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Assessing Common Methods Bias in Organizational Research

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The potential inflation of correlations between measures assessed via the same method (e.g., self-report) is well known. This study applied CFA models to 24 multitrait-multimethod correlation matrices in order to assess the extent of common methods bias (CMB). While not trivial, CMB is often minor in magnitude

The influence of common methods variance (CMV) has been a pervasively cited concern in organizational research (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). As outgoing editor of Journal of Applied Psychology, John Campbell explicitly cited exclusive use of self report measures as an indication that a study contributes little to the literature (Campbell, 1982). Additionally, reviewers continue to cite CMV as a source of concern, particularly for research involving self-report measures (Spector, 2006). As a result, several researchers have investigated the extent to which CMV has biased correlations in psychological and organizational research (e.g., Crampton & Wagner, 1994; Doty & Glick, 1998). While these studies prove insightful as to the nature and extent of the effects of common methods of measurement, they differ considerably in methodology and scope. In this study, we examined the extent to which CMV is pervasive in organizational research as well as the extent to which these methods are likely to have biased trait correlations.

Common Methods Variance v. Common Methods Bias

In the decades since Campbell and Fiske (1959) unveiled the multi-trait multi-method (MTMM) model, many researchers have investigated the extent to which common methods may inflate correlations among variables. Campbell and Fiske initiated concern regarding common method effects as they noted that when MTMM heterotrait-monomethod correlations are higher than heterotrait-heteromethod correlations, some portion of the variance in a measure can be attributed to the method used. This variance, CMV, is a form of systematic error variance and can cause observed correlations among variables to differ from their population values (Doty & Glick, 1998).

Recently, Podsakoff et al. (2003) summarized the CMV literature and identified a number of potential sources of CMV organized into four major types. These include sources due to having a common rater (e.g., social desirability, leniency), item characteristic effects (e.g., item ambiguity), item context effects (e.g., priming effects, grouping of items), and measurement context effects (e.g., simultaneous measurement of predictor and criterion variables). In sum, there are a number of ways in which methods can be similar, any of which can give rise to CMV.

While the effects of CMV are virtually universally acknowledged, one important consideration is that CMV does not necessarily imply an upwards bias in correlations among variables (Doty & Glick, 1998). In other words, CMV is not the same as common methods bias (CMB; Spector, 2006). Whereas CMV implies that variance in observed scores is partially attributable to a methods effect, CMB refers to the degree to which correlations are altered (inflated) due to a methods effect. This distinction is important because a significant effect of CMV may not be particularly problematic if the inflation (i.e., bias) in the correlations among measures is trivial in magnitude. As such, the important research question is not whether CMV has a significant effect (i.e., accounts for significant variance in scores), but whether the CMB is large.

Methods of assessing CMV and CMB

As stated previously, CMV and CMB have been investigated several times, with different authors arriving at decidedly different conclusions regarding the extent to which CMV/CMB is problematic. For example, Spector (1987) concluded that CMV is trivial in nature, Crampton and Wagner (1994) concluded that the effects of CMV are not trivial but are small, while other researchers concluded that CMV poses a significant threat to validity (Cote & Buckley, 1987; Doty & Glick, 1998; Williams, Cote, & Buckley, 1989). Part of the difference in findings may be due to the different methodology used in these studies. Recently, Podsakoff et al. (2003) cataloged the advantages and disadvantages associated with methods of assessing and controlling for CMV/CMB. Among the various methods (e.g., Harman's single factor test, partial correlation, etc.), those based on confirmatory factor analysis (CFA) tend to be the most rigorous (Podsakoff et al., 2003).

There are four primary CFA methods used to assess and/or control for CMV/CMB. In the first, method effects are modeled as a latent factor using directly measured scale items as indicators (e.g., negative affectivity; Williams & Anderson, 1994; Williams, Gavin, & Williams, 1996). This latent factor is then modeled such that it directly affects all other items administered. In this model, CMV is controlled by explicitly incorporating the effects of a latent method factor on each observed indicator. While this method may be useful in controlling for method effects due to the commonality of a single type of method, a large number of potential method effects remain unmodeled.

