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An Assessment of Formative and Reflective Constructs in IS Research

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Abstract

Construct development and the use of structural equation modeling has become an important aspect of IS research. However, a review of recent MIS Quarterly (MISQ) articles indicates that little attention is given during theoretical development as to the formative or reflective nature of these constructs. This lack of attention has three implication issues that involve 1) construct misspecification, 2) construct identification and 3) construct validation. This research provides a review of these issues in terms of the current recommendations for formative and reflective constructs and reviews the most recent MISQ articles in terms of their adherence to these recommendations. Guidelines for IS researchers to address construct development and aid in the determination of whether their constructs should be tested as formative or reflective variables are presented to enhance the transportability of constructs.

Keywords: Formative, Reflective, Structural Equation Modeling (SEM), measurement model

1 INTRODUCTION

Recently, Structural Equation Modeling (SEM) has become more popular in Information Systems research. One benefit of SEM is that you can simultaneously assess the measurement model (relationship between constructs and measures) and the path model (relationship between the constructs) to test theoretical relationships. This advantage of SEM, therefore, is useful in theoretical research which includes (a) the relationships between constructs and (b) describes the relationships between the construct and measures (Edwards et al. 2000). Our paper focuses specifically on issues regarding the measurement model: misspecification, identification, and construct validation. Recent marketing research has highlighted issues of measurement model misspecification and suggests that empirical findings reported in the literature may be misleading. (Jarvis et al. 2003; MacKenzie et al. 2005). When researchers do not carefully consider the direction of the relationship between measures and latent constructs, measurement model misspecification exists. Thus, the direction of the relationship between measures and constructs can flow in two directions: directly from the measure to the construct or directly from the construct to the measure. It is important for researchers to pay attention to the direction of causality between measures and constructs. Inattention to directional causality leads to serious consequences. The two types of latent construct measurement models are reflective and formative. Reflective measures are caused by the latent construct, whereas, formative measures cause the latent construct. Misspecification exists when a latent construct has reflective (formative) measures when indeed it should be formative (reflective).

The implications of measurement model misspecification affect current and future research. Construct misspecification issues within structural equation models lead to "serious consequences for the theoretical conclusions drawn from the model" (Jarvis et al. 2003). MacKenzie et al. (2005) found that construct misspecification affects the results of the structural model analysis leading to Type I and II errors. In their research, they found that paths coming from a misspecified construct are substantially inflated (Type I error) while paths leading into a misspecified construct are likely to be deflated (Type II error). Thus, studies may have been rejected during the review process due to a lack of understanding that validation depends on the direction of relationship between the measures and the construct. As researchers, we often rely on the testing and validation of published works using those same measurement models to theoretically test our structural (path) models. If those constructs are misspecified, then we will incur the same issues as described above. Therefore, it is our responsibility as researchers to understand and question how constructs from the literature are developed, identified and validated. In addition, if we are creating new constructs, it is our responsibility to clearly discuss the development, measurement, and validation of the construct.

As researchers, we have the responsibility to clearly describe construct development and directional causality of the measures. Its absence can lead to inappropriate conclusions regarding verification of relationships among constructs and support for theory or implicitly asserting causalities that are not warranted. It should not be left up to the reader to assume or imply what the researcher is doing. In addition, researchers should understand some fundamentals of measurement models with the understanding that all measurement models are not treated equally.

The remainder of this section will discuss the misspecification, identification, and validation of constructs. We then present our findings from a review of articles in MIS Quarterly using SEM. In conclusion, we provide guidelines and suggestions for researchers.

1.1 Measurement Model Misspecification: Reflective vs. Formative

We first define constructs and measures prior to our discussion of the relationships between the two. Constructs can describe the unobservable (i.e. attitudes) and are "verbal surrogates" for the phenomena named by the construct. These are also known as latent variables. Measures are defined as “an observed score gathered through self-report, interview, observation, or some other means” (Edwards et al. 2000). Measures are quantifiable, for example, an empirical score gathered from a survey instrument.

