

Specifying Formative Constructs in Empirical Research

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MIS Quarterly, Vol. 31, No. 4, pp. 623-656, December 2007.

Development of Research Models

- ▶ Many focus on the relationship between constructs...
- ▶ But give less consideration on the relationship between measures and the associated construct.
- ▶ Structural Equation Modeling (SEM) is used to evaluate both the structural and measurement model.
 - ▶ However...we sometimes neglect the measurement model.



Misspecifying the measurement model may lead to mispecification in the structural model.

Agenda

- ▶ What Are We Talking about Anyway?
- ▶ Why Should We Care about ‘Specifying Constructs?’
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- ▶ I Have a Formative Construct, Now What?
- ▶ Where Do I Go From Here?



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Terminology

▶ Formative vs. Reflective

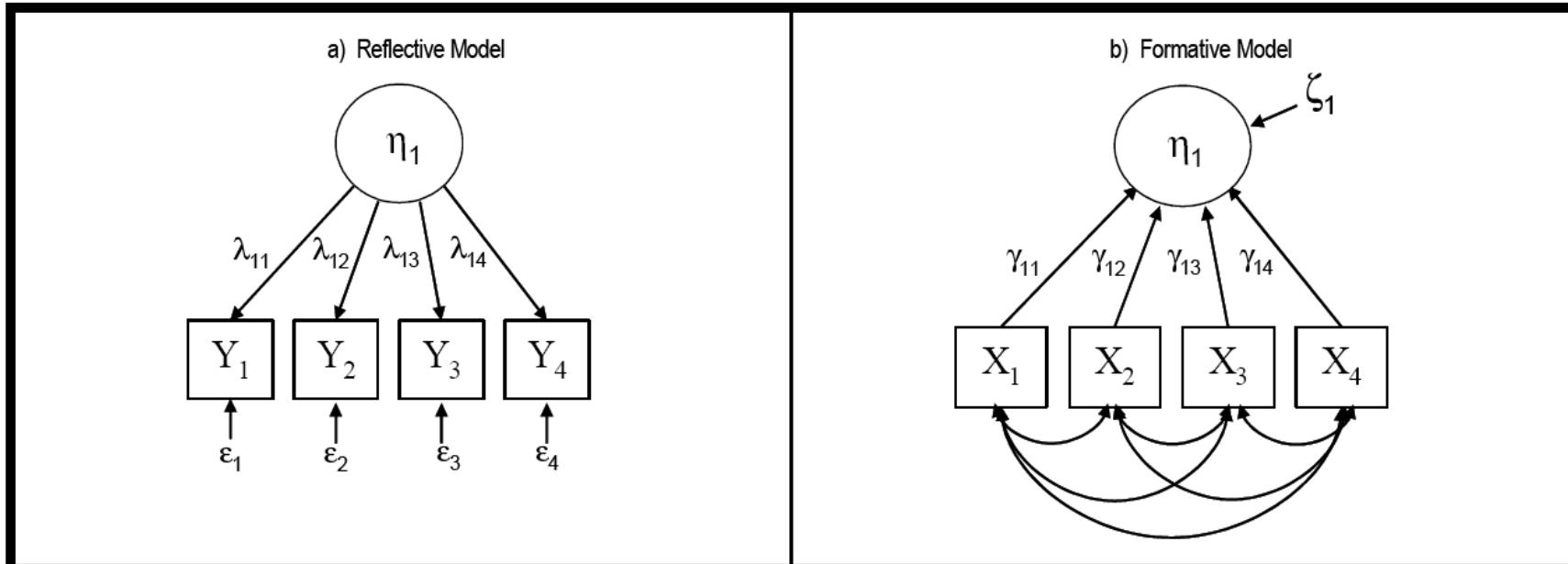


Figure 1. Diagram of Reflective and Formative Measurement Models (From K. Bollen and R. Lennox, “Conventional Wisdom on Measurement: A Structural Equation Perspective,” *Psychological Bulletin* (110:2), 1991, pp. 305-314. Copyright © 1991 by the American Psychological Association. Reproduced with permission.)

A construct could be measured reflectively or formatively.
Constructs are not necessarily (inherently) reflective or formative.
(When we talk about the “nature” of a construct being formative or reflective in our MISQ paper, we mean “the construct-once-measured.”)

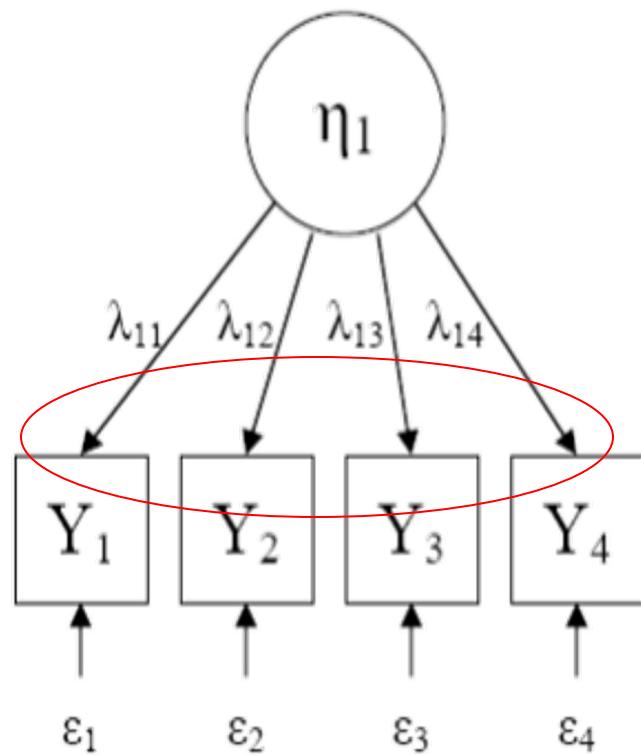
Terminology

▶ Formative vs. Reflective

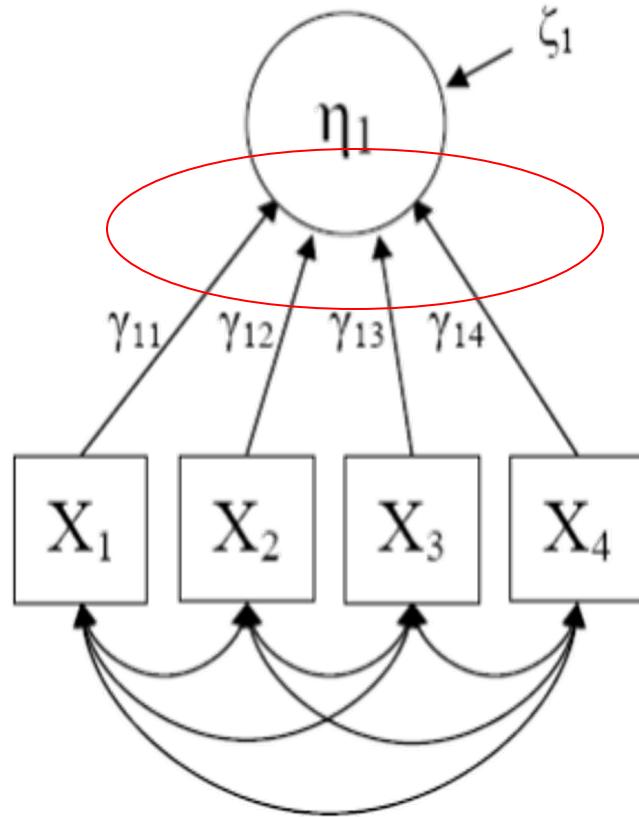
- ▶ Let's take **firm performance** as an example.
- ▶ We can create a reflective scale that measures top managers' views of how well the firm is performing.
 - ▶ These scale items can be interchangeable, and in this way let the researcher assess the reliability of the measures in reflecting the construct.
- ▶ Or we can create a set of metrics for firm performance that measure disparate elements such as ROI, profitability, return on equity, market share, etc.
 - ▶ These items are not interchangeable and, thus, are formative.

