



MIXED METHODS RESEARCH: NVIVO CAN QUALITATIVELY VALIDATE A CAUSAL QUANTITATIVE MEASUREMENT MODEL STUDY

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ABSTRACT

Mixed methods research combines qualitative and quantitative approaches to provide a more comprehensive understanding of research questions. Nvivo, a qualitative data analysis software, plays a crucial role in this integration by allowing researchers to validate causal quantitative measurement models through qualitative insights. The qualitative statistical analysis package nvivo can provide a strong mixed methods validation tool for researchers pursuing quantitative statistical modelling analysis - such as in structural equation modelling path analysis studies.

Keywords: Thematic analysis, Word cloud, Word tree, Cluster analysis, Project map, Model framework, Validation, Research.

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1. INTRODUCTION

Statistical modelling typically encompasses a literature and experimentally-designed survey instrument capturing information regarding likely model construct items Each of these sample data constructs typically house data capture of a series of items and/or probability distributions, measurements and/or thematic information combined with mathematical construct linkages, These can form statistical models that relate constructs and their linkages into relation model components that collectively are often focused towards specific, pre-determined measurement outcomes. Hence, from a survey sample data set it is possible to advance theoretical, measurement and real-world predictions, but generally under explicit and restrictive assumptions.

1.1. NVivo Qualitative Stats

Nvivo is a leading software analysis package for qualitative and mixed methods investigations. It aids researchers to collate unstructured data from numerous sources such as surveys, observations, interviews, images, digital data, and articles into categorized and coded formats around specifically chosen themes, concepts, or experiences. These format collations can be individually, or conjointly, framed and modelled using approaches such as frequency charts, word clouds, word trees, comparison diagrams, cluster analysis, project maps, mind maps, concept maps, 2D and 3D relational diagrams, circle graphs, and dendrograms. Systematic-assessment of such approaches can provide new findings or insights, meaningful-interpretation, descriptive solutions and/or analytical conclusions.

As a qualitative analysis package NVivo introduces the expertise of the researcher in first setting key themed parameters. However, NVivo also provides features like correlations and cluster analysis, and these can support the study's reliability, plus help systematically validate the supporting and related quantitative analysis study.

1.2. Structural equation modelling (SEM) quantitative stats

SEM is a leading quantitative analysis package used in experimental and observational research to analyse complex relationships between variables (herein termed constructs). These constructs are latent and are made up of measured indicator items. SEM combines a measurement model and a structural model to deliver both measurement of the construct items and directional causality of the relationships between the engaged constructs. SEM applies to business, IT/IS/AI, social sciences, health and medicine, education, and training, and sometimes extends down to scientific studies such as in genetics. SEM can even be conducted with non-normal data and can extend to multi-level models (using MPlus). In addition, input data can be categorical, ordinal, or binary.

SEM can involve inferential, exploratory, causal, or predictive analysis approaches. SEM combines factor analysis with multiple regression path analysis into an overall combined rigorous model fit. SEM applies multiple statistical tests in including frequencies, outliers, missing values, Little's MCAR, factor reduction, item loadings, mean and standard deviation, Cronbach alpha, AVE, composite construct load, error and critical reliability measures, skew, kurtosis, Mahalanobis distancing, model chi-square, degrees of freedom, regressions with covariance significance, beta path weight significance, correlations, standardized total effects, bootstrapping, and fit indices, plus eliminating non-normality, cross loading problems, item and construct fit problems, path problems, error problems, dataset size problems, and so forth.

This SEM modelling process typically creates an intuitive, visual, flow framework that engages mathematical relationships between random and non-random constructs. These sequentially, and often causally, directionally link participating model constructs into a dataflow progression – starting from exogenous input constructs, via endogenous intermediate constructs, through to endogenous outcomes variables. This SEM modelling helps identify relationships between constructs, isolate model pathways, and make ongoing predictions.

1.1.3. Combining NVivo and SEM

Nvivo and SEM combined as a strong conjoint study approach offers an overall cross-validity approach across a study's analysis and results. This mixed methods triangulation approach uses the literature and theories, multiple methods, and multiple data sources to reduce bias and to increase both the credibility and findings of the study. In this situation, and when appropriately structured, each statistical package contributes its net strengths to the research, rather than one statistical package validating the other. This study now investigates how this process can be meaningfully structured.

1.1.4. Triangulation – literature and theories into framework model

Nvivo provides one perspective of triangulation, SEM provides another and the literature and associated theories provide the third perspective. This combined process integrates multiple literature and theory components into each perspective or framework approach, applies interviews, open-ended statements, documents, observations, and measurement questionnaires, and collectively zeros in on the comprehensive conjoint mixed methods research. This can visualize as a Figure-1 targeted mixed methods triangulation solution - labelled ‘Solⁿ.’ This solution is achieved by applying multiple and diverse approaches, and offers a comprehensive literary, theoretical, and practical understanding around the investigated topic solution.