Measures, also called indicators or scale items, can be distinguished as either ones that are influenced by (reflect) or influence (form) latent variables (Bollen et al. 1991). Measurement model misspecification occurs when researchers do not pay attention to the directional relationship between measures and the construct (Chin 1998). Indicators that are influenced by latent variables are called ‘effects’ indicators. The measurement models that validate these indicators and their latent variables are known as reflective models. Figure 1 – Reflective Latent Variable shows a common latent factor structure with reflective indicators and show that changes in the underlying latent construct are reflected by changes in the indicators. In addition, the indicators are subjected to errors of measurement in the reflective model.

An example of a reflective measurement model well-known to the IS community is Perceived Ease of Use (Davis et al. 1989). Perceived Ease of Use is defined as “the degree to which a person believes that using a particular system would be free of effort”. Perceived Ease of Use is measured by six reflective indicators: easy to learn, controllable, clear and understandable, flexible, easy to become skilful, and easy to use. Based upon this example, an increase in Perceived Ease of Use is reflected by an increase in all six indicators. Therefore, the measures all represent the underlying construct in a reflective model and are expected to be correlated. Due to the high correlations between the indicators, the indicators are also interchangeable and dropping an indicator should not alter the conceptual meaning of the construct (Jarvis et al. 2003).

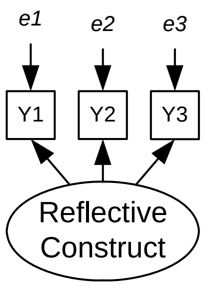

Figure 1 – Reflective Latent Variable

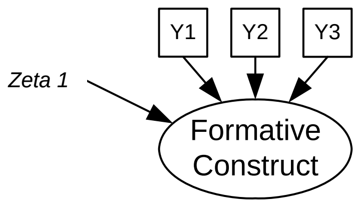

Figure 2 – Formative Composite Variable

The second type of measurement model is called formative. As indicated in Fig. 2 – Formative Composite Variable, the indicators influence the construct. These are often called ‘causal’ indicators and the construct is often termed as a combination variable (Maccallum et al. 1993) or composite variable (MacKenzie et al. 2005). This means that the measures cause the construct and that the construct is fully derived by its measurement. As indicated in Figure 2, the measurement error is at the construct level, meaning that part of the construct is not explained by the measures.

An example of a formative construct is Socio-Economic Status (SES) (Heise 1972). SES is caused by three measures: education, income, and occupational prestige. For example, an increase in income would increase SES even if there are no increases in education or occupational prestige. Therefore, one would not require a simultaneous increase in all of the indicators (Bollen et al. 1991).

Due to the direction of causality with formative models, high correlation between the indicators is not expected, required or a cause for concern. However, dropping an indicator would be similar to dropping a part of the construct (Bollen et al. 1991) and should not be done once an indicator is verified as part of a construct.

Practical guidelines exist to assist researchers on the development and evaluation of reflective and formative constructs (Jarvis et al. 2003; MacKenzie et al. 2005). A simple exercise discussed in Chin

(1998) asks the question: “Is it necessarily true that if one of the items (assuming all coded in the same direction) were to suddenly change in a particular direction, the others will change in a similar manner?” If one answers ‘no’ to this question, the construct is formative. First and foremost, however, researchers must clearly define their construct domain, and then it will be easier to evaluate the relationship between the measures and the construct. Table 1 – Formative vs. Reflective provides a summary of differences between the two models.

