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The Presence of Equivalent Models in Strategic Management Research Using Structural Equation Modeling

Assessing and Addressing the Problem

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The use of structural-equation modeling (SEM) in strategic-management research has grown dramatically during recent years. Although this statistical technique offers researchers a valuable tool for testing hypothesized models, certain challenges accompany the use of SEM. The current article examines one of these challenges, equivalent models, and its prevalence in strategy research. An equivalent model is an alternative model that fits the data equally well, thus producing the same covariance or correlation matrix but often differing significantly in theoretical interpretation. We examined the application of SEM in 109 strategic-management studies and found that equivalent models are a cause for concern in most strategic-management studies. Using a published article, we also provide a statistical demonstration of the potential effect of equivalent models. This article highlights both the extent of potential equivalent models in strategy research and the possible effect of such models on strategic-management theory.

Keywords: *structural equation modeling; equivalent models; alternative models*

The use of structural-equation modeling (SEM) is becoming increasingly prevalent in strategic-management research. This technique has been heralded by some as a great analytical advancement (Bentler, 1980; Cliff, 1983), whereas others question its true value (Brannick, 1995). Because of its potential to enhance the testing of theoretical models significantly (Kelloway, 1995) and its capability of testing multiple hypothesized relationships within the framework of an overall model, many researchers have embraced the technique. However, even with the advancements SEM offers, it also presents problems that must be acknowledged and addressed to advance knowledge. The present article examines one of these problematic issues—equivalent models—within the strategy arena of management research.

Structural-equation modeling combines the logic of confirmatory factor analysis, multiple regression, and path analysis in the application of a single technique (Breckler, 1990). The uniqueness of the technique is grounded in SEM's ability to test relationships among multiple dependent and independent variables simultaneously. With this technique, multiple relationships are tested concurrently; variables can be treated as dependent and independent variables simultaneously. Therefore, researchers are allowed to test the full scope of their hypothesized relationships within one statistical approach rather than being forced to use multiple approaches consecutively as in prior research (Shook, Ketchen, Hult, & Kacmar, 2004). Furthermore, the inclusion of the confirmatory-factor-analysis component of the technique via the measurement model allows the researcher to measure and account for measurement error explicitly. Therefore, both hypothesis testing and factor analysis can be accomplished through the application of this single method (Shook et al., 2004).

The goal of SEM is to determine how well the hypothesized model fits the observed data. More specifically, the technique determines whether the hypothesized causal structure is consistent with the correlation or covariance matrix of the data being considered (Breckler, 1990). However, the existence of equivalent models can result in inference problems (Williams, Bozdogan, & Aiman-Smith, 1996). An equivalent model is an alternative model that fits the data equally well, thus producing the same covariance or correlation matrix (Luuben, 1991) but often differing significantly in theoretical interpretation. Consequently, all goodness-of-fit statistics will be equal for each of these models (Breckler, 1990; MacCallum, Wegener, Uchino, & Fabrigar, 1993). Accordingly, fit statistics alone cannot be used to support the hypothesized model, because no distinction between fit of the models is present (Breckler, 1990). Further analysis of the equivalent models concerning theoretical foundations and implications associated with particular parameters must be undertaken to provide clear support for one model over another (MacCallum et al., 1993).

The problem in organizational research using SEM is that the presence of such equivalent models rarely is acknowledged (Breckler, 1990) and even less frequently evaluated (MacCallum et al., 1993). Organizational-behavior researchers have investigated this problem and concluded that equivalent models are often present in research using SEM (Breckler, 1990; MacCallum et al., 1993). In their recent review of SEM practices in strategic-management research, Shook et al. (2004) examined strategy researchers' treatment of equivalent models in a limited fashion and found that strategy researchers very rarely acknowledged the possible existence of equivalent models. Because of the considerable impact of failing to account for potential equivalent models, a better understanding of equivalent models and the potential effects as well as methods to help alleviate equivalent models appears warranted.

Organizational Research Methods (*ORM*) appears to be an ideal venue for the present article. Although *ORM*'s scope covers the entire domain of organizational and management studies, strategy research appears to be very underrepresented in the journal. Indeed, in an examination of the 92 studies published during the 5 years between 2000 and 2005, 3 have been explicitly strategy-related, whereas 38 have been explicitly related to either organization behavior or human resources. Thus, there is a need for more strategy studies in *ORM*, and the present article fits in nicely with past SEM research in *ORM*.

Since its inception, *ORM* has been a forum for discussion of the advances offered by and the challenges associated with the use of SEM. The discussions primarily have focused on the utility offered by SEM. For example, Wong and Law (1999) discussed the appropriate use of SEM as a means to test reciprocal relations using cross-sectional data. The techniques available for testing interaction effects with SEM were highlighted by Cortina, Chen, and Dunlap (2001), and M. W. Cheung and Chan (2004) introduced *ORM* readers to the use of SEM as a unified framework to test dependent and independent correlational hypotheses. Studies also have highlighted the use of confirmatory factor analysis to assess measurement equivalence and invariance (Meade & Lautenschlager, 2004) and to test individual differences and group mean differences within a single, integrated network (Ployhart and Oswald, 2004).

One of the challenges associated with SEM is assessing the fit between the theory-based model and the data. *ORM* has served as a forum for discussing issues involving model fit. For example, Landis, Beal, and Tesluk (2000) alerted researchers to the superiority of using composite measures formed from individual items rather than using representative individual items in achieving better model fit. The effects of model parsimony and sampling error on model fit were highlighted by G. W. Cheung and Rensvold (2001). The present article also involves an issue related to model fit. More specifically, this article examines the issue of equivalent models (different models that exhibit identical levels of model fit) within a specific arena of management research.

In the following sections, we first identify causes and consequences of equivalent models and discuss the effects of failing to acknowledge the existence of equivalent models on interpretation and theoretical advancement by statistically demonstrating two possible equivalent models for a published study in the field. We then report the results of an examination of strategy research using SEM to demonstrate the prevalence of the problem of equivalent models in this arena. Finally, this article addresses the possible consequences of failing to identify and evaluate possible alternative equivalent models as well as available ways of eliminating equivalent models.