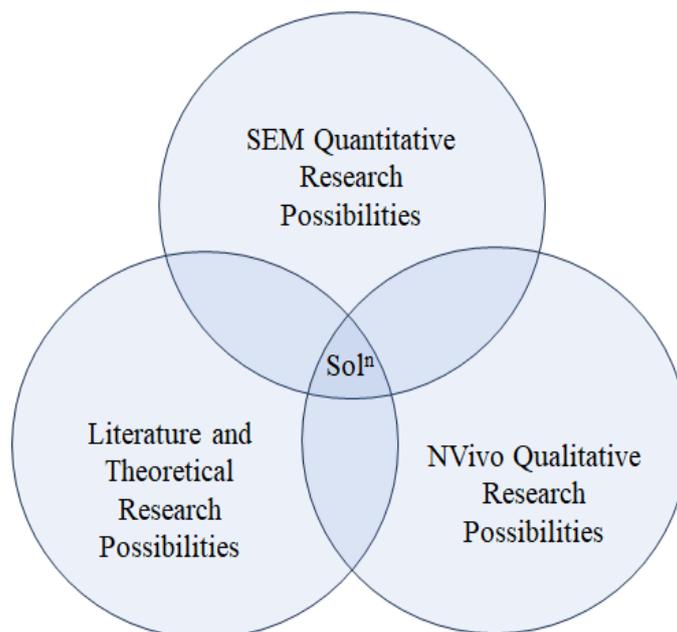


Figure-1: Triangulation as Mixed Methods Visualization towards the Tri-Overlapping Solution.

2. LITERATURE REVIEW

Mixed methods research combines qualitative and quantitative approaches to provide a more comprehensive understanding of research questions. NVivo, a qualitative data analysis software, plays a crucial role in this integration by allowing researchers to validate causal quantitative measurement models through qualitative insights.

Grootel et.al (2020) find out that in mixed methods reviewing, data from quantitative and qualitative studies are combined at the review level. One possible way to combine findings of quantitative and qualitative studies is to quantify qualitative findings prior to their incorporation in a quantitative review. There are only a few examples of the quantification of qualitative findings within this context. Their study adds to current research on mixed methods review methodology by reporting the pilot implementation of a new four-step quantifying approach. We report how we extract and quantify the strength of relationships found in qualitative studies by assigning correlations to vague quantifiers in text fragments. Their article describes:

- (a) how the analysis is prepared;
- (b) how vague quantifiers in text fragments are organized and transformed to numerical values;
- (c) how qualitative studies as a whole are assigned effect sizes; and
- (d) how the overall mean effects size and variance can be calculated.

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The pilot implementation shows how findings from 26 primary qualitative studies are transformed into mean effect sizes and corresponding variances.

2.1. Role of NVivo in Mixed Methods Research:

2.1.1. Quantifying Qualitative Data

NVivo helps researchers quantify findings from qualitative interviews and focus groups. This process involves coding qualitative data into themes and sub-themes, which can then be analyzed alongside quantitative data to identify relationships and patterns Lumivero (2015).

2.1.2. Integration of Data

By using NVivo, researchers can merge qualitative insights with quantitative data, enhancing the understanding of complex issues. For instance, qualitative data can provide context to quantitative findings, helping to explain the "why" behind observed trends Lumivero (2023).

2.1.3. Validation of Measurement Models

NVivo can be utilized to qualitatively validate causal quantitative measurement models. This involves using qualitative data to assess the relevance and accuracy of the constructs measured quantitatively, ensuring that the models reflect real-world complexities Lumivero.

2.1.4. Project Management

NVivo also serves as a project management tool, helping researchers organize and analyze multiple datasets efficiently. This is particularly useful in studies that require iterative rounds of data collection and analysis Lumivero.

2.2 Practical Applications

Researchers have successfully applied NVivo in various projects, such as:

- Evaluating community engagement in research by developing and validating new survey tools through qualitative interviews Lumivero (2023).
- Analyzing the experiences of marginalized groups to inform policy and practice, thereby ensuring that quantitative measures are grounded in lived experiences Lumivero (2015).

In summary, NVivo is instrumental in mixed methods research by facilitating the integration of qualitative and quantitative data, thus enhancing the validity and depth of causal measurement models.

3. BUILDING THE TRIANGULATED SOLUTION

This study now presents a multi-stage process approach towards delivering a meaningful theory and literature approach and couples it with a NVivo qualitative approach that can then link into a SEM quantitative cross-model validated research approach.

3.1. Stage 1: Framing causal structures

Causality implies a rational process. Causality likely emerged from Aristotle, who perceived it as a rational explanatory process or answer to a posited question. Aristotle's four-step 'theory-of-causation' encompasses material cause, formal cause, efficient cause, and final cause (Falcon, 2011). Thus, a causal investigation, if successful, results in a causal knowledge development of relevance to causes applied.

Today, causality typically arises in social sciences when one (or more) event(s), theme(s), construct(s), process(es), step(s), or stage(s) contributes to (or may be described as), the resultant assembly, change, or production of other effected constructs. Thus, causal factors generally follow a past to present to future framework - where cause precedes resultant effects. In line with agency theory and efficacy theory causality also extends to processes and systems applications.

