Construct Transportability: a Choice that Matters

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Abstract

Construct Transportability is the conveyance of a latent construct from prior research for reuse in new theoretical models without the loss of meaning or reliance on the nomological network. The basis of construct transportability is fundamental to building upon existing literature. Recent reviews of the IS literature suggest inconsistencies in measurement models of similarly defined latent constructs. Their theoretical meaning appears to be neither inherently reflective nor formative thus creating a dilemma for researchers to determine the measurement model for reuse. This study addresses the construct transportability issue using IT Capabilities, which was represented empirically in the literature as four different latent constructs (1st and 2nd order constructs as both formative and reflective). We empirically evaluate these measurement representations. The tradeoffs of each representation are discussed with insights provided as to how construct selection impacts the research model and the loss of meaning that may accrue.

1. Introduction

Structural Equation Modeling (SEM) techniques are increasing in use and popularity within Information Systems research. The use of SEM to study theoretical constructs explaining information systems allows for a growing complexity in the descriptive nature of information systems and organizational phenomena that are difficult to observe directly. Thus, the importance of construct measurement and validation are emphasized in Information Systems (IS) literature with many contributions of practical guidelines to IS researchers to improve the quality of scholarly research. This includes the areas of: unidimensionality and validity [4], partial least squares [1, 18, 29], formative constructs [7, 26, 31], interaction effects [20], statistical power [21], and general guidelines [19].

A body of knowledge is built upon its prior contributions. Theoretical constructs from prior research are used in current research to accumulate these contributions. However, a dilemma is presented to researchers when a latent construct exhibits multiple variations of measurement representations from published research. To build an adequate body of cumulative knowledge, researchers using SEM techniques must continue to improve their understanding of the potential tradeoffs when investigating a latent construct. Researchers must determine if a different representation creates interpretational losses in the conceptual meaning of the construct measure which can impact construct transportability for future structural models. Thus, this research focuses on the following question:

How does one ensure the transportability of a latent construct measure from one context to another?

We regard the idea of construct transportability as the ability to reuse a latent construct from one structural model to the next without the effect of interpretational confounding. Interpretational confounding infers an ambiguous meaning of the construct and “occurs as the assignment of empirical meaning to an unobserved variable which is other than the meaning assigned to it by an individual a priori to estimating unknown parameters,” [5]. Evidence of interpretational confounding is determined when coefficients linking indicators (observable measures) to the latent variable significantly change dependent upon other endogenous constructs in the model.

Recent IS research addressed the issue of formative measures, misspecification, and interpretational confounding [7, 26]. However, in the empirical tests using the formative measure, reliance upon the structural model was necessary else the formative measure would be underidentified. No evidence was presented as to the changed meaning of the construct. Only the effect on the nomological network was assessed. With an understanding that misspecification can lead to interpretational confounding, “the potential for interpretational confounding is made worse when the model is underidentified” [3]. The illustrative example of the formative construct service quality [7] makes the same construct oversite by assessing only the nomological network effects and does not provide guidance as to the techniques necessary for ensuring consistent construct representation from network to network.
This gets to the essence of our interpretation of construct transportability. For both reflective and formative constructs, a latent measure indicates a structural relationship between a theoretical concept and that which is observable. Conceptually appropriate measures, those that do not contribute to interpretational confounding, indicate the direction of causality either as flowing from the construct to the measures (reflective) or flowing from the measures to the construct (formative). Although not exclusively, interpretational confounding is predominantly problematic to formative constructs. Methods for improving the interpretational stability of reflective constructs are addressed through the assessment of unidimensionality [17].

When the flow of causality between the construct and its measures is misspecified, (e.g. reflective when it should be formative), the manifestation of Type I and II errors occur at the structural model level [25, 31]. The consequences of misspecification suggest that a priori considerations of construct measurement should move from theoretical conceptualization to the empirical measure. However, the distinction and selection of whether measurement items are formative or reflective is not always clear [8]. Indeed, some constructs in the IS literature are mixed, with prior research illustrating the construct with reflective measures, while other research depicts the same construct with formative measures [31].