The Causes and Consequences of Equivalent Models

Models can be defined as equivalent if they reproduce the same set of covariance matrices even when their parameters vary (Raykov & Penev, 1999). These models will result in equal goodness-of-fit indices, and therefore, can be differentiated only through additional measures (Raykov & Penev, 1999). For many models, numerous equivalent models are a distinct possibility (Raykov & Penev, 1999), and the supported model is only one of many means for explaining the data (Raykov & Marcoulides, 2001). Although such models produce equivalent fit statistics, these models can be distinguished by significance and interpretability of the parameters, practical meaningfulness of the model, and design features that eliminate the plausibility of particular paths (MacCallum et al., 1993; Raykov & Penev, 1999). It is important to note that this potential problem of equivalent fit is not limited strictly to SEM but also can be of concern in other multivariate statistical techniques. For example, in multiple regression models, because of the assumption that all independent variables are mutually intercorrelated when influencing the dependent variable, several possible coefficient weights and changes in directional influence on the dependent variable can result in equivalent levels of variance accounted for (R^2) in the dependent variable (MacCallum et al., 1993). Additionally, when using exploratory factor analysis, the factor pattern often can be rotated without changing the fit of the model to the data but significantly changing the individual loadings of specific items to a certain factor. In either case, the interpretation of the multiple regression results or factor loadings would be changed without altering the overall significance level of the model.

The concern for those building on prior research is that these equivalent models frequently support conflicting theoretical implications. For example, many equivalent models reflect the redirection of causal relationships. Other equivalent models reflect correlation rather than causation. Therefore, the conclusions from such models are significantly different, and the plausibility of the findings from each must be evaluated. Reliance on fit measures does not provide full support for hypothesized relationships. If researchers merely rely on these measures of fit without interpreting the model's parameters, the resulting conclusions will be limited and likely flawed (Kelloway, 1995).

For many supported models, numerous other structural models may exist that produce the same levels of fit but suggest significantly different relationships among the constructs (Raykov & Penev, 1999). A key consequence for not reviewing these equivalent models is the threat of biasing future research. Building on these results in future studies can be extremely problematic and lead to conflicting conclusions if based on incorrectly specified models (MacCallum et al., 1993; Raykov & Penev, 1999). Therefore, unless equivalent models have been identified and eliminated, subsequent researchers may continue to extend prior studies that reported spurious findings. The support of a particular theory, and the foundation on which it is grounded, may prove questionable. As a result, equivalent models must be handled properly by the researcher (Raykov & Penev, 1999) to avoid such limitations to theoretical advancement. Indeed, some researchers have proposed that to claim that a particular model is valid, the researcher must eliminate all other equivalent models (Jöreskog & Sörbom, 1990). Consequently, it is also important for researchers to determine whether the equivalent model is relevant to their research. For example, a model may produce equivalent fit statistics but prove theoretically implausible. Such models would not contain the same threat to future research as equivalent models that are theoretically plausible.

Methods for Identifying Equivalent Models

It is apparent that the problem of equivalent models entails many potential negative consequences for theory development and advancement. However, acknowledging the causes and concerns associated with these equivalent models is only one step in remedying the problem. Researchers also should be able to identify potential equivalent models. Only by identifying, and when possible, eliminating equivalent models can researchers alleviate the accompanying concerns about the accuracy of their findings.

The problem of equivalent models has been addressed within the statistical and research-methods fields of research (e.g. Jöreskog & Sörbom, 1990; Luuben, 1991; Raykov & Penev, 1999) and rules have been established to guide researchers in identifying equivalent models (Lee & Hershberger, 1990; Raykov & Penev, 1999; Stelzl, 1986). For example, Raykov and Penev (1999) have derived a treatment that provides a basic definition of equivalent models and a general prescription for identifying their presence in empirical research. More specifically, whereas some have regarded the number of equivalent models for any given model to be infinite (Raykov & Marcoulides, 2001), others have proposed explicit methods for taking a supported model and determining those alternative models that would produce identical covariance matrices.

Stelzl (1986) first proposed four rules for the generation of equivalent models that involved replacing one parameter with another so that the number of free parameters in the model would remain constant. These rules later were simplified and subsumed into what is referred to as the replacing rule by Lee and Hershberger (1990). Whereas Stelzl's (1986) rules are applicable only to recursive models, Lee and Hershberger's (1990) guideline holds for both nonrecursive and recursive models (those that contain no reciprocal directional effects or feedback effects as well as no covariances between residual terms—MacCallum et al., 1993). Both sets of rules involve generating equivalent models through the replacement of direct paths with residual correlations, the replacement of residual correlations with direct paths, and/or the reversal of path directions (Lee & Hershberger, 1990) where appropriate. These changes in path structure are applied only to the structural model, not the measurement model, and the number of paths used always remains constant. Although no complete formal logical proof has been provided for the replacing rule, Raykov & Penev (1999) have shown that the rule is a special case of their treatment of equivalent models and can be used as a general tool for identifying the presence of equivalent models. Although researchers have acknowledged that these rules do not account fully for all potentially equivalent models (e.g. Raykov & Penev, 1999), the guidelines do establish clearly those equivalent models that can be generated using the variables found in the original model.

Because Lee and Hershberger's (1990) rule is more general and builds on Stelzl's (1986) rules, it is applicable to a greater number of structural models. Thus, the present article uses Lee and Hershberger's (1990) replacing rule to identify equivalent models in strategy research. Because some researchers have claimed that if there is one equivalent model present, there also may be infinitely more (Raykov & Marcoulides, 2001) and because of the fact that identification of some of these equivalent models is not feasible because of the possible effect of phantom variables (MacCallum et al., 1993), the present article does not attempt to quantify the total number of equivalent models present for a given model. Instead, this article focuses on identifying (a) if an equivalent model is present, via the replacing rule, and (b) what type of changes in model structure (e.g., reversal of causality, introduction of causality, etc.) would result.

