What Matters for Immovable Asset Data Quality? Evidence from Malaysian Asset Management Practitioners

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ABSTRACT

Reliable asset information is central to immovable asset management, yet the relationship between organizational priorities and data quality priorities requires empirical clarification. This study examines associations between the importance practitioners assign to People, Technology and Process factors and the importance they assign to eleven immovable asset data quality dimensions. A cross-sectional survey yielded 274 responses from Malaysian practitioners recruited through asset management workshops. Reflective partial least squares path modelling was independently reproduced from the survey export, with uncertainty assessed using 10,000 case-bootstrap resamples and two sensitivity analyses. All item means exceeded 4.00 on the five-point importance scale. People (β = .271), Technology (β = .297) and Process (β = .312) showed positive associations with data quality importance, with all 95% percentile confidence intervals excluding zero. The model accounted for 68.8% of the variance in the endogenous importance score. However, Technology and Process were not adequately distinguished (HTMT = .957), and coefficient ordering changed under sensitivity analysis. The findings provide exploratory evidence of connected practitioner priorities rather than independently validated effects on achieved data quality. The study extends empirical examination of the People–Process–Technology framework and identifies measurement boundaries requiring refinement. Practical application should combine stakeholder priorities with independent record audits and evidence of organizational implementation.

Keywords: Immovable Asset Data Quality, Immovable Asset Management, Digital Transformation Public Sector Asset Management; Asset Information Management; Data Governance.

INTRODUCTION

Managing an immovable asset requires information that remains useful beyond its initial registration. A building's location and ownership may establish its identity, but decisions concerning maintenance, renewal and continued use require information about its condition, components and operational history. These information needs connect asset management with the continuing task of maintaining reliable records. Research on building information modelling in facilities management illustrates the potential of digital models to support this task through the integration of product and asset information (Pärn et al., 2017). For asset managers, however, the relevant question extends beyond whether information is stored: it concerns whether that information is suitable for the decisions it must support.

Data quality provides a basis for examining this suitability. Wang and Strong (1996) established that data consumers understand quality more broadly than accuracy alone. Their framework distinguishes intrinsic, contextual, representational and accessibility dimensions, recognising that information must be appropriate to its intended task, clearly presented and accessible to its users. Applied to immovable assets, this perspective directs attention to the relationship between asset information and its use. A record may contain a correct asset identifier while lacking information needed for a maintenance decision; information may also be complete but unavailable when required. These examples illustrate why assessing asset information requires attention to several dimensions rather than a single measure of correctness.

The organisational arrangements surrounding information are equally relevant to this discussion. Khatri and Brown (2010) distinguish data governance from data management by identifying the decisions to be made and the allocation of responsibility for those decisions. Their framework includes accountability for establishing data quality standards. Abraham et al. (2019) likewise position data governance around the exercise of authority and control over data management. Together, these perspectives provide a basis for examining data quality alongside the organisational provisions through which information is collected, maintained and used. In asset management, this raises questions about personnel responsibilities, data handling procedures and the information systems supporting them.

Previous research in Malaysian public immovable asset management has identified relevant provisions through expert interviews. Subri, Sapri, et al. (2025) examined factors influencing data quality, drawing attention to the organisational context in which asset information is managed. Related work developed a People–Process–Technology framework and discussed its application to immovable asset data quality (Subri, Nasaruddin, et al., 2025). These studies provide a foundation for specifying relevant factors and dimensions. The present paper builds on that foundation by examining the quantitative relationships between practitioners' judgements of the importance of organisational factors and their judgements of the importance of data quality dimensions. Its purpose is to extend the empirical examination of the framework rather than to present its initial development as a new contribution.

The distinction between perceived importance and achieved quality is central to this examination. A practitioner may consider staff training, standardised collection procedures or system integration highly important without indicating that these provisions are adequately implemented in their organisation. Similarly, assigning high importance to accuracy or completeness does not demonstrate that existing asset records satisfy those dimensions. The questionnaire used in this study elicits importance judgements for both organisational factors and data quality dimensions. Consequently, the relationships examined concern patterns in practitioner perceptions, rather than measured effects on database quality or asset performance.

Against this background, the study asks: How are practitioners' assessments of the importance of People, Process and Technology factors associated with the importance they assign to immovable asset data quality dimensions? The analysis draws on the thesis survey dataset, which reports 274 valid responses from Malaysian practitioners involved in asset and facilities management and related functions. People, Process and Technology provide the organising structure for the explanatory constructs, while eleven data quality dimensions represent the information quality priorities examined. Partial least squares structural equation modelling is used to evaluate the proposed measurement structure and the associations between these constructs.

The intended contribution is an empirical examination of how organisational priorities and information quality priorities are connected in practitioners' assessments of immovable asset management. This provides a more specific basis for interpreting the People–Process–Technology framework while preserving the distinction between perceived importance and demonstrated effectiveness. For practice, the findings can inform discussion of the organisational provisions that should accompany the specification of asset data quality expectations. They do not establish the effectiveness of particular interventions. The following sections develop the conceptual framework, explain the research methods, present the measurement and structural results, and discuss their implications and limitations.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Data Quality in Immovable Asset Management

Data quality in immovable asset management concerns the suitability of information for the decisions and activities it supports. This perspective extends assessment beyond whether individual records are correct. Wang and Strong (1996) distinguish intrinsic, contextual, representational and accessibility aspects of quality, demonstrating that information must also be appropriate to its purpose, understandable and accessible. Their consumer-oriented approach provides a foundation for examining the importance practitioners assign to

different properties of asset information. It does not, however, imply that these properties are equally important for every asset management task.

Asset management research has subsequently examined data quality within more specific organisational and technical settings. Lin et al. (2007) proposed a data-quality framework addressing the characteristics of engineering asset management. In facilities management, Zadeh et al. (2017) developed a framework for ass-

essing the quality of information contained in building information models. Chang et al. (2022) similarly examined information quality for effective asset management, identifying the need to consider quality dimensions alongside the technical arrangements through which information is generated and managed. These studies support a contextual understanding of quality: the usefulness of an asset record depends on its relationship with an identifiable information requirement.

Information requirements and information quality nevertheless address different questions. Requirements specify what information is needed; quality concerns the characteristics that make that information suitable for use. Abideen et al. (2024), for example, used expert judgements to prioritise information requirements for integrating building information modelling with operations and maintenance. Such prioritisation helps establish the required information content, but does not establish whether the information subsequently supplied is accurate, complete or accessible. The present study focuses on the importance assigned to these quality expectations and their association with organisational-factor importance.

Organisational Foundations and Synthesis of the Literature

The People–Process–Technology perspective provides an organising structure for examining the provisions surrounding asset information. Its value lies in distinguishing related aspects of information management without treating technology as a sufficient explanation of quality. Sociotechnical thinking provides a conceptual foundation for this position. Clegg (2000) treats social and technical arrangements as interdependent aspects of work-system design. Applied to asset information, this suggests that the roles of personnel, working procedures and information systems should be considered together, even when their associations are examined separately.