Thus, a causal structure sets a logical, stagewise, knowledge pathway development. It often commences with a suite of available inputs that typically create a motivational or competencies position. This suite of available inputs together aids the support and building of additive, and/or agile operational actions, into a suite of emerging deliverable capabilities. These two development suites conjointly interact and influence resultant unique sustainable advantage outcomes and these collectively makeup a net competitiveness positioning (Hamilton & Maxwell, 2023). This causality visualizes as Figure-2

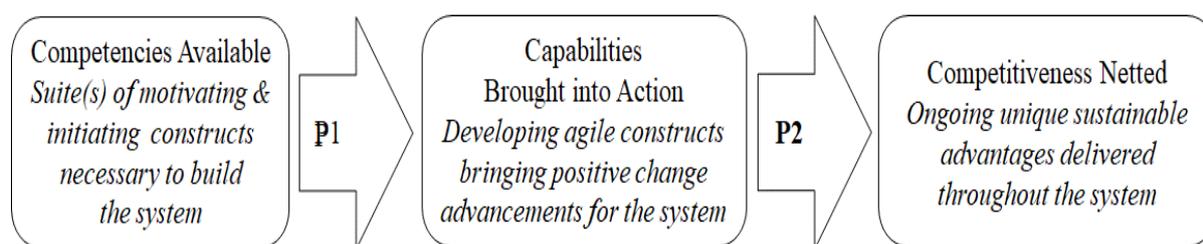


Figure-2: Stagewise causality framework applicable to modelling research.

Multiple theories support the Figure-2 framework model including competencies theory, competencies to capabilities theory, capabilities to sustainability theory, competencies and capabilities to sustainability theory. Other theories support various construct relationships across the stagewise model. These depend on the type of study under investigation. For example, profitable ongoing business sustainability is within resource-based theory (Barney, 1991; Kuznetsov, 2014; Hamilton et al. 2024; Kemp, 2024), stakeholder theory (Schaltegger et al. 2019), shareholder theory, institutional theory (Rezaee, 2016), model precision theory, theory of planned behaviour (Ajzen, 1991), value creation (Barney et al. 2021). Action research (Chevalier, 2019) adds real time participatory support to this approach. However, this researcher claims Figure-2 can also generally apply and frame stagewise causality research at a national, business, operational, personal, behavioural, software and AI, or even genetics level.

3.2. Stage 2: Literature and Methodology framing survey constructs and the causal model

The literature is initially scoured to source relevant model constructs and determine their embedded items – with each competency construct, each capability construct, and each unique sustainable advantage construct typically gauged via 5+ measurement items that are relevant to the research being undertaken. For example, Adamopoulou and Daskalakis (2023) and Ambedkar and Prakash (2024) group software and AI competencies as knowledge creation and innovative new capacities, but other competencies also exist within this digital domain.

Thus, based on the above and the literature, a Figure-3 directional and causal framework research model can establish as an expansion model of Figure-2 - complete with all relevant literature-sourced constructs added, along with the consideration and recognition of any exposed constraints. The number of constructs also governs the quantitative covariance-based SEM (CB-SEM) survey sample size – with a suitable minimum of twenty respondents per construct fulfilling Cunningham’s (2008) and Hair et al.’s (2019) modelling requirements. Thus, Figure-3’s 12 constructs requires a useable final dataset of 240+ respondent dataset cases.

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CB-SEM helps confirm theories, and/or test hypotheses, and/or compare alternatives. However, the PLS-SEM which works with small data sets down to around 30-50, can also be used to help develop theories, run predictions, or confirm measurement models. Again, a minimum sample size of at least ten respondent dataset cases is required (Hair et al, 2019). These minimum size requirements ensure the mathematics behind these SEM packages work sufficiently well, but in complex models, PLS-SEM seeks to maximize the explained variance of exogenous dependent variables to circumvent overfitting problems.