Table 1 – Formative vs. Reflective

Concept	**Reflective**	**Formative**
Causal Priority	Indicators are realized From construct to indicators	Indicators are explanatory From indicators to construct
Measurement Error	Established practices important at the item level	Statistical assessment is problematic, but should be done at the construct level
Internal Consistency	Indicators should possess internal consistency	Internal consistency is not implied
Correlations	Should be high	Not expected
Identification	“Rule of three”	Two emitting paths plus formative indicators
Error terms	Yes, at indicator level	No – only disturbances at construct level
Measurement Interchangeability	Removal of an item does not change the essential nature of the underlying construct	Omitting an indicator is omitting a part of the construct

1.2 Measurement Model Identification

A second issue that needs to be addressed is one of model identification. Identification refers to measurement models that have no unique solution (Loehlin 2004). This can be illustrated with the following mathematical example: $2x + y = 7$

In equation (1) there is no unique solution, there are an infinite number of solutions to solve this equation. Because there is no unique solution, equation (1) would not be identified. However in the following equations, there is a unique solution for x and y (x=4, y= -1): $2x + y = 7$ $x - 3y = 7$

For identification in reflective latent constructs, Bollen (1989) suggests a three measure rule meaning that a single factor measurement model should have at least three indicators. We refer to this as the “rule of three” when assessing construct identification issues. A construct with three reflective measures allows for the covariances among the measures to be used to estimate the factor loading. In this case, the reflective construct can be considered identified by its own indicators. In contrast, a necessary condition for identification of a formative construct is to emit more than one path (Maccallum et al. 1993). For example, the formative construct shown in Fig 3 panel 1 (reproduced from Jarvis et al. 2003) is not identified.

