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Contemporary process to test the theory of a research model through covariance-based structural equation modeling in business research: Is it science, quasi-science or just non-science ...?

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Contemporary process to test the theory of a research model through covariance-based structural equation modeling in business research

Is it science, quasi-science or just non-science …?

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Abstract

Purpose – The purpose of this paper is to describe potential flaws and pitfalls in the contemporary process of testing the theory of a research model in business research through the use of covariance-based structural equation modeling (CB-SEM).

Design/methodology/approach – This paper offers a foundation for discussion, debate and questioning regarding the contemporary process of testing the theory of a research model in business research through CB-SEM.

Findings – The contemporary process to test theory of a research model through CB-SEM in business research lacks to a large extent a stepwise and iterative process of an accumulation of knowledge to build sound and rigorous business theory that is both reliable and valid over time as well as across contexts.

Research limitations/implications – This paper provides an awakening toward further debate and discussion on the relevance and suitability of the contemporary process to test the theory of a research model through CB-SEM in business research – is it science, quasi-science or just nonsense?

Practical implications – The primary implication of this paper is that its content will challenge most readers' preconceptions of the topic and stimulate debate. Subsequently, it is the author's hope that the content is thought-provoking and counterintuitive. Some scholars might reject the content, while others may find it valuable.

Originality/value – The paper intends to provide counterintuitive thoughts regarding the contemporary process of testing the theory of a research model in business research through the use of CB-SEM. CB-SEM offers potentially valuable merits in business research settings, if applied and performed properly.

Keywords Structural equation modeling, PLS

Paper type Conceptual paper

Introduction

Business research reported and published in scholarly journals is increasingly based on second-generation multivariate techniques, such as covariance-based structural equation modeling (CB-SEM) (Hair *et al.*, 2010) and, in recent years, also partial least squares structural equation modeling (PLS-SEM) (Hair *et al.*, 2014).

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These second-generation multivariate techniques have a lot in common, but are nevertheless different in a number of ways. The primary purpose of CB-SEM is to *test theory*, while the primary purpose of PLS-SEM is to *develop theory* (for further meaning of "theory", see Svensson, 2013). PLS-SEM focuses on explaining the variance in the dependent variables when examining the model (Hair *et al.*, 2014), while CB-SEM is used to confirm or reject existing theory (Babin and Svensson, 2012). CB-SEM could furthermore be viewed as a *confirmatory approach*, while PLS-SEM could be viewed as an *exploratory approach* to build theory (Hair *et al.*, 2014). Both techniques, however, use a graphic interface to determine the measurement and structural properties of research models consisting of constructs, items/indicators and paths. After highlighting the differences and similarities between the two techniques, the remainder of this article focuses on CB-SEM, and not PLS-SEM.

To the author's knowledge, there are a limited number of articles that provide explicitly or critically reflective discourses to address the contemporary process of testing the theory of a research model through CB-SEM in business research in a challenging and thought-provoking way. CB-SEM has become a mainstream approach in several subject areas of business research and as such it should be scrutinized, debated and questioned. The objective of this article is, therefore, to describe potential flaws and pitfalls in the contemporary process of testing the theory of a research model in business research through the use of CB-SEM.

Importantly, this article is not about CB-SEM as a multivariate technique (i.e. it is not about its inherent algorithms or statistical technicalities), but rather, the article deals primarily with the way it is currently used and applied by scholars in business research processes. The author intends to provide counterintuitive thoughts regarding the contemporary process of testing the theory of a research model in business research through the use of CB-SEM.

The paper raises the question whether the current process of testing the theory of a research model in business research is science, quasi-science or non-science. In addition, the article also implicitly raises the question whether CB-SEM is an appropriate application or tool in research processes to explore business settings. CB-SEM is about testing the theory of a research model, but is this type of research really testing theory in business settings? Some would argue that it is over-rated and over-stated. Business settings are humanly created phenomena and involve behaviors and attitudes of people and their rationalities as well as irrationalities. The article raises the question whether it is meaningful and possible, under these circumstances and conditions, to test in reality the theory of a research model through CB-SEM.

The article provides a perspective without any desire to contradict the perspectives or views of others. Rather, it is counterintuitive to raise doubts about the relevance of the contemporary process of testing the theory of a research model in business research through CB-SEM. Furthermore, the desire is not to lambaste existing research in literature. On the contrary, it is about providing a different point of reference for further discussion, debate and consideration.