Reflective and Formative Constructs

(Panel a) Reflective Model

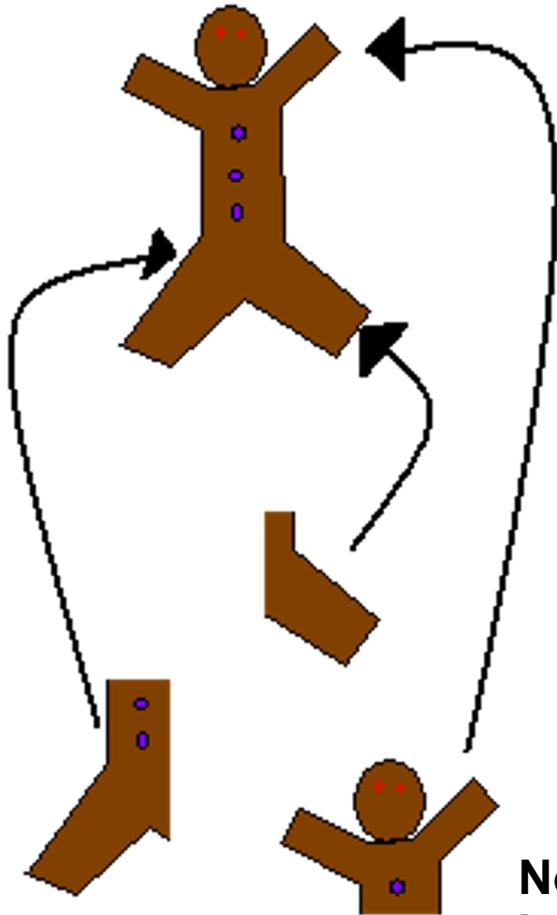


(Panel b) Formative Model

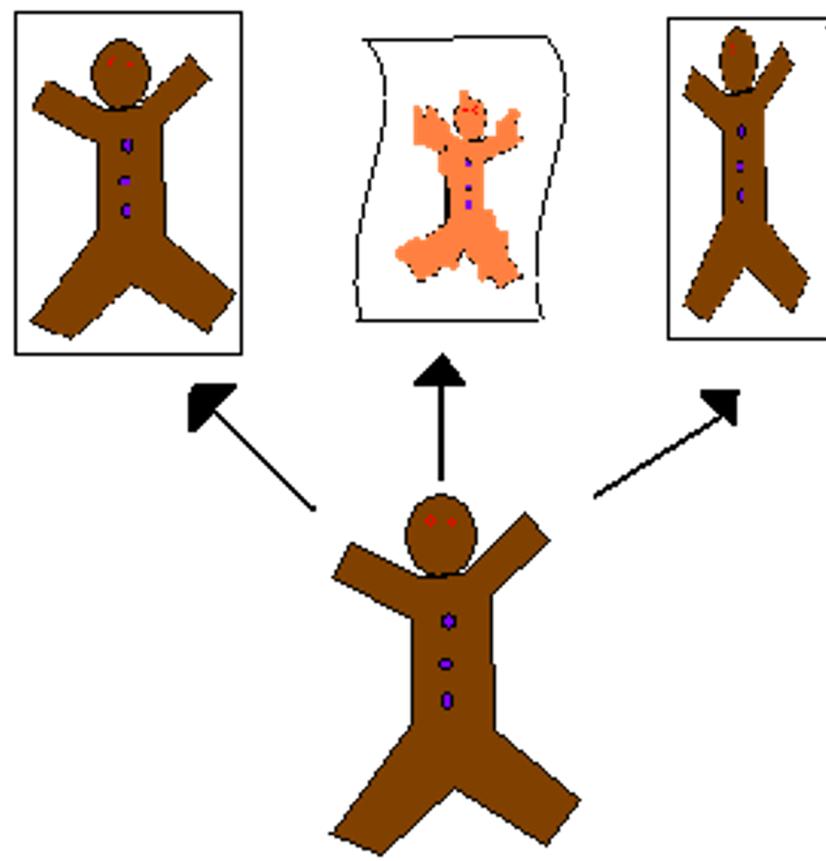


An Analogy

Formative Construct



Reflective Construct



Not
Interchangeable

Interchangeable

One Construct: Measured Reflectively & Measured Formatively

Reflective Measures of Intention to Omit Security Actions

| Code | Item | Loading | T-stat | Composite reliability |
|--------|--|---------|---------|-----------------------|
| OMIT7 | I take measures to protect my information from security violations: Never...always | 0.9383 | 53.2516 | .959 |
| OMIT13 | I take precautions against information security violations: Never..always | 0.9514 | 70.2334 | |
| OMIT57 | I use information security protections: Never..always | 0.9357 | 50.1780 | |

Scale developed according to Ajzen's (2002) recommendations for measuring intentions.

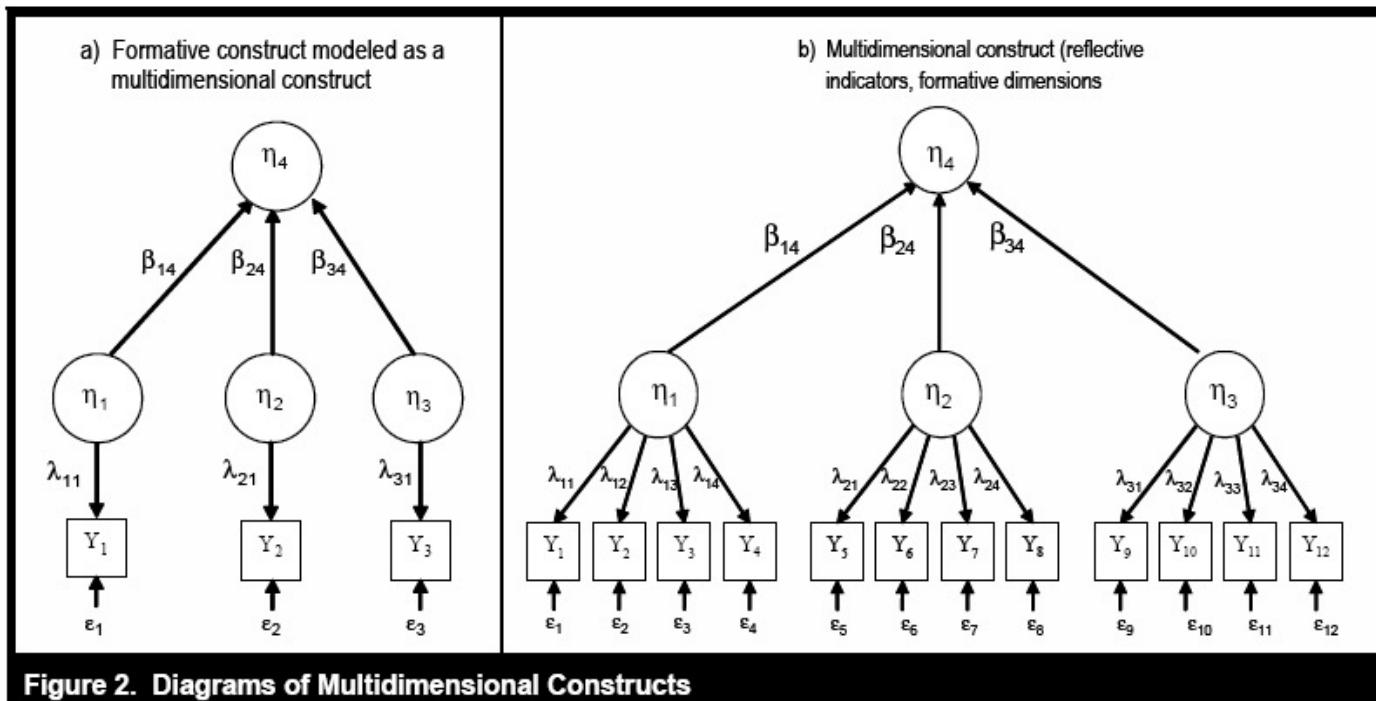
Formative Measures of Intention to Omit Security Actions

| Code | Item | Weight | T-stat |
|----------|-----------------------------------|---------|---------|
| PWDOMIT | Computer logs of password changes | 0.6051 | 18.2871 |
| UPOMIT | Computer logs of security updates | 0.5162 | 15.8049 |
| BACKOMIT | Computer logs of backups | -0.1002 | 4.7784 |