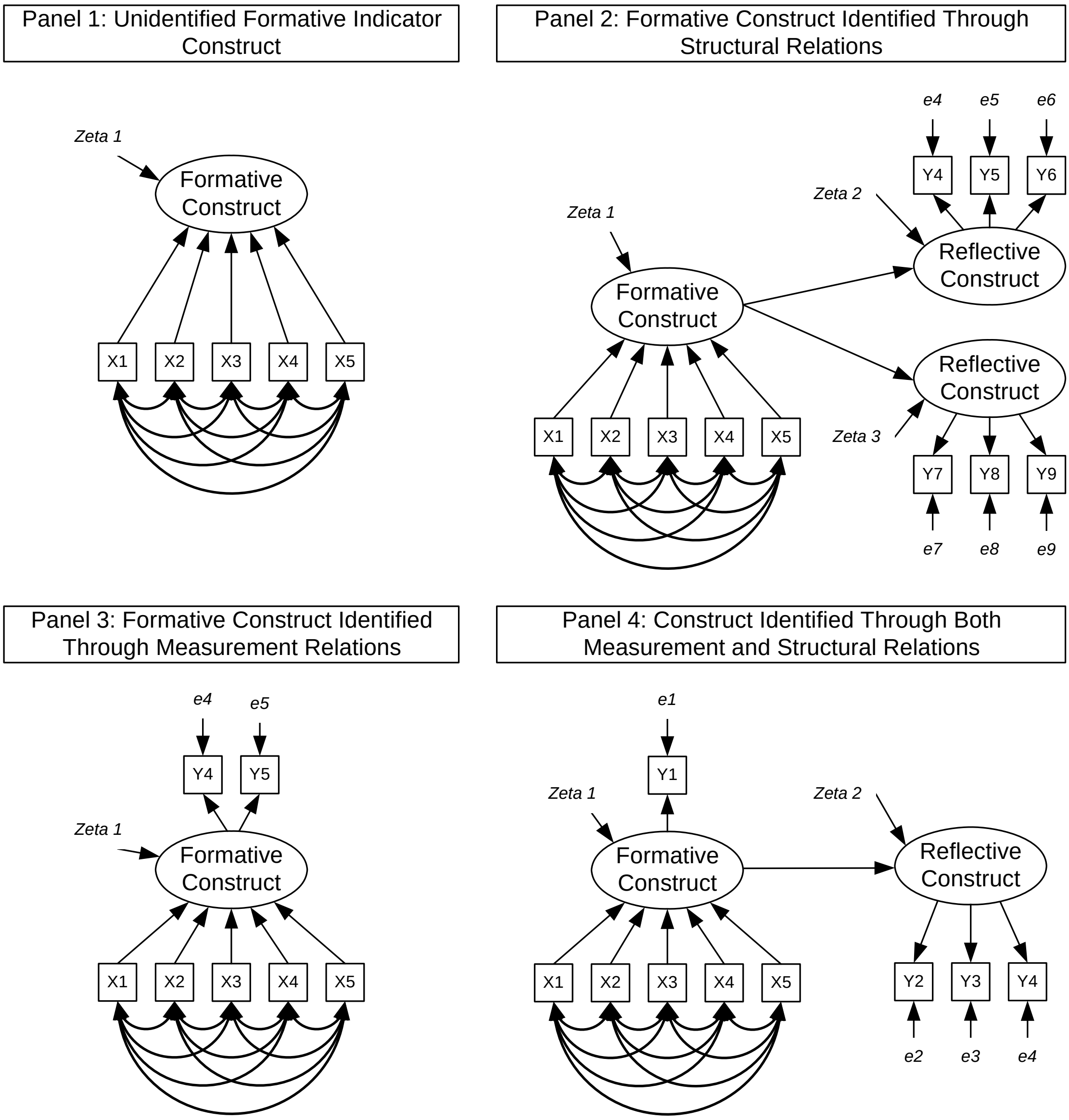

Figure 3 – Formative Construct Identification – Jarvis et al. (2003)

Jarvis et al. (2003) provide three alternatives to achieving identification in formative measurement models. The first method, shown in Fig 3 Panel 2, identifies the formative construct through emitting paths to two unrelated reflective constructs. The second method, shown in Fig 3 Panel 4, also identifies the formative construct through its positioning in the structural model. This method shows one path emitting from the formative construct to a reflective indicator and one path to an unrelated reflective construct. The third, and ideal alternative, shows two paths emitting from the formative construct to two reflective indicators. This third alternative is ideal because the formative construct is not dependent upon the structural model; therefore, this construct can be either an exogenous or endogenous construct and can go anywhere in the model. This third alternative is also known as a multiple indicators and multiple causes model (MIMIC) (Diamantopoulos et al. 2001). By specifying a formative construct with the method in Figure 3 Panel 3, future researchers are not bound by any constraints on how that construct is used in their theoretical model.

1.3 Construct Validation

A third common measurement model issue is related to construct validation. Construct validation relates to how well the theoretical concept is operationalized in the measurement of the construct. For the reflective model, the researcher uses 'classical test theory' (Jarvis et al. 2003). Reflective constructs imply the assumptions of classical test theory; therefore, construct validation through Confirmatory Factor Analysis (CFA) (i.e. convergent and discriminant validity) and reliability testing (i.e. Cronbach's Alpha) is appropriate. In contrast, validity for formative constructs is concerned with the strength and significance of the path from the indicator to the construct (MacKenzie et al. 2005).

The differences between the two measurement models have been emphasized in the Psychology literature noting that the traditional methods of construct validity and reliability are not appropriate for formative constructs (Bollen et al. 1991). Therefore, reliability in the internal consistency sense and construct validity in terms of convergent and discriminant validity are not meaningful for formative constructs (Diamantopoulos et al. 2001). Internal consistency (reliability testing) of indicators is difficult for formative constructs because the indicators are not reflections of the underlying latent variable. Convergent validity for formative constructs is also not relevant. This is due to the fact that formative construct indicators are not necessarily correlated. Discriminant validity however can be tested for both the reflective and formative construct by testing for "whether the constructs are less than perfectly correlated" (MacKenzie et al. 2005).

Diamantopoulos and Winklhofer (2001), however, detail issues related to the success of formative models which are helpful for construct validity purposes. First, understanding the contextual domain of the construct is important. Failure to include all facets of the conceptual domain of the construct leads to exclusion of the construct itself. Defining the construct is an important first step of this process. Once the construct is adequately defined, the contextual domain is better understood. Within the contextual domain, indicators must cover the entire scope of the domain. Therefore, an extensive literature review of the contextual domain is necessary. Third, multicollinearity of the indicators can be problematic, because the focus on the formative indicator is to assess the strength and significance of the path from the indicator to the composite construct. This is treated similarly to multiple regressions. Fourth, if possible, nomological validity should be considered.