With a premise that the contextual meaning of a latent construct may have multiple measurement representations, we provide an example of a construct with multiple measurement representations found within the IS literature. We then illustrate and empirically evaluate the various representations from a construct transportability perspective. We then discuss the interpretational tradeoffs related to these various measurement representations as well as the applicability of subsequent construct transportability. This research expands prior research of formative and reflective measurement by looking at how the choice of construct measurement representation impacts the interpretation of the measure as well as the ability to reuse and transport latent constructs to other theoretical structural models. As within the tradition

Figure 1 – Formative-Reflective Models

of IS methodology research, we provide practical guidelines to researchers.

2. Multiple measurement representations

The various measurement representations of a theoretical latent construct are depicted along two dimensions showing four possible measurement representations (Fig. 1). The first dimension of the framework relates to the generality or specificity of the researcher’s theoretical interest in the conceptual elaboration of the construct [27]. This dimension is depicted from top to bottom of Figure 1 (first order to second-order). The main difference between a first-order and second-order construct is that a first-order construct is a single theoretical concept [23] whereas a second-order construct has distinct but related concepts [14]. Thus, the researcher recognizes important conceptual distinctions between the sub-dimensions of a latent construct for a second-order construct. The second-dimension is dependent on the flow of causality as it relates to the structural relationship between the conceptual and the observational. This is shown in comparing the left side of Figure 1 (reflective) to the right side of Figure 1 (formative).

Although these four measurement representations are contextually equivalent, empirically they are measured differently, resulting in unique observations and understandings of the meaning of the construct [30]. Thus, construct development is a
choice that matters with possible affects on the resulting structural research model.

A construct’s meaning is conceptualized from theory and is represented within the researcher’s interpretational framework of the construct. A researcher’s challenge is transitioning from the theoretical meaning to the operationalization of the construct measure. For latent constructs, the operationalization decision is determining if observable measures either create the latent construct or capture an overall reflective meaning of the construct [28]. The literature review of IT Capabilities construct provides a similar contextual example with different measurement representations (Table 1). IS research often describes IT Capabilities as a complex construct and the transition from theoretical to operational appears inconsistent among researchers of IT capabilities which is often viewed thru the lens of dynamic capabilities theory.

Determining if a construct representation should remain at a first order level or become multidimensional is based upon one’s “theoretical interest” [28]. However, a “complex construct that is the main topic of study may deserve to be modeled as a multidimensional construct so as to permit a more thorough measurement and analysis” [31]. Thus, the better the measure, the better the ability to understand the relationships between the construct of interest within the structural model. Because of the inconsistent measurement representations depicted in Table 1 for IT Capability, we illustrate our concept of construct transportability using an example of the multiple measurement representations found in the literature of the theoretical concept of IT Capability.

3. Methodology

To examine the various measurement representations from our framework depicted in Figure 1, multiple methods of evaluation must be addressed. For the formative construct measurement, guidelines were followed according to [28]. The guidelines are two fold: 1) Provide a measurement model for IT Capability as a formative construct that could be utilized in other structural models and 2) The identification of IT Capability does not depend on the structural model or nomological network, thus allowing for either an exogenous or endogenous construct. Thus, the formative construct will have a minimum of two reflective scale items in addition to its formative scale items. The two reflective scale items are required in order to provide identification of the latent construct, IT Capability in this case, separate from the structural model [25].

Survey methodology was used to collect data in which to illustrate the various representations of IT capabilities. All survey questions were adapted from prior research. Scale items from the prior literature include items that are both formative and reflective measures. Therefore, the scale items allow for the modeling of the different measurement representations as depicted from the prior literature.

The survey was sent to IT managers from 880 manufacturers. Dillman’s ‘Tailored Design’ survey methodology was followed [12]. 157 responses were received representing a response rate of 17.8%. 15 of the surveys were incomplete, thus 132 complete survey responses were used to perform the model comparisons.