In the second CFA method, each item is an indicator not only of its substantive trait, but also of an unmeasured latent method factor (e.g., Podsakoff & MacKenzie, 1994; Podsakoff, MacKenzie, Moorman, & Fetter, 1990). The advantages of this model are that no special scale needs to be administered and multiple types of method effects can be simultaneously modeled with the latent methods factor. As with the explicitly modeled methods effect approach, this model controls for CMV via the factor loadings between the methods factor and the indicators. However, identification problems are often encountered with this model (Podsakoff et al., 2003).

The third CFA method models both latent trait and method factors using MTMM data (Widaman, 1985, 1992). This model (the correlated-trait correlated-method model; CTCM) has the advantages of fully utilizing information available in the MTMM correlation matrix and providing direct estimates of the relative effects of both traits and methods on observed correlations. This model also best corresponds to Campbell and Fiske's (1959) conceptualization of the MTMM (Lance, Noble, & Scullen, 2002). The CTCM model controls for CMV via the modeled latent methods factors. Typically, the presence of CMV is assessed by comparing the fit of a model that includes latent methods factors as compared to a model that does not include these factors (i.e., a trait-only model). Further, CMB can be estimated as the difference in trait correlations in the CTCM and trait-only models. Note however that this model is also fraught with identification and estimation problems, especially when few methods are used (Marsh, 1989).

In response to the estimation problems commonly encountered with the CTCM, Marsh and colleagues (Marsh, 1989; Marsh & Bailey, 1991) developed the correlated uniqueness model (CTCU). The CTCU model does not explicitly model latent method factors. Instead, correlations between uniqueness terms for indicators assessed via the same method are allowed. One advantage of this model is that it tends to converge more often than does the CTCM (Becker & Cote, 1994; Conway, 1998; Marsh, 1989; Marsh & Bailey, 1991). However, there are some disadvantages to this model. For example, methods are constrained to be orthogonal and trait variance estimates may be biased (Lance et al., 2002).

In sum, previous investigations of the impact of CMV/CMB have resulted in different conclusions, partly due to differing methodology. Whereas Doty and Glick (1998) found CMB to be pervasive and problematic, Crampton and Wagner (1994) and Spector (1987) found little evidence of problematic CMB. This study attempts to build on previous CMV/CMB research in several ways. Like Doty and Glick (1998), we employ CFA models for MTMM matrices. While the meta-analytic approach used by Crampton and Wagner (1994) is certainly informative, the MTMM approach represents a purer assessment of method effects by concentrating exclusively on those studies that have made use of MTMM designs. While we used the same general method as Doty and Glick, note that this study expands on that work in many ways. First, Doty and Glick located MTMM studies in only six journals in the timeframe of 1980-1992, whereas we searched 23 journals in the interval from 1959 to 2005. Second, Doty and Glick exclusively fit trait-only and CTCM CFA models to their data. Given that the CTCM model is known to have convergence problems, a number of MTMM correlation matrices were excluded from their analysis that may have been estimable by other procedures. Towards this end, we estimated trait-only, CTCM, and CTCU models for each correlation matrix. We were interested in three research questions:

Research Question 1: How extensive is the presence of CMV in organizational research?

Research Question 2: To what extent are correlations among traits biased by the presence of CMV?

Research Question 3: To what extent will the estimates of CMB differ across the trait-only/CTCM and trait-only/CTCU comparisons?

Method

Literature Review

In order to locate MTMM matrices, we conducted an extensive literature search using PsycInfo and the Social Science Citation Index searching for the terms: "multitrait," “multi-trait”, "multirater," "multisource," and "MTMM." We added to this list the 28 matrices analyzed by Doty and Glick (1998). Once we had generated an initial list of potential studies, we excluded data from assessment centers as they are designed to measure different aspects of the same constructs under different conditions, rather than to represent pure MTMM designs. We also narrowed our results to include only studies published in the top 23 I/O journals according to a recent review by Zickar and Highhouse (2001).

Analyses

For each MTMM matrix, we estimated three CFA models. In the first, we modeled only latent traits and no method factors, with trait correlations freely estimated. As no methods factors were modeled, correlations between MTMM indicator variables due to method factors are reflected via inflated trait factor loadings and factor correlations.