It is also intended that this article stimulates the reader's own thoughts with respect to the discussion presented in this article. Subsequently, very few references are included in the article. The works of the authors that are indeed referenced (Babin and Svensson, 2012; Hair *et al.*, 2014, 2010; Svensson, 2009, 2012, 2013) are referenced so as

not to bias the article's view of potential flaws and pitfalls in the contemporary process of testing the theory of a research model in business research through CB-SEM.

As mentioned earlier, this article's focus is limited to business research. Nevertheless, perspectives and applications from other subject areas in social science may be meaningful and relevant. The perspective given here is not intended to be dogmatic or normative, it is intended to be thought-provoking and intellectually challenging, as it is different from most other current views.

Naturally, there may be different practices in business research across varying subject areas. However, this article contends that there are merely marginal differences between the mainstream practices discussed later on in the article. The remainder of the article is structured around a number of fundamental themes that include:

- covariance-based structural equation modeling;
- the process of testing the theory of a research model through CB-SEM in business research;
- implications; and
- concluding thoughts.

Covariance-based structural equation modeling

Structural equation modeling (SEM) as a multivariate technique emerged in the 1970s. Jöreskog and Sörbom (1976) traced its roots and origins going back to the 1920s (Wright, 1921). As such, it has been characterized as an advanced statistical technique or second-generation multivariate technique (Hair *et al.*, 2014).

Over time, CB-SEM has gained broad acceptance in business research and is widely used to test theory. It is dependent on previous steps in the research process and considers complex patterns of cause-and-effect relationships (Babin and Svensson, 2012). It is, therefore, not appropriate to isolate its application (i.e. from antecedents and postcedents as well as over time and across contexts) in the research process. Such isolation may undermine the research process, causing the researcher to make misleading or false contributions to the knowledge of science.

CB-SEM can be viewed as a set of statistical techniques that seek to explain the relationships among multiple constructs. In fact, it is an extension of several multivariate techniques, such as factor analysis and multiple regression analysis. SEM is able to examine a series of dependence relationships simultaneously. In such a situation, a hypothesized dependent variable may become independent in a subsequent dependence relationship. CB-SEM estimates a series of separate, but interdependent, multiple regression equations simultaneously by specifying a structural model. CB-SEM is also a multivariate technique that allows the simultaneous estimation of multiple equations. It is essential to keep in mind that CB-SEM draws upon theory, prior experience and research objectives to distinguish which independent variables predict each dependent variable. Eventually, it tests and potentially confirms theory. It is, thus, a confirmatory method guided more by theory than by empirical results. In essence, it strives to assess how well the theory fits reality as represented by the data (Hair *et al.*, 2010).

There are six stages in a CB-SEM process (Hair *et al.*, 2010):

(1) define individual constructs;

(2) develop the overall measurement model;

(3) design a study to produce empirical results;
(4) assess the measurement model validity;
(5) specify the structural model; and
(6) assess structural model validity.

Subsequently, it is vital to position SEM in a wider context and content beyond it only being a tool to perform statistical analyses through second-generation multivariate techniques.

It is important to note that a research model should not be developed for use with CB-SEM without considering the theory that underlies the research model. In short, theory assists in developing the specifications of measurement and structural models. CB-SEM is a technique that provides comprehensive information through the use of software (e.g. AMOS to compare a so-called "proposed theory" with "reality").

The "proposed theory" (of the reality) either verifies or refutes the empirical findings in previous research and existing theory, or it is a logic-based explanation of "how the world works" as it were. The proposed theory should be empirically testable, but may not have been empirically tested yet. It is a hypothetical process that can be represented with a model. The proposed theory is based on an estimated covariance matrix providing unstandardized estimates. A path model is drawn to provide a graphical representation of the reality. It is about whether the proposed theory is true or not. "Reality" refers here to empirical findings in previous research and existing theory. They are based on an observed covariance matrix providing unstandardized estimates, and are about the actual reality (i.e. data). The graphical representation drawn by the proposed theory is tested.

SEM refers to the testing of a proposed theory against reality. The *p*-value for the chi-square test compares how similar the proposed theory (i.e. the estimated covariance matrix) is to the reality (i.e. observed covariance matrix). The closer the two matrices are to each other, the stronger the evidence of confirming the theory (i.e. fit). Subsequently, there are goodness-of-fit estimates – e.g. normed fit index (NFI) and comparative fit index (CFI) – that compare the proposed theory with reality or the degree of similarity between the proposed theory and the reality. There is also a badness-of-fit estimate – e.g. root mean square error of approximation (RMSEA) – that indicates the degree of difference between the reality and the proposed theory (i.e. can be thought of as the opposite of goodness-of-fit indicators).

