Methodology (DSRM) [25] to develop, demonstrate, and evaluate the proposed meta-model. The first stage will refine artifact requirements using two complementary sources: the literature will provide theoretically grounded distinctions, while the preliminary review will identify recurring representational needs concerning proxy explicitness, selection rationales, validation-related practices, and measurement limitations. These inputs will be integrated to formulate candidate design requirements, which will then be refined iteratively based on their relevance to the identified problem, conceptual distinctiveness, and applicability across cases.

The meta-model will then be iteratively specified and applied to selected studies representing contrasting forms of proxy measurement. Cases revealing missing concepts, ambiguous distinctions, or redundancy will inform revision. Once sufficiently stable, the meta-model will be applied to the remaining reviewed studies and, where feasible, to additional studies to assess representational coverage and broader applicability.

Evaluation will focus on four related criteria: clarity, representational coverage, application consistency, and usefulness. Clarity concerns whether the model's concepts, definitions, and relationships are understandable and sufficiently distinct. Representational coverage concerns whether relevant proxy-based measurement reasoning can be represented across heterogeneous published cases without important omissions. Application consistency concerns whether different users can apply the meta-model in a reasonably consistent manner to the same cases. Usefulness concerns whether the structured representation helps surface proxy rationales, assumptions, contextual boundaries, alternative explanations, and supporting evidence more explicitly and systematically than conventional methodological descriptions alone. This criterion reflects the broader design-science emphasis on evaluating the efficacy and utility of an artifact [26].

Evaluation will proceed in stages. First, formative expert review will be conducted with researchers with relevant expertise in IS measurement, conceptual modeling, or secondary-data research. Experts will examine the model definitions, relationships, and example applications to identify ambiguities, missing elements, unnecessary distinctions, and difficulties in application; related ontology research has used comparable expert applicability assessments to guide refinement [20]. Second, selected published cases will be independently represented by multiple users to examine consistency in applying the meta-model. Agreement and disagreement in the identification of model elements and relationships will be compared systematically to identify definitions or distinctions requiring further clarification. Third, once the artifact has sufficiently stabilized, a comparative evaluation will assess whether the meta-model enables relevant proxy-based measurement reasoning to be identified and compared more systematically than when relying on the methodological descriptions in the original studies alone. The precise operationalization of these evaluation criteria will be finalized as the artifact is refined.

6. Current Status and Expected Contributions

6.1. Current Status

The study is currently at an early design stage. A preliminary review has been conducted, the research problem and question have been refined, relevant measurement and conceptual modeling literature have been examined, and an initial meta-model and design requirements have been developed. Over the next six months, the meta-model will be refined through application to published cases. Expert review, application by multiple users, and comparative evaluation are planned for the following nine months. The remaining nine months will focus on final refinement, synthesis of the findings, and completion of the dissertation. Potential risks include persistent ambiguity among model concepts and inconsistent application across users. These risks will be addressed through iterative refinement of the model, its definitions, and application guidance.

6.2. Expected Contributions

The proposed meta-model is intended to provide a reusable representation of construct-proxy relationships centered on the Proxy Claim: a structured measurement argument linking an empirical representation to its rationale, assumptions, context, alternative explanations, and validation evidence. By separating these elements, the model may improve measurement transparency and distinguish evidence about the construct-proxy relationship from robustness or

sensitivity checks focused on downstream results. This emphasis on explicit reasoning parallels XAI, where explanations make model functioning understandable to an audience [27], while here the explanatory target is the measurement claim linking an empirical representation to a theoretical construct.

For conceptual modeling, the study examines whether modeling principles can be extended to represent measurement reasoning across theoretical, observational, data, and evidential levels. The resulting structure may also support comparison of alternative proxies by making differences in their rationales, assumptions, evidence, and contextual boundaries explicit.

7. Conclusion

Proxy-based measurement is common in secondary-data IS research, yet the reasoning linking empirical representations to theoretical constructs is often dispersed. The proposed meta-model brings this reasoning into a common representation for comparison and will next be refined and evaluated through published cases.

Declaration on Generative AI

During the preparation of this work, the author used ChatGPT to: paraphrase, reword, and improve writing style. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

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