A number of comparisons are enabled between the different IT Capabilities model representations. The comparisons include: 1) Scale Item Construction differences between formative and reflective indicators, 2) Measurement Models of IT Capability can exhibit differences when represented as a 1st Order or 2nd Order construct as well as both formative and reflective constructs, 4) examination of model fit statistics to determine Model Comparison differences, and 5) Transportability of the different measurement model representations. Covariance structural equation modeling with AMOS 6.0 was used. The following sections provide evidence for the assembly of the Construct Transportability Guidelines.

3.1 Scale item construction

Scale item construction for IT Capability, and in any research, begins at a theoretical level with a review of the prior historical context of the construct. Duncan [13] first theoretically conceptualized IT infrastructure capability, referred to as Infrastructure Flexibility, to include different components. Considering these components as ‘building blocks’, Byrd and Turner [6] operationalized Duncan’s conceptualization into two main classifications, referred to as Technical IT Infrastructure and

<table>
<thead>
<tr>
<th>Construct Name</th>
<th>Source</th>
<th>Measurement Type</th>
<th>How Used</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT (Capabilities, Infrastructure, Leveraging)</td>
<td>[34]</td>
<td>2nd Order Form.</td>
<td>Endogenous</td>
<td>Covariance</td>
</tr>
<tr>
<td></td>
<td>[43]</td>
<td>1st Order Refl.</td>
<td>Exogenous</td>
<td>Covariance</td>
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<tr>
<td></td>
<td>[36]</td>
<td>2nd Order Form.</td>
<td>Exogenous</td>
<td>Component</td>
</tr>
<tr>
<td></td>
<td>[38]</td>
<td>Regression</td>
<td>Endogenous</td>
<td>Component</td>
</tr>
<tr>
<td></td>
<td>[40]</td>
<td>1st Order Refl.</td>
<td>Exogenous</td>
<td>Covariance</td>
</tr>
<tr>
<td></td>
<td>[37]</td>
<td>1st Order Form.</td>
<td>Exogenous</td>
<td>Component</td>
</tr>
<tr>
<td></td>
<td>[42]</td>
<td>1st Order Refl.</td>
<td>Exogenous</td>
<td>Component</td>
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<tr>
<td></td>
<td>[26]</td>
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<td>Exogenous</td>
<td>Component</td>
</tr>
<tr>
<td></td>
<td>[39]</td>
<td>2nd Order Refl.</td>
<td>Endogenous</td>
<td>Component</td>
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</tbody>
</table>
Human IT Infrastructure. Within each of these major classifications, Byrd and Turner [6] operationalized sub-dimensions and validated the construct at the first-order and second-order levels and concluded that the second-order model was a more accurate representation of the data. Thus, the second-order representation of Technical IT Infrastructure included the sub-dimensions of integration and modularity.

The IT Infrastructure construct was measured as first-order reflective [32]. Ray et al.’s [32] IT Infrastructure is consistent with Byrd and Turner’s [6] dimension of IT Compatibility. Byrd and Turner’s [6] survey questions were pre-tested with professionals to establish validity and reliability. An understanding of how survey questions were previously validated provides researcher’s with a basis of comfort in determining if their construct of interest is transportable.

The scale items used in this survey are adapted from prior research with theoretically developed and validated scale items for IT infrastructure capability [13]. The rigor in survey construction provides a unique opportunity to assess differences that arise from a focus on the meaning of a construct, its scale items and how interpretational differences arise and are carried forward to future research. The immediate impact for scale item construction are the differences when constructing an item for use in a formative vs. reflective manner. Reflective and formative scale items, when grouped together, have material differences in their construction. (Table 2).

Reflective scale items direct respondents to exercise their ability to accurately assess IT Capability in the context of the organization as a whole. Because there are three scale items that reflectively measure IT Capability, this first order reflective construct is considered ‘just-identified’. The formative scale items, however, focus on the components theorized to build IT Capabilities. The emphasis for these questions focus on a narrower part of the organization and ones that are seen not to co-vary. These questions are intended to identify Integration, Modularity, and IT Personnel as components that form IT capability. Theoretically, this is explained such that an increase in modularity creates an increase in IT capability; however, it does not necessarily mean that IT Personnel skills increase as well. Further, note that Q2, Q4 and Q8 were scale items designed to accompany additional scale items (items available upon request) to reflectively measure the formative 1st order reflective constructs of Integration, Modularity and IT Personnel. The use of the scale items as formative or reflective indicators is based on the nature of the items chosen by the researcher to measure the construct [30].