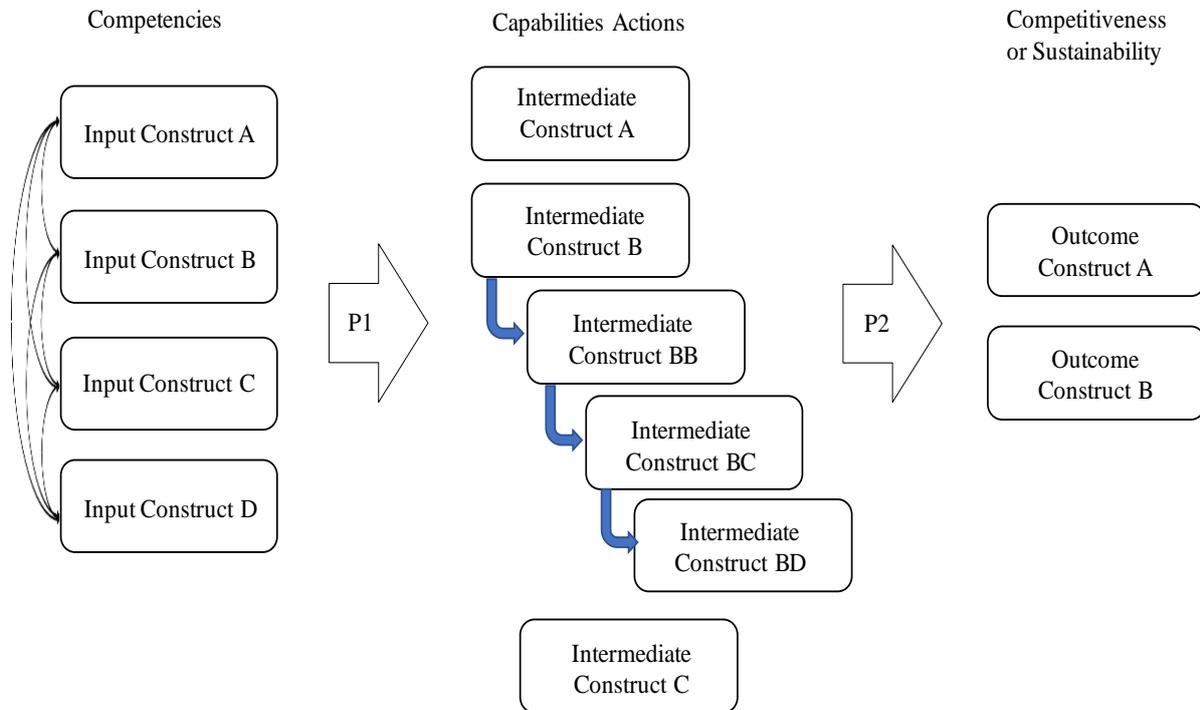


Figure-3: Literature developed Framework Research Model.

4. METHODOLOGY

4.1. Survey

The opening survey quantitative section involves literature supported item fit measures for each construct. These are prepared as typically succinct questionnaire items, and they are Likert scale rated as strongly disagree (1) to either five point (5) or seven point (7) strongly agree respondent selections. In respondent focused surveys the author consistently finds only tiny differences between 5- or 7-point ratings – so five point is preferred, as with less choice respondents are quicker to select their rating of each item.

The middle demographics section – particularly in business studies surveys, typically needs age, experience, qualifications, gender, role, nationality, income, firm-type, etc. This allows a validity-check concerning respondent capacities to answer or rate each question, plus it facilitates sectioning and comparison of data.

The concluding qualitative section has two approaches that can deliver an open-ended statements section to the questionnaire. Both approaches work well. Method 1 provides a general open-ended statement regarding the status of the study's competencies, this method is repeated for capabilities, and for unique sustainable advantage. A fourth statement seeks opinion regarding the future around this study's focus.

These answers generally unzip into smaller but useful items or phrases, suitable for NVivo nodal (construct) placements and subsequent qualitative analysis. This approach works well in large complex mixed methods surveys.

Method 2 uses AI. The above quantitative measures for each construct are condensed each into one statement using ChatGPT and then Copilot. These two AI generated statements are compared to the desired construct description, and a compiled open-ended statement is finally developed for each construct used in the questionnaire. Each open-ended statement is used to semi-structure and guide the respondent qualitative response for each construct. The above quantitative constructs are used as NVivo themed nodal clusters (TNCs), and the respondent open-ended comments are often sub-sectioned into relevant items or small phrases – each for one TNC only, and these are utilized in qualitative analysis. This approach works well in qualitative surveys and in smaller mixed methods surveys.

4.2. Stage 3: Methodology to understand and validate the causal model

The respondent dataset is first cleaned to remove quantitative missing values and checked again for anomalies. Each demographics component is suitability assessed for (1) distribution, range, and outliers, (2) characterization and descriptive trends, (3) correlations, significance, and accuracy, (4) other specifics. This process helps support the demographics dataset's validity, and its reliability. Key online survey instruments like Qualtrics and Survey Monkey also offer useful excel respondent positional, density and heat mapping as another respondent target market validity check (Hamilton et al. 2024a) Thus demographics add critical information and provides comparison opportunities within (or across multiple) studies.

The qualitative dataset is initially cross assessed by multiple research assessors to validate the perspective views of the respondents. Initially the questionnaire respondent text is assessed for meaningful interpretation against the specific open-ended statement. The accepted qualitative statement dataset is then sectioned into relevant short phrases, or items, and entered against the appropriate NVivo TNC (construct). Next, data interpretation is node (construct) extended using multiple NVivo assessment approaches such as frequencies, word clouds, word trees, correlations, cluster analysis, project mapping, dimensional mapping methods and compared to literature, and/or data types, and/or other datasets.

The quantitative dataset is individually construct and embedded item checked for possible respondent patterns (skew, kurtosis, range). Once accepted – possibly with a missing values replacement correction, a straightforward sequential measurements and model interpretation process is undertaken - ideally with a sufficiently large data set, that is randomly 60%-50% split into a confirmation dataset – to establish a significant model with excellent model fit, and a second 40%-50% validation dataset to re-test and check the identical model for model fit and consistency.