2 METHODOLOGY

The popularity of using SEM as well as the ease with which many SEM programs allow the testing of relational models necessitates sound theoretical grounding of constructs. A review of recent IS articles indicates the explanation of constructs is not sufficiently described to determine if they have been properly grounded as either reflective or formative constructs. This initial review identifies shortcomings in construct development and explanation that follow the three issues previously discussed. We begin by outlining our article selection.

2.1 Article Selection

We restricted our search for relevant articles to the leading IS journal, MIS Quarterly. For the current stage of this research, we searched journal articles from 2003 (Volume 27 Issue 1) to 2006 (Volume 30 Issue 1). Each author addressed the search for relevant articles in two methods. The first method involved a key word search for those articles containing the words formative or reflective in the body of the text. An assumption that all authors would not address this issue was made. Therefore, an additional key word (SEM) was used to further identify potentially relevant articles. The second method involved a review of each abstract in order to determine the articles potential applicability to the research.

The inclusion of each article was based on two criteria. The first criteria required that some form of latent variables were used in the research. The second criteria necessitated some form of structural model to be empirically tested in the article. Once the two separate lists were assembled, the authors compared the two lists of articles and constructs. Agreement was reached as to which articles to include. The final data set included 21 articles which can be found in Table 2 – Article list.

Table 2 - Article list

MISQ Article	Title
(Awad et al. 2006)	Personalization Privacy Paradox
(Moores et al. 2006)	Ethical Decision Making in Software Piracy
(Pavlou et al. 2006)	Extending the Theory of Planned Behavior
(Tanriverdi 2006)	IT Synergies in Multi-Business Firms
(Venkatesh et al. 2006)	Web and Wireless Site Usability
(Ahuja et al. 2005)	Effects of Work Environment & Gender
(Gattiker et al. 2005)	After ERP Implementation
(Tanriverdi 2005)	IT Relatedness, KM Capability, and Performance
(Bock et al. 2005)	Behavioral Intention Formation in Knowledge Sharing
(Ko et al. 2005)	Knowledge Transfer from Consultants to Clients
(Wasko et al. 2005)	Social Capital & Knowledge Contribution
(Barua et al. 2004)	Net Enabled Business Value
(Bassellier et al. 2004)	Business competence of IT Professionals
(van der Heijden 2004)	Hedontic Information Systems
(Bhattacherjee et al. 2004)	Changes in Belief and Attitude Toward IT Usage
(Subramani 2004)	Benefits from IT Use in Supply Chain Relationships
(Lewis et al. 2003)	Influences on Beliefs about IT Use
(Venkatesh et al. 2003)	User Acceptance of IT
(Enns et al. 2003)	CIO Lateral Influence Behaviors
(Susarla et al. 2003)	Understanding the Service Component of ASP
(Teo et al. 2003)	Predicting Intention to Adopt IOL

2.2 Determining Misspecification

Once the articles had been selected, classifying the constructs as either formative or reflective was important to begin the determination of whether a misspecification had potentially occurred. Several constraints were placed on the selection of constructs for inclusion as either formative or reflective.

In all cases, when the authors indicated a formative or reflective construct, this designation was accepted and the construct placed in the appropriate category. For those constructs not designated by the author(s), we assumed these constructs to be reflective and follow classical test theory. This assumption is made since identification of a formative construct is more rigorous and we did not wish to place an additional burden on an unspecified construct. These criteria resulted in a total of 170 constructs from the 21 previously identified articles in Table 2.

The results of this classification indicated that 71% of the constructs were unspecified as to whether they were formative or reflective (Table 3 – Construct Review). Of the eleven specified formative constructs, all of the authors provided some theoretical or explanative support as to the constructs formative nature. This provides substantial evidence that a sound theoretical base has been explored in the assembly of these constructs and greatly reduces the chance of misspecification. The focus to this point has been to provide the landscape for potential construct misspecification. The overall analysis indicates that only a meager attempt has been made to reasonably explain the decision of formative or reflective in the development of constructs used in IS research. Thus, leaving the reader to conjecture the meaning ascribed to prior constructs, misspecification is more likely to occur in either the current research or future research attempting to duplicate or further the IS knowledge base.