Before identifying the presence of equivalent models in current strategy research, it is important to understand fully how such equivalent models are generated via the replacing rule. To determine which models would produce equivalent fit levels, Lee and Hershberger (1990) propose first partitioning a given model into three blocks of latent variables. These blocks are identified as the preceding block, the focal block, and the succeeding block (Lee & Hershberger, 1990; MacCallum et al., 1993). Partitioning into these sets of variables must result in the recursiveness of relationships within the focal block and the relationships between variables in different blocks (MacCallum et al., 1993). In other words, within the focal block and between each of the blocks, no covariance between residuals must be present and no bidirectional relationships are allowed. Furthermore, those variables in the preceding block may not receive arrows from any variable outside of that preceding block (MacCallum et al., 1993). Also, the replacing rule allows the relationships between variables in the preceding block to be nonrecursive, as it does those within the succeeding block (Lee & Hershberger, 1990). The replacing rule can be applied to the focal block and to the preceding block under certain conditions. An example is presented in the appendix.

An Example From Strategic-Management Research

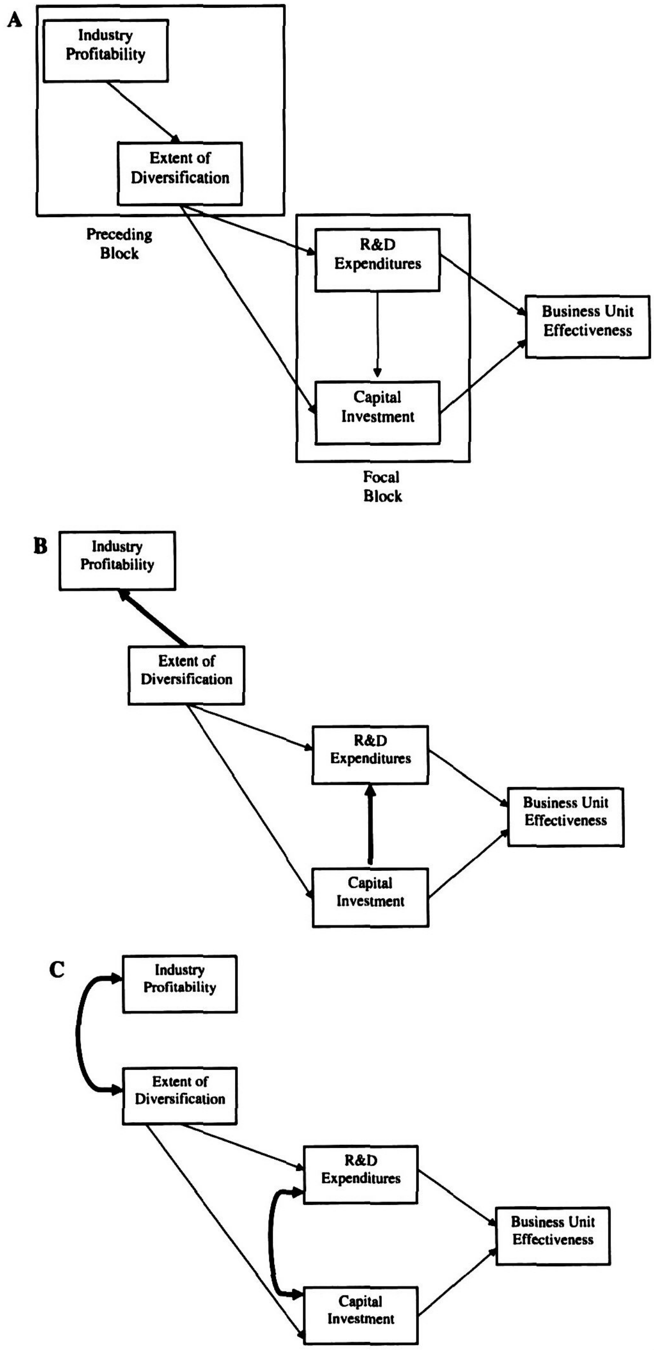
To demonstrate equivalent models in strategy research, a published strategic-management article was evaluated for the presence of equivalent models. The empirically supported model presented in Stimpert & Duhaime (1997) and two equivalent models are shown as Models A, B, and C, respectively, in Figure 1. The published model possesses both a saturated preceding block (industry profitability and extent of diversification) as well as a symmetric focal block (R&D expenditures and capital investment). In the original model (Model A), industry profitability is negatively related to diversification, and R&D expenditures are a determinant of capital investment. As can be seen in Model B of Figure 1, the direction of the relationships between extent of diversification and industry profitability and between R&D expenditures and capital investment also can be reversed without changing model fit. Model B highlights the important role of theory in assessing the threat equivalent models pose to the conclusions reached. Theoretically, it would be unlikely that the extent of a firm's diversification would affect the profitability of an entire industry, and thus, that equivalent model could be discounted. However, an equivalent model that includes a reversal of the relationship between capital investment and R&D expenditures could not be discounted so easily. Capital investment may require firms to make extensive R&D expenditures to improve their processes and products in an effort to improve the return on the firm's investment.

As shown in Model C of Figure 1, the direct effects between extent of diversification and industry profitability and between R&D expenditures and capital investment could be replaced with covariance. In assessing equivalent models that involve replacing causality with covariance, the theoretical plausibility of a construct not included in the model that could affect the correlated constructs is key to determining the danger posed to the conclusions by the equivalent model. In this example, it would seem quite possible that R&D expenditures and capital investment both could be affected by the firm's previous performance and general economic trends.

It is important to note that although we present only two possible equivalent models in this demonstration, further equivalent models could be produced from this original model. For example, after the direction of the relationship between industry profitability and extent of diversification is reversed, the three-variable block consisting of extent of diversification, R&D expenditures, and capital investment would become a saturated preceding block and all possible relationships between these variables would result in equivalent fit. In this example, the theoretical implausibility of a company's diversification's affecting industry profitability reduces the threat posed by the equivalent models spawned by the first equivalent model. Nonetheless, these model changes illustrate that the presence of one equivalent model can spur the creation of additional ones. Accordingly, researchers should be especially diligent in assessing and eliminating equivalent models.

To demonstrate statistically how equivalent models can call into question the conclusions reached in strategic-management research, we reanalyzed the results of Stimpert and Duhaime's (1997) study to further investigate the two possible equivalent models discussed above. We do this only to demonstrate how equivalent models can be quite different from the published model, not to criticize or call into question the theoretical underpinnings of Stimpert and Duhaime's study. Using the reported correlations, means, and standard deviations for the variables, AMOS 5 (Arbuckle, 1999) was used to model the data in three different ways:

Figure 1
Alternative Equivalent Models for Stimpert & Duhaime (1997, pp. 38–40)



Source: Stimpert & Duhaime (1997, pp. 38-40). Reprinted with permission from Academy of Management.
Note: Model A is the original model, Model B is the reversed casuality model, and Model C is the correlated variables model.