5. ANALYSIS & RESULTS

5.1. Demographics and literature compilation

Many simple stats tests can at times be applied to demographics data, these include mean, SD, skew and kurtosis, T-test, chi-square, and sometimes ANOVA, Friedman, post hoc tests, etc. Demographic relationships can be further investigated out using cross-tabulations. Thus, understanding demographics provides detailed understanding about the data applicability provided by the respondent cohort.

To complement the above demographics and the literature sourced Figure-2 and Figure-3 framework assessments, the mixed methods triangulation next applies two independent studies – a detailed qualitative NVivo investigation, and a full quantitative SEM analysis.

5.2. Qualitative Analysis

NVivo TNC's are developed from the questionnaire's individual respondent datasets. Each TNC captures a particular construct, and provides multiple perspectives around at least four broad, open-ended questions – one on competencies, one on capabilities, one on competitiveness and one on the future. These open-ended semi-structured questionnaire feedback responses are then aligned to the literature and Figure-2 and Figure-3 theme dissected, and TNC-framed against the appropriate construct. These individual opinions are each point, item, or phrase segmented, and theme-coded separately to the agreeance of each author and collated via an author agreed cross-comparison process (Dalkin et al. 2021; Dhakal, 2022). Each point, item, or phrase segment fits into one only Figure-3 construct, and each segment of the dataset capture information imports into NVivo 14 as part of the TNC structure, with each TNC representing a different foal area of literature and its data capture. A table such as Table-1 provides the total codes captured for each TNC, along with the number of references, and the number of respondents who contributed to the questionnaire's qualitative data capture. This indicates whether each construct is sufficiently recognized by the respondent cohort. With such numbers and codes, word clouds and word trees, capturing the top 30 or 50 words, are likely achievable.

Table-1: Qualitative Data Collection Details.

Nodal Construct (TNCs)	Codes	References
Input Construct A	197	1195
Input Construct B (etc.)	183	1299
Intermediate Construct A	175	1145
Intermediate Construct B (etc.)	173	712
Unique Sustainability Construct A (AI Connections)	159	540
Unique Sustainability Construct B (Performance (etc.))	142	693

5.2.1. NVivo Analysis

Amongst the 30 or 50 most common words per construct or TNC, each NVivo TNC word cloud typically shows relevant and predictable TNC differences – ones that differentially best represent each construct's focal area of data capture. This visually described word cloud comparison indicates how respondents see each construct and its likely Figure-3 model interactions. Hence, a progression to NVivo cluster analysis and project mapping is likely useful as another deeper focus towards determining sustainability outcomes.

An NVivo Pearson (r) correlation table (Table-2) can sometimes reveal patterns, similarities, and/or relationships amongst pairs of constructs (Allsop et al. (2022). The Pearson correlations represents the distance from the line of best- fit. It identifies how far away all these data points are to this line of best fit and identify relational thematic patterns and its tabulated 'coefficient of determination' (r^2) identifies the standardized strength (0 to 1) of each model correlation TNC pair relationship with $r^2 > 0.1$ (weak), $r^2 > 0.3$ (moderate), and $r^2 > 0.5$ (strong).

Table-2: TNC Pearson (r) Correlations.

Cluster Analysis (50 word similarity)		Pearson Correlation	
Input Construct A	↔	Input Construct B	0.58
Input Construct A	↔	Intermediate Construct A	0.47
Input Construct A	↔	Intermediate Construct B, etc.	0.39
Input Construct A	↔	Sustainability Construct A	0.25
Input Construct A	↔	Sustainability Construct B	0.36
Sustainable Connectivities	↔	Sustainable Performance	0.47

NVivo word trees of top one hundred, or fifty, or thirty thematic words should each consistently form word clusters within the same branches. For validity, this requires a large number of codes (ideally > 150) and references (ideally > 600) per TNC (construct). Thematic word clusters typically fit a NVivo word tree such as shown in Figure-5. Figure-5 also suggests a possible causal structure towards a solution.

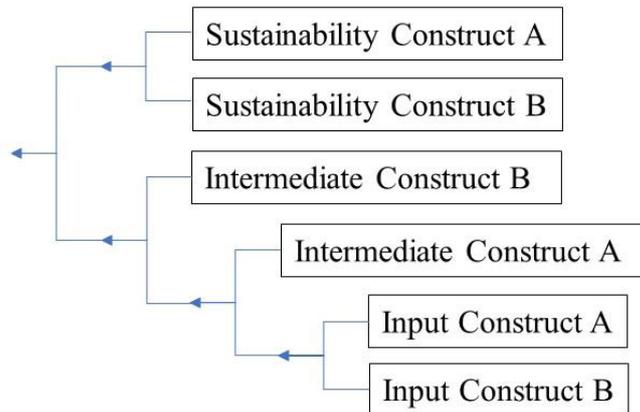


Figure-5: Word Tree of Primary Branching Associations.

Considering the bidirectionality of the Table-2 Pearson correlations, and still seeking a directional or causal solution, assumptions likely need to be implemented. First, it is assumed that no additional TNCs can be found to directly affect the framework model. Second, it is assumed that the literature framed Figure-2 causal relationship may apply across the Figure-3 framework model. Third, it is assumed that the structural causality of Figure-5 can support Figure-3.