Data governance adds a complementary emphasis on responsibility and decision-making. Khatri and Brown (2010) identify the allocation of decision rights and accountability as central governance concerns, including responsibility for data-quality standards. Abraham et al. (2019) place these concerns within a broader framework of authority and control over data management. For the present study, these perspectives help distinguish the organisational provisions considered important from the information characteristics those provisions are intended to support.

The literature therefore offers several complementary contributions: definitions of quality, explanations of organisational responsibility, and evidence concerning information management in asset and facilities management. Table 1 synthesises these contributions. It is a thematic literature synthesis rather than a report of a completed systematic literature review.

Table 1. Literature synthesis relevant to immovable asset data quality

Theme	Key studies	Main contribution	Relevance to this study
Data-quality dimensions	Wang and Strong (1996); Zadeh et al. (2017); Chang et al. (2022)	Establish multidimensional and use-dependent perspectives on information quality.	Supports examining practitioners' quality priorities beyond accuracy alone.
Asset management context	Lin et al. (2007)	Proposes a data-quality framework for engineering asset management.	Grounds quality assessment in asset management practice.

Organisational alignment	Clegg (2000)	Treats social and technical arrangements as interdependent.	Provides a conceptual basis for considering People, Process and Technology together.
Data governance	Khatri and Brown (2010); Abraham et al. (2019)	Connects data management with responsibility, decision rights and organisational control.	Supports examining management commitment and data-handling responsibilities.
People and technological readiness	Pärn et al. (2017); Konanahalli et al. (2022)	Examines integration challenges, competence requirements and readiness in digital facilities management.	Provides context for People and Technology factors.
Collection and information exchange	Fang et al. (2022); Tsay et al. (2023)	Identifies shortcomings in asset-information structures, flows and BIM information quality.	Supports examining collection procedures, registration and integration.
Information requirements	Abideen et al. (2024)	Prioritises information requirements through expert judgements.	Distinguishes required information content from information quality.
Malaysian immovable asset management	Subri, Sapri, et al. (2025); Subri, Nasaruddin, et al. (2025)	Identifies relevant organisational factors and develops a PPT-based assessment framework.	Provides local construct content for further quantitative examination.

Note: The studies differ in their designs and measures. Evidence concerning information quality, implementation barriers or framework development is not treated as direct evidence of associations between importance ratings.

Within the Malaysian context, Subri, Sapri, et al. (2025) identified factors relevant to public immovable asset data quality through expert interviews. Related work by Subri, Nasaruddin, et al. (2025) developed a framework organised around People, Process and Technology. These contributions establish a local foundation for the present investigation. The question pursued here is more specific: whether practitioners who assign greater importance to these organisational provisions also assign greater importance to the dimensions of asset data quality.

People Factors and Data-Quality Priorities

The People construct encompasses the importance assigned to management commitment, personnel competence and training, and motivation and rewards. In the survey, these provisions include management initiatives, resources for education and training, relevant asset management knowledge, practical training and recognition of personnel contributions. The construct therefore concerns the human and managerial provisions practitioners consider important, rather than an assessment of employees' actual competence.

The literature provides a rationale for examining these provisions alongside information-quality priorities. Governance scholarship links the management of data with identifiable responsibilities and organisational decisions (Abraham et al., 2019; Khatri & Brown, 2010). Within facilities management, Konanahalli et al. (2022) identified skill gaps, inadequate preparedness and governance difficulties among the barriers to implementing big-data analytics. Although their study concerns technology implementation, it reinforces the relevance of personnel and organisational arrangements to data-intensive practice.

The proposed association in this paper follows from practitioners' recognition of these dependencies. A respondent who regards reliable asset information as important may also place greater importance on the knowledge, training and management support required to produce and maintain it. Conversely, valuing personnel development may be accompanied by stronger recognition of the information standards that such

development is intended to support. This is an expectation about connected professional priorities, not evidence that training or management commitment has already improved data quality.

H1: The perceived importance of People factors is positively associated with the perceived importance of immovable asset data-quality dimensions.

Technology Factors and Data-Quality Priorities

The Technology construct concerns the importance assigned to information-system capabilities, support for strategic asset information management, system effectiveness and integration. These provisions relate to how asset information is organised, exchanged and made accessible. In this study, they represent respondents' assessments of the importance of technological support, rather than a measure of the sophistication or performance of systems currently deployed.

Research on building information modelling illustrates both the potential and the limitations of this support. Pärn et al. (2017) examine the integration of BIM with facilities management, including the challenges of capturing and managing information for operational use. Fang et al. (2022) address portfolio-based strategic asset information management through an information-flow framework and a structured approach to non-geometric data. Together, these studies connect technological arrangements with the organisation and movement of asset information.

The existence of a digital model nevertheless does not establish the quality of its contents. Tsay et al. (2023) identified incomplete, inaccurate, inconsistent and insufficiently intelligible information in BIM-for-FM delivery. Their findings direct attention to the quality criteria that digital information must satisfy, rather than assuming that digitisation itself resolves quality problems.

For the present model, practitioners who place greater importance on integrated and functional information systems are expected to place greater importance on the characteristics that make the information delivered through those systems useful. This expectation concerns the alignment of technological priorities with information-quality priorities. It does not imply that technology operates independently of personnel or procedures.

H2: The perceived importance of Technology factors is positively associated with the perceived importance of immovable asset data-quality dimensions.

Process Factors and Data-Quality Priorities

The Process construct concerns the importance assigned to data-collection strategies, collection characteristics, standardised asset registration and information-exchange arrangements. These provisions describe how information is captured and organised for asset management. Their relevance extends beyond the initial creation of a record to the procedures through which information is checked, maintained and transferred.

Fang et al. (2022) identified shortcomings associated with missing data attributes, insufficient standardisation and weaknesses in information flows within strategic asset management. Tsay et al. (2023) likewise demonstrate the importance of examining whether information delivered through project processes satisfies facilities management requirements. These findings support attention to the arrangements through which information is produced and exchanged, alongside the systems used to store it.

The proposed perceptual association follows from the connection between procedures and their intended information outcomes. Practitioners who consider standardised collection and registration important may also attach greater importance to consistency, completeness and accessibility because these qualities help explain the purpose of procedural discipline. The expectation is therefore that the importance assigned to Process factors will be positively associated with the importance assigned to data-quality dimensions.

H3: The perceived importance of Process factors is positively associated with the perceived importance of immovable asset data-quality dimensions.

Construct definitions and measurement boundaries

A distinction is necessary between the organisational provisions represented by the PPT constructs and the information properties represented by the IADQ construct. Table 2 specifies this distinction at the level measured by the questionnaire.