In the second model (CTCM), both latent traits and method factors were estimated. Traits were allowed to freely correlate, as were methods, however, no correlations were estimated between the traits and methods (see Figure 1 for an example CTCM model for a 3x3 MTMM design). As method effects are explicitly modeled in the CTCM, correlations among observed indicators can be reflected via pathways among the factor loadings and correlations of traits and among the factor loadings and correlations of methods. As a result, correlations among latent traits will be smaller in this model than the trait-only model.

In the third model (CTCU), latent traits were modeled and allowed to freely correlate. No latent methods factors were modeled, but uniqueness terms for those indicators assessed via the same method were allowed to correlate. As this model does not allow correlations among methods, correlations among indicator variables will tend to be reflected via trait correlations and factor loadings to a greater extent than in the CTCM. Note, however, that these trait correlations are expected to be lower than in the trait-only model in most cases.

Assessing CMV and CMB

We assessed CMV as the improvement in model fit between the trait-only and CTCM models using a chi-square difference test (cf. Doty & Glick, 1998). However, as the CTCM often does not result in an admissible solution, we also compared the fit of the trait-only model with that of the CTCU model. CMB was assessed as the averaged difference in correlations among the same traits in the trait-only and CTCM/CTCU models.

Results

In total, we located 72 MTMM matrices in 61 published articles that met our criteria for inclusion in the study. Of these, a high percentage encountered problems with model convergence (n=31) or improper parameter estimates (n=18) in either the trait-only model (n=43), and/or both the CTCM and CTCU models (n=37). As a result, 23 correlation matrices were available for additional analysis. Of these 23 correlation matrices, 9 resulted in proper solutions in the CTCM model, while 19 resulted in proper solutions in the CTCU model. Proper solutions for all three models (trait-only, CTCM, and CTCU) were obtained for four MTMM correlation matrices.

CMV

Fit of the trait-only models was compared to that of the CTCM model using the chi-square difference test. All nine of the trait-only/CTCM model comparisons indicated significantly better model fit in the CTCM model (see Tables 1 and 2). Fit of the trait-only model was also compared to that of the CTCU model. Of the 19 CTCU models, 15 (79%) of the trait-only/CTCU model comparisons indicated a significant improvement in model fit in the CTCU model (see Table 1). Therefore, significant method effects were present in nearly all of the MTMM correlation matrices analyzed.

CMB

The weighted (by sample size) average correlation among traits in the trait-only models was .54 (SD=.17) whereas this weighted average correlation was .36 (SD=.19) in the CTCM and .47 (SD=15) in the CTCU. The differences in average correlation for each study are reported in Table 3. As can be seen in Table 3, differences in trait correlations were moderate in magnitude in the trait-only/CTCM comparisons (weighted mean difference=.21). Conversely, differences in trait correlations in the trait-only/CTCU comparisons varied from negligible to small in magnitude (weighted mean difference=.05).

There were four correlation matrices for which analysis of all three models resulted in proper solutions. These four matrices allow the most direct comparison of the effects of choice of the CTCM or

CTCU as a comparison model on CMB estimates. The weighted average trait correlation in the four trait-only models was .47 (SD=.20), .31 (SD=.21) in the CTCM, and .42 (SD=.20) in the CTCU. The averaged weighted difference in trait correlations was .22 in the trait-only/CTCM comparisons and was .05 in the trait-only/CTCU comparisons.

Discussion

This study addressed three research questions. First, we found that CMV is pervasive in organizational psychological research. All of the studies assessed via the CTCM model showed significantly improved fit over the trait-only model. Additionally, 79% of those models assessed via the CTCU model showed improved fit over the trait-only model. As such, it seems that methods do account for a significant portion of the variance in observed scores in organizational research.

A more important question (Research Question 2), is "to what extent are correlations among traits biased by CMV?" We found that the extent of this bias varied considerably by methodology. The CTCM often showed moderate differences in trait correlations as compared to the trait-only model. On the other hand, the CTCU showed small (and often negligible) differences in trait correlations as compared to the trait-only model. Thus, the pervasiveness of bias in trait correlations is at least to some extent a function of the model used to represent method effects (Research Question 3).