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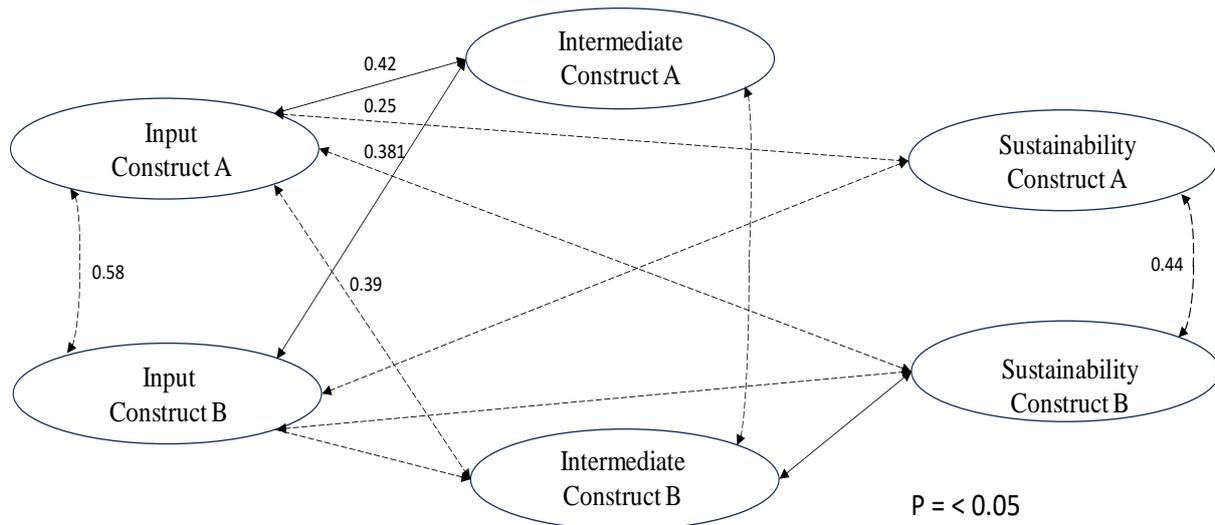


Figure-6: Proposed Non-Directional Structure and Linkages for Project Map Framework development.

(Pearson Coefficient of Determination (r^2) measures, each significant at $p < 0.05$)

This then suggests the input TNCs should at least co-correlate, and together likely exert direct net co-correlation contributions with each of the intermediate TNCs. Hence, these TNC input-to-intermediate relationships may possibly add towards a suggested directional causality. Pearson bi-directional relationships suggest each input construct may directly or indirectly impact on each sustainability TNC outcome. This correlation branching structure also supports a structure and linkages as framed in Figure-6.

Further to the above, a directional or causal inputs-to-outcomes framework, when aligned to the literature, and Figure-2, has both logical and literature support (Stawicka, 2021; Thananusak, 2019; Hamilton et al. 2024). This suggests the input TNCs may covary. Further support is found by assessing respondent comments – as these typically support an ‘inputs-to-outcomes’ directionality and/or causality.

NVivo project map (Figure-7) of the one hundred most common words offers multiple associations between pairs of constructs. These can be further grouped to expose the similar content meaning of various words in a relational cluster, and to expose a recognizable model structure, somewhat similar to a literature established Figure-3.