Table 3 - Construct Review

	# of Constructs	% of Total	% of Total Specified	% of Total Unspecified
Reflective	159	94%	23%	71%
Formative	11	6%	6%	0%
Total # of Constructs	170	100%	29%	71%

2.3 Construct Identification

The theoretical identification of a construct is different for formative and reflective indicators. The goal of this assessment is whether each of the 170 constructs can be identified in isolation. If a construct can be identified in isolation, this enhances its ability to be transported to other models with greater success since the construct is not dependent on the structural model in which it is placed. The "rule of three" was followed for the 159 reflective constructs to determine those constructs that could not be identified in isolation (See Figure 1). For the identification of the 11 formative constructs. The first, and most important, requirement is that the construct must have two emitting paths. These two emitting paths must be to reflective indicators in order to more easily transport the construct.

Formative constructs have two other methods of identification that were reviewed in Figure 3 (Panels 2 and 4). None of the formative constructs achieved the ideal identification that was specified in Figure 3-Panel 3. Only two of the eleven formative constructs achieved any form of identification. These two constructs had at least three formative indicators and two emitting paths to reflective latent variables (Similar to Figure 3-Panel 2). A single emitting path was the reason for the failure of identification of the remaining formative constructs.

The reflective constructs represented the only latent variables that achieved identification in isolation. There were a total of 123 reflective constructs that represented 72% of all constructs and 77% of reflective constructs that achieved identification in isolation. The remainder of the constructs could only achieve identification in the context of an extended measurement model or a structural model.

For the reflective constructs with only one or two indicators, only the two indicator constructs can be identified in terms of the overall model. For constructs with two indicators, the model may be identified if there are no correlated errors, each indicator loads on only one factor, and none of the variances or co-variances among constructs is equal to zero (Tabachnick et al. 2001). The single indicator constructs are considered unary in their representation of the latent variable. Since there exists no way to assess measurement error, the latent variable cannot be identified with a single indicator.

The focus on construct identification can highlight the existing IS research shortcomings on formative indicators. An emphasis must be placed on including at least two emitting paths for each formative construct. These paths would ideally lead to two reflective indicators in order to provide future researchers with an easily transportable construct. The 77% identification of reflective constructs is encouraging, but this still indicates that one of every four reflective constructs used in research may not be identified.

2.4 Validation

Reflective construct validation uses the established procedures of classical test theory. All 21 articles reviewed follow these guidelines for the testing of their reflective constructs. These procedures include convergent and discriminant validity as well as unidimensionality, reliability and internal consistency. Expounding on minor issues with the validation of the 159 reflective constructs reviewed would be tedious and uninformative. Reflective constructs will therefore not be reviewed unless necessary to contrast them with the need for improved construct validation of formative latent variables.

The procedures for establishing construct validation for formative latent variables are not widely known. This is due partly to the still limited use of formative constructs in IS research (only 6% of the constructs reviewed were specified as formative). This limited quantity will be reviewed with some of the suggestions made from Psychology literature in the Construct Validation section as to how to assess formative constructs. The suggestions on assessment will start with the contextual domain and conclude with the three suggestions for nomological validity.

Good theoretical discussion and grounding surrounded each of the formative constructs reviewed. The authors provided a thorough literature review for each construct in addition to specific reasons for operationalizing them as formative.

The first step for nomological validity assessed the correlations of the formative construct's indicators. High indicator correlations may not exist with formative constructs. High correlations among formative indicators could indicate that the scale items are measuring essentially the same concept. This could lead to a multi-collinearity problem and the need to eliminate one or more indicators.

When formative constructs are operationalized as 2nd order variables, authors should provide construct correlations. This statistical review, similar to discriminant validation, of the relationships of indicators and 1st order constructs does not provide final validation that the formative construct has been correctly operationlized. It can provide an indication that duplication of measurement has not occurred. Of the five articles reviewed, only two provided indicator/construct correlations in order to assess this potential issue. These two articles encompassed six of the eleven formative constructs.