Table 2. Construct definitions and scope of interpretation

Construct	Definition in this study	Content represented
People-factor importance	Importance assigned to human and managerial provisions supporting asset data management.	Management commitment; competence and training; motivation and rewards.
Technology-factor importance	Importance assigned to technological provisions supporting asset information management.	Information-system capabilities, strategic support, effectiveness and integration.
Process-factor importance	Importance assigned to procedures and arrangements for collecting, registering and exchanging asset information.	Collection strategy and characteristics; standardised registration; collection and exchange platforms.
IADQ-dimension importance	Importance assigned to the specified quality characteristics of immovable asset information.	Accuracy, reliability, consistency, security, timeliness, completeness, relevance, currency, understandability, conciseness and availability.

Source: Survey questionnaire. Definitions summarise the intended scope of the item groups; they do not indicate achieved organisational capability or measured record quality.

The eleven quality dimensions provide the content domain examined in the survey. Their inclusion does not mean that they are interchangeable or equally important. In particular, the questionnaire's currency item refers to the representation of asset value, rather than to the recency of information. This study therefore retains its instrument-specific meaning and does not interpret the item as an additional measure of timeliness.

The boundaries between the organisational constructs also require care. Some People items refer to procedures and technological assistance, while several Technology and Process items explicitly mention data-quality characteristics. The categories consequently represent related areas of practice rather than completely separate organisational domains. This overlap is substantively understandable, but it limits how sharply the corresponding statistical relationships can be interpreted.

Similarly, an association between two sets of importance ratings may reflect recognition of a meaningful organisational relationship, overlap in item content, or a general tendency to regard data management provisions as important. The theoretical model identifies the substantive relationships of interest; it does not, by itself, exclude these alternative explanations. Assessment of the measurement structure and interpretation of the results must remain sensitive to this distinction.

Research Gap and Proposed Conceptual Model

The literature reviewed establishes that asset information quality is multidimensional and that its management involves organisational as well as technological considerations. It also provides context-specific frameworks and evidence of difficulties in delivering information suitable for asset and facilities management. These contributions justify examining People, Process and Technology, but they do not automatically establish how importance judgements concerning those factors relate to importance judgements concerning data quality.

The present study addresses that narrower empirical question. It builds on the existing Malaysian framework by examining the associations among practitioners' assessments, rather than claiming to introduce PPT to immovable asset management or to demonstrate the effectiveness of particular interventions. The contribution

lies in clarifying how the organisational and informational aspects of the framework are connected within practitioner perceptions.

Figure 1 presents the proposed conceptual model. People, Technology and Process are specified as three explanatory constructs associated with the importance assigned to IADQ dimensions. The model does not impose a sequence among the three organisational constructs, propose mediation between them or rank their expected associations.

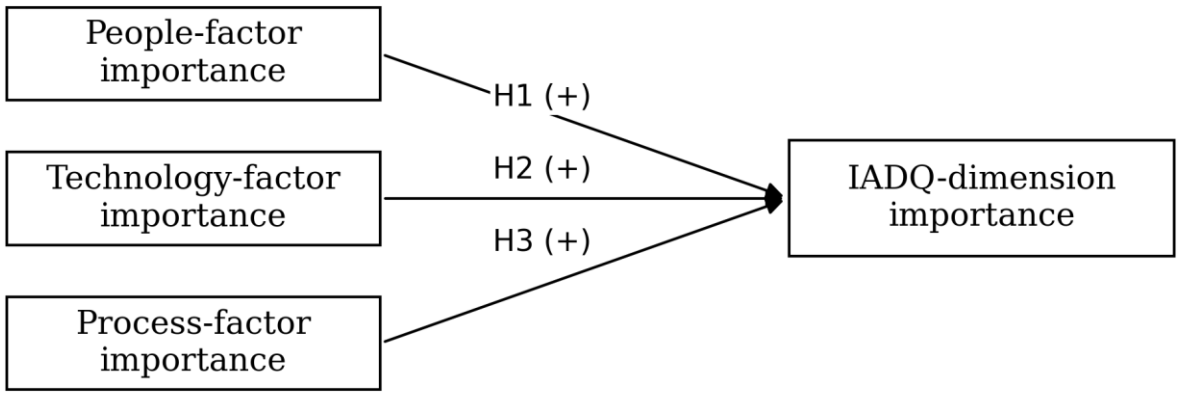


Figure 1. Conceptual model of associations between organisational-factor importance and immovable asset data-quality importance.

Note: All constructs represent practitioner importance judgements. Arrows indicate the specified direction of the hypothesised associations, not established causal effects. The figure presents the conceptual relationships; indicator specification and measurement assessment are addressed in the methods and results.

This formulation connects the literature with the survey while preserving the distinction between recognising the importance of data quality and demonstrating its achievement. The subsequent analysis examines whether the proposed associations are supported and how far they can be interpreted given the content and structure of the measures.

RESEARCH METHODOLOGY

Research Design

A cross-sectional questionnaire survey was used to examine the associations between the importance practitioners assigned to organisational factors and the importance they assigned to immovable asset data-quality dimensions. The individual practitioner constituted the unit of analysis. The survey addressed People, Technology and Process factors alongside eleven dimensions of immovable asset data quality.

The design was appropriate to the study's focus on professional judgements across a group of practitioners involved in asset and facilities management. The measures captured the importance respondents attached to the specified provisions and information characteristics. They did not measure the extent to which those provisions had been implemented or independently assess the quality of asset records. Accordingly, the structural relationships were interpreted as associations between importance judgements.

Participants recruitment and data collection

The survey targeted Malaysian practitioners involved in public immovable asset management and associated professional activities. These included government officers and industry practitioners working in asset management, facilities management, maintenance, engineering, property management and related information-

management functions. Respondents identified their professional roles, including whether they acted as data users, data collectors or data custodians.

Recruitment was undertaken through online asset-management change-management workshops. The workshop programme comprised 24 sessions involving 22 agencies and recorded 596 participants between February and August 2021. A questionnaire link was circulated through this programme, providing access to practitioners familiar with the operational and organisational context of immovable asset management. Recruitment was therefore based on access to a relevant practitioner group, with voluntary participation, rather than selection through a documented probability-sampling procedure.

The questionnaire was administered using Google Forms. Participants were given two weeks to complete the questionnaire after receiving the invitation. The survey export contained responses recorded between 29 March and 3 September 2021. These timestamps describe the observed response window and do not establish the opening and closing dates of invitations. Responses were collected electronically and prepared for statistical analysis.

The dataset comprised 274 completed questionnaires. Although workshop participation records provided an indication of the accessible recruitment group, the number of individuals who actually received the survey invitation was not established. A response rate was therefore not calculated using workshop attendance as the denominator. The sample provides evidence concerning the participating practitioners; its recruitment procedure does not establish statistical representativeness of all Malaysian asset-management practitioners.