3.2 Measurement models

Measurement models are constructed to assess the convergence and discriminant validity of a construct.

<table>
<thead>
<tr>
<th>Q#</th>
<th>Intended Use</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Formative</td>
<td>Integration: Our organization has very high flexibility in its IT links and connections</td>
</tr>
<tr>
<td>4</td>
<td>Formative</td>
<td>Modularity: Reusable software modules are widely utilized in our organization’s systems development</td>
</tr>
<tr>
<td>8</td>
<td>Formative</td>
<td>IT Personnel: Our IT personnel work well in cross-functional teams addressing business problems</td>
</tr>
<tr>
<td>10</td>
<td>Reflective</td>
<td>Our company has established corporate rules and standards for hardware and operating systems to ensure platform compatibility.</td>
</tr>
<tr>
<td>11</td>
<td>Reflective</td>
<td>Our company has identified and standardized data to be shared across systems units.</td>
</tr>
<tr>
<td>12</td>
<td>Reflective</td>
<td>We can access all data pertinent to a customer through a single interface.</td>
</tr>
</tbody>
</table>
Generally, measurement models are used to assess only the current data set and does not necessarily provide a comparison from the current interpretation of a construct to the "identical" construct in prior research. Since the data collected represents the theoretical and contextual intent of prior research for IT Capability, a comparison of the prior representations as a reflective or formative 1st and 2nd order construct allows us a basis for comparison of these constructs, and their potential ability to transport between different research models. An analysis of only the first-order reflective measurement representation (Fig. 2) indicates all factor loadings of the items are above the acceptable range of .50 [22] as well as significant at the p < .001 level. Item reliability is also above acceptable levels with a cronbach alpha of .70 [2, 16]. This reliability indicates consistency with Ray et al. [32] and is a good indicator of transportability of the construct. Because the measurement model is ‘just-identified’, the model has zero degrees of freedom and ‘fit’ statistics are consistent with that of a fully saturated model. Scale items previously validated provide the researcher with a level of confidence this construct representation can be used in theoretical structural models.

The first-order formative representation (Figure 2), following the guidelines of MacKenzie et al. [28], works equally as well for theoretical structural models. However, validation of the construct is quite different. First, the scale items are not required to covary thus rendering construct validation via classical test theory irrelevant. Accordingly, reliability evaluation includes the examination of multicollinearity of the formative scale items [31]. Since a squared multiple correlation (R^2_{smc}) between each variable that is greater than .90 suggests a multicollinearity problem, the Variance Inflation Factor (VIF) calculation should be within levels less than 3.3 [11]. The VIF is calculated as 1/1-R^2_{smc} [27]. For the first order formative measurement model, VIF is well below the 3.3 threshold (Table 3). In addition, the formative construct provides additional information that is not provided from a reflective measure.

Because the scale items form the construct, an R^2 value is estimated. The interpretation is similar to that of linear regression. For the first-order formative representation, 40% of variability is explained. It is also noted that the scale item representing Integration is not significant whereas all other scale items are significant (p< .05). Although a scale item is not significant in this measurement model, it is argued that the component of Integration helps to theoretically explain the construct of IT Capability and should not be eliminated due to non-significant loadings.

More importantly, the formative construct error (disturbance) must be assessed [11]. A researcher must conceptualize all conceivable components to explain a formative construct with the error term representing the ‘impact of all remaining causes other than those represented by the indicators included in the model’ [11]. The error term of the construct is therefore interpreted as ‘missing causes’ of the construct and a large-error term indicates that the formative construct is not well-conceived. The first-order formative model as represented has an error term of .11 which is relatively moderate and appears to have captured the conceptualization of IT capabilities. Diamantopoulos [10] provides four interpretations and recommendations of the formative error term as suggested using Cohen’s effect size [9] where \( \text{R}^2_{X} = 0.2, 0.15, \) and \( 0.35 \) is small, medium, and large effect size, respectively (Table 4).