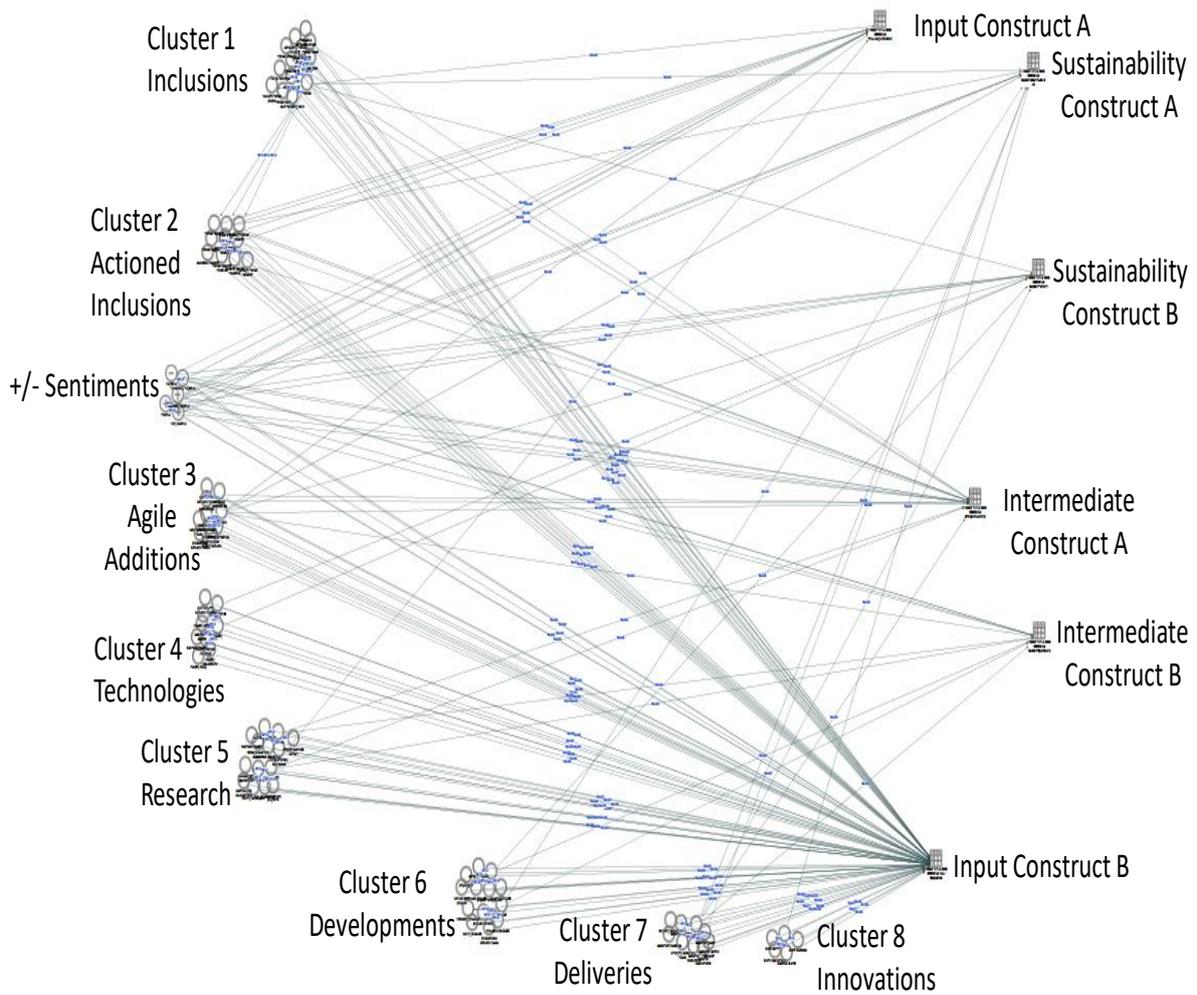


Figure-7: Project Map of Qualitative Data.

(thematically clustered across 889 codes, 4740 references, 130 respondents)

Figure-7, considered against Figure-2 and Figure-3, simplifies to a stagewise causal development structure as shown in the Figure-8 framework of associations.

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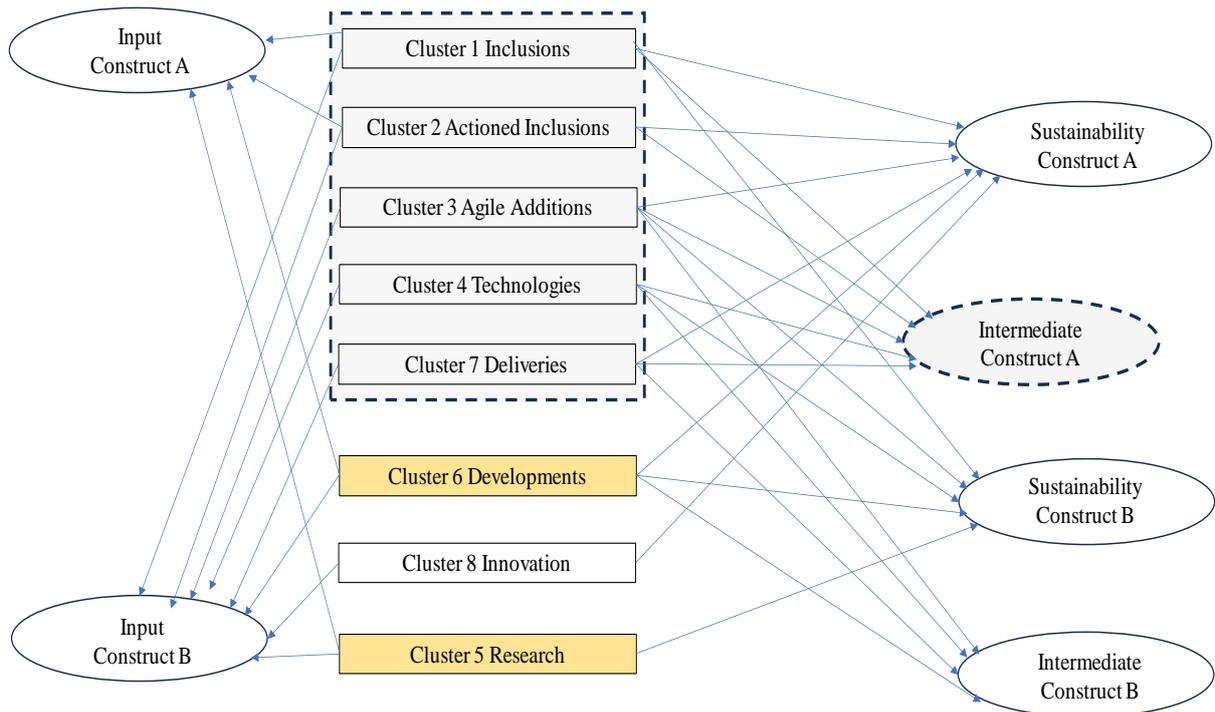


Figure-8: Project Map to framework the thematically clustered word associations.