While our numerical findings for the CTCM are similar to those of Doty and Glick (1998), our conclusions are more closely aligned with those of Crampton and Wagner (1994) and Spector (1987, 2006). That is, while we believe that CMV and CMB do exist in organizational research, we believe the magnitude of the CMB is likely to be small to moderate in most instances. Note that we assessed the extent to which trait correlations are subject to CMB at the latent level. As CFA latent correlations are disattenuated to correct for measurement error and unreliability, the trait correlations estimated in this study are considerably higher than would be expected with the observed scores that researchers typically analyze and report. With higher estimated latent trait correlations come larger estimates of bias due to CMB. In other words, once subject to unreliability and other measurement errors, observed differences in trait correlations would be considerably smaller than those we report.

The finding that stronger CMB effects were found in the trait-only/CTCM comparisons than in the trait-only/CTCU comparisons was not surprising. Observed correlations between indicator variables are modeled as products of factor loadings and correlations among latent factors. In the CTCM model, indicator correlations are modeled via both products of the trait factor loadings and correlations and the method factor loadings and correlations. In the CTCU model, method factors are uncorrelated. As a result, observed correlations between indicators are more readily reflected via higher trait factor loadings and correlations than by method factor loadings and correlated uniqueness terms. As a result, the CTCU shows improved model fit over the trait-only model, but trait correlations remain considerably higher than in the CTCM.

What is less clear is the extent to which trait correlations in the CTCU can be said to be inflated with respect to their true population values. While the CTCM is perhaps closer to Campbell and Fiske's (1959) conceptualization of the MTMM, some conceptual ambiguity remains as to the meaning of method correlations. While some types of methods are similar in nature (e.g., Likert-scales and "faces" scales), others remain conceptually distinct. For cases in which methods are clearly distinct, it is unclear as to what latent method correlations conceptually represent. Thus, for these cases, the CTCU may be more conceptually appropriate.

Implications, Limitations and Future Directions

We found that CMV clearly does affect observed correlations, though the magnitude of CMB was variable and a largely function of the chosen methodology. Moreover, our estimated CMB was at the latent level with CMB among observed scores likely to be considerably smaller. We believe that organizational researchers should continue to be diligent in averting CMB when possible. Use of negatively worded items, randomized item order, and multiple methods and raters whenever possible are advisable. However, the presence of common assessment methods hardly necessitates large and problematic CMB. In many cases, CMB may be trivially small and certainly does not necessarily jeopardize the validity of study conclusions in every case.

There were some limitations associated with this study. First, many of the trait-only, CTCM, and CTCU models did not result in proper solutions. This was somewhat unexpected given that Doty and Glick (1998) obtained satisfactory solutions for 28 analyses using the CTCM model. In our study, there were only four matrices in which the trait-only, CTCM, and CTCU all resulted in proper solutions. It is unclear why this is the case. Another limitation is that we did not attempt to identify patterns that may account for the differing levels of CMB across studies. Both Doty and Glick (1998) and Crampton and Wagner (1994) coded studies on the basis of several variables (such as ambiguity of the construct assessed and research content domain). We hope to pursue this avenue in the future to potentially identify causes of CMB in the matrices analyzed.

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Table 1.