Questionnaire Development and Measures

The questionnaire was developed from the literature and preceding investigations of immovable asset data quality. Earlier qualitative work informed the organisational factors, while prior examination of data-quality dimensions supported the selection of the information characteristics included in the survey. The present analysis forms part of the same research programme as the related qualitative and framework publications (Subri, Nasaruddin, et al., 2025; Subri, Sapri, et al., 2025), which are treated as construct-development sources rather than independent replications.

Before the main survey, the instrument was piloted with 30 respondents comprising academics and asset and facilities management practitioners. The pilot examined the clarity of the questionnaire and the internal consistency of its item groups using Cronbach's alpha. Feedback informed minor revisions to item wording before the main administration.

The final questionnaire contained three parts. Part A collected respondents' academic and professional backgrounds, employment sector, experience, organisational position, functional responsibilities and roles in handling asset data. Part B contained 17 items addressing People, Technology and Process factors. Part C contained eleven items addressing immovable asset data-quality dimensions.

Both substantive parts used five-point importance scales. In Part B, the scale ranged from 1, "Least Important", to 5, "Extremely Important". In Part C, the scale ranged from 1, "Least Important", to 5, "Most Important". Higher scores therefore indicated greater perceived importance. The measures were not agreement scales or assessments of organisational performance. Table 3 summarises the operational content of the four constructs.

Table 3. Operationalisation of the study constructs

Construct	Item codes	Operational content
People	P1–P3	Management commitment and initiatives; resources for education and training; policies and standard operating procedures for data-quality improvement.
People	P4–P6	Personnel attitudes, skills and knowledge; relevant asset and facilities management experience; structured practical training.

People	P7–P9	Procedural and technological support for performing tasks; motivation and management appreciation; performance-related rewards.
Technology	T1–T4	Information-system capabilities; strategic use of asset information; system effectiveness and relevance; integration and configuration.
Process	PR1–PR4	Data-collection strategy; collection and processing characteristics; standardised asset registration; information collection and exchange platforms.
IADQ dimensions	DQ1–DQ6	Accuracy, reliability, consistency, security, timeliness and completeness.
IADQ dimensions	DQ7–DQ11	Relevance, currency, understandability, conciseness and availability.

Note. The table summarises item content rather than reproducing the questionnaire verbatim. People, Technology and Process contained nine, four and four items, respectively; IADQ contained eleven items.

Interpretation followed the wording presented to respondents. In particular, the currency item concerned whether data represented the real worth of an immovable asset. It was therefore interpreted as an asset-value-related judgement rather than as a measure of information recency. Several organisational-factor items also referred explicitly to procedures, technological support or data-quality characteristics. These features were retained when defining the constructs and considered when interpreting their empirical separation.

Data Preparation and Preliminary Assessment

Preliminary analysis in the original study was undertaken using IBM SPSS Statistics 25. For this manuscript, descriptive statistics, screening diagnostics and model estimates were independently recomputed from the respondent-level survey export. The 274 questionnaires contained no missing responses in the analysed variables; missing-value imputation was therefore unnecessary. All 28 substantive items contained integer values from 1 to 5. Frequencies and descriptive statistics were used to examine the respondent profile and item distributions. Skewness and kurtosis were inspected to describe distributional characteristics.

Potential multivariate outliers were examined using Mahalanobis distances calculated from the mean scores of People, Technology and Process, using the sample covariance matrix. The reference threshold was $\chi^2 = 11.345$ with three degrees of freedom at the upper-tail .01 level. Six cases exceeded this threshold. Cook's distance was examined in a regression of mean IADQ importance on the three organisational mean scores with an intercept; the maximum was .286. All 274 responses were retained in the primary analysis. A separate sensitivity analysis excluded the six flagged cases to examine their influence on model estimates.

A second sensitivity analysis excluded respondents who selected an identical rating across all 28 substantive items. This diagnostic did not presume that uniform responses were invalid. The two exclusions were examined separately rather than sequentially. Preliminary mean-score diagnostics were distinguished from predictor collinearity and measurement assessment in the PLS model.

Model Specification and Analytical Approach

The model specified People, Technology and Process as explanatory constructs, with IADQ-dimension importance as the endogenous construct. Three direct paths represented H1, H2 and H3. No mediation or moderation relationships were specified. The original study used SmartPLS; the estimates and bootstrap intervals reported here were obtained through an independent Python implementation of standard PLS path modelling. They are not presented as output from a new SmartPLS execution.

PLS-SEM was used to estimate the relationships among the multi-item constructs and examine the variance accounted for in IADQ-dimension importance. Measurement quality and structural relationships were assessed separately, following the distinction outlined in methodological guidance on PLS-SEM reporting (Hair et al., 2019). The use of PLS-SEM did not alter the observational nature of the design or provide a basis for causal interpretation.

All four constructs were specified reflectively in the estimated model. Under this specification, the indicators were treated as manifestations of a common importance orientation within each construct. For IADQ, this interpretation concerns a respondent's general emphasis on the specified quality characteristics; it does not imply that accuracy, security, completeness and the other dimensions are interchangeable properties of actual asset records.

This specification entails a substantive assumption. A reflective model requires an explanation of why the underlying construct should account for variation in its indicators; satisfactory reliability coefficients alone cannot establish that explanation. The distinction between reflective and formative measurement therefore remains relevant to interpreting the model, particularly given the breadth of the IADQ dimensions and the organisational provisions included within PPT (Coltman et al., 2008).

The reanalysis used Python 3.12.14, NumPy 2.3.5, pandas 2.2.3 and SciPy 1.17.0. All blocks used Mode A outer weighting and path inner weighting. Indicators were standardised within each sample to zero mean and unit population variance. Initial outer weights were +1, construct scores were normalised to unit variance, and score orientation followed a positive sum of block weights. Iteration stopped when the maximum absolute change in normalised weights fell below 10^{-7}, with a maximum of 3,000 iterations. A separately implemented row-score calculation reproduced the primary path estimates to within 10^{-8}.

Measurement and Structural Model Assessment

The reflective measurement models were assessed through indicator loadings, internal consistency, convergent validity and discriminant validity. Internal consistency was examined using Cronbach's alpha and composite reliability, while convergent validity was assessed using average variance extracted. Indicator loadings were reviewed alongside their contribution to construct coverage.

The assessment used conventional reference values of approximately .70 for indicator loadings and internal consistency, and .50 for average variance extracted. These values informed evaluation rather than operating as automatic deletion rules. Indicators with loadings between .40 and .70 were considered in relation to the consequences of removal for reliability, convergent validity and substantive interpretation, consistent with PLS-SEM guidance (Hair et al., 2019).

Discriminant validity was examined using the Fornell–Larcker criterion, indicator cross-loadings and the heterotrait–monotrait ratio of correlations (HTMT). HTMT was calculated using absolute indicator correlations and assessed against a .90 reference value, following Henseler et al. (2015). Interpretation also considered conceptual proximity and overlap in questionnaire content. Two-sided percentile intervals described uncertainty in HTMT; they were not treated as the one-sided bias-corrected HTMT inference procedure.