Table 1
Fit Indices for the Three Models

	Chi-square	*df*	*p*	GFI	AGFI	CFI	RMSEA
Original model	1.827	4	.767	.995	.983	1.000	.000
Reversed causality model	1.827	4	.767	.995	.983	1.000	.000
Correlated variables model	1.827	4	.767	.995	.983	1.000	.000

Note: GFI = goodness of fit index; AGFI = adjusted goodness-of-fit index; CFI = Comparative Fit Index; RMSEA—root mean square error of approximation.

Table 2
Standardized Path Estimates for the Three Models

Variables	Original Model	Reversed Causality Model	Correlated Exogenous Variables Model
Industry profitability and diversification	–.260*	–.260*	–.260*
Diversification and R&D expenditures	–.230*	–.167*	–.230*
Diversification and capital investment	–.067	–.160*	–.160*
R&D expenditures and capital investment	.404*	.393*	.399*
R&D expenditures and business-unit effectiveness	.102	.102	.102
Capital expenditures and business-unit effectiveness	.257*	.257*	.257*

*$p < .05$.

(a) Stimpert and Duhaime's baseline model (Figure 1, Model A), (b) a reversed causality model (Figure 1, Model B), and (c) a correlated-variables model (Figure 1, Model C).

As expected, the three models returned identical fit indices (see Table 1). As shown in Table 2, the standardized path estimates were similar but not identical across the three models. The most striking difference is the standardized path estimate representing the extent of diversification's effect on capital investment. The original model exhibited a nonsignificant value of –.07 for this relationship. In the two alternative models, the standardized path estimate for this relationship increased in strength to –.16 ($p < .05$). In sum, an important substantive insight is different for the alternative models; diversification influences capital investment in a statistically significant negative way in the alternative models, whereas this relationship was not demonstrated in the original model. It is important to note that this example model is relatively simple, and the differences in parameter estimates in a more complex model likely would be more dramatic. This example clearly supports Williams et al.'s (1996) findings that it is not just the conclusions reached about the parameters that are altered using the replacement rule that may be questionable. Instead, all parameter estimates may be altered in an equivalent model.

Prevalence of Equivalent Models in Strategy Research

Sample and descriptive statistics. We examined published applications of SEM in strategic-management research between 1984 and 2004. Each article was examined to determine (a) if an equivalent model was present and (b) what type of variation from the original model is created in the equivalent model. The studies were pulled from electronic and physical searches of nine different empirical journals: *Academy of Management Journal*, *Administrative Science Quarterly*, *Decision Sciences*, *Journal of Management*, *Journal of Management Studies*, *Management Science*, *Organization Science*, *Organization Studies*, and *Strategic Management Journal*, based on MacMillan's (1994) "forum for strategy research." To qualify for inclusion in the present analysis, the article had to contain an application of SEM and address at least one of the traditional subdomains of strategy research—strategy, environment, leadership/organization, and performance (Summer et al. 1990)

The 109 studies we identified are listed alphabetically in Table 3. The majority of the studies using SEM were published during the past 5 years, between 1999 and 2004 (59, 54%), and the remaining half were published between 1984 and 1998 (50, 46%). Most of the studies were published in either *Strategic Management Journal* (43, 39%) or *Academy of Management Journal* (25, 23%). We also coded the nature of the data (i.e., cross-sectional, experimental, or longitudinal). The majority of articles represented cross-sectional data (81, 74%) as opposed to longitudinal (27, 25%) or experimental data (1, 1%). This finding is important because the use of longitudinal or experimental data may make the reversal of causality found in many equivalent models implausible, and thus, effectively eliminate such equivalent models from further consideration. Because the issue of equivalent models applies only to the structural models, studies also were coded to determine whether they used confirmatory factor analysis only. These studies (30, 28%) then were excluded from further analysis.

Coding reliability. All 109 studies were coded independently by the two lead authors with an interrater reliability of 93%, which compares favorably to the coding-agreement levels found in similar studies (e.g., 83%—Ford, MacCallum, & Tait, 1986; 93%—Ketchen & Shook, 1996; 92%—Shook et al., 2004). All discrepancies were resolved by the authors after reviewing each article and coming to a joint decision. Items then were recoded as necessary.

Findings. The 79 studies testing the fit of a hypothesized structural model were examined to determine whether researchers acknowledged the existence of possible equivalent models. Whereas some researchers tested multiple alternative models, only one article (0.9%) acknowledged the issue of equivalent models and their potential implications. Furthermore, this same article was the only one (0.9%) that actually examined any alternative models specifically believed to be equivalent in terms of fit. Without the acknowledgement and possible elimination of these models, it is difficult for the author to state accurately that the relationships, although supported statistically, capture the true relationships between the constructs. As a result, researchers instead may be opening the door for more questions than they are answering, because the presence of alternative models may fit the data equally well but may have not been eliminated plausibly or theoretically.