Terminology

► Multidimensional Constructs

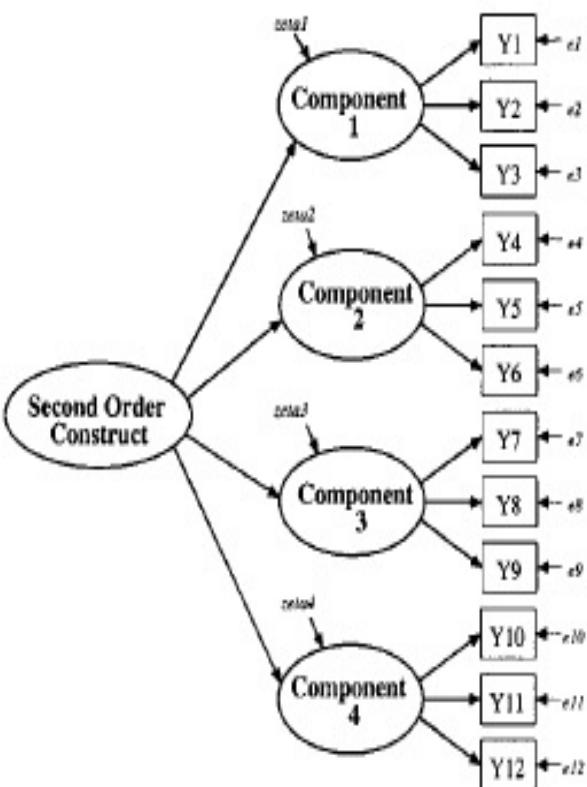
- Each dimension can be measured using formative or reflective indicators.
- The dimensions may be formatively or reflectively related to the construct.



ALTERNATIVE SECOND-ORDER FACTOR SPECIFICATIONS

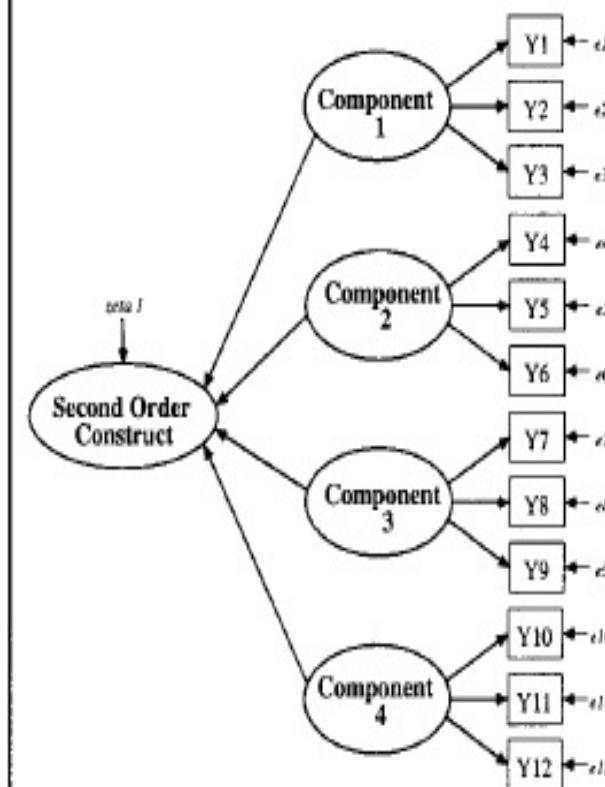
Type I

Reflective First-Order, Reflective Second-Order

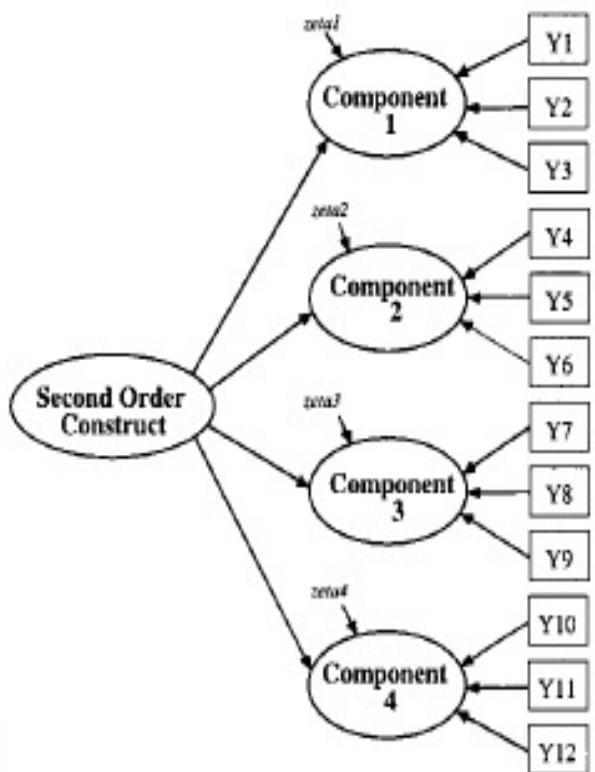


Type II

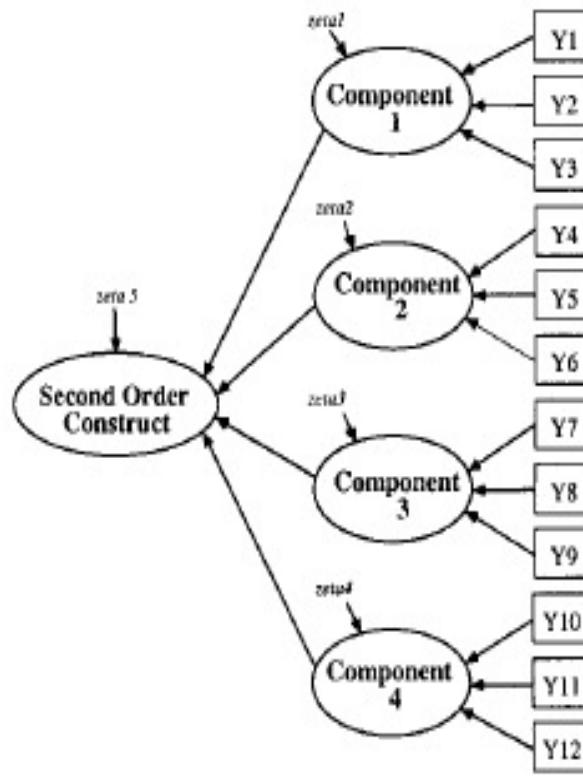
Reflective First-Order, Formative Second-Order



Type III
Formative First-Order, Reflective Second-Order



Type IV
Formative First-Order, Formative Second-Order



The Problem with Misspecification

▶ Jarvis et al. (2003)

- ▶ Bias when a single formative construct was misspecified as reflective (five construct model)
 - ▶ Structural paths from misspecified constructs – Upward bias
 - ▶ Structural paths leading to misspecified constructs - Downward bias

▶ MacKenzie et al. (2005)

- ▶ Bias when one or two formative constructs were misspecified as reflective (two construct model)
 - ▶ Exogenous construct was misspecified – Upward Bias
 - ▶ Endogenous construct was misspecified – Downward Bias
 - ▶ Both constructs misspecified – Slight downward bias

These simulations focused on accuracy of parameter estimates.
What about the significance of the parameter estimates?

The Problem with Misspecification

- ▶ Is the downward bias strong enough to lead to a Type II error (i.e., false negative)?
- ▶ Is the upward bias strong enough to lead to a Type I error (i.e., false positive)?

The answer...