A contemporary process to test theory of a research model through CB-SEM

As previously mentioned, the measurement and structural properties of a research model through CB-SEM are commonly derived from previous studies and existing theory. For example, researchers create a measurement model based on previous scales of construct applications (i.e. consisting of definitions, constructs and items/indicators). Furthermore, each hypothesized relationship in the structural model is based on empirical findings and conclusions drawn in previous studies regarding cause-and-effect between constructs.

Figure 1 illustrates a contemporary process to test theory (i.e. the reality) of a research model (i.e. the proposed theory) in business research through CB-SEM.

Labels (i) to (v) in Figure 1 represent fragments from previous studies (i.e. not entire studies, but only selected relevant components) and existing theory developed over time and across contexts. Each fragment of a study or theory is used to substantiate either measurement or structural properties of a research model to test theory (Hair *et al.*, 2014).

Therefore, this article argues that the contemporary process to test theory of a research model through CB-SEM is based on a fragmented approach of business reality. Fragments from different empirical studies and different sources in theory are brought together in the development of a research model that is to be tested. Subsequently, the contemporary process of CB-SEM may be characterized as "taking a little bit from here and a little bit from there".

In essence, it is an approach where measurement and structural properties are selected arbitrarily from different sources that are not necessarily interconnected, but are then melted together assuming that they are all linked together. The linkage between fragments in research models appears to be mostly superficial. For example, separate quotes and specific conclusions in previous studies underpin the substantiation of structural properties of hypothesized relationships in research models. Separate definitions and measurement properties of constructs are linked to each other. This article debates that it is doubtful whether this kind of process is proper science, as definitions, constructs and items/indicators are not empirically interconnected. It appears to be merely quasi-science logic or, at worst, non-science.

Subsequently, this article opines that it may not be a sound or rigorous process of science to bring fragments of measurement and structural properties between constructs together and then create a research model that assumes making a contribution to existing theory without first being thoroughly replicated and validated. The dilemma in business research is that developed and tested research models are only on rare occasions fully replicated and validated; only fragments are taken from them and put together with other fragments into research models, ignoring the fact that CB-SEM is a full information multivariate technique. The contemporary process appears to be violating the underlying logic to test theory of a research model through CB-SEM in business research.

Implications

The contemporary process to test the theory of a research model through CB-SEM in business research, as described previously in Figure 1, makes valuable contributions to the application of the methodology of CB-SEM and demonstrates how its use may or may not contribute to theory. The increasingly high proportion of publications that

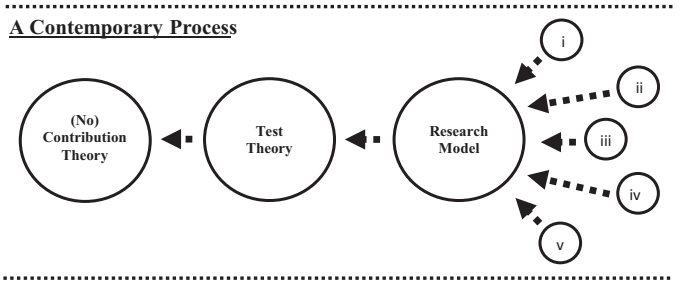
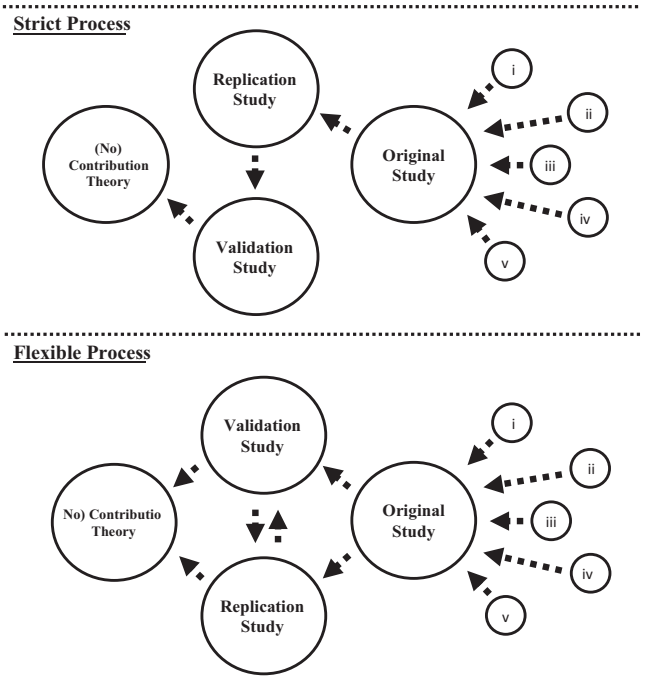


Figure 1.
A contemporary process to test theory of a research model through CB-SEM in business research

contain CB-SEM models is regarded by a significant proportion of the business research community to represent high-quality research. It is increasingly seen as a role model for contributing to relevant and important scientific progress within business subject areas and disciplines.