Table 3
Strategy Articles That Used SEM

Author(s)	Journal	Year
Amason	*Academy of Management Journal*	1996
*Anderson, Forsgren, & Holm	*Strategic Management Journal*	2002
Barr & Glynn	*Strategic Management Journal*	2004
Bartunek & Franzak	*Journal of Management*	1988
*Baum & Wally	*Strategic Management Journal*	2003
Bensou, Coyne, & Venkatraman	*Strategic Management Journal*	1999
*Blaum, Locke, & Smith	*Academy of Management Journal*	2001
*Boyd	*Strategic Management Journal*	1990
*Boyd	*Strategic Management Journal*	1994
*Boyd & Fulk	*Journal of Management*	1996
Boyd & Reuning-Elliot	*Strategic Management Journal*	1998
*Branzei, Ursacki-Bryant, Vertinsky, & Zhang	*Strategic Management Journal*	2004
Busenitz, Gomez, & Spencer	*Academy of Management Journal*	2000
*Capron	*Strategic Management Journal*	1999
*Capron, Mitchell, & Swaminathan	*Strategic Management Journal*	2001
Combs & Ketchen	*Strategic Management Journal*	1999
*Daily & Johnson	*Journal of Management*	1997
Daily, Johnson, & Dalton	*Decision Sciences*	1999
Daily, Johnson, Ellstrand, & Dalton	*Academy of Management Journal*	1998
Dooley, Fryxell, & Judge	*Journal of Management*	2000
*Droge, Claycomb, & Germain	*Decision Sciences*	2003
Dukerich, Golden, & Shortell	*Administrative Science Quarterly*	2002
Farh, Hoffman, & Hegarty	*Decision Sciences*	1984
Finkelstein & Boyd	*Academy of Management Journal*	1998
*Fryxell	*Journal of Management*	1990
Fryxell & Barton	*Journal of Management*	1990
Fryxell & Wang	*Journal of Management*	1994
Geletkanycz, Boyd, & Finkelstein	*Strategic Management Journal*	2001
*Gerbing, Homilton, & Freeman	*Journal of Management*	1994
*Ginsberg & Venkatraman	*Organization Studies*	1995
Goerzen & Beamish	*Strategic Management Journal*	2003
*Golden, Dukerich, & Fabian	*Journal of Management Studies*	2000
*Gupta, Dirsmith, & Fogarty	*Administrative Science Quarterly*	1994
*Hagedoorn & Schakenraad	*Strategic Management Journal*	1994
Harris	*Journal of Management Studies*	2004
Heide & Miner	*Academy of Management Journal*	1992
*Hitt, Hoskisson, Johnson, & Moesel	*Academy of Management Journal*	1996
*Holm, Eriksson, & Johanson	*Strategic Management Journal*	1999
*Hopkins & Hopkins	*Strategic Management Journal*	1997
Hoskisson, Cannella, Tihanyi, & Faraci	*Strategic Management Journal*	2004
*Hoskisson, Hitt, Johnson, & Grossman	*Academy of Management Journal*	2002
*Hoskisson, Hitt, Johnson, & Moesel	*Strategic Management Journal*	1993
*Hoskisson, Johnson, & Moesel	*Academy of Management Journal*	1994
Hult	*Decision Sciences*	1998
*Hult & Ketchen	*Strategic Management Journal*	2001
Hult, Ketchen, & Nichols	*Academy of Management Journal*	2002

(continued)

Table 3 (continued)

Author(s)	Journal	Year
*Isobe, Makino, & Montgomery	*Academy of Management Journal*	2000
*Jansen	*Organization Science*	2004
Johnson & Greening	*Academy of Management Journal*	1999
Johnson, Korsgaard, & Sapienza	*Strategic Management Journal*	2002
Judge & Douglas	*Journal of Management* Studies	1998
Judge & Zeithaml	*Academy of Management Journal*	1992
*Kale, Singh, & Perlmutter	*Strategic Management Journal*	2000
*Kearns & Lederer	*Decision Sciences*	2003
Keats	*Journal of Management*	1990
*Keats & Hitt	*Academy of Management Journal*	1988
Ketokivi & Castaner	*Administrative Science Quarterly*	2004
*Knight, Pearce, Smith, Olian, Sims, Smith, & Flood	*Strategic Management Journal*	1999
*Koka & Prescott	*Strategic Management Journal*	2002
Kotabe, Martin, & Domoto	*Strategic Management Journal*	2003
Kotha & Vadlamani	*Strategic Management Journal*	1995
*Kroll, Wright, & Heiens	*Strategic Management Journal*	1999
*Larson & Finkelstein	*Organization Science*	1999
Li & Atuahene-Gima	*Academy of Management Journal*	2001
Li & Atuahene-Gima	*Strategic Management Journal*	2002
*Lin & German	*Strategic Management Journal*	2003
Lukas, Tan, & Hult	*Journal of Management*	2001
*Marcoulides & Heck	*Organization Science*	1993
Matusik	*Strategic Management Journal*	2002
McEvily & Chakravarthy	*Strategic Management Journal*	2002
*Mcevily & Zaheer	*Strategic Management Journal*	1999
*McGrath, Tsai, Venkataraman, & MacMillan	*Management Science*	1996
*Miller	*Management Science*	1991
*Miller, Droge, & Toulouse	*Academy of Management Journal*	1988
*Miller, Droge, & Vickery	*Journal of Management*	1997
*Mjoen & Tallman	*Organization Science*	1997
Murtha, Lenway, & Bagozzi	*Strategic Management Journal*	1998
*Palmer & Wisema	*Strategic Management Journal*	1999
Phan & Hill	*Academy of Management Journal*	1995
*Rothaermel & Deeds	*Strategic Management Journal*	2004
*Schilling & Steensma	*Organization Science*	2002
*Schroeder, Bates, & Junttila	*Strategic Management Journal*	2002
Sethi & King	*Management Science*	1994
Sharma	*Academy of Management Journal*	2000
*Simonin	*Academy of Management Journal*	1997
Simonin	*Strategic Management Journal*	1999
*Singh	*Academy of Management Journal*	1986
*Song & Montoya-Weiss	*Academy of Management Journal*	2001
*Spanos & Lioukas	*Strategic Management Journal*	2001
*Steensma & Lyles	*Strategic Management Journal*	2000
*Stimpert & Duhaime	*Academy of Management Journal*	1997
Stimpert & Duhaime	*Strategic Management Journal*	1997
Subramani & Venkatraman	*Academy of Management Journal*	2003

(continued)

Table 3 (continued)

Author(s)	Journal	Year
Tippins & Sohi	*Strategic Management Journal*	2003
*Venkatraman	*Journal of Management Studies*	1990
Venkatraman	*Management Science*	1989
Venkatraman & Ramanujam	*Journal of Management*	1987
Venkatraman & Ramanujam	*Management Science*	1987
*Walker & Poppo	*Administrative Science Quarterly*	1991
*Walker & Weber	*Academy of Management Journal*	1987
*Wally & Baum	*Academy of Management Journal*	1994
*Walters & Bhuian	*Journal of Management*	2004
*Wong & Birnbaum-More	*Organization Studies*	1994
*Worren, Moore, & Cardona	*Strategic Management Journal*	2002
*Yeoh & Roth	*Strategic Management Journal*	1999
Yli-Renko, Autio, & Sapienza	*Strategic Management Journal*	2001
*Young-Ybarra & Wiersema	*Organization Science*	1999
*Zahay & Griffin	*Decision Sciences*	2004
*Zaheer, McEvily, & Perrone	*Organization Science*	1998

Note: SEM = structural-equation modeling.
*Indicates the presence of an equivalent model.