Chi-Square Model Fit for Trait-Only, CTCM, and CTCU Model Comparisons

		Trait		CTCM				CTCU			
Study	Dimension (MxT)	χ^2	df	χ^2	df	$\Delta\chi^2$	Δdf	χ^2	df	$\Delta\chi^2$	Δdf
Arora (1982)	3x3	107.62	24	16.99	2	90.63***	22	21.7	15	85.92***	9
Avison (1978)	3x3	46.25	24	-	-	-	-	29.52	15	16.73	9
Bajtelsmit (1979)	2x4	20.85	14	-	-	-	-	1.53	2	19.32	12
Barling & MacEwen (1988)	4x4	276.52	98	166.11	76	110.41***	22	181.65	74	94.87***	24
Becker & Vance (1993)	3x3	293.61	24	-	-	-	-	17.59	15	276.02***	9
Birnbaum et al. (1986)	2x5	81.32	25	15.10	14	66.22***	11	-	-	-	-
Boruch & Wolins (1970)	3x5	140.46	80	-	-	-	-	67.52	50	72.94***	30
Bouchard (1968)	3x3	186.67	24	-	-	-	-	57.14	15	129.53***	9
Conway (1998)	3x3	141.57	24	7.85	7	133.72***	12	22.12	15	119.45***	9
Dickinson & Zellinger (1980)	3x6	149.69	120	-	-	-	-	101.84	75	47.85	45
Gillet & Schwab (1975)	2x4	34.79	14	2.09	5	32.7***	9	-	-	-	-
Goffin & Gellatly (2001)	3x2	13.15	8	-	-	-	-	.95	5	12.2**	3
Huelsman, Furr & Nemanick (2003)	4x2	101.85	19	-	-	-	-	89.08	15	12.77*	4
Johnson, Smith, & Tucker (1982)	2x5	457.52	35	101.80	24	355.72***	11	-	-	-	-
Lawler (1967)	3x3	100.94	24	-	-	-	-	19.95	15	80.990***	9
Manson, Levine, & Brannick (2000)	3x4	162.93	48	-	-	-	-	71.11	30	91.82***	18
Mayes & Ganster (1983)	2x4	21.87	14	-	-	-	-	1.72	2	20.15	12
MacNab & Fitzsimmons (1987)	4x8	2440.09	436	934.21	398	1505.88***	38	731.51	324	1708.58***	112
Meier (1984)	3x3	64.82	24	-	-	-	-	30.67	15	34.15***	9
Silverman et al. (1983)	2x8	937.40	76	117.08	59	820.32***	14	-	-	-	-
Smith & Singer (1977)	3x2	88.99	8	-	-	-	-	49.19	5	39.8***	3
Turner & Walton (1984)	2x5	213.51	25	-	-	-	-	10.14	5	203.37***	20
Van Iddekinge, Raymark, & Roth (2005)	3x3	85.77	24	13.95	12	71.82***	12	22.38	15	63.39***	9

*p<.05, **p<.01, ***p.001.

Table 2.

Additional Fit Statistics Trait-Only, CTCM, and CTCU Models

	Trait-only					CTCM					CTCU				
Study	TLI	NFI	GFI	RMSR	RMSEA	TLI	NFI	GFI	RMSR	RMSEA	TLI	NFI	GFI	RMSR	RMSEA
Arora (1982)	.78	.82	.81	.08	.18	.97	.97	.96	.06	.064	.97	.96	.95	.06	.065
Avison (1978)	.88	.86	.94	.06	.071	-	-	-	-	-	.88	.91	.96	.05	.075
Bajtelsmit (1979)	.99	.98	.98	.02	.044	-	-	-	-	-	1.0	1.0	1.0	.01	.000
Barling & MacEwen (1988)	.76	.73	.72	.10	.14	.84	.84	.82	.09	.094	.81	.82	.80	.09	.12
Becker & Vance (1993)	.57	.70	.80	.13	.21	-	-	-	-	-	.99	.98	.99	.04	.024
Birnbaum et al. (1986)	.68	.78	.76	.11	.21	.99	.96	.95	.04	.017	-	-	-	-	-
Boruch & Wolins (1970)	.88	.81	.86	.08	.083	-	-	-	-	-	.94	.91	.94	.06	.045
Bouchard (1968)	.35	.54	.74	.15	.19	-	-	-	-	-	.73	.86	.88	.16	.70
Conway (1998)	.77	.83	.76	.08	.22	1.0	.99	.98	.04	.000	.98	.97	.96	.06	.062
Dickinson & Zellinger (1980)	.97	.89	.86	.10	.025	-	-	-	-	-	.95	.92	.90	.09	.043
Gillet & Schwab (1975)	.95	.96	.97	.03	.076	1.0	1.0	1.0	.01	.000	-	-	-	-	-
Goffin & Gellatly (2001)	.89	.87	.94	.07	.094	-	-	-	-	-	1.0	.99	1.0	.02	.000
Huelsman, Furr & Nemanick (2003)	.93	.94	.91	.08	.13	-	-	-	-	-	.92	.95	.92	.08	.14
Johnson, Smith, & Tucker (1982)	.24	.40	.48	.09	.63	.80	.87	.79	.08	.25	-	-	-	-	-
Lawler (1967)	.72	.77	.84	.11	.17	-	-	-	-	-	.97	.96	.96	.05	.046
Manson, Levine, & Brannick (2000)	.89	.89	.77	.06	.16	-	-	-	-	-	.94	.95	.89	.05	.11
Mayes & Ganster (1983)	.96	.94	.96	.05	.061	-	-	-	-	-	1.0	1.0	1.0	.02	.000
MacNab & Fitzsimmons (1987)	.87	.86	.68	.07	.12	.96	.95	.89	.06	.054	.96	.96	.91	.06	.051
Meier (1984)	.97	.97	.95	.03	.076	-	-	-	-	-	.98	.99	.98	.02	.055
Silverman et al. (1983)	.79	.86	.64	.12	.24	.98	.98	.96	.03	.053	-	-	-	-	-
Smith & Singer (1977)	.79	.88	.94	.06	.14	-	-	-	-	-	.82	.93	.97	.05	.13
Turner & Walton (1984)	.63	.78	.69	.18	.28	-	-	-	-	-	.95	.99	.98	.06	.091
Van Iddekinge, Raymark, & Roth (2005)	.88	.88	.90	.09	.12	.99	.98	.98	.03	.034	.97	.97	.97	.04	.056

