Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 15 / ISSUE 2 / MAY 2020 / I-V

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762020000200101

Editorial: How to Prevent, Detect and Control Common Method Variance in Electronic Commerce Research

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Co-Editor
May 2019

Introduction

Many empirical studies submitted to the *Journal of Theoretical and Applied Electronic Commerce Research* make use of questionnaire instruments to collect data. Usually, these questionnaires contain self-report scales to measure the explanatory or predictor constructs, as well as the dependent or criterion constructs. In addition to this, the data used in the analyses is often collected over a specific timeframe, so a single sample provides all the data for the study.

When, in an electronic commerce study, all scale items have been measured by means of a single questionnaire survey and at the same time, there is the prospect that the tested relationships among the constructs might be distorted by the effect of common method variance (CMV) - a serious and problematic issue that has the potential to jeopardize the validity of the research findings [19]. The bias generated by CMV, known as *common method bias*, appears when the estimated relationship between one construct and another might be inflated; put differently, CMV produces a systematic covariation above the true relationship between the scale items [10]. As a consequence, the altered values of the observed correlations and of other relevant indicators might lead to: either incorrect estimates of the reliability and convergent validity constructs in the study, or erroneous parameter estimates related to the magnitude and the significance of the relationships among constructs [14].

For example, a long questionnaire instrument, used in a cross-sectional study to collect all the data from a sample, might become a potential cause of CMV [7], [14]. Because questionnaires require substantial cognitive effort to generate accurate responses [7], toward the end of a long questionnaire, respondents might feel fatigue and thus be less willing to respond truthfully. Consequently, respondents might be less thorough [9] and give responses more consistent with within-scale measures, and perhaps also across-scale measures [21]. In turn, this can lead to incorrect considerations about the scales' reliability and validity, and the causal and moderating pathways between constructs [14].

Other potential sources of CMV include, but are not limited to: the respondent's limited ability to respond to the scale items, scale items' complexity, items' ambiguity, double-barreled items, items that require retrospective recall, the respondent's lack of experience of thinking about the topic at hand, the respondent's low involvement in the topic, the salient positioning of scale items of a criterion construct (so respondents infer that there are causal relationships with other constructs), the respondent's apprehension about being evaluated, the respondent's reluctance to self-disclose, the respondent's need to show socially acceptable behavior, the respondent's tendency to agree (or disagree) with any assertion made in the scale items regardless of their content, the respondent's disposition to offer extreme responses, the respondent's implicit presumptions about the topic, and the respondent's willingness to offer consistent answers to a series of questions [3], [7], [9], [13], [15].

Methods for Coping with CMV

Survey methodology literature has identified two main approaches to deal with CMV issues. First, a series of procedural remedies, to be applied by researchers in the early stage of questionnaire design, have been suggested to prevent the emergence of CMV [9], [13]. These procedural remedies are preventative (i.e. ex-ante) because they seek to increase the respondent's willingness to answer a questionnaire and provide truthful, non-influenced responses. Second, a range of statistical techniques have been offered to allow researchers to assess the effectiveness of the previous procedural measures so as to detect and mitigate the effects of CMV post-hoc [8], [15], [25], [26].

Research in the CMV area recommends a mixed methodological strategy, which combines the use of preventative measures along with effective ex-post statistical techniques [5].

Preventative Remedies

The possibility of CMV arising in an electronic commerce survey might be dismissed ex-ante, by implementing a variety of preventative measures at the research design stage. Some of the most advisable ex-ante procedures recommended by the literature to reduce the threat of CMV are summarized here.

- Probably, the best option consists of using two or more information sources to gather data about the constructs in the model. It is particularly worthwhile to measure the dependent or criterion constructs using a different information source than the one employed to measure the explanatory constructs. Alternatively, researchers might collect the data about some key constructs at different points in time, in different locations or using different media [13], [14].

- With the purposes of preventing respondents from misinterpreting scale items and reducing random responses, it is highly advisable to: make the wording of the questions clear, concise and accurate; define or illustrate unfamiliar or complex concepts with examples; and adapt the scale items to the focal context of the study [6], [9], [13]. It is also suggested that pretesting methods be used to improve and refine the item wording [7].

- A guaranteed anonymity for the survey respondents and explanations that there are no correct or incorrect responses help to diminish respondents' reluctance to being evaluated and make them less likely to provide answers that are socially desirable and consistent across questions [11], [13], [20]. Similarly, researchers might let respondents know that data gathered will be securely protected, aggregated (so only researchers will have access to individual responses) and used only for research purposes, since this encourages potential respondents to participate and provide honest responses [17], [20].

- So as to control for bias effects caused by the salient positioning of some questions and to reduce the effects of the respondent's desire for consistency [15], researchers might change the questions' order and spatially separate the scale items of predictor constructs from those measuring criterion constructs [13].