Results of applying the replacing rule (Lee & Hershberger, 1990) to each of these 79 studies showed that 59 studies (75%) possessed at least one equivalent model. As noted previously, this is a conservative test, because the existence of one equivalent model often spawns more equivalent models. The presence of one equivalent model can threaten the validity of the conclusions drawn based on the apparent statistical support of the proposed relationships. Furthermore, because the different changes associated with the various applications of the replacing rule can result in considerably different conclusions, these 79 studies also were examined to determine the type of change possible from the original model (e.g. reversal of causality, correlation instead of causality, or vice versa).

The results showed that in 56 studies (71%), the directional causal paths presented could be replaced by covariance of the residuals of those factors. As a result, causal relationships could be eliminated and replaced with correlation while maintaining the same level of fit. The replacement of a causal relationship with a correlational one could have a significant effect on the interpretation of the relationship between two constructs and the subsequent relationships between other constructs in the same model. For example, when comparing Model A of Figure 1 to Model C of Figure 1, the causal relationship between capital investment and R&D investment can be replaced with a covariance relationship between these two factors without changing overall model fit. Consequently, the question becomes whether we can be confident that one of these variables is stimulating the other (e.g., R&D expenditures drive capital investment) or simply find that they tend to covary together as the result of causal relationships with a common construct not included in this model (e.g. R&D expenditures and capital investment covary based on cash flow generated by past organizational performance).

Causality was reversed in nearly half of the studies analyzed (48%). Such changes would result in completely opposite interpretations of the model while maintaining overall fit measures. For example, in an article of the market for corporate control and firm innovation by Hitt, Hoskisson, Johnson, & Moesel (1996), the strategic controls used to process external and internal information were found to be determinants of the importance of financial controls in evaluating division managers' performance. However, an equivalent model suggests that this relationship can be reversed such that the reliance on financial controls significantly influences the use of strategic controls. This altered relationship between financial and strategic controls would not affect overall model fit but would change the interpretation of the observed relationships significantly.

The 38 studies that produced an equivalent model reversing causality then were examined according to their study design. This analysis was conducted in an effort to determine the true significance of the causality-reversal issue. If replacing the rules results in an equivalent model that involves reverse causality in studies that involved longitudinal and/or experimental designs, such claims actually may be implausible. However, only 9 of these studies applied such a design. Thus, the majority of the studies in which causality could be reversed without changing the level of fit were cross-sectional in design, further questioning their causality claims.

Lastly, causality was introduced in 15 studies (19%). As a result, interpretation of the model would again vary significantly when two variables that were proposed to merely covary actually exhibited a direct affect on one another. These changes in causality were caused by the presence of a saturated preceding block in 35 studies (44%) and/or a symmetric focal block in 14 studies (18%).

Our findings are not meant to suggest that the alternative equivalent models are necessarily better than the ones presented by the authors (MacCallum et al., 1993). Instead, this analysis is designed to show that equivalent models are present in a significant amount of strategy research and that their alternative structures can result in considerably different conclusions. When future researchers accept models as being supported and further these conclusions by building on past studies that failed to consider the effect of equivalent models, theoretical development may be limited significantly. As a result, the advancement of the body of knowledge suffers.

Conclusions and Implications

Structural-equation modeling has been both heralded as a great advancement in empirical research (Kelloway, 1995) and criticized as a complex statistical tool ripe for mistake and incorrect causal interpretation (Brannick, 1995). Some opponents of SEM have stated that simpler, more familiar techniques can be used to communicate study findings better (Brannick, 1995). However, proponents of SEM claim that the quality of the application depends on the knowledge of the researcher using it (Kelloway, 1995). In other words, SEM, as well as all other statistical techniques, can be useful only if applied correctly. Structural-equation modeling presents the researcher with unique new challenges but also can provide valuable new ways of testing hypothesized relationships.

The particular problem we addressed in this article involves the concern about equivalent models. Researchers who fail to acknowledge these equivalent models and eliminate them based on study design or theoretical foundation may be limited in their findings and conclusions. Continuing to build off of these fallacious conclusions will affect theoretical advancement negatively. As a result, researchers must become aware of the potential for equivalent models in their research and the implications of failing to address such alternative models.

Our discussion has been focused on model equivalence in single-group analysis. However, in multigroup analysis, researchers may find that equivalent models may become differentiated when certain equality constraints in the models are imposed. Raykov (1997) demonstrated this point in the following manner. In testing the model equivalence of model M_a (a two-construct causal model) and another model M_b (a two-construct model with causality reversed) across two sample groups, Raykov found nonequivalence for the two-group versions of these models when the structural-path coefficients were constrained to be equal. However, when the structural paths were not constrained and other parts of the models were constrained to be equal across the groups (such as the error variances or the factor loadings), the two-group versions of these models were found to be equivalent. Likewise, the unconstrained models were found to be equivalent. In Raykov's (1997) analysis, it was one specific type of equality constraint that resulted in finding differentiated models. Such findings suggest that a high degree of diligence might be required of researchers who seek to evaluate model equivalence in multigroup analysis. Therefore, the complexities associated with identifying and rectifying the presence of equivalent models for strategic-management researchers may become even more problematic when testing relationships within multigroup models.

The current article has shown that equivalent models are a cause for concern in strategic-management research by not only showcasing how often these models are present but also highlighting the specific model ramifications of such equivalent models by replicating the statistical results presented in a published article and demonstrating the potential changes in directional paths and weight of parameter estimates in possible equivalent models. Of additional concern, we also found that researchers rarely acknowledge or test such equivalent models. Only one study explicitly tested an equivalent model and demonstrated that although this model produced equivalent fit statistics, theoretical grounding supported the original model proposed in the study (Kale, Singh, & Perlmutter, 2000). Therefore, these authors were able to eliminate the plausibility of this equivalent model based on theory. However, such acknowledgement and testing of equivalent models is quite rare in strategic-management research. Furthermore, equivalent models could be constructed for the vast majority of the studies examined. In the future, acknowledgement and testing of equivalent models must become standard practice in research using SEM. One limitation of the current study is the fact that some researchers may have eliminated these equivalent models before publication but failed to present these alternatives in their research. However, such information is vital to confidently build on prior theory testing that has applied SEM.