YES

Likelihood of Type I or Type II Error

Table 1. Summary of Decision Rules to Determine Presence of Type I or Type II Errors

| Error | Conditions for Occurrence | Identification of Error |
|---------|--|---|
| Type I | <p>The following criteria must be met for Type I error to occur:</p> <ul style="list-style-type: none">• Formative construct is endogenous• Structural path emanates from formative construct• Sample size is high (i.e., 500)• Moderate to high correlation among formative measures (i.e., 0.4 or higher inter-item correlations)• Can occur regardless of whether the model is specified correctly (i.e. formative) or incorrectly (i.e., reflective). | <p>To determine if a Type I error has occurred, ask the following:</p> <ul style="list-style-type: none">• Where is the potential formative construct in my model? Is it endogenous?• Is my sample size large?• Do I have moderate to high inter-item correlations?• What is the parameter estimate for structural paths emanating from the correctly specified formative construct? Are they particularly small? Do they have any practical significance? |
| Type II | <p>The following criteria must be met for Type II error to occur:</p> <ul style="list-style-type: none">• Formative construct is endogenous• Structural path leads to formative construct• Sample size is low (i.e., 250)• Moderate to high correlation among formative measures (i.e., 0.4 or higher inter-item correlations) <p>OR</p> <ul style="list-style-type: none">• Formative construct is endogenous• Structural path leads to formative construct• Sample size is high (i.e., 500)• High correlation among formative measures (i.e., 0.7 or higher inter-item correlations) | <p>To determine if a Type II error has occurred, ask the following:</p> <ul style="list-style-type: none">• Where is the potential formative construct in my model? Is it endogenous?• Do I have moderate to high inter-item correlations?• What is my sample size? |

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Why Do We Care about Misspecification?

- ▶ Errors in the measurement model may lead researchers to wrong conclusions about theory confirmation when, in fact, the theory was disconfirmed. Or vice versa.
- ▶ However...maybe measurement misspecification is not a problem in the IS field.
 - ▶ Unfortunately, this is not the case.
 - ▶ Consistent with marketing (29% as reported in Jarvis et al., 2003), approximately 30% of constructs measured in three top IS journals over a three year period suffered from misspecified constructs.

Servqual: Usually Specified as Reflective....Is It?

| Item No. | Item Description | Factor 1 |
|----------|--|----------|
| 1 | Convenient operation hours | 0.807 |
| 2 | Perform service right | 0.835 |
| 3 | Has user interest in heart | 0.865 |
| 4 | Willingness to help | 0.860 |
| 5 | Capability to do what is promised | 0.849 |
| 6 | Knowledge to do job well | 0.848 |
| 7 | Sincere interest toward problem solving | 0.863 |
| 8 | Responsiveness to user | 0.881 |
| 9 | Capability to keep user information safe | 0.749 |
| 10 | Consistent courteousness | 0.870 |
| 11 | Capability to give user individual attention | 0.818 |
| 12 | Capability to understand user needs | 0.790 |

If, in their factor analysis, the researchers had forced the SPSS software to find more factors, the construct will start to break apart.

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Identifying Formative Constructs

Table 3. Decision Rules to Identify Construct as Formative or Reflective (Table 1 from "A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research," C. B. Jarvis, S. B. MacKenzie, and P. M. Podsakoff, *Journal of Consumer Research* (30), September 2003, p. 203. Copyright © 2003, University of Chicago Press. Used with permission.)

| Decision Rule | Formative Model | Reflective Model |
|--|---|--|
| 1. Direction of causality from construct to measure implied by the conceptual definition Are the indicators (items) (a) defining characteristics or (b) manifestations of the construct? Would changes in the indicators/items cause changes in the construct or not? Would changes in the construct cause changes in the indicators? | Direction of causality is from items to construct Indicators are defining characteristics of the construct Changes in the indicators should cause changes in the construct Changes in the construct do not cause changes in the indicators | Direction of causality is from construct to items Indicators are manifestations of the construct Changes in the indicator should not cause changes in the construct Changes in the construct do cause changes in the indicators |
| 2. Interchangeability of the indicators/items Should the indicators have the same or similar content? Do the indicators share a common theme? Would dropping one of the indicators alter the conceptual domain of the construct? | Indicators need not be interchangeable Indicators need not have the same or similar content/indicators need not share a common theme Dropping an indicator may alter the conceptual domain of the construct | Indicators should be interchangeable Indicators should have the same or similar content/indicators should share a common theme Dropping an indicator should not alter the conceptual domain of the construct |
| 3. Covariation among the indicators Should a change in one of the indicators be associated with changes in the other indicators? | Not necessary for indicators to covary with each other Not necessarily | Indicators are expected to covary with each other Yes |
| 4. Nomological net of the construct indicators Are the indicators/items expected to have the same antecedents and consequences? | Nomological net for the indicators may differ Indicators are not required to have the same antecedents and consequences | Nomological net for the indicators should not differ Indicators are required to have the same antecedents and consequences |

Table 6. Examples of Properly Specified Reflective Constructs in the IS Literature

| Construct Name (Study) | Indicators Used to Measure Construct |
|---|---|
| Perceived User Resources (Mathieson et al. 2001) | Have resources, opportunities and knowledge to use system No barriers to using system Would be able to use system if I wanted to Have access to resources I need to use system |
| Ease of Use (Brown and Venkatesh 2005; Gefen et al. 2003; Karimi et al. 2004; Lewis et al. 2003; van der Heijden 2004; Wixom and Todd 2005) | Interaction with software is clear and understandable Easy to get software to do what I want it to do Easy to use software Learning to use software is easy for me |
| Role Overload (Ho et al. 2003) | Need to reduce parts of my role I feel overburdened in my role I have been given too much responsibility My work load is too heavy Amount of work given interferes with quality |
| Source Credibility (Sussman and Siegal 2003) | Person writing message is knowledgeable Person is an expert on message topic |
| Team Cohesion (Jarvenpaa et al. 2004) | I feel part of a team My team works together My team helps one another My team gets along better |
| Task Efficiency (Gattiker and Goodhue 2005) | Employees need less time since system has been implemented The system saves time System is less time-consuming System helps employees be more productive |
| Client Learning (Majchrzak et al. 2005) | Dialogue reoriented thinking Dialogue questioned preconceptions Dialogue expanded scope of thinking |
| Trust Propensity (Pavlou and Gefen 2005) | Trust sellers unless I have a reason not to Give sellers benefit of the doubt Trust sellers until they prove otherwise |
| Reputation (Wasko and Faraj 2005) | I earn respect by participating I feel that participation improves my status in the profession I participate to improve my reputation |

Table 4. Examples of Properly Specified Formative Constructs in the IS Literature

| Construct Name (Study) | Indicators Used to Measure Construct |
|--|---|
| Perceived User Resources (Mathieson et al. 2001) | Specific resources needed to use a software package: Access to hardware and software Necessary knowledge Time Financial resources Available assistance Documentation Access to data |
| Project Champion (Wixom and Watson 2001) | Champion for project is from: IS Functional area |
| Team Skills (Wixom and Watson 2001) | Team members had: Technical skills Interpersonal skills |
| User Participation (Wixom and Watson 2001) | Users worked with IS on project Users assigned full time to project Users performed activities related to project |
| Declarative Knowledge (Yi and Davis 2003) | Ability to understand tasks in Excel, such as: Copying formulas Copy contents of cells Use menu shortcuts Using operators |
| Task Performance (Yi and Davis 2003)) | Ability to perform tasks in Excel, such as: Compute profits Compute sales, expenses Compute average amounts of profits, sales, and expenses Compute year-to-date profits Calculate change in sales |
| Perceived Effectiveness of Institutional Structures (Pavlou and Gefen 2005) | Confidence and effectiveness of feedback technologies Trust and protection of escrow services Protection and confidence in credit card guarantees Trust in Intermediary |
| Sellers' Performance (Pavlou and Gefen 2005) | Competitive pricing Timeliness of product delivery High quality products |
| Sources of Psychological Contract Violation with Individual Seller (Pavlou and Gefen 2005) | Fraud Product misrepresentation Contract default Delivery delay Failure to acknowledge product guarantees Refusal to comply with payment policy |

Table 5. Examples of Properly Specified Multidimensional Constructs in the IS Literature

| Construct Name – Type of Construct(study) | Sub-construct Name (Type of Construct) | Examples of Indicators Used to Measure Construct |
|--|--|---|
| Observational Learning Processes – Formative (Yi and Davis 2003) | Attention (Reflective) | Paid close attention Able to concentrate Held my attention Was absorbed |
| | Retention (Reflective) | Summarize the key aspects Symbolically process Mentally visualize Mentally practice |
| | Production (Reflective) | Accurately reproduce Enough practice Produce the procedural steps Helped me practice |
| | Motivation (Reflective) | Motivated me Helped me see usefulness Increased my intention Showed me the value |
| Trustworthiness – Formative (Serva et al. 2005) | Integrity (Reflective) | Truthful Honest Keeps commitments Sincere and genuine |
| | Benevolence (Reflective) | Acts in my best interests Does its best to help me Concerned about my well-being |
| | Ability (Reflective) | Competent and effective Performs role well Capable and proficient Knowledgeable |
| Firm Performance – Formative (Rai et al. 2006) | Operational Excellence (Formative) | Product delivery cycle time Timeliness of after sales service Productivity improvements |
| | Customer Relationship (Formative) | Strong and continuous bond with customers Knowledge of buying patterns of customers |
| | Revenue Growth (Formative) | Increasing sales of existing products Finding new revenue streams |

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Before Data Collection

▶ Content Validity

- ▶ Ensure full domain of construct is captured.
- ▶ Establishing content validity
 - ▶ Literature review
 - ▶ Expert panel
 - ▶ Q-sort

While often neglected for reflectively measured constructs, formatively measured constructs should ALWAYS be examined for content validity.