The empirical findings generated from application of CB-SEM are often accepted as scientifically sound and rigorous, providing both reliable and valid research findings. Subsequently, research based on CB-SEM has become commonplace in getting articles and reports published in reputable scholarly business journals. CB-SEM appears to be a mainstream business research format that is increasingly performed and has led to an evolving and emerging methodological paradigm shift in subject areas of business research (e.g. marketing). Although this is the case, not everyone follows it.

While this article agrees that CB-SEM has its merits in business research settings, if applied and performed properly, the contemporary process to test theory of a research model through CB-SEM in business research largely lacks a stepwise and iterative process (i.e. both replication and validation studies of multiple iterations) – an accumulation of knowledge to build sound and rigorous business theory. It should be reliable and valid over time as well as across contexts. Replications and validations of original studies (i.e. complete studies) are rare in business research, as shown in Figure 2 (for further details about the meaning of "replication" and "validation", see Svensson, 2013). It is, therefore, unfortunate that the interpreted contemporary process to test theory fails in this respect. In fact, it is not very scientific at all.



Source: Adopted from Svensson (2013)

Figure 2.
STRICT versus FLEXIBLE processes to test theory of a research model through CB-SEM in business research

Two different processes may be distinguished, as shown in Figure 2: strict and flexible. The strict process to test theory is based on a research model of an original study that is first replicated and then validated through at least two additional studies before it could possibly make a contribution to existing theory. The flexible process, instead, offers the possibility of making a contribution to existing theory through either one additional replication or a validation study in relation to the original study (Hair *et al.*, 2014). However, both processes are based on the fact that the measurement and structural models of research are the same, while there are several differences that can also be identified, as shown in Table I.

An original study based on CB-SEM is *unique* in terms of the measurement and structural models – while methodology, data analysis techniques and context of research are not unique in relation to previous studies. A replication study based on CB-SEM is a copy of an original study (i.e. measurement and structural models, methodology and data analysis techniques are the same) in the *same context* of research, but in *another setting*. A validation study is different from original and replication studies applying the same measurement and structural models, methodology and data analysis techniques, but in a *different context and another setting*.

In short, this article argues that it is not appropriate to claim a contribution to theory if there is no substantiation of replication and validation studies (i.e. one or more of each).

Considering the fact that CB-SEM is a full information multivariate technique, the outcome of CB-SEM will be altered when a research model is changed by:

- omitting or aggregating one or several constructs;
- changing measurement properties of constructs (e.g. definitions and items/indicators); or
- changing structural relationships between constructs (e.g. path direction of hypothesized cause-and-effect relationships).

This article contends that the contemporary process to test the theory of a research model in business research through CB-SEM frequently omits replication and validation studies, which thereby make no contribution to existing theory. CB-SEM appears to be an approach that resembles a scientific process, or, at worst, a non-scientific one. The interpreted contemporary process to test the theory of a research model through CB-SEM takes a dangerous shortcut to making theoretical contributions, which omits the crucial phases of empirical replications and validations over time and across contexts, thereby making seemingly valid and reliable contributions to existing theory. It is potentially a fatal flaw that leads to false and non-scientific contributions to theory. In addition, it may undermine the credibility of research disciplines. The belief that

Table I. Distinguishing criteria of original, replication and validation studies

Study	Measurement model	Structural model	Methodology	Data analysis techniques	Context	Occasion (time)
Original	Unique	Unique	Not unique	Not unique	Not unique	Different
Replication	Same	Same	Same	Same	Same	Different
Validation	Same	Same	Same	Same	Different	Different

business settings resemble settings in natural science (e.g. law-bound relationships) appears to be driving business research astray from truly scientific practices in some subject areas.

There appears to be a rush or a push -through in the process of confirming and fabricating proposed theories to be tested – i.e. fragmented substantiations to test theory. This has led to a lack of sound and rigorous nomological frameworks of constructs in business research as well as a lack of consensus in research communities and in literature. The empirical foundations necessary to make theoretical contributions through the contemporary processes to test theory through CB-SEM in business research appear not only to be insufficient, but surprisingly poor in the absence of stepwise and iterative processes of replication and validation studies.