Beyond simply acknowledging equivalent models in the results or limitation sections, strategy researchers can be proactive in the elimination of plausible equivalent models. Researchers can take steps to decrease the plausibility of equivalent models by engaging in longitudinal or experimental designs (Breckler, 1990). Furthermore, researchers must build theoretically sound structural models and avoid treating respecified models as theoretical models. If structural models can be grounded clearly in prior theory and specification searches can be avoided, equivalent alternative models may prove unlikely and practical significance may supersede

Table 4
Five-Step Plan for Addressing Equivalent Models in SEM Research

1.	Acknowledge the potential impact of equivalent models.
2.	Identify potential equivalent models.
3.	Determine whether or not identified potential equivalent models are plausible.
4.	Eliminate, to the extent possible, any relevant models through study design.
5.	Note as a limitation the potential effect of any equivalent models that cannot be eliminated.

Note: SEM = structural-equation modeling.

statistical significance (Anderson & Gerbing, 1988). For example, in the Daily and Johnson (1997) study of CEO power and firm profitability, equivalent models would involve reverse causality. However, the longitudinal study design combined with theory could be used to discount equivalent models. As a result, equivalent models such as these could have been eliminated easily by mere acknowledgement and theoretical discussion.

When theoretically justifiable, researchers can design their models to avoid the inclusion of symmetric focal blocks, and accordingly, reduce the number of equivalent models. This may be done by adding control variables or direct effects unique to one factor in the proposed model. For example, in Baum and Wally (2003), researchers eliminated the possibility of reversing causality of a direct path between strategic-decision speed and firm performance by including past firm performance as an additional variable influencing current firm performance. Had this variable of past firm performance not been included in the model, current firm performance and strategic-decision speed would have shared all of the same predictors (i.e., formed a symmetric focal block); thus, the proposed direct influence of strategic-decision speed on current firm performance could have been reversed or replaced with covariance and still resulted in equivalent model-fit statistics. Because past firm performance was linked only to current firm performance, reversing causality or replacing the causal relationship with covariance while maintaining the same level of fit no longer was possible. Thus, the inclusion of this additional construct reduced the number of equivalent models that otherwise could have been created. If researchers can take steps during study design to include unique direct effects on proposed outcome variables, the problem of equivalent models could be reduced substantially.

To summarize our suggestions for researchers using SEM in their empirical analysis, we present a five-step plan (see Table 4) for proactively addressing equivalent models when conducting research. Unfortunately, it does not appear that any of the studies included in the current examination of the presence of equivalent models in strategic-management research follows such a plan. We suggest that researchers first must acknowledge the potential effect of equivalent models and then identify possible equivalent models. Researchers should be aware of the Stelzl's replacing rule and how it applies to their hypothesized models. Once possible models have been identified, researchers must determine the relevance of these alternative models by investigating whether each model is theoretically plausible. Researchers then should take steps to eliminate alternative relevant models through the design of the study, such as investigating a phenomenon via a longitudinal design that allows identification of the appropriate direction for predicted paths. Finally, we suggest that researchers using SEM should acknowledge the potential effect of any equivalent models that have not been eliminated through these preceding steps. The presence of these models should be included as a limitation to their presented findings.

Overall, the present article has demonstrated that strategic-management researchers must consider equivalent models when drawing conclusions and reporting findings and that such consideration does not appear to be standard practice in current strategic-management research. Failing to do so weakens the study and may lead to future problems in theory testing and development when building on prior studies. Structural-equation modeling is incredibly useful as it provides the researcher with a comprehensive approach for factor analysis and hypothesis testing. Therefore, this technique holds great promise for empirical research. Failing to apply it properly by not addressing the presence of equivalent models will serve only to damage the credibility of this valuable statistical technique.