Figure-8 exposes that clusters 6 and 8 only form relationships direct from input constructs to outcomes constructs as suggested via Table-2. This models as Figure-9's directional and causal model.

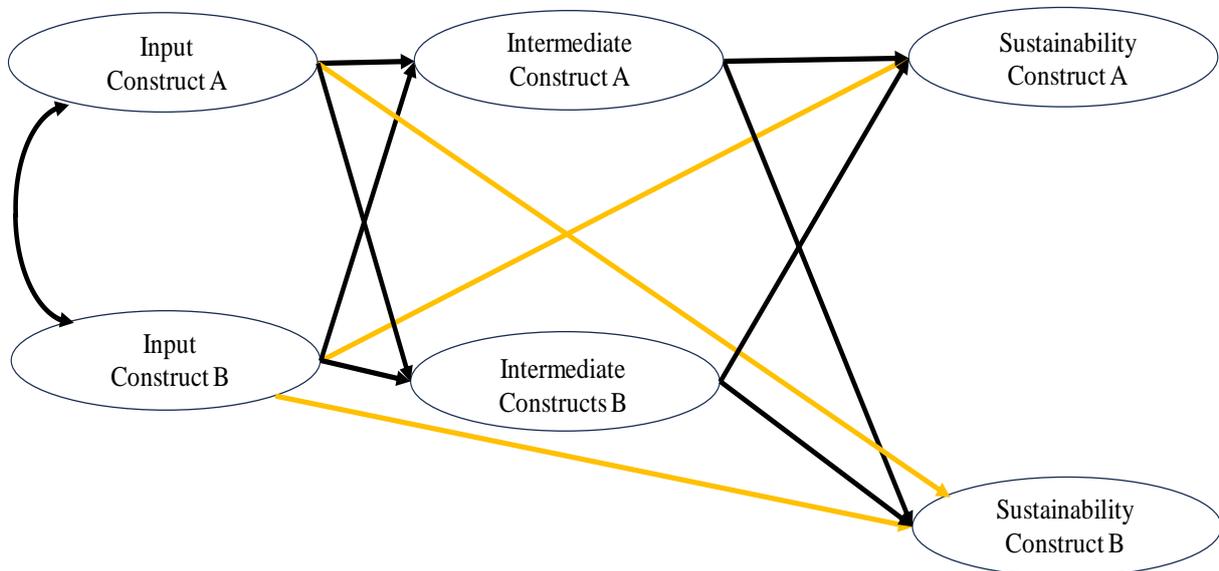


Figure-9: Project Map to Directional Causal Model.

Thus Figure-9 is a qualitative NVivo thematic solution. It shows each TNC possesses multiple embedded theme items of differing relational levels and of differing model importance. This qualitative solution typically meshes with the literature, and with relevant theories, and it provides the NVivo qualitative approach provides the second component of the mixed methods triangulation.

Hence, the above two mixed methods can be further investigated, changed, or rejected, in pursuit of ongoing sustainability outcomes. Further they can likely mixed methods triangulate with the relevant questionnaire Likert scale data as it is quantitatively SEM researched based on the framework relevant to Figures 2 and 3.

6. CONCLUSION

Mixed methods research combines qualitative and quantitative approaches to provide a more comprehensive understanding of research questions. NVivo, a qualitative data analysis software, plays a crucial role in this integration by allowing researchers to validate causal quantitative measurement models through qualitative insights. This article shows how the qualitative statistical analysis package NVivo can be astutely applied to provide a strong mixed methods triangulation validation component for researchers when pursuing quantitative statistical modelling analysis - such as in structural equation modelling – and particularly in either CB-SEM or PLS-SEM path analysis, or across model influence studies.

7. CONTRIBUTIONS TO RESEARCH

This study successfully links the literature and relevant theories and qualitative open-ended statement ‘expert’ respondent feedback. This NVivo research approach stagewise gathers constructs either as input, or intermediate or outcome components, and relationally focuses them into an appropriate framework position thereby allowing researchers, and/or managers, and/or industrial firms to in near real-time gain a quick understanding around the relative stagewise developmental influences that can deliver a unique sustainability advantage.

8. LIMITATIONS OF RESEARCH

Several limiting research queries and ongoing questions apply to this study:

1. To what extent do the respondent’s demographics such as gender, education level, age, business role, experience, and nationality individually affect this desired ‘expert’ capture and its respondent processes?
2. Does the quality and forethought in delivering the optimal semi-structured open-ended statements to appropriate ‘experts’ achieve and represent its target population?
3. To what extent should wide empirical testing of other developed qualitative models (developed akin to Figure-9) be pursued and assessed as externally validations of the approach herein?
4. To what extent can corroborative studies concerning this new approach to NVivo’s role in mixed methods triangulation studies be developed to cross-check the approach developed herein?
5. Why is the approach herein a good approach to mixed methods triangulation research?

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