Subsequently, business theory appears to be suffering from fragmentation, where there is deficiency of validity and reliability of measurement and structural properties of constructs in existing theory over time and across contexts. For example, the measurement properties of constructs (i.e. definitions and items/indicators) are not universal. There is also no consensus in many subject areas of literature since numerous options (e.g. models, frameworks and scales) are evident with respect to the same phenomenon confirming or falsifying previous empirical findings – not because they have necessarily been adapted across contexts or have been developed over time, but because they have not been properly replicated and validated in previous studies. Stepwise and iterative processes (replications and validations) to test the theory of identical research models through CB-SEM are rarely seen in the contemporary processes of business research. It is questionable and troublesome that existing business theory in part does not rest upon truly scientific foundations.

Once measurement and structural models have been successfully replicated and validated, changes (i.e. omissions and/or aggregations of constructs, measurement and structural properties) can be made to it to extend the nomological framework. A reason why replications and validations based on CB-SEM are rare in business research may be the fact that it is difficult to confirm the empirical findings in an original study in subsequent replication and validation.

Subsequently, this article suggests that genuine and solid contribution to theory cannot be achieved without replication and validation studies that confirm previous empirical findings (Svensson, 2013). This is, however, challenging due to the complexity and dynamics involved in business settings over time and across contexts. This may then be an indication that CB-SEM is not an appropriate multivariate technique on which to build theory in business research. Evidently, CB-SEM appears to offer an arena of scientifically sound and rigorous research processes to test theory of a research model generating sophisticated estimates based on advanced algorithms. However, the question remains unanswered as to why business research tends to ignore the importance of replication and validation studies in the quest to make contributions to theory (e.g. a nomological framework).

It can also be argued that the contemporary research processes to test theory of a research model in business research, based on CB-SEM, suffer from grounded flaws and pitfalls in the application of an appropriate methodical process. In fact, business research appears to be fragmented and often does not build on previous studies and existing theory.

As stated previously, it has to be kept in mind that CB-SEM is a full information technique and can be likened to a panel debate. During a panel debate, the discussion will inevitably change, as the composition of panelists or participants changes, even though the topic remains unaltered. CB-SEM works similarly – one cannot make changes to a research model without changing the covariance matrix. This raises serious concerns regarding the interpreted contemporary process to test the theory of a research model through CB-SEM in business research, as the underlying covariance matrix will change if "something" (e.g. one or several constructs, paths and/or items) in the research model to test theory is changed.

Four situations are shown in Figure 3. The first situation refers to the research model from an original study. The second situation refers to one or several constructs, paths and/or items that have been excluded (i.e. purposely omitted) from the original research model. The third situation refers to one or several constructs, paths and/or items that have been added (i.e. amended) to the original research model. In the fourth situation, one or several constructs, paths and/or items have been changed (i.e. neither omitted nor amended) in relation to the original research model.

The underlying covariance matrix changes from situation (i) if any changes, as indicated in situations (ii), (iii) and (iv), are effected. This means that the original model is neither replicated nor validated. This should, therefore, be seen as an alteration of an original model that has not yet been replicated or validated. The approach to test the theory of a research model through CB-SEM, as addressed in Figure 2, should be applied to the original study, before the changes presented in the situations in Figure 3 are made to make a genuine theoretical contribution in business research.

Expressed differently, there is always a butterfly-effect (i.e. a subsequent effect somewhere that changes the ball game in focus to some degree – i.e. the content and context of a research model). It would be like comparing apples and pears; they may be comparable in some aspects, but they are still not the same. When there is no stepwise and iterative process (i.e. both replication and validation studies of multiple iterations) in place that can test and retest a research model over time and across contexts, it becomes dubious and spurious to build theory based on pieces or fragments from multiple sources.