Second-order constructs are multidimensional in nature. A multidimensional representation is intended to provide additional interpretation of the construct [14]. Therefore, it is expected that the interpretational quality is more robust with the second-order representation as compared with the first order representation. As depicted in the bottom left half of Figure 1, the second-order reflective measurement variation is examined. The interpretation of the second-order reflective measurement of IT capability is by three first order constructs: Integration, Modularity, and IT skills.

### Table 3: Variance Inflation Factors

<table>
<thead>
<tr>
<th>Formative Construct</th>
<th>Correlations</th>
<th>r</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Order</td>
<td>Q4 – Q8</td>
<td>.35</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>Q4 – Q15</td>
<td>.47</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>Q8 – Q15</td>
<td>.38</td>
<td>1.17</td>
</tr>
<tr>
<td>Second Order</td>
<td>Integration - Modularity</td>
<td>.59</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>Integration – IT Personnel</td>
<td>.55</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>Modularity – IT Personnel</td>
<td>.61</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Variance Inflation Factor (VIF) is calculated as \( 1/1-R^2_{smc} \) representation.
that the R² explained variability has increased from non-significant. However, further analysis indicates with the first-order formative, integration remains loadings from the first order constructs is consistent Capability. Assessment of the coefficient factor interpretation is that an increase in one or more of the necessarily expected to correlate. Thus, the indicate that past researchers often Recent reviews of the IS literature direct inhibits accurate interpretational confounding that result in a type II error [31].

The 2nd Order formative construct for IT Capability (bottom right of Figure 2) is a multidimensional construct with the same first order constructs of Integration, Modularity, and IT Skills; however, this representation theorized that these constructs form IT Capabilities and are not necessarily expected to correlate. Thus, the interpretation is that an increase in one or more of the first-order constructs creates an increase in IT Capability. Assessment of the coefficient factor loadings from the first order constructs is consistent with the first-order formative, integration remains non-significant. However, further analysis indicates that the R² explained variability has increased from the first-order formative construct to .46 and the error term has improved to .10. Thus, it is concluded that conceptualizing to a multidimensional construct from a first order construct for the formative representation provides an increase in explained variability. Multicollinearity is checked with Variance Inflation Factors and are found well below the threshold of 3.3 [11]. Model fit indices (Table 5) also provide evidence of an acceptable model.

3.3 Model comparisons

When comparing the different models, recall that the base assumption is that the construct IT Capability does not change between the various representations. The initial focus on scale item construction and subsequent placement of those scale items into a measurement model lead to the question of just how far off the construct may be if formatively designed scale items are used in a reflective manner. The potential error in representation contributes to the interpretational confounding that directly inhibits accurate transportability of a construct. Recent reviews of the IS literature indicate that past researchers often make the mistake of modeling a construct measure reflective when it should be formative [31]. In addition, simulated data show that when these measures are misspecified, Type I and II errors occur within the structural model.

The scale items for the first order reflective and formative construct representations (Fig. 2) provide an opportunity to understand the severity of the measurement error that may occur when scale items designed for use in a formative manner are misspecified and used in a reflective manner. Given that the contextual meaning is similar, the question becomes, how poorly has the construct been transported? To determine the difference in measurement, we correlate the 1st order reflective construct using the reflective scale items (Q10-Q12) as they were designed in prior research [32] with the best designed formative scale items (Q2, Q4, and Q8). The best items were selected based on the IT Capability 2nd Order Formative construct. One formative scale item, based on loadings, was selected from each of the 1st Order factors forming IT Capability. The formative items are modelled reflectively to intentionally create the misspecification. The correlation between these two constructs (r = .68), provides evidence of the loss of construct meaning when scale items are misspecified. The misspecified construct resulted in a measurement loss that likely will weaken the structural relationship and result in a type II error [31].

To our knowledge, more extensive work to test this loss of interpretation has not been done and could only be done through the construction of multiple indicators designed to assess this potential impact. Researchers who rely only on the fit statistics of the correlated model are misled since the fit statistics indicates a good representation of the constructs under study. What is normally hidden or not observed in models, but has been brought to light here, is that an attempt is made to measure the same latent construct. The correlational difference suggests a loss in measurement which can jeopardize a theoretical model when the goal is to provide constructs that can be accurately transported from one context to another.