Table 3.

Trait Correlations for Trait-Only, CTCM, and CTCU Models

		Trait-only		CTCM				CTCU			
Study	N	M	SD	M	SD	ΔM	SD of Δ	M	SD	ΔM	SD of Δ
Arora (1982)	96	0.37	0.07	0.22	0.17	0.43	0.26	0.31	0.09	0.07	0.04
Avison (1978)	148	0.19	0.22	-	-	-	-	0.21	0.17	0.01	0.06
Bajtelsmit (1979)	239	0.77	0.08	-	-	-	-	0.75	0.10	0.02	0.03
Barling & MacEwen (1988)	75	0.59	0.36	0.55	0.27	0.18	0.23	0.52	0.29	0.11	0.20
Becker & Vance (1993)	265	0.78	0.12	-	-	-	-	0.61	0.12	0.17	0.01
Birnbaum et al. (1986)	57	0.70	0.23	0.56	0.27	0.14	0.17	-	-	-	-
Boruch & Wolins (1970)	124	0.40	0.22	-	-	-	-	0.38	0.18	0.08	0.08
Bouchard (1968)	78	0.58	0.35	-	-	-	-	0.41	0.22	0.28	0.20
Conway (1998)	102	0.74	0.03	0.20	0.15	0.55	0.15	0.62	0.02	0.13	0.02
Dickinson & Zellinger (1980)	86	0.43	0.24	-	-	-	-	0.41	0.23	0.02	0.04
Gillet & Schwab (1975)	273	0.43	0.16	0.25	0.15	0.16	0.03	-	-	-	-
Goffin & Gellatly (2001)	78	0.55		-	-	-	-	0.36	-	0.19	-
Huelsman, Furr & Nemanick (2003)	250	0.50		-	-	-	-	0.51	-	0.01	-
Johnson, Smith, & Tucker (1982)	100	0.46	0.12	0.26	0.12	0.21	0.08	-	-	-	-
Lawler (1967)	113	0.74	0.09	-	-	-	-	0.62	0.08	0.12	0.01
Manson, Levine, & Brannick (2000)	80	0.46	0.33	-	-	-	-	0.44	0.33	0.02	0.01
Mayes & Ganster (1983)	136	0.38	0.28	-	-	-	-	0.33	0.24	-0.01	0.08
MacNab & Fitzsimmons (1987)	438	0.31	0.19	0.22	0.16	0.14	0.06	0.29	0.17	0.03	0.02
Meier (1984)	320	0.46	0.41	-	-	-	-	0.45	0.40	0.00	0.02
Silverman et al. (1983)	353	0.79	0.20	0.56	0.19	0.22	0.09	-	-	-	-
Smith & Singer (1977)	69	0.55		-	-	-	-	0.64	-	0.09	-
Turner & Walton (1984)	114	0.42	0.20	-	-	-	-	0.48	0.25	-0.06	0.20
Van Iddekinge, Raymark, & Roth (2005)	143	0.73	0.23	0.64	0.22	0.10	0.05	0.74	0.19	-0.01	0.05

Note: Absolute value of correlations taken for mean in Trait-only, CTCM, and CTCU results above. Absolute values were not taken in computing mean differences (as some trait correlations may change signs). As a result, the mean difference in trait correlations need not equal the differences in the model mean correlations.

Figure 1. CTCM Model for 3x3 MTMM Design.