Following measurement assessment, the structural model was examined using predictor variance inflation factors, standardised path coefficients and bootstrap confidence intervals. The coefficient of determination, R^2, summarised the variance accounted for in IADQ-dimension importance. Effect sizes, f^2, measured incremental explained variance when each explanatory construct was omitted, holding the full-model construct scores fixed.

Uncertainty was estimated using 10,000 nonparametric case-bootstrap resamples for each analysis, each of the same size as its analysed sample. Standardisation, outer weights and paths were re-estimated in every resample. Two-sided 95% percentile confidence intervals used the 2.5th and 97.5th percentiles with linear quantile interpolation. Standard errors were the sample standard deviations of bootstrap estimates. Fixed PCG64 seeds were 20261008 for the full sample, 20261009 for exclusion of the six flagged cases and 20261010 for exclusion of uniform-response cases. All 30,000 resamples converged. An interval excluding zero indicated evidence of a non-zero association at the corresponding two-sided 5% level.

The path estimates were interpreted jointly with measurement quality and collinearity diagnostics. Differences in coefficient magnitude were not, by themselves, treated as evidence that one organisational factor was more

important than another. Likewise, explained variance concerned practitioners' importance ratings rather than observed asset-record quality. The bootstrap resampled individual records; workshop-level dependence could not be assessed because workshop identifiers were unavailable.

Ethical Considerations

Participants were informed of the research purpose and the nature of their involvement before completing the questionnaire. Participation was voluntary, and the questionnaire stated that responses would be treated confidentially and used for research purposes. The questions concerned respondents' professional backgrounds and judgements about immovable asset information management.

RESULTS

Respondent Characteristics and Data Completeness

The analysis comprised 274 practitioner responses. Public-sector respondents accounted for 61.7% of the sample, private-sector respondents for 36.5%, and other sectors for 1.8%. A total of 173 respondents (63.1%) reported more than ten years of experience. Operational personnel constituted the largest organisational group (54.7%).

Table 4. Respondent characteristics (n = 274)

Characteristic	Category	n	%
Employment sector	Public	169	61.7
	Private	100	36.5
	Other	5	1.8
Experience	Fewer than 6 years	62	22.6
	6–10 years	39	14.2
	11–15 years	71	25.9
	16–20 years	50	18.2
	More than 20 years	52	19
Organisational level	Strategic	70	25.5
	Tactical	54	19.7
	Operational	150	54.7
Functional responsibility[1]	Asset/facilities management	148	54
	Real estate/property management	12	4.4
	Building maintenance management	80	29.2
	Project management/design office	52	19
	Engineering management	38	13.9
	Information and communication technology	41	15
	Other	50	18.2
Asset-data role[1]	Data user	190	69.3
	Data collector	132	48.2
	Data custodian	80	29.2

Note: [1]Multiple-response categories. Percentages use 274 as the denominator; totals may differ from 100% because of rounding or multiple selections.

All 28 substantive items contained valid responses from 1 to 5, with no missing observations. No records were identical across all 36 source fields. The recorded responses spanned 29 March to 3 September 2021. These dates describe the observed response window rather than the dates on which invitations were issued. The full sample was retained for the primary analysis.

Descriptive Patterns in Importance Ratings

Mean ratings were above 4.00 for every item (Table 5). People-item means ranged from 4.186 to 4.387, Technology from 4.255 to 4.307, and Process from 4.241 to 4.314. Among the IADQ dimensions, accuracy had the highest mean (4.478), followed by completeness (4.380). Reliability and consistency shared a mean of 4.369. Currency, interpreted according to its asset-value wording, recorded the lowest IADQ mean (4.237).

Table 5. Descriptive statistics for the 28 survey items

Item	Abbreviated content	Mean	SD
P1	Management commitment	4.332	0.748
P2	Education and training resources	4.299	0.71
P3	Policies and SOPs	4.332	0.718
P4	Personnel attitudes, skills and knowledge	4.387	0.734
P5	Relevant professional experience	4.259	0.733
P6	Structured practical training	4.307	0.722
P7	Procedural and technological assistance	4.259	0.728
P8	Motivation and appreciation	4.325	0.732
P9	Performance-related rewards	4.186	0.863
T1	IT capabilities	4.259	0.686
T2	Strategic use of asset information	4.255	0.746
T3	System effectiveness and relevance	4.307	0.675
T4	System integration and configuration	4.277	0.708
PR1	Data-collection strategy	4.241	0.751
PR2	Collection and processing characteristics	4.292	0.713
PR3	Standardised asset registration	4.314	0.708
PR4	Information collection and exchange	4.281	0.709
DQ1	Accuracy	4.478	0.696
DQ2	Reliability	4.369	0.689
DQ3	Consistency	4.369	0.689
DQ4	Security	4.361	0.729
DQ5	Timeliness	4.343	0.726
DQ6	Completeness	4.38	0.681
DQ7	Relevance	4.292	0.707
DQ8	Currency	4.237	0.73
DQ9	Understandability	4.336	0.698
DQ10	Conciseness	4.299	0.72
DQ11	Availability	4.339	0.683

Note: n = 274 for every item. SD uses the sample denominator n − 1. All responses are importance ratings on a five-point scale. Abbreviated labels preserve the operational meanings in Table 3.

These differences are descriptive and do not establish statistically distinct priorities. The highest response category was selected by 39.4%–58.4% of respondents across IADQ items. The complete response distributions are presented in Supplementary Figure S1.

Measurement Model Results

Cronbach's alpha ranged from 0.903 to 0.950 and composite reliability from 0.929 to 0.957. AVE ranged from 0.595 to 0.779. These results met the internal-consistency and convergent-validity reference values specified in the research methodology section. They do not, by themselves, establish separation between constructs.

Table 6. Internal consistency and convergent validity

Construct	α	CR	AVE
People	0.912	0.929	0.595
Technology	0.905	0.934	0.779
Process	0.903	0.932	0.775
IADQ	0.95	0.957	0.667

Note. α = raw-score Cronbach's alpha; CR = composite reliability; AVE = average variance extracted.

Table 7. Standardised outer loadings for all 28 retained indicators

Construct	Outer loadings
People	P1 = 0.688; P2 = 0.842; P3 = 0.840; P4 = 0.814; P5 = 0.760; P6 = 0.770; P7 = 0.795; P8 = 0.744; P9 = 0.672
Technology	T1 = 0.848; T2 = 0.889; T3 = 0.902; T4 = 0.891
Process	PR1 = 0.856; PR2 = 0.881; PR3 = 0.875; PR4 = 0.909
IADQ	DQ1 = 0.785; DQ2 = 0.852; DQ3 = 0.847; DQ4 = 0.731; DQ5 = 0.819; DQ6 = 0.852; DQ7 = 0.827; DQ8 = 0.789; DQ9 = 0.835; DQ10 = 0.806; DQ11 = 0.837

Technology loadings ranged from 0.848 to 0.902 and Process loadings from 0.856 to 0.909. IADQ loadings ranged from 0.731 to 0.852. Within People, seven indicators exceeded 0.70; P1 and P9 recorded loadings of 0.688 and 0.672.