Before Data Collection

- ▶ Consider your choice of statistical analysis tool...
 - ▶ If using CB-SEM, consider if the model is identified.
 - ▶ If not, then...
 - ▶ Could you constrain structural paths or error terms (consider theoretical implications of this choice)?
 - ▶ Could you have two structural paths from formative construct to reflective constructs?
 - ▶ Could you include two reflective measures as part of the construct?
 - ▶ Could you decompose model if formative construct has only one emanating path?

Multiple Indicator, Multiple Cause Construct (MIMIC)

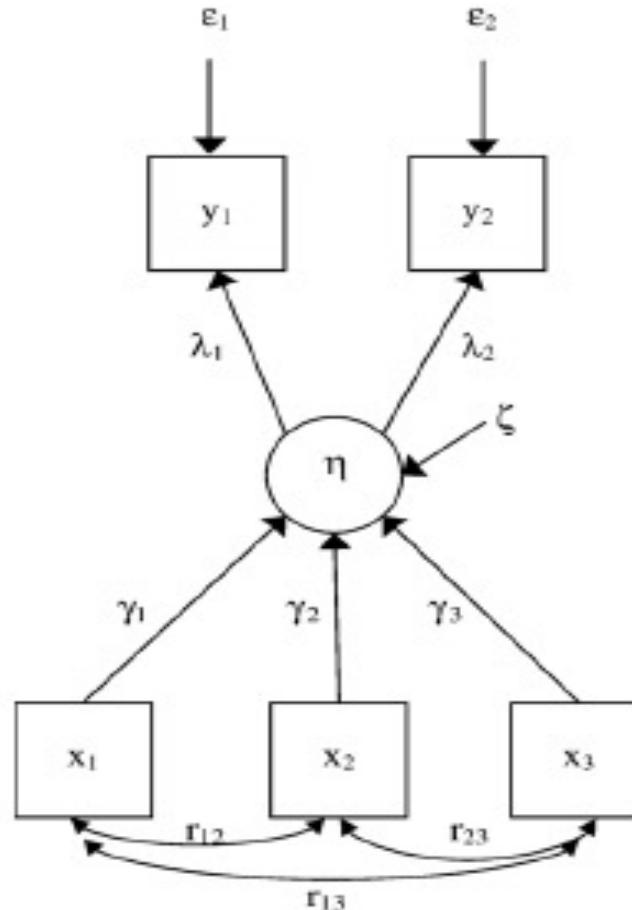
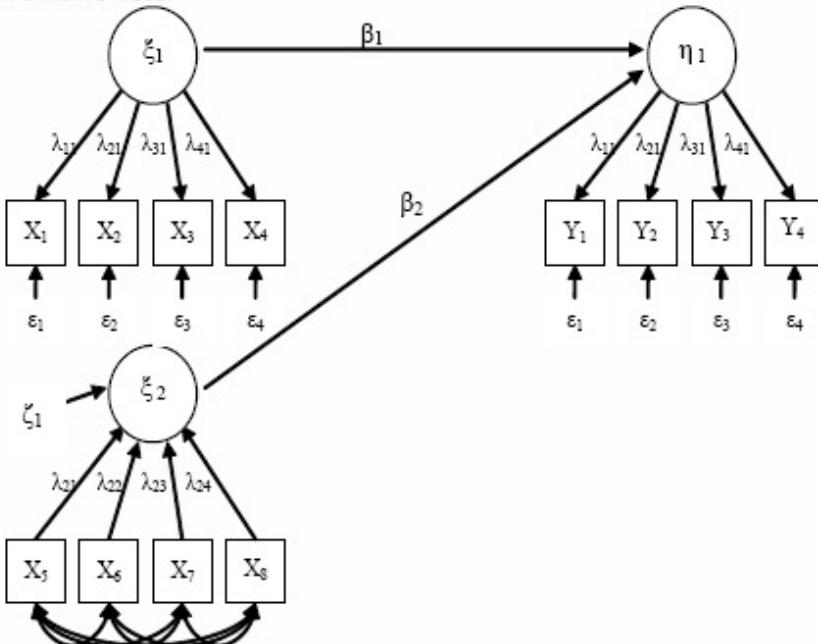


Fig. 4. Identification using a MIMIC model.

See example in Barki et al, ISR, 2007

a) Original Formative Model



b) Decomposed Formative Model

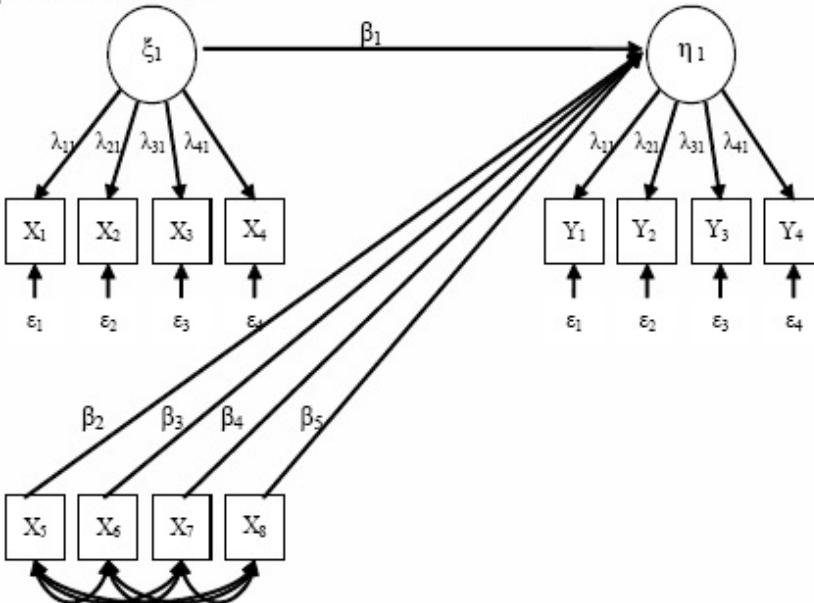


Figure 3. Decomposed Formative Model

After Data Collection: Validation

▶ Construct Validity

- ▶ Convergent and discriminant validity may not be as relevant for formative constructs.
- ▶ Use Principal Components Analysis (not Common Factor Analysis) to evaluate weights.
- ▶ Nonsignificant weights need careful consideration.
- ▶ But.....