Our review of the prior literature indicated four different measurement representations of IT Capabilities. Because these different representations are all conceptualizing the same theoretical construct, it is important to understand and assess these

<table>
<thead>
<tr>
<th>Type</th>
<th>Order</th>
<th>df</th>
<th>Chi²</th>
<th>Chi²/df</th>
<th>RMSEA</th>
<th>NNFI</th>
<th>CFI</th>
<th>TLI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective</td>
<td>1st</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Formative</td>
<td>1st</td>
<td>6</td>
<td>15</td>
<td>2.5</td>
<td>.093</td>
<td>.93</td>
<td>.97</td>
<td>.90</td>
</tr>
<tr>
<td>Reflective</td>
<td>2nd</td>
<td>24</td>
<td>41</td>
<td>1.73</td>
<td>.074</td>
<td>.96</td>
<td>.97</td>
<td>.96</td>
</tr>
<tr>
<td>Formative</td>
<td>2nd</td>
<td>48</td>
<td>87</td>
<td>1.81</td>
<td>.077</td>
<td>.96</td>
<td>.97</td>
<td>.93</td>
</tr>
</tbody>
</table>
different representations by determining if one representation is theoretically consistent when evaluating the data collected.

We begin our assessment based upon this underlying assumption. First, we can draw inferences from comparing the 1st order and 2nd order reflective representations. Similarly we can also compare the 1st order and 2nd order formative representations. The multidimensional construct is merely an expanded representation to the 1st order construct with the similar causal direction meaning that the two should be highly correlated. Since we are primarily interested in only the correlation between the two representations, we fix the loadings and error terms to that of their independent measurement assessment. Ideally, the first order and second-order reflective (Fig. 2) representations of IT Capability would be identical latent constructs. However, the results of the correlational comparison are .57. This concordant reduction indicates inconsistencies with the reflective measurement model. The theoretical arguments of how IT Capability is constructed becomes critical at this point and the differences between the representations suggests that IT Capability might be better represented as a formative construct. This would be an indication that the 2nd order reflective representation’s 1st order factors are not reflective of increases (or decreases) in IT Capability but do independently contribute to the formation of IT Capability.

A similar approach to comparing the 1st order and 2nd order formative constructs requires us to fix the loadings and error terms to that of their independent measurement. The assumption is the same, theoretically these are the same constructs and the expectation is that they will have a high correlation with one another. Because our only interest is in the correlation between the two latent variables, the examination of the correlation and covariance matrix is straightforward. The correlation between the two constructs is 1.0 indicating that the two variables are perfectly correlated with each other and is described as perfect linear dependency [33]. Thus, in this example, the perfect linear dependency provides further evidence that the formative representation is of greater stability and therefore the more consistent construct.

### 3.4 Transportability

Different measurement model representations can lead to a deterioration in construct interpretation. As constructs from prior research are used to theoretically test other structural models of interest, these constructs must be transportable from one structural model to the next. The transportability of a latent construct ensures the theoretical contribution of new constructs based on prior research. Transportability guidelines are provided for researchers who desire to reuse latent constructs in their structural models and to insure the transportability of constructs to future research (Table 6).

The transportability guidelines begin at the scale item level and extends to the structural model. From a scale item perspective, we have seen from prior research that carelessness in the determination of the measures (e.g. reflective measures which should be formative) have the potential for Type I and II errors in the structural model. Researchers must determine if the theoretical argument applied to constructs used in prior research are adequately argued as to the causal direction. In addition, a researcher should approach a construct from prior research with caution if it has been represented differently without theoretical justification as to the differences in representation. Sound theoretical justification as to the construct meaning and the directional causation is essential for good construct measurement.

Once the theoretical orientation and multidimensional nature of the construct is determined, researchers should view their scale item construction in a formative or reflective manner. Reflective scale items will encompass larger aspects of organizational constructs and have a causal impact on multiple 1st order constructs when the reflective construct is a 2nd order or higher. Formative scale items will focus on more specific aspects of an organization.