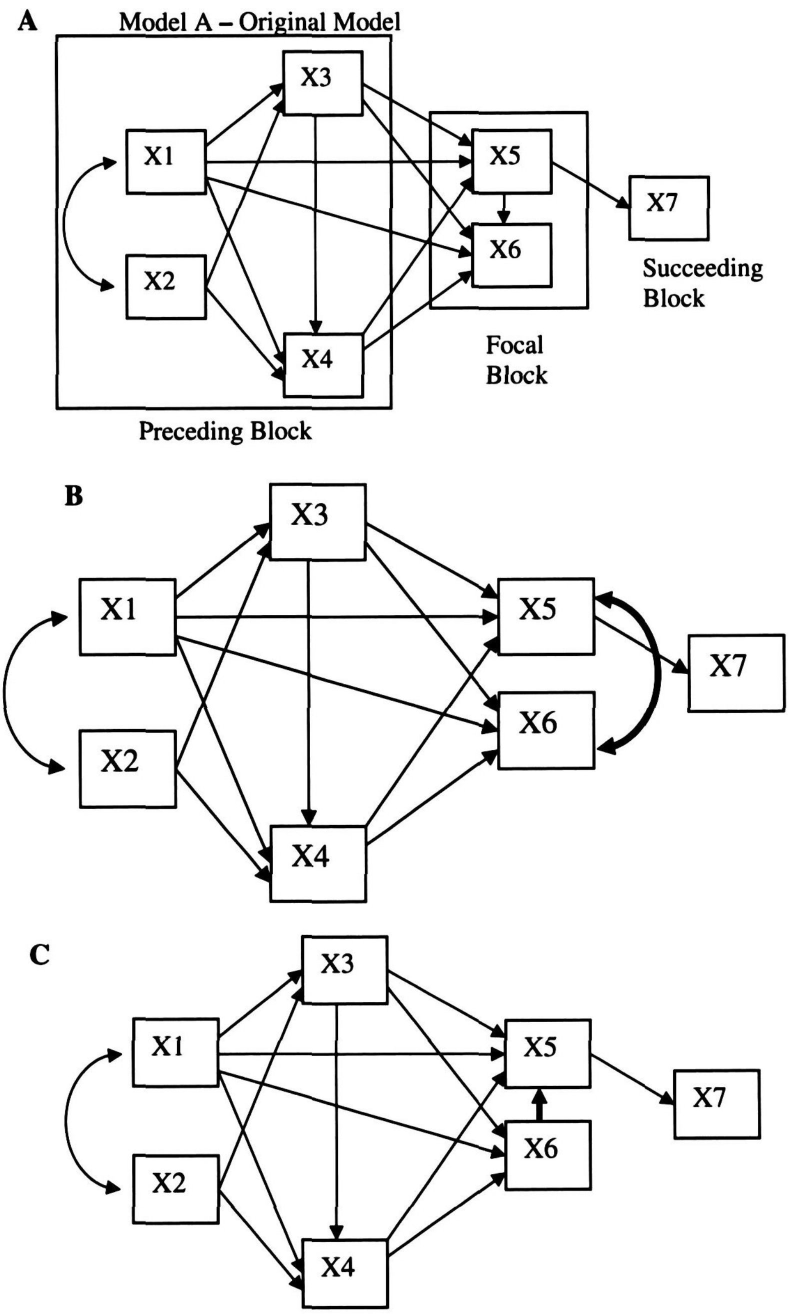
Appendix

In the example to follow, the focal-block replacements will be addressed first, followed by the preceding block changes. The following illustration of the replacement rule will be applied to the models seen in Figure A1. In Model A of Figure A1, the original model, X1, X2, X3, and X4 represent the preceding block, X5 and X6 compose the focal block, and X7 represents the succeeding block. In reviewing the focal-block rule, Lee and Hershberger (1990) state that if variables within the focal block share the same predictors, their directional path can be replaced by the covariance of their error terms, as shown in Model B of Figure A1. Additionally, special cases of focal-block replacement occur when the source and effect variables not only share the same predictors but also have no other predictors influencing either of these variables (MacCallum et al., 1993). In this case, the focal block is referred to as a symmetric focal block, and the direction of causality between the two variables in the symmetric focal block also can be reversed (Lee & Hershberger, 1990). This change is reflected in Model C of Figure A1. In this case, equivalent models are produced both by removing causality and replacing it with a covariance of error terms as well as by redirecting the causal path. Each of these changes would produce the same covariance matrix as the original model. However, both changes could have substantially different theoretical implications.

Although Lee and Hershberger's (1990) replacing rule is designed to address focal-block changes, preceding blocks can be considered focal blocks themselves in certain situations. In models in which the preceding block is partitioned so that all possible paths between the variables in that block are connected in some manner, such as through direct paths or covariance of error terms, the preceding block is referred to as saturated or just-identified (MacCallum et al., 1990), and the replacing rule can be applied. In these blocks, all available paths are accounted for, and as a result, all paths can be changed without affecting the overall covariance of the variables.

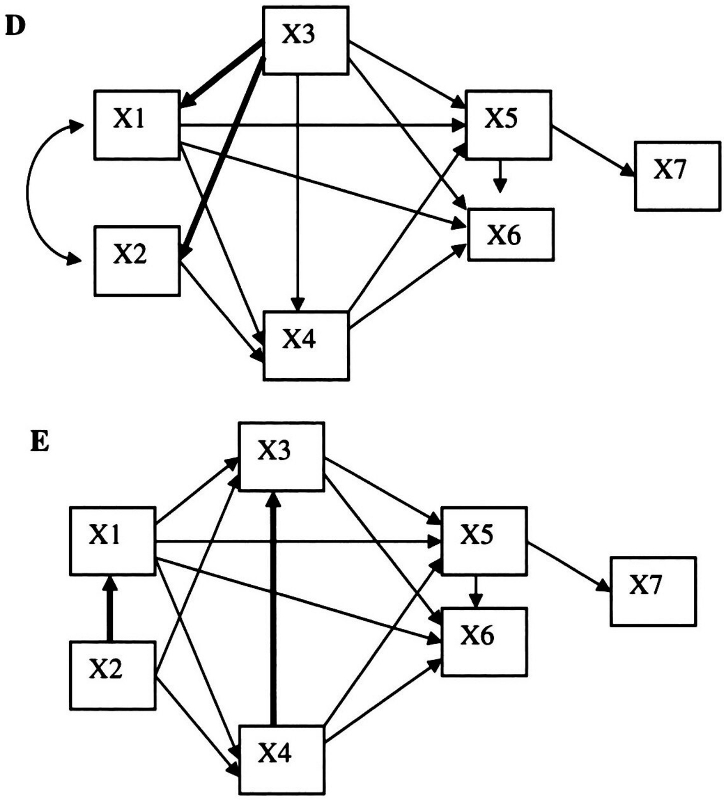
In Model A of Figure A1, the variables X1, X2, X3, and X4 compose a saturated preceding block because each variable is related to all other variables in some manner. For example, X1 is assumed to covary with X2 and to influence both X3 and X4 directly. All possible relationships—paths—are extinguished in this saturated preceding block. Consequently, all relationships can be changed without affecting the overall fit of the model. For example, in Model D of Figure A1, the direction of the paths between X3 and both X1 and X2 is reversed. Additional changes can be noted in Model E, in which the bidirectional relationship between X1 and X2 is replaced by a direct influence of X2 on X1, and the direction of the relationship between X3 and X4 is reversed. It is important to note that these examples reflect only two of the possible changes to the saturated preceding block. In actuality, 81 different combinations of these four latent variables are possible that would produce the same covariance matrix and fit levels (MacCallum et al., 1993).

Figure A1
General Illustration of the Application of the Replacement Rule to Focal and Preceding Blocks



(continued)

Figure A1 (continued)



This brief example has shown the significant effect of equivalent models on overall model meaning and interpretation. It is important also to consider that the production of one equivalent model can lead to the new models that then necessitate their own equivalent models (MacCallum et al., 1993). For example, a symmetric focal block could become a saturated preceding block in future model iterations, thus creating additional equivalent models. Also, although the replacing rule does not exhaust all possible equivalent models (MacCallum et al., 1993; Raykov & Marcoulides, 2001), it does provide valuable insight into the existence of equivalent models and their potential effect on theoretical conclusions.

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