- The inclusion of both positively and negatively worded items for the same scale might help to prevent extreme responses and acquiescence (or disacquiescence) response style biases [3].

- Because it is not always possible to keep the questionnaire short and multi-item scale measurements can be perceived as repetitive, it is worthwhile to reduce common scale properties by: reversing the wording of some scale items, presenting scale items in diverse formats, and using varying types of scale response options and anchor labels [13], [14]. This helps to avoid respondents perceiving the similarity of the response formats and thus using their responses to one question to answer subsequent questions [14].

Post-hoc Techniques

A variety of ex-post statistical techniques have been suggested to check the effectiveness of the ex-ante remedies. If favorable, the results yielded in these tests will allow electronic commerce researchers to discard systematic response biases and give evidence that the potential existence of CMV does not significantly affect the interpretation of the results (see summary in Table 1).

Two of these post-hoc techniques are Harman's single-factor test, also known as *Harman's one-factor test* [15], and the correlation matrix procedure [2]. Although relatively widespread among electronic commerce researchers, these techniques only allow researchers to detect CMV. By contrast, the directly measured latent factor technique, tagged also as *measured CMV cause model* [18], and the measured response style technique [22], [23] let researchers not only detect CMV but also examine the bias generated by CMV, which allows them to measure the CMV and eliminate its undesirable effects. However, they require having previously identified the potential sources of CMV.

A third group of techniques exists that includes the correlation-based marker technique [8], the general factor covariate technique [15], the confirmatory factor analysis (CFA) marker technique [26] and the unmeasured latent method factor technique [25]. These techniques effectively uncover and control for CMV; and might be applied without having to establish hypothetical sources of CMV.

Techniques that Only Detect CMV

Harman's single-factor test is a simple and widespread statistical tool that detects CMV [5]. Following this technique, researchers introduce all the scale items into an exploratory factorial analysis and examine the unrotated factor solution to obtain the number of components with eigenvalues greater than 1 that explain the aggregate variance. The assumption here is that, if CMV exists, only one component will account for more than 50% of the covariance between the items and the criterion constructs [13], [15]. Electronic commerce researchers should be aware, however, that the use of Harman's single-factor test is not exempt from possible drawbacks, mainly because the test is not accurate enough to uncover small to moderate levels of CMV [4]; and also because it only spots CMV, so it does not offer mechanisms to quantify CMV and control for it [10].

Another simple test to detect possible CMV problems was initially suggested by Bagozzi et al. [2], who highlighted the effects of CMV on the discriminant validity of the constructs. This method was applied by Pavlou et al. [12] in electronic commerce research, and examines the correlation matrix between all research constructs. When applying this technique, researchers interpret a very high correlation between any pair of constructs in the model (greater than 0.9) as a sign of CMV effects. Similar to Harman's single-factor test, this procedure can just be used to obtain evidence of the presence of CMV.

Techniques that Examine the Potential Sources of CMV and Control their Effects

Apart from using Harman's single-factor test and the correlation matrix procedure, it is recommended that researchers apply other statistical techniques, such as the directly measured latent factor method and the measured response style technique, that allow researchers not only to detect CMV but also to assess the nature and the magnitude of the bias [14].

Through the directly measured latent factor method, researchers model some potential sources of CMV (e.g. a respondent's tendency to agree; willingness to give socially desirable responses) as latent constructs. This lets them quantify the potential biases and partial out their effects on the research variables [24]. An important limitation of this technique, however, is that there are some other potential causes of CMV that cannot be directly measured - including consistency biases and common scale properties [13].

When the possibility exists that CMV is caused by scale response options that are prone to acquiescence response bias, extreme response styles or midpoint answers, the measured response style technique can be used. Here, researchers systematically control the common response styles and remove their effects by considering multiple, specifically designed indicators that measure simultaneously all response styles [23].

Techniques to Control for CMV without Identifying its Sources

However, if the researchers are not aware of potential CMV sources, or there are no valid measures of CMV sources available, they might employ other methods to uncover and partial out CMV, such as the correlation-based marker technique, the general factor covariate technique, the CFA marker technique or the unmeasured latent method factor technique.

The correlation-based marker technique controls for measurement errors despite not having identified their nature. In the research design, researchers include an additional construct (tagged as a *marker*) that, on the grounds of relevant literature, is utterly unrelated to at least one construct in the study. Thus, the correlation between the marker's scale items and any (theoretically) unrelated construct can be interpreted as an indicator of CMV effects [8]. Next, researchers exclude the effects of CMV by removing from all correlations the minimum correlation between the marker construct and the theoretically uncorrelated constructs.