There are several means by which a researcher can gain confidence in the measurement representation of a construct prior to its use in their structural model. First, the researcher should examine how the construct has been utilized previously. For example, a reflective construct utilized in prior research allows for one to examine the coefficients linking the indicators to the construct. These coefficients should not have a large variation of change from one study to the next because it is expected that the observable indicators are consistently measuring the latent construct. Variation in coefficients for the construct of interest from one study to the next may raise the concern of interpretational confounding [5]. If this is the case, the researcher may need to understand these differences. The construct may not be equivalent for different types of respondents or groups, thus resulting in a construct bias.

Although formative constructs used previously in the literature must be reviewed, the transportability potential of the formative construct is based upon two
conditions. The first condition is to examine the disturbance term of the formative construct. From an examination of the error term, the researcher is able to determine if the formative construct as it is represented indicates an adequate conceptualization of the construct or if ‘missing causes’ exist and further exploration of the measure is needed. An inadequate conceptualization of a formative construct indicates that the measure is not fully developed and therefore transportability is noneffective.

The second condition for transportability of a formative construct requires that the construct is properly identified. A formative construct must emit paths to two unrelated reflective measures [28]. Recent research [7, 26] indicate the potential interpretational confounding within a nomological network, but provide no guidance to insure the construct is consistently represented. Kim et al. [26] note the path coefficient changes due to misspecification. However, the coefficient changes of the IT Infrastructure Flexibility construct is potentially confounded by the fact that the formative construct obtains its identification from the nomological network instead of in isolation of that network. To achieve formative construct identification, one of three options must exist: emit at least two paths to two unrelated reflective constructs in the structural model, emit one path to one reflective indicator and one reflective construct in the structural model, or emit at least two paths to two reflective indicators. The first two options have been addressed by prior literature. The third option, emitting two paths to two reflective indicators, is the only option that insures the transportability of constructs. A formative construct created in this manner allows future researchers to transport that particular construct from prior research to their current theoretical structural models with a consistent meaning and reduce the risk of interpretational confounding.

Disturbingly, a recent five year review of formative constructs in the IS literature indicated that none of the formative constructs from the review achieved construct identification using the ideally transportable third option [15]. A formative construct that relies on the structural model for identification purposes creates difficulty of transportability for researchers who desire to utilize the construct for a different structural model. Formative constructs used previously in the literature that rely on the structural model requires a researcher to develop and test reflective indicators so that the construct may be transportable to the new structural model of interest.

4. Conclusions and contributions

Three measurement issues have been identified that can also assist a researcher in determining if a prior construct is transportable. The first measurement issue raised is how correlated a construct may be when reflective and formative scale items have been “mixed”. Researchers need to evaluate scale items that are reused, to insure that

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Table 6 - Transportability Guidelines

<table>
<thead>
<tr>
<th>Section</th>
<th>Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scale Item Comparison</strong></td>
<td></td>
</tr>
<tr>
<td>Formative scale items construction should focus on specific components that shape the construct. Scale items will not co-vary.</td>
<td>Reflective scale items construction should provide a broad assessment of all components of the construct under study. Scale items will co-vary.</td>
</tr>
<tr>
<td><strong>Measurement Models</strong></td>
<td></td>
</tr>
<tr>
<td>Variance Inflation Factor is used to assess multicollinearity of 1st and 2nd order formative factors and their scale items. Values less than 3.3 are kept.</td>
<td>Reflective 1st Order and 2nd Order exogenous constructs cannot have their explained variance assessed.</td>
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<tr>
<td>Formative exogenous constructs can have their explained variance assessed.</td>
<td>A 2nd Order reflective construct can assess the explained variance of its 1st order constructs.</td>
</tr>
<tr>
<td>Examination of the formative construct’s disturbance ζ provides information as to ‘missing causes’ of the construct. A high error term indicates that further research is needed to determine additional causes.</td>
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<tr>
<td>Misspecifications of scale items create interpretational losses. (~25% loss was demonstrated in this analysis)</td>
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<tr>
<td>Don’t rely solely on fit statistics to determine the best model representation, for nested models use a chi-square test while non-nested model comparisons use a BIC test.</td>
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<tr>
<td>1st &amp; 2nd order constructs can exhibit “perfect” linear dependency</td>
<td>1st and 2nd order constructs can exhibit a wide discrepancy</td>
</tr>
<tr>
<td>Examine the prior literature for the latent construct of interest and determine if significant coefficient changes exist between studies. Differences must be further researched as to any interpretational confounding.</td>
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<tr>
<td>Identification of the formative construct should not be reliant upon the structural model. Latent construct must be identified through two measurement relations.</td>
<td>Reflective constructs do not rely on the structural model for identification.</td>
</tr>
</tbody>
</table>
they have been properly used. The second measurement issue is the use of the VIF to determine if problems exist in a formative construct. Researchers should strive for values less than 3.3 to be confident of no multicollinearity problems. The final measurement issue is a comparison of path coefficients from prior studies with the current study. Similar coefficients should be observed and researchers may need to compare the scale item construction to determine consistency of measurement. Researchers are cautioned to understand the complexity that arises when a formative measure is reliant upon the structural model for identification as this may affect the consistency of the coefficients.