Modified MTMM (Loch et al. 2003)

| | V10A | V10B | V14A | V14C | TC1 | V12A | V13D | SN | V15 | V14E | TC2 | YEARS | AGE | EMAIL | F2F | TEL | FAX |
|--------------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|---------|--------|---------|-------|-----|
| V10A | --- | | | | | | | | | | | | | | | | |
| V10B | .394** | --- | | | | | | | | | | | | | | | |
| V14A | .221** | .279** | --- | | | | | | | | | | | | | | |
| V14C | .181* | .231* | .486** | --- | | | | | | | | | | | | | |
| TC1 | .410** | .673** | .772** | .761** | --- | | | | | | | | | | | | |
| V12A | -.095 | -.033 | .281** | .257** | .200* | --- | | | | | | | | | | | |
| V13D | -.337** | -.292** | .074 | .097 | -.082 | .332** | --- | | | | | | | | | | |
| SN | -.275** | -.181* | .210* | .170 | .059 | .792** | .801** | --- | | | | | | | | | |
| V15 | .076 | .190* | .415** | .235** | .357** | .328** | -.034 | .166 | --- | | | | | | | | |
| V14E | .115 | .192* | .613** | .458** | .543** | .371** | .064 | .243** | .574** | --- | | | | | | | |
| TC2 | .098 | .263** | .420** | .235** | .390** | .328** | -.050 | .158 | .995** | .577** | --- | | | | | | |
| YEARS | .568** | .024 | .013 | .078 | .102 | -.049 | -.083 | -.056 | -.103 | -.064 | -.103 | --- | | | | | |
| AGE | .432** | -.017 | -.033 | .041 | .046 | -.177 | -.130 | -.166 | -.160 | -.141 | -.165 | .880** | --- | | | | |
| EMAIL | -.077 | -.053 | -.010 | .017 | -.045 | -.094 | .105 | .008 | -.177 | -.113 | -.183 | -.037 | .050 | --- | | | |
| F2F | -.024 | -.139 | -.113 | .120 | -.084 | .012 | .428** | .281** | -.112 | -.145 | -.120 | .106 | .160 | .238** | --- | | |
| TEL | -.049 | -.128 | -.047 | .201* | -.030 | .068 | .055 | .062 | .052 | -.003 | .039 | -.099 | -.066 | .165 | .597** | --- | |
| FAX | -.061 | .020 | .063 | .117 | .084 | .165 | .182 | .164 | -.019 | .069 | -.025 | -.193* | -.248** | -.049 | -.312** | -.186 | --- |

N.B. TC1 is the technological culturation composite value for Model 1. Similarly with TC2 and Model 2. SN is the composite value for social norms.

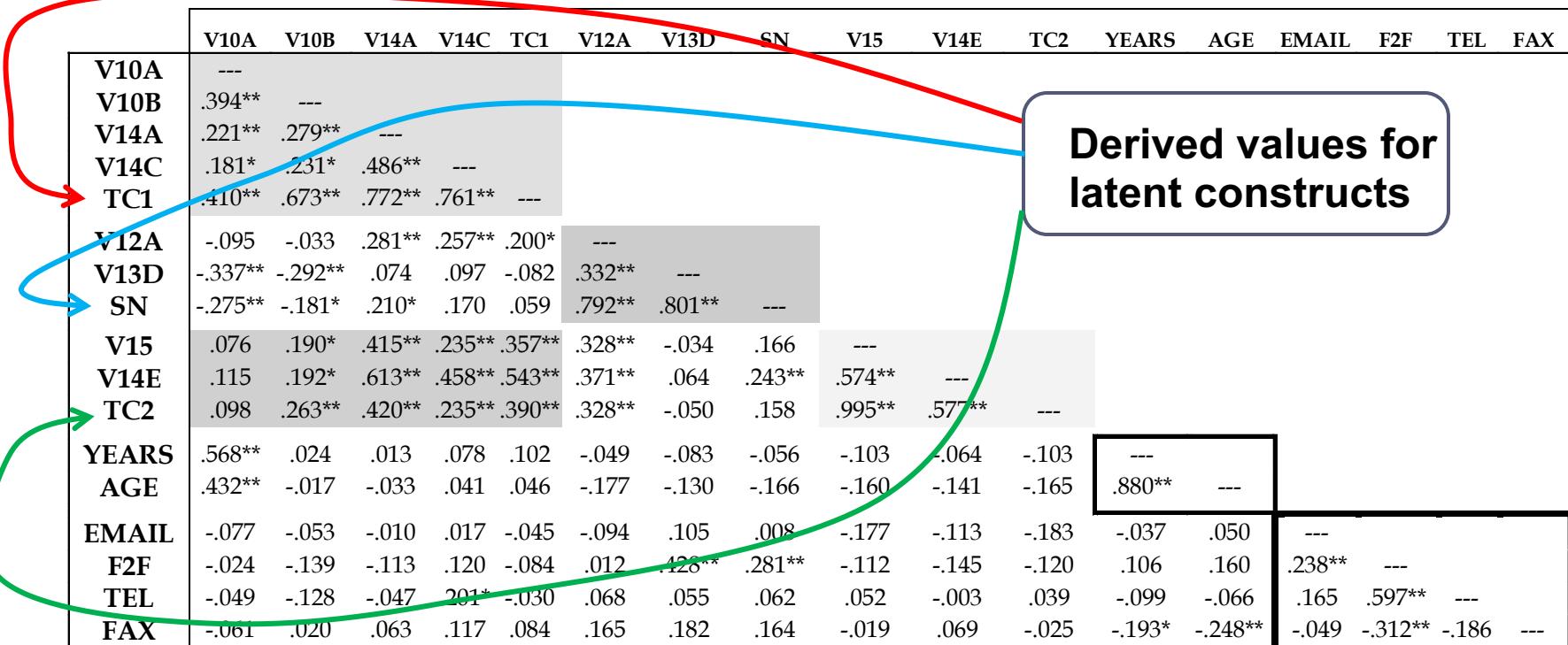
** Correlation is significant at the .05 level (2-tailed).

*Correlation is significant at the .10 level (2-tailed).

Instrument (Loch et al. 2003)

| | A great deal of travel | A fair amount of travel | A small amount of travel | Have not traveled at all | | | | |
|---|------------------------|-------------------------|--------------------------|--------------------------|-------------------|--|--|--|
| 10a. How much do you travel in the <i>non-Arab industrialized world</i> for business purposes? | — | — | — | — | | | | |
| 10b. How much do you travel in the <i>non-Arab industrialized world</i> for pleasure? | — | — | — | — | | | | |
| | Strongly Agree | Agree | Neutral or Not Sure | Disagree | Strongly Disagree | | | |
| 14a. I have learned a great deal about the Internet from experts (Arab or non-Arab) trained in technologically advanced countries | — | — | — | — | — | | | |
| 14b. Most people in my organization feel strongly that the Internet will strengthen Arab family and community ties. | — | — | — | — | — | | | |
| 14c. I have learned a great deal about the Internet by visiting other businesses in the non-Arab industrialized world. | — | — | — | — | — | | | |

Modified MTMM (Loch et al. 2003)



| | V10A | V10B | V14A | V14C | TC1 | V12A | V13D | SN | V15 | V14E | TC2 | YEARS | AGE | EMAIL | F2F | TEL | FAX |
|-------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|---------|--------|---------|-------|-----|
| V10A | --- | | | | | | | | | | | | | | | | |
| V10B | .394** | --- | | | | | | | | | | | | | | | |
| V14A | .221** | .279** | --- | | | | | | | | | | | | | | |
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| V15 | .076 | .190* | .415** | .235** | .357** | .328** | -.034 | .166 | --- | | | | | | | | |
| V14E | .115 | .192* | .613** | .458** | .543** | .371** | .064 | .243** | .574** | --- | | | | | | | |
| TC2 | .098 | .263** | .420** | .235** | .390** | .328** | -.050 | .158 | .995** | .577** | --- | | | | | | |
| YEARS | .568** | .024 | .013 | .078 | .102 | -.049 | -.083 | -.056 | -.103 | -.064 | -.103 | --- | | | | | |
| AGE | .432** | -.017 | -.033 | .041 | .046 | -.177 | -.130 | -.166 | -.160 | -.141 | -.165 | .880** | --- | | | | |
| EMAIL | -.077 | -.053 | -.010 | .017 | -.045 | -.094 | .105 | .008 | -.177 | -.113 | -.183 | -.037 | .050 | --- | | | |
| F2F | -.024 | -.139 | -.113 | .120 | -.084 | .012 | .428** | .281** | -.112 | -.145 | -.120 | .106 | .160 | .238** | --- | | |
| TEL | -.049 | -.128 | -.047 | .201* | -.030 | .068 | .055 | .062 | .052 | -.003 | .039 | -.099 | -.066 | .165 | .597** | --- | |
| FAX | -.061 | .020 | .063 | .117 | .084 | .165 | .182 | .164 | -.019 | .069 | -.025 | -.193* | -.248** | -.049 | -.312** | -.186 | --- |

Derived values for latent constructs

N.B. TC1 is the technological culturation composite value for Model 1. Similarly with TC2 and Model 2. SN is the composite value for social norms.