Retaining these indicators preserved coverage of management commitment and performance-related rewards, although their relationships with the People construct were weaker than those of the remaining items.

The estimates indicate coherent item groups within the specified domains. Technology and Process composite reliability were 0.934 and 0.932, respectively.

The relatively high IADQ internal-consistency estimates describe shared variation in the importance judgements; they do not establish that the eleven quality dimensions are interchangeable properties of asset records. Interpretation of the organisational domains also depends on the discriminant-validity assessment.

Discriminant validity and predictor collinearity

The assessment did not establish adequate separation of all four constructs. Technology–Process HTMT was 0.957, exceeding the 0.90 reference value. Its two-sided 95% percentile interval, [0.919, 0.991], also lay above 0.90 (Table 8). This result identifies a substantive limitation in distinguishing these two organisational domains.

Table 8. HTMT estimates and bootstrap confidence intervals

Construct pair	HTMT	95% percentile CI
People–Technology	0.886	[0.837, 0.930]
People–Process	0.895	[0.833, 0.945]
People–IADQ	0.814	[0.730, 0.884]
Technology–Process	0.957	[0.919, 0.991]
Technology–IADQ	0.847	[0.780, 0.905]
Process–IADQ	0.850	[0.783, 0.908]

Note: 10,000 case-bootstrap resamples; two-sided 95% percentile intervals. These are descriptive uncertainty intervals, not the one-sided bias-corrected HTMT inference procedure. IADQ denotes IADQ-dimension importance.

People–Technology and People–Process point estimates were below 0.90, at 0.886 and 0.895, but their intervals extended above that value. Intervals for Technology–IADQ and Process–IADQ also crossed 0.90. Thus, a conclusion of uniformly satisfactory discriminant validity would not be supported by the reanalysis.

The Fornell–Larcker assessment raised a further concern. The square root of People AVE was 0.771, below its correlations with Technology (0.812) and Process (0.818). The other constructs satisfied their corresponding comparisons. Every indicator nevertheless loaded most strongly on its assigned construct. This favourable cross-loading pattern did not remove the overlap identified through HTMT and the People comparisons.

Structural VIF values were 3.471 for People, 4.574 for Technology and 4.704 for Process. Although below 5, all exceeded 3, indicating appreciable overlap among the explanatory scores. The three paths are therefore reported as exploratory conditional associations within the specified model. They should not be interpreted as separately validated effects of empirically distinct organisational domains.

Structural associations with IADQ importance

All three estimated paths were positive, and their two-sided 95% percentile intervals excluded zero (Table 9). People-factor importance was associated with IADQ-dimension importance at $\beta = 0.271$, Technology-factor importance at $\beta = 0.297$, and Process-factor importance at $\beta = 0.312$. The point estimates reproduced those of the original thesis analysis to three decimal places; confidence intervals were estimated using the procedure described in the subsection on measurement and structural model assessment.

Table 9. Structural estimates from the full sample

Hypothesis and path	β	Bootstrap SE	95% CI	f^2	VIF
H1: People → IADQ	0.271	0.082	[0.123, 0.438]	0.068	3.471
H2: Technology → IADQ	0.297	0.076	[0.150, 0.451]	0.062	4.574
H3: Process → IADQ	0.312	0.089	[0.127, 0.473]	0.066	4.704

Note: n = 274; $R^2 = 0.688$. SE = bootstrap standard error. Intervals use 10,000 case resamples and percentile limits. f^2 measures incremental explained variance with the full-model construct scores held fixed. No inference establishes a ranking of coefficients.

Collectively, the model accounted for 68.8% of the variance in IADQ-dimension importance within this sample. The incremental contributions were smaller: f^2 was 0.068 for People, 0.062 for Technology and 0.066

for Process. The contrast between collective and incremental explained variance is relevant given the overlap among the explanatory domains.

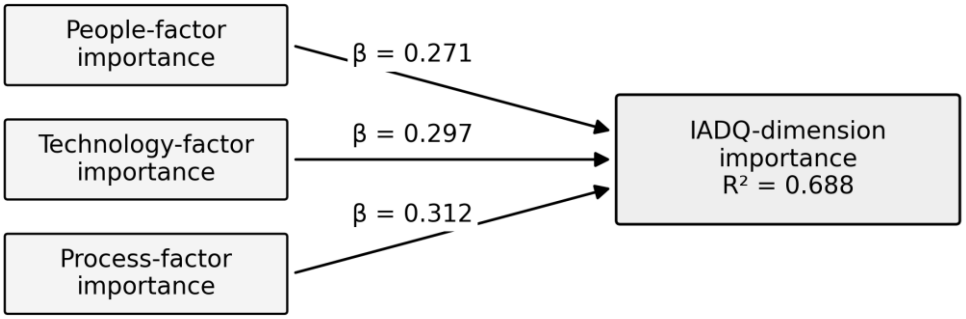


Figure 2. Estimated associations with IADQ-dimension importance

Note: All constructs represent importance judgements. Arrows specify modelled associations, not causal effects. Technology and Process did not satisfy the HTMT reference criterion; the paths must be interpreted with that limitation.

The coefficient directions were consistent with H1–H3, but the measurement findings prevent an unqualified claim that the hypotheses were confirmed for three empirically distinct domains. The results indicate connected practitioner priorities. They do not demonstrate that particular organisational provisions improved asset-record quality or that one domain mattered more than another.

Sensitivity to Unusual and Uniform Response Patterns

Mahalanobis screening of the three organisational mean scores identified six cases above the χ^2 threshold of 11.345 with three degrees of freedom at the upper-tail .01 level. The maximum Cook's distance in the preliminary mean-score regression was 0.286. These observations were retained in the primary analysis and excluded only in a separate sensitivity analysis.

After excluding the six cases, all three paths remained positive and their 95% intervals excluded zero. However, People increased from 0.271 to 0.359 and Process decreased from 0.312 to 0.220. R^2 increased from 0.688 to 0.699. The directions were stable, while coefficient magnitudes and their numerical ordering were sensitive to the case set.