The transportability of constructs is an important aspect for researchers to understand and the improvement in understanding is necessary to advance the knowledge concerning constructs. The construction of the Transportability guidelines (Table 6) is designed to assist researchers in the development of constructs that can be consistently used in future research. The construction of the Transportability guidelines was facilitated by showing that the comparisons of different IT Capability representations bring to light the difficulties that are encountered when considering the transportability of IS constructs. Transporting constructs from context to context can enhance and refine the development of measurement constructs such that researcher contributions can be consistent across the IS domain. Insuring the transportability of constructs begins with scale item construction. The presentation to respondents, in the form of an assessment question, is important to obtain the closest consistent concept of the theoretical construct under study. Questions designed for formative constructs must be asked such that there is no overlap of concept. Conversely, questions for reflective constructs must encompass the broad range of the factor conceptualization.

The difficulties in transporting prior constructs has been demonstrated from a review of the prior literature and the various forms of measurement representations. The data for this study was collected in order to assess the various measurement representations. Our analysis indicates what a researcher must understand when considering a prior construct from the literature and how transportable it is into their structural model. Our measurement model comparisons indicate that, theoretically, a second-order representation is a deeper manifestation of the first-order representation provided that the theoretical justification is met. These considerations are provided as guidelines to researchers.

5. Limitations and future research

Addressing the transportability of latent constructs brings to light many considerations that researchers may encounter. Although this issue is not unique to the IS community, we have seen that one theoretical construct, IT capability, is inconsistently represented in prior research. The scope of this research is of necessity limited by the adequacy of the scale items adapted from prior research on IT Capability. To the extent possible, steps were consistently applied to ensure the meaning of the various representations transported to the IT Capability constructs presented. The initial limitation of this research is that other constructs may have either greater or fewer issues with transportability. Articles that use prior constructs would provide additional benefits to the field by commenting on how they have addressed the transportability of their constructs. Further analysis of other frequently used theoretical constructs within the Information Systems research community would be beneficial.

The second limitation is that the analysis conducted did not place the various measurement models in structural models to assess how the interpretation may change. This would further increase the understanding of the potential effects of creating constructs that are not easily transportable. Simulations may be ran to provide additional insights as to how the measurement models affect the structural model. These simulations can help to rule out confounds, such as inappropriate measurement, sample representativeness or other issues unique to the empirical study.

A third limitation of our research is that we focused on covariance measurement instead of principle component based structural equation modeling. The IS community has seen a substantial increase in the use of PLS. The findings and suggestions for improving the transportability of constructs has not been assessed for component based SEM. Further research on understanding the implications between covariance and component based applications as it relates to transportability are needed.

Finally, model comparisons using predictive fit indices are often used to compare non-nested models. As in this case, the comparisons of reflective to formative representations are considered non-nested model comparisons. These predictive fit indices assumes a hypothetical replication sample of similar size and from the same population [27]. Applying the Baye’s Informaiton Criterion can provide additional informational comparisons for latent constructs.
6. References