** Correlation is significant at the .05 level (2-tailed).

*Correlation is significant at the .10 level (2-tailed).

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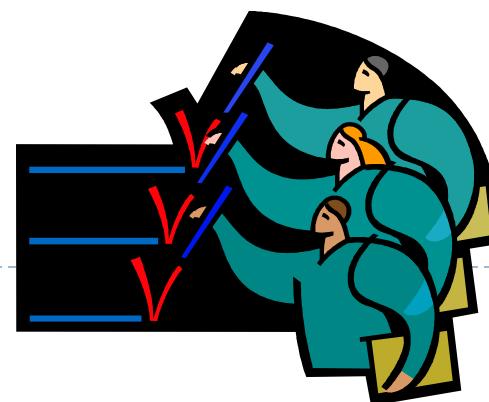
From the paper....

- ▶ “The logic for discriminant validity is that the inter-item and item-to-construct correlations should correlate more highly with each other than with the measures of other constructs, and, in our case, with the composite constructs themselves.
- ▶ By comparing values in the TC1, TC2 , and SN rectangles with values in their own rows and columns, we can see that there are only a few violations of this basic principle.
- ▶ Campbell and Fiske (1959) point out that normal statistical distributions in a large matrix will result in exceptions that are not necessarily meaningful.
- ▶ They suggest that one uses judgment in determining whether the number of violations is low enough to conclude that the instrument items discriminate well.”

After Data Collection: Validation

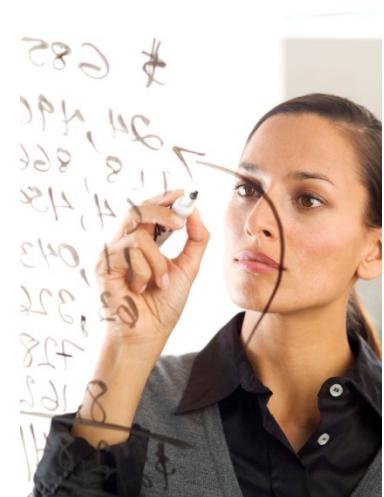
► Reliability

- ▶ Reliability is more difficult to determine for formative constructs.
 - ▶ Multicollinearity destabilizes research model.
 - ▶ Suggests construct may be multidimensional.
- ▶ Use a multicollinearity assessment based on VIF.
 - ▶ $VIF > 10$ (Cohen: based on multiple regression assessment)
 - ▶ $VIF > 3.3 - 4$ (Petter et al, 2007; Diamantopoulos et al, 2008)
- ▶ With covariance-based SEM, use the construct disturbance term.
- ▶ Test-retest reliability does not depend on relationships between the items, and so it also works.



After Data Collection: Analysis

- ▶ Covariance-Based SEM
 - ▶ Model specification (co-varying exogenous items)
 - ▶ Consider nested models.
 - ▶ Perform chi-square difference test to determine best model
 - ▶ Examine measurement and structural model.
 - ▶ Error term of formative construct
 - Large error term may suggest problems with items
 - ▶ Examine other measures of model fit .
 - ▶ Components-Based SEM
 - ▶ Examine weights for formative measures,
loadings for reflective measures.
 - ▶ Examine R² values and other parameters.



After Data Collection: Analysis

- ▶ Covariance-Based and Components-Based SEM
 - ▶ Cenfetelli & Basselier (2009, *MISQ*) offer guidelines for how to interpret formative statistics and to validate the constructs.
 - ▶ These guidelines are fairly detailed, but they include:
 1. the examination of multicollinearity,
 2. the number of indicators,
 3. the possible co-occurrence of negative & positive indicator weights,
 4. the absolute versus relative contributions made by a formative indicator,
 5. the nomological network effects, and
 6. the possible effects of using PLS versus CB SEM techniques.



After Data Collection: Analysis

- ▶ Illustration from Cenfetelli & Basselier (2009, MISQ)

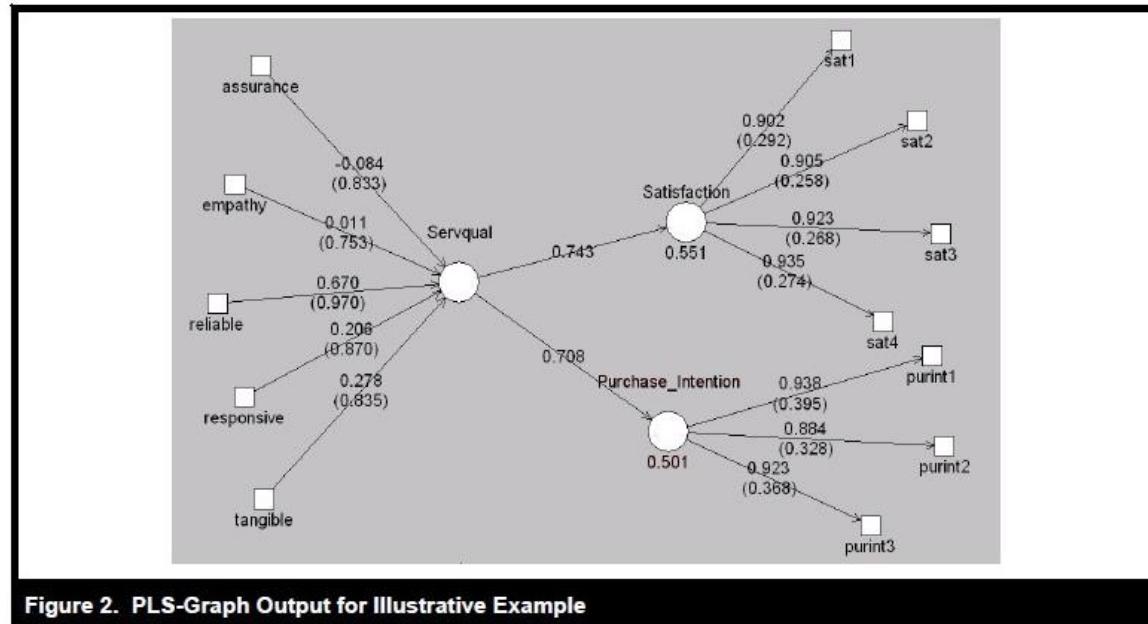


Figure 2. PLS-Graph Output for Illustrative Example

Table 2. Indicator Weights and Significance for Illustrative Example

| | Path | t-stat | p value |
|-------------|-------|--------|---------|
| Assurance | -0.08 | -0.98 | 0.33 |
| Empathy | 0.01 | 0.18 | 0.86 |
| Reliability | 0.67 | 9.27 | 0.00 |
| Responsive | 0.21 | 2.38 | 0.02 |
| Tangibles | 0.28 | 4.80 | 0.00 |

After Data Collection: Analysis

- ▶ Do further tests listed in Kim, Shin & Grover (2010, MISQ)
- ▶ Their sample dataset showed problems with formative constructs whether they were misspecified or not.
- ▶ Can we abandon formative constructs, though?