Table 10. Sensitivity of structural associations to case selection

Analysis	n	Predictor	β	95% CI	R^2
All responses	274	People	0.271	[0.123, 0.438]	0.688
		Technology	0.297	[0.150, 0.451]	
		Process	0.312	[0.127, 0.473]	
Six flagged cases excluded	268	People	0.359	[0.228, 0.499]	0.699
		Technology	0.301	[0.157, 0.454]	
		Process	0.22	[0.068, 0.359]	
Uniform responses excluded	224	People	0.23	[0.075, 0.405]	0.578
		Technology	0.279	[0.125, 0.440]	
		Process	0.315	[0.133, 0.483]	

Note: Each analysis used 10,000 case-bootstrap resamples. The six flagged cases and the 50 uniform-response cases were excluded in separate analyses, not sequentially. All respondents remained in the primary analysis.

A further 50 respondents (18.2%) assigned the same rating to all 28 substantive items: 29 selected 5 throughout, 14 selected 4 and seven selected 3. Such responses cannot be classified as invalid from this pattern alone. Their exclusion was examined as an additional diagnostic rather than as a replacement for the primary sample.

In the remaining 224 responses, all paths remained positive and their intervals excluded zero, but R^2 decreased to 0.578. Technology–Process HTMT remained high at 0.939, compared with 0.957 in the full sample and 0.971 after excluding the six outliers. The measurement concern was therefore not removed by either sensitivity analysis. These checks support the persistence of positive associations while qualifying claims about their magnitude, explanatory power and distinctiveness.

DISCUSSION

The survey identifies a positive relationship between the importance practitioners assign to organisational provisions and the importance they assign to immovable asset data quality (IADQ). However, the measurement results do not establish clear separation between Technology and Process. These two findings frame the discussion: organisational priorities are associated with data quality priorities, but the evidence does not validate three independent influences on achieved data quality.

Practitioner Priorities for Asset Information

Respondents attached considerable importance to all assessed organisational factors and data quality dimensions, with every item mean exceeding 4.00 on the five-point scale. Accuracy and completeness received the highest mean ratings among the IADQ dimensions. Reliability, consistency, security and the remaining dimensions also attracted high ratings, indicating that respondents considered several information characteristics important to asset management.

This pattern is consistent with Wang and Strong's (1996) account of data quality as extending beyond accuracy to include contextual, representational and accessibility requirements. For immovable assets, this means considering whether information is suitable for a particular decision, understandable to its user and available when required. The present survey provides evidence about practitioners' recognition of these requirements; it does not establish whether their organisations' records satisfy them.

The descriptive ordering should not be treated as a statistically demonstrated hierarchy because differences between item means were not tested. Interpretation also depends on the questionnaire wording. In particular, "currency" referred to the real worth of an asset, rather than information recency. Its comparatively lower mean therefore does not indicate that respondents regarded up-to-date records as less important.

Associations Between Organisational and Data Quality Priorities

The estimated associations were positive for People ($\beta = .271$), Technology ($\beta = .297$) and Process ($\beta = .312$), with all three 95% bootstrap confidence intervals excluding zero. Their directions were also retained in both sensitivity analyses. Respondents who assigned greater importance to organisational provisions generally assigned greater importance to the data quality dimensions. This is evidence of related professional judgements, rather than evidence that implementing these provisions improves asset records.

The model accounted for 68.8% of the variance in the IADQ importance score. This is an in-sample result concerning perceptions, not a measure of actual database quality or evidence of predictive performance elsewhere. Each domain added only a modest amount of explanatory information after accounting for the others ($f^2 = .062–.068$). Although Process had the largest coefficient in the primary model, People had the largest coefficient after the six statistically unusual cases were excluded. The data therefore do not establish a stable ranking for investment or intervention.

The measurement boundary between Technology and Process

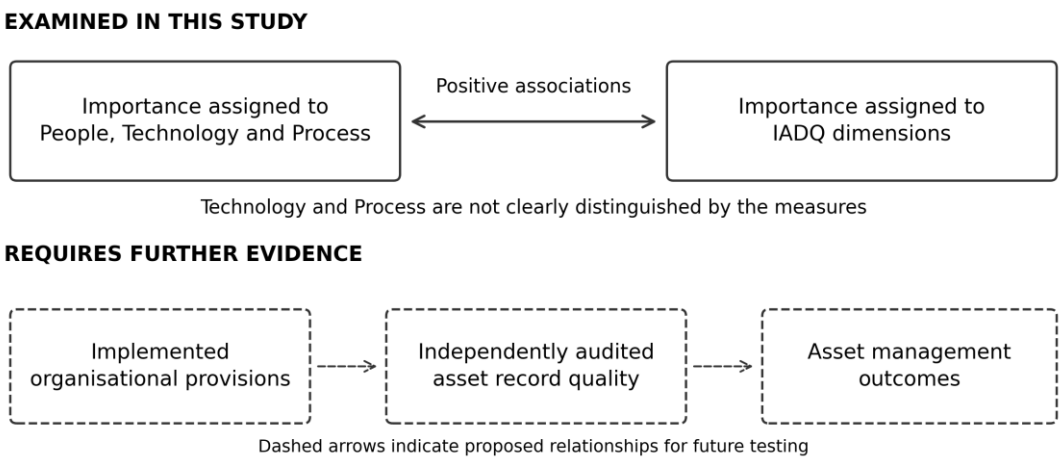
The Technology–Process HTMT value of .957 exceeded the .90 reference criterion, and the overlap persisted in both sensitivity analyses. These measures cannot therefore be treated as clearly distinguishable in the present sample. The People construct also failed the Fornell–Larcker comparisons with Technology and Process, indicating that the measurement concern extends beyond a single pairwise result.

One plausible explanation is that practitioners regarded systems and procedures as closely connected aspects of managing asset information. A registration procedure, for example, may be understood through the platform used to perform it. However, some Process items explicitly refer to information platforms, while the People items include procedural and technological support. Shared content and a general tendency to assign high importance ratings could also contribute to the overlap. The survey cannot determine which explanation predominates.

Acceptable internal consistency and convergent validity do not resolve this issue. Nor does the finding that indicators load most strongly on their assigned constructs establish adequate separation. Henseler et al. (2015) showed that cross-loadings and the Fornell–Larcker criterion can fail to detect discriminant validity problems. The HTMT findings must consequently qualify interpretation of the structural paths, even where their bootstrap intervals exclude zero.

The contribution is therefore an exploratory examination of how organisational priorities and information quality priorities are connected, together with evidence that the proposed domain boundaries require refinement. The overlap does not demonstrate technological–procedural synergy or automatically justify merging the constructs. A combined or higher-order specification would require conceptual justification and further validation. Figure 3 distinguishes the relationship examined here from the implementation and performance relationships that remain untested.

Figure 3. Scope of the empirical evidence and relationships requiring further study



Note. The solid double-headed arrow denotes an observed association, not a causal effect. Dashed arrows represent proposed relationships for future testing. Source: Authors' synthesis of the study findings.