Connecting and reconnecting PLS-SEM and CB-SEM provides researchers with a combination of multivariate techniques to potentially enhance the outlined contemporary process of developing and testing theory in business research (Table II). This will assist in indicating the extent to which there are similarities and differences between the results from PLS-SEM and CB-SEM. Preferably, the similarities should be more than the differences, pointing to an acceptable degree of validity and reliability. The results will, however, always differ, as these data analyses are based on different algorithms and also assess measurement and structural properties of research models differently. An original study could

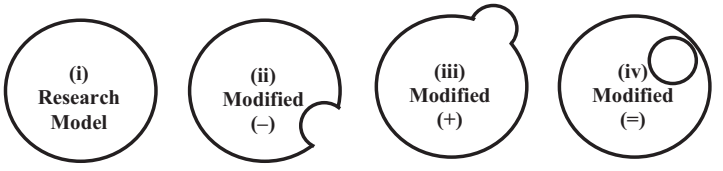


Figure 3.
Change in research model causes change in covariance matrix

typically utilize PLS-SEM followed by CB-SEM. CB-SEM, in turn, could be used in replication and validation studies of the same research model. When a research model is slightly modified, CB-SEM could initially be used and PLS-SEM subsequently to verify the consistency of results.

Fortunately, a counterweight to the predominant view on CB-SEM has evolved in recent years (Hair *et al.*, 2014), where PLS-SEM offers other opportunities and conditions to perform quantitative research and develop theory. Though it is at first sight not remarkably different, its underlying logic and algorithms are different, as indicated previously. The successive emergence of second-generation multivariate techniques to develop theory, such as PLS-SEM, is needed to complement quantitative research approaches. The future will indicate whether or not PLS-SEM contributes to enhanced validity and reliability of theory over time and across contexts in business research.

Although many in the business research community believe that quantitative research approaches are superior rather than complementary to qualitative approaches, and vice versa, it should be kept in mind that theory in business settings should not be based solely on quantitative research designs, but qualitative research designs should also be considered.

Concluding thoughts and reflections

SEM techniques – such as CB-SEM and PLS-SEM – are only tools in the research processes involving antecedents (e.g. item structures and metric measures) and postcedents (e.g. developed and tested theory, replications and validations – Babin and Svensson, 2012). It is not a magic formula or a holy grail.

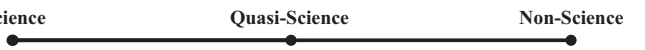
One has to remember that research processes are also governed by the logic and truth: "rubbish in – rubbish out!". Figures 1-3 have attempted to pinpoint the simplicity and insufficiency of the outlined contemporary process to test theory of a research model through CB-SEM in business research. What is evident is that it should involve a sequence of parallel and successive steps of validity and reliability in research processes and other aspects of relevance in SEM processes (Babin and Svensson, 2012).

It is furthermore clear that business research, based on CB-SEM, is making contributions to existing theory based on judgmental grounds (i.e. the views of editors and reviewers) and not truly through empirical findings. Scientifically, it is

Table II.
Combining CB-SEM and PLS-SEM

	Research model	
	Original	Modified
Multivariate technique	1st PLS-SEM 2nd CB-SEM	1st CB-SEM 2nd PLS-SEM

Figure 4.
The contemporary process to test theory through CB-SEM – science, quasi-science versus non-science



not until a research model has been repeatedly tested over time and across contexts that it makes a real contribution to theory. Currently, the research community has become a playground for arbitrary views regarding reality, rather than proof-driven evidence based on empirical findings. It is surprising and unfortunate that the process to test theory in research models in business research through CB-SEM has become highly subjective, rather than being based on valid and reliable empirical findings.

Studies often do not even describe the population their sample represents, so they are simply confirming a theory that applies only to their sample (Hair *et al.*, 2014). It is often assumed that empirical findings extrapolate to the population when this claim is not appropriate. Potentially, the authors who use CB-SEM neglect to fully disclose the limitations of the method and the results. Subsequently, the doubt arises whether empirical findings limited to a single sample really make a contribution to theory. Perhaps much of what has been published based on CB-SEM gives a disproportionate impression of the value of this method to the research discipline and theory it is over-populating.

Given the spectrum as shown in Figure 4, the question is how the contemporary process to test the theory of a research model through CB-SEM in business research can be characterized. The author is of the opinion that the reader should reflect on it with an open mind, without blinkers and without the preconceptions and preconceived lessons learned or heard from others of what dominates the subject area or research discipline regarding CB-SEM. The question the reader should really ask is: "What is my opinion and where would I place my tick on this spectrum in Figure 4 […] […] and importantly, why […] ?"

Evidently, the content and topic addressed by the author is debatable and challenging, as well as hopefully thought-provoking and counterintuitive. Some scholars will reject it as complete nonsense, while others may find value in it. The author hopes that it is at least an eye-opener toward further debate and discussion on the relevance and suitability of the contemporary process to test the theory of a research model through CB-SEM in business research – is it science, quasi-science or just non-sense?

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