Table 2. Measure correlations of exogenous constructs

| IT infra. Flexibility | x1 | x2 | x3 | x4 | Relational Knowledge | x1 | x2 | x3 | x4 |
|--------------------------|------|------|------|------|-------------------------|------|------|------|------|
| x1 | 1.00 | | | | x1 | 1.00 | | | |
| x2 | 0.24 | 1.00 | | | x2 | 0.83 | 1.00 | | |
| x3 | 0.36 | 0.44 | 1.00 | | x3 | 0.77 | 0.83 | 1.00 | |
| x4 | 0.23 | 0.38 | 0.36 | 1.00 | x4 | 0.79 | 0.84 | 0.88 | 1.00 |

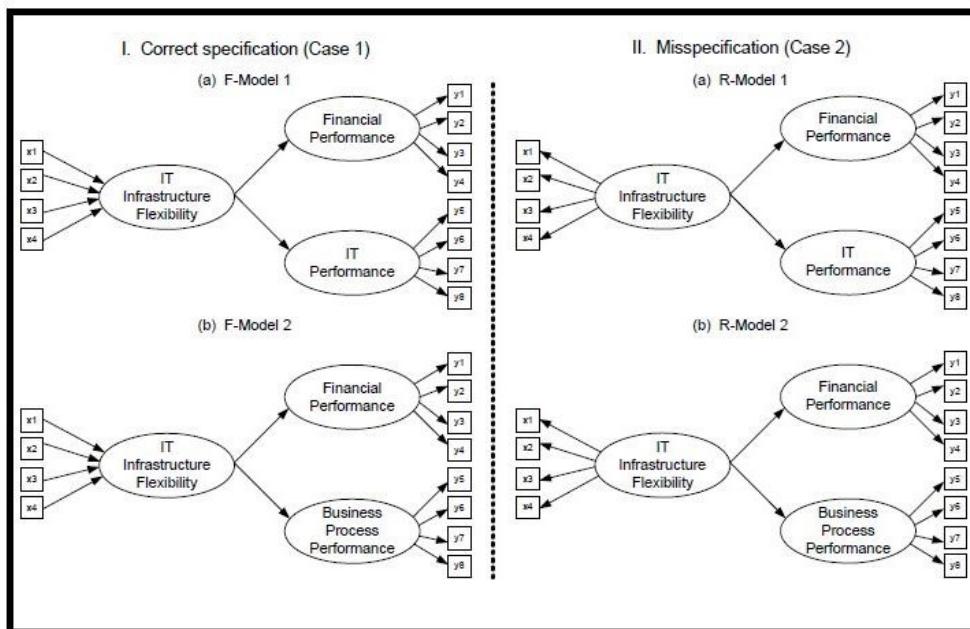


Figure 1. Research Model: *IT Infrastructure Flexibility*

Table 7. Summary of Literature Related to Assessing and Analyzing Formative Constructs

| Phase I: Prior to Data Collection | |
|---|--|
| Step 1.1: Identify Formative Constructs | |
| Using the following criteria, determine if you have formative constructs: | |
| 1) Do the indicators predict the construct? (Diamantopoulos and Winklhofer 2001; Jarvis et al. 2003) 2) Does dropping a measure change what the construct is measuring? (Diamantopoulos and Winklhofer 2001; Jarvis et al. 2003) 3) Does a change in one measure of the construct not require a change in all other measures of the construct? (Diamantopoulos and Winklhofer 2001; Jarvis et al. 2003) 4) Do the measures have different antecedents and consequences? (Diamantopoulos and Winklhofer 2001; Jarvis et al. 2003) | |
| If all of these criteria are true, then we are in the presence of a formative construct. If a majority of the criteria are true, then you should consider if the theory base typically views it as a formative construct. | |
| Step 1.2: Validate Formative Constructs | |
| Assess Content Validity | 1) Evaluate if the set of indicators underspecify the domain of the construct based on explicated facets in the theory base 2) Q-sorting or Expert Validation to evaluate if the measures can be categorized as per theoretical predictions (Straub et al. 2004) |
| Step 1.3: Assess Structural Model | |
| Examine Structural Model Identification (Jarvis et al. 2003; MacCallum and Browne 1993; MacKenzie et al. 2005) | Assess if the structural model will have problems with identification (if using covariance-based SEM). If appropriate, modify the model to prevent problems with identification by taking one or more of the following steps: 1) Constrain one or more structural paths or construct error terms to zero 2) Decompose the formative construct if it only emits a single path to a reflective construct (see Figure 3) 3) Ensure the formative construct has at least two structural paths to reflective constructs 4) Include two reflective measures as part of the formative construct 5) Include one reflective measure as part of the formative construct and one structural path leading to a reflective construct |
| Phase II: After Data Collection | |
| Step 2.1: Validate Formative Constructs | |
| Assess Construct Validity | Use principal components analysis (rather than common factor analysis) to examine the item weightings for measures. 1) May choose to eliminate nonsignificant items (Diamantopoulos and Winklhofer 2001) 2) May choose to keep nonsignificant items to preserve content validity (Bollen and Lennox 1991) |
| Evaluate Reliability | Examine multicollinearity to determine if $VIF < 3.3$ for formative constructs (Diamantopoulos and Siguaw 2006). If multicollinearity exists, available options include: 1) Model construct as having both formative and reflective measurement items 2) Remove correlated items if content validity is not affected 3) Collapse correlated items into a composite index 4) Convert into a multidimensional construct Test-Retest Item Reliability (if appropriate) |
| Step 2.2 (Option A): Analyze Formative Constructs via Covariance-Based SEM (e.g., LISREL OR EQS) OR | |
| Evaluate Model Specification (Jarvis et al. 2003) | 1) Analyze model with items within exogenous formative constructs co-varying with other items within the formative construct and all other exogenous constructs 2) Analyze model with inter-item correlation among items within the formative construct, but no correlation between formative items and other exogenous constructs 3) Analyze model with no inter-item correlation among items within the formative construct and no correlation between formative items and other exogenous constructs 4) Perform chi-square difference test to determine which model to use |
| Step 2.2 (Option B): Analyze Formative Constructs via Components-Based SEM (e.g., PLS) | |
| Assess Model (Chin 1998b) | 1) Specify formative constructs in the research model using Mode B (all formative constructs in model) or Mode C (both formative and reflective constructs in model) 2) Examine model weights for formative measures and model loadings for reflective measures. 3) Assess R^2 values for endogenous variables in structural model |

Agenda

- ▶ What Are We Talking about Anyway?
- ▶ Why Should We Care about ‘Specifying Constructs?’
- ▶ How Do I Identify Formative Constructs?
- ▶ I Have a Formative Construct, Now What?
- ▶ Where Do I Go From Here?



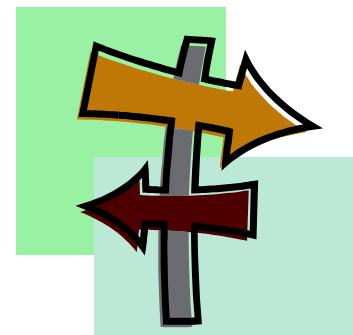
Where Do You Go From Here as a Reviewer?

- ▶ Examine if constructs are specified correctly as formative or reflective.
- ▶ Consider the validation approaches used for examining formatively measured constructs.
- ▶ Do not assume that all research models using formative constructs must be analyzed using PLS.



Where Do You Go From Here as a Researcher?

- ▶ Remember to consider the measurement model.
- ▶ BEFORE collecting data, consider the types of measures you want to use.
 - ▶ Consider the measures and analysis before collecting data.
 - ▶ Is there a good reason for using formative vs. reflective measures?
 - ▶ Focus on content validity – especially if using formative or multidimensional constructs.
 - ▶ Consider the tool you want to use.
 - ▶ Is the research model identified?
 - ▶ CB-SEM can be used with formative constructs. If choose to use PLS, have a reason other than “it’s easier to use”



Where Do You Go From Here as a Researcher?



- ▶ AFTER collecting data, validate formative measures appropriately.
 - ▶ You may still have to educate reviewers (i.e., no need to examine reliability or maybe even construct validity).
- ▶ Decomposed models or indices can change the meaning of the theoretical relationship.
 - ▶ Consider the theoretical implications (not just empirical).
- ▶ Tune into ongoing debates about formatively measured constructs.

Where Do You Go From Here as a Researcher?

Forthcoming (2011) MISQ Research Commentaries (for copies, <http://misq.org>)

1. “**Measurement and Meaning in Information Systems and Organizational Research: Methodological and Philosophical Foundations**” by **Richard P. Bagozzi** (preprints available)
2. “**Incorporating Formative Measures into Covariance-Based Structural Equation Models**” by **Adamantios Diamantopoulos**
3. “**Construct Measurement and Validation Procedures in MIS and Behavioral Research: Integrating New and Existing Techniques**” by **Scott B. MacKenzie, Philip M. Podsakoff, and Nathan P. Podsakoff**
4. “**Evaluating Effect, Composite, and Causal Indicators in Structural Equation Models**” by **Kenneth A. Bollen**