Implications for Asset Information Management

The findings provide a basis for reviewing asset information priorities across staff responsibilities, systems and operational procedures. They do not prescribe how resources should be distributed between these domains. An organisation could use the questionnaire topics to structure discussion of who specifies information requirements, who verifies records, how changes are authorised and how information is exchanged. This proposed use is compatible with the broader emphasis on explicit governance arrangements in Khatri and Brown (2010), but its effectiveness remains to be evaluated.

A practical review should distinguish what staff consider important from what is implemented and what can be

demonstrated in the records. For example, assigning high importance to completeness provides a reason to discuss required fields; an audit is still needed to determine whether those fields are populated appropriately. Similarly, prioritising accuracy does not establish that verification procedures exist or that recorded values agree with reliable source evidence. Table 11 translates selected findings into review questions and identifies the additional evidence each application would require.

Table 11. Practical interpretation of the findings and evidence needed for application

Survey finding	Proposed management review	Additional evidence needed
High importance assigned to accuracy and completeness	Define required attributes and record verification responsibilities.	Checks against reliable sources; missing-field and completeness audits.
Positive People association	Review training needs, role clarity and support for data handling.	Competency assessments; observed practices and correction records.
Technology and Process overlap	Review system functions alongside registration, updating and exchange procedures.	Workflow observation; system configuration and transaction records.
Coefficient ordering changes in sensitivity analysis	Avoid allocating budgets by path coefficient rank.	Local defect severity, operational risks, costs and intervention evaluations.
Importance ratings do not measure achieved quality	Set measurable quality requirements and assess records separately.	Independent quality audits repeated over time.

Note. Proposed management reviews and evidence requirements are implications for further application, not interventions tested in this survey. Source: Authors' synthesis.

Implementation decisions should combine these priorities with observed defects, operational requirements and costs. Evaluating a targeted change against a documented baseline would provide stronger grounds for action than assuming that the highest-rated factor will deliver the greatest improvement.

LIMITATIONS AND FUTURE RESEARCH

Voluntary recruitment through workshops limits generalisation beyond the participating practitioners. Public-sector respondents formed the majority, but the sample also included private-sector and other participants. The findings should therefore be interpreted as evidence from a mixed practitioner group rather than as representative estimates for all Malaysian public asset organisations. The data also capture judgements at one point in time and cannot establish how priorities develop as organisational practices change. All substantive measures were collected through one questionnaire. Shared measurement conditions, item overlap and general importance-rating tendencies may have contributed to the associations. Fifty respondents selected the same rating across all 28 items. Such responses are not necessarily invalid, but excluding them reduced explained variance from .688 to .578 while retaining positive path directions. This result distinguishes the stability of the directions from the sensitivity of their magnitudes. Neither this exclusion nor removal of the six statistically unusual cases resolved the Technology–Process overlap.

Future instrument development should clarify the boundaries between technological capabilities and operational procedures, review items containing content from several domains, and reassess the reflective specification. Cognitive interviews could establish whether respondents interpret each item as intended, including whether the asset-value meaning of "currency" should be retained under a clearer label. Removing indicators solely to improve statistical thresholds would risk narrowing substantive coverage without resolving the conceptual problem. Revised measures should instead be assessed in an independent sample. Subsequent research should distinguish perceived importance, implemented organisational provisions and achieved information quality. Linking practitioner surveys to independent record audits would allow examination of whether stated priorities correspond to measurable conditions. Longitudinal or appropriately designed

intervention studies could then examine whether changes in organisational provisions precede improvements in asset records and, subsequently, asset management outcomes. These extensions would move the evidence beyond related perceptions while preserving the distinctions identified in Figure 3.

CONCLUSION

This study examined how Malaysian asset management practitioners' assessments of the importance of People, Technology and Process factors were associated with the importance they assigned to immovable asset data quality dimensions. Analysis of 274 survey responses identified positive associations for all three organisational domains. These relationships indicate that respondents who placed greater emphasis on organisational provisions also tended to place greater emphasis on data quality requirements. They concern practitioners' judgements and do not establish the effects of implemented provisions on the quality of asset records. The measurement findings qualify this conclusion. Technology and Process were not sufficiently distinguishable in the present instrument, and the relative magnitudes of the structural coefficients changed under sensitivity analysis. The study therefore provides exploratory evidence of connected organisational and information quality priorities, while identifying a need to refine the boundaries between the proposed constructs. It does not establish a stable ranking of the three domains or validate them as independent determinants of achieved data quality.

The contribution lies in extending the empirical examination of the People–Process–Technology framework within immovable asset management and clarifying what importance-based measures can establish. For practitioners, the findings offer a basis for discussing personnel responsibilities, information systems and data handling procedures alongside explicit quality requirements. Decisions about improvement measures should additionally draw on observed deficiencies, operational needs and implementation costs. Further progress requires clearer measures and evidence connecting organisational practices with independently assessed asset information. Refining the instrument and linking practitioner assessments to record audits would enable subsequent research to examine whether stated priorities translate into implementation and measurable improvements in data quality.

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SUPPLEMENTARY MATERIAL

The chart shows the observed distributions for all eleven IADQ items. It supplements the item means by showing the concentration of responses in the upper categories. Categories 1–5 correspond to the original importance scale; n = 274 for each item.

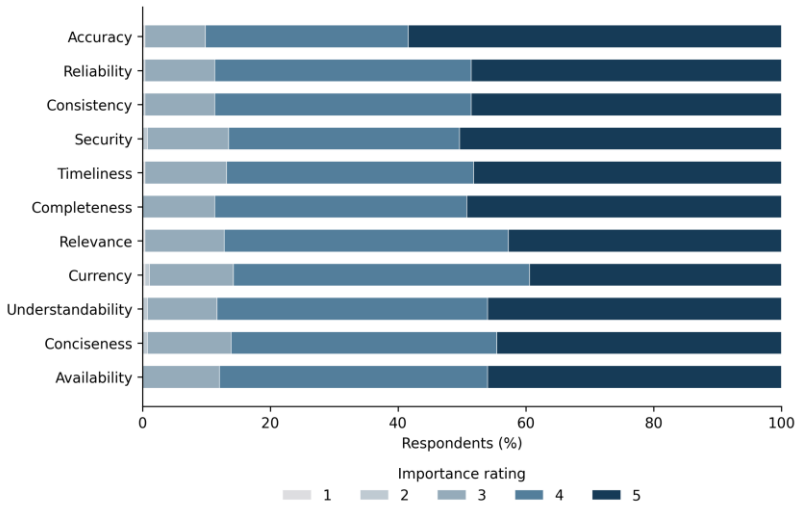


Figure S1. Response distributions for IADQ-dimension importance

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Note. Dimension order follows the questionnaire. Currency refers to asset value in this instrument; n = 274 for each item.

Accuracy received the highest proportion of rating-5 responses (58.4%). Currency received the lowest such proportion (39.4%), although its mean remained above 4.00. Similar marginal distributions do not imply that the same respondents selected the same ratings: reliability and consistency have identical means and standard deviations, but their response columns are not identical.