Likewise, the general factor covariate technique does not take into consideration possible sources of CMV and is based on partial correlation procedures [15]. With this technique, an exploratory factor analysis of the research items is used in order to have an approximation of CMV through the scores obtained in the unrotated first factor. In the event that there are CMV issues, it is expected that the first factor captures the most important part of the common method bias from all initial research variables. If so, correlations are then partialed out. Although this procedure is relatively easy to perform, it suffers from two main shortcomings: it does not consider possible measurement errors, and it cannot distinguish the variances coming from the true causal links between the constructs from those due to CMV [13].

Because the abovementioned techniques based on partial correlation procedures do not control some frequent CMV sources that are unrelated to a marker construct [13] (such as the respondents' inner assumptions about the connection between relevant constructs in the study), researchers might use the CFA marker technique [26]. This method consists of a three-step CFA using SEM, which is performed by including marker latent variables with marker scale items that share identical characteristics with those that measure relevant constructs. This allows researchers to: test the existence of CMV effects; quantify to what extend CMV affects constructs' reliability; and examine the sensitivity of the estimates of the correlations between constructs to CMV [14], [26].

Finally, through the unmeasured latent method factor technique, researchers introduce a first-order construct, known as *method factor* [1]. This method factor does not have scale items of its own. Rather, the scale items of this factor are those associated with the constructs under study that are presumably affected by CMV [25]. Researchers load all the items on the constructs and then examine the significance of the structural indicators in the model, both with and without the method factor. This technique allows researchers to model the impact of CMV at the measurement level without previously determining the specific cause of CMV. Nevertheless, and similarly to the marker techniques, this method removes all variance between the common method factor and the construct studied, including variance that is not produced by CMV [16].

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ISSN 0718–1876 Electronic Version
VOL 15 / ISSUE 2 / MAY 2020 / I-V
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DOI: 10.4067/S0718-18762020000200101

Table 1: Post-hoc statistical techniques to test for CMV

	Do they detect CMV?	Do they require knowing the potential sources of CMV?	Do they measure CMV and eliminate its effects?	Studies
Harman's single-factor test	Yes	No	No	[4], [5], [10], [13], [15]
Correlation matrix procedure	Yes	No	No	[2], [12]
Directly measured latent factor method	Yes	Yes	Yes	[13], [18], [24]
Measured response style technique	Yes	Yes	Yes	[22], [23]
Correlation-based marker technique	Yes	No	Yes	[8]
General factor covariate technique	Yes	No	Yes	[13], [15]
CFA marker technique	Yes	No	Yes	[14], [26]
Unmeasured latent method factor technique	Yes	No	Yes	[16], [25]

Conclusions and Recommendations

In electronic commerce mono-method survey studies, CMV is a source of potential measurement errors because it might systematically inflate the values of the correlations and other relevant statistical indicators in the empirical analyses. This can lead the authors either to offer new theoretical accounts for relationships among constructs that are apparently acceptable (although they are not empirically supported) or to overturn a prior theory on the basis of unwarranted empirical findings.

Time and cost considerations might restrict the data collection options of authors writing for the *Journal of Theoretical and Applied Electronic Commerce Research* and lead them to use a single questionnaire survey. Authors who use cross-sectional surveys cannot overlook the impact of CMV and, thus, should use convincing techniques that help to prevent and control for CMV, and be aware of the advantages and limitations of each of these methods.

The application of a range of preventative procedures and a combination of post-hoc techniques are highly encouraged as a feasible and effective route to cope with CMV and offer valid findings for theory building in the electronic commerce arena. Introduced at the research design stage, preventative procedures are aimed to help researchers reduce the threat of common method variance. These ex-ante procedures lead to careful construction of the questionnaire instrument so as to mitigate the chance that the measurement items will be misunderstood by the respondents, and ensure the responses are anonymous and confidential. These procedures can also reduce the effects of a respondent's willingness to provide: (a) consistent answers, (b) extreme answers, (c) acquiescent responses or (d) answers through a relatively automatic process, which requires minimum cognitive effort.

Once the data has been collected, ex-post statistical techniques help researchers to uncover, or even partial out, the impact of CMV before analyzing the data. A first group of post-hoc techniques exist that help to straightforwardly detect CMV (i.e., Harman's single-factor test and the correlation matrix procedure). But because these approaches cannot control for CMV, it is suggested complementing them with more sophisticated methods. A second group of statistical remedies let researchers not only test CMV but also measure and partial out the bias generated by CMV (i.e., the directly measured latent factor method and the measured response style technique). However, these techniques require previously knowing the sources of CMV, which is not always possible. Finally, there is a third group of techniques that can be applied to test and control for CMV without having to identify and measure the sources of CMV (i.e., the correlation-based marker technique, the general factor covariate technique, the CFA marker technique and the unmeasured latent method factor technique).

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