The second step of nomological validity assesses the construct in isolation (MIMIC). This involves the creation of a measurement model for only the formative construct and is the most rigorous and definitive method. The guidelines for developing this model were outlined in the previous section on Construct Identification. If a formative construct measurement model can be created, the model statistics will give an indication as to the goodness of fit. None of the formative constructs reviewed provided an indication of construct model fit.

The final step to assessing nomological validity is the placement of the formative construct in the context of a structural model. The analysis of the structural model fit then provides an indication of the significance of the formative constructs included in the model. However, only two articles representing four of the eleven constructs provided structural model fit results.

3 DISCUSSION

This paper discusses three issues relating to measurement models: misspecification, identification, and construct validation. The implications of these issues are of importance to both researchers and reviewers. For researchers, not paying close attention to the directional causality of the measures and construct can lead to measurement model misspecification. For reviewers, an awareness and recognition of these issues can provide guidance to researchers in addressing these issues and place fewer burdens on the reader to make assumptions of the research.

Based on our examination of articles in the IS literature, we found that a disparaging number of articles published do not specifically state if the constructs are formative or reflective. We feel that this places an undue burden on the reader to make assumptions in addition to having an impact on future research. To make a significant contribution to the future of IS research; researchers must understand the differences between formative and reflective constructs and their respective methods of identification and validation. We therefore suggest the following guidelines for researchers as shown in Table 4. The contextual domain for both reflective and formative constructs must maintain its current emphasis. This is especially critical for formative constructs and the researchers need to proactively address this issue. A clear construct definition assists in understanding the contextual domain of the construct and how that construct is measured.

Researchers should recognize that there are clear differences between reflective and formative constructs. Construct identification and validation depends on the type of construct specified by the researcher. Researchers should not assume that all constructs are treated similarly and should clearly state the type of construct.

Table 4 – Guidelines for Researchers

Issue	Researchers
Misspecification	Researchers need to clearly define the construct and the contextual domain of the construct. This will provide an understanding as to how to generate a set of measures that represent the constructs domain. Pay careful attention to the directional relationship between the construct and measures. All constructs should not be assumed reflective. When using a construct from prior literature, the researcher should ensure that the theoretical reasoning of the construct is clearly defined as either formative or reflective.
Identification	For reflective models, careful consideration to the number of indicators is necessary, i.e. “rule of three”. For formative models, two paths must emit from the measurement model. This is either done in isolation of the structural model (two reflective indicators) or within the structural model (paths emit to latent reflective constructs).
Validation	For reflective models, use classical test theory to validate the construct (CFA, convergent and discriminant validity, measurement reliability). For formative models, use nomological validity methods. Assess the strength of the path coefficient from the indicators to the construct. Address any multi-collinearity issues. i.e. Variance Inflation Factor

4 LIMITATIONS AND FUTURE RESEARCH

We recognize that there exist certain limitations of this research that will lead to an expansion of research in the analysis of formative and reflective constructs. The first limitation is the restricted timeframe, only the most recent three years, of articles collected and constructs reviewed. This timeframe should be expanded to cover an extended period of IS research. This expansion would allow the assessment of constructs used over the course of several articles and could begin to comment on “established” reflective and formative constructs in the IS domain.

The second limitation is the focus on only one IS journal. MISQ is recognized as one of the leading IS journals and provides an excellent avenue for assessing construct development. However, the article review and construct analysis should be expanded to include more leading IS journals. This expansion would allow a richer view of construct development and more accurately represent the entire IS community.

The third limitation is a result of the constraints placed on the classification of constructs. The largest constraint placed is the assumption that any unspecified construct would be considered reflective. A more thorough search of literature referenced by each article may provide clearer interpretations of whether the constructs were formative or reflective if not explicitly specified. Constructs that have been reused from prior literature should not necessarily need to be reanalyzed in every article.

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