

Technical Appendices to “On Managerially Efficient Experimental Designs”

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Technical appendix 1: M-balanced and M-orthogonal designs may not minimize M-errors

Managerial quantities:

$$M = \begin{bmatrix} 0 & 0 & 1.1002 & 0 & -0.1375 & 0.1375 & -0.1375 \\ 0 & 0 & 0 & 0 & 1.0199 & -0.1298 & -0.1669 \\ 0 & 0 & 0 & 0 & 0 & 0.7547 & -0.4047 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Balanced and Orthogonal design, X :

$$X = \begin{bmatrix} +1 & +1 & -1 & -1 & -1 & -1 & -1 \\ +1 & -1 & +1 & -1 & +1 & +1 & +1 \\ +1 & +1 & +1 & +1 & -1 & +1 & +1 \\ +1 & -1 & -1 & +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 & +1 & +1 & -1 \\ +1 & +1 & -1 & +1 & -1 & +1 & +1 \\ +1 & +1 & -1 & -1 & +1 & -1 & +1 \\ +1 & -1 & -1 & -1 & -1 & +1 & -1 \\ +1 & -1 & +1 & -1 & -1 & -1 & +1 \\ +1 & -1 & +1 & +1 & -1 & -1 & -1 \\ +1 & +1 & +1 & +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 & +1 & +1 & -1 \end{bmatrix}$$

Covariance matrix of managerial estimates under X :

$$M.(X'.X)^{-1}.M' = \begin{bmatrix} 0.1056 & -0.0113 & 0.0133 & -0.0115 \\ -0.0113 & 0.0904 & -0.0025 & -0.0139 \\ 0.0113 & -0.0025 & 0.0611 & -0.0337 \\ -0.0115 & -0.0139 & -0.0337 & 0.0833 \end{bmatrix}$$

$$M_A\text{-error}(X) = 1.0214$$

$$M_D\text{-error}(X) = 0.9202$$

M-orthogonal and M-balanced design, Y :

$$Y = \begin{bmatrix} +1 & -1 & -1 & -1 & -1 & -1 & -1 \\ +1 & +1 & +1 & -1 & +1 & +1 & +1 \\ +1 & +1 & +1 & +1 & -1 & +1 & +1 \\ +1 & -1 & -1 & +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 & +1 & +1 & -1 \\ +1 & +1 & -1 & -1 & -1 & +1 & +1 \\ +1 & +1 & -1 & +1 & +1 & -1 & +1 \\ +1 & -1 & -1 & -1 & -1 & +1 & -1 \\ +1 & -1 & +1 & -1 & -1 & -1 & +1 \\ +1 & -1 & +1 & +1 & -1 & -1 & -1 \\ +1 & +1 & +1 & +1 & +1 & +1 & -1 \\ +1 & -1 & -1 & +1 & +1 & -1 & -1 \end{bmatrix}$$

Covariance matrix of managerial estimates under Y :

$$M.(Y'.Y)^{-1}.M' = \begin{bmatrix} 0.1135 & 0 & 0 & 0 \\ 0 & 0.1135 & 0 & 0 \\ 0 & 0 & 0.1135 & 0 \\ 0 & 0 & 0 & 0.1135 \end{bmatrix}$$

$$M_A\text{-error}(Y) = 1.3618$$

$$M_D\text{-error}(Y) = 1.3618$$

Technical appendix 2: Illustrative Fast Food Restaurant Example

We extend the list of parameters to include the interactions of interest, resulting in design and managerial matrices with 18 columns corresponding respectively to the intercept, x_1, x_2, x_3, x_4, x_5 (3 columns), $x_1*x_2, x_2*x_3, x_2*x_4, x_1*x_5$ (3 columns), x_2*x_5 (3 columns), and $x_2*x_3*x_4$. For ease of exposition, we provide only the diagonal elements of W and we omit the columns corresponding to the interactions in the designs.

Case 1: Different W

	Managerial quantities:	Weights on managerial quantities:
$M =$	$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$	$W =$
		$\begin{bmatrix} 3 \\ 3 \\ 3 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$

D-efficient design, X_1 :

$$X_1 = \begin{bmatrix} +1 & +1 & +1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & +1 & +1 & +1 & -1 & 0 & 1.63 & -0.58 \\ +1 & +1 & +1 & -1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & -1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & +1 & -1 & +1 & -1 & 0 & 1.63 & -0.58 \\ +1 & +1 & -1 & +1 & -1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & -1 & +1 & 0 & 1.63 & -0.58 \\ +1 & +1 & -1 & -1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & -1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & -1 & -1 & 0 & 0 & 1.73 \\ +1 & -1 & +1 & +1 & +1 & 0 & 1.63 & -0.58 \\ +1 & -1 & +1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & -1 & 0 & 0 & 1.73 \\ +1 & -1 & +1 & -1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & -1 & +1 & 0 & 0 & 1.73 \\ +1 & -1 & +1 & -1 & -1 & 0 & 1.63 & -0.58 \\ +1 & -1 & +1 & -1 & -1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & +1 & -1 & 0 & 0 & 1.73 \\ +1 & -1 & -1 & -1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & -1 & -1 & 0 & 1.63 & -0.58 \end{bmatrix}$$

Covariance matrix of the managerial estimates under X_I :

$$M.(X_I' . X_I)^{-1} . M' = \begin{bmatrix} 0.0469 & 0.0156 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.0156 & 0.0469 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.0469 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.0547 & 0 & 0.0111 & -0.0064 & -0.018 & 0.0111 & -0.0064 & -0.0180 & 0 \\ 0 & 0 & 0 & 0 & 0.0547 & 0.0111 & 0.0191 & 0 & 0.0111 & 0.0191 & 0 & 0 \\ 0 & 0 & 0 & 0.011 & 0.0111 & 0.0550 & 0.0045 & -0.0064 & 0.0236 & 0.0045 & -0.0064 & 0 \\ 0 & 0 & 0 & -0.0064 & 0.0191 & 0.0045 & 0.0599 & 0.0036 & 0.0045 & 0.0286 & 0.0036 & 0 \\ 0 & 0 & 0 & -0.018 & 0 & -0.0064 & 0.0036 & 0.0573 & -0.0064 & 0.0036 & 0.0260 & 0 \\ 0 & 0 & 0 & 0.0111 & 0.0111 & 0.0236 & 0.0045 & -0.0064 & 0.0550 & 0.0045 & -0.0064 & 0 \\ 0 & 0 & 0 & -0.0064 & 0.0191 & 0.0045 & 0.0286 & 0.0036 & 0.0045 & 0.0599 & 0.0036 & 0 \\ 0 & 0 & 0 & -0.0180 & 0 & -0.0064 & 0.0036 & 0.0260 & -0.0064 & 0.0036 & 0.0573 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.0469 \end{bmatrix}$$

$$M_1\text{-error}(X_I) = 1.2299$$

Managerial design obtained from the modified Federov algorithm, X_2 :

$$X_2 = \begin{bmatrix} +1 & +1 & -1 & +1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & -1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & -1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & -1 & -1 & 0 & 1.63 & -0.58 \\ +1 & -1 & +1 & -1 & -1 & 0 & 1.63 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & -1 & +1 & 0 & 1.63 & -0.58 \\ +1 & -1 & -1 & -1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & -1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & -1 & -1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & +1 & -1 & 0 & 0 & 1.73 \\ +1 & +1 & -1 & -1 & -1 & 0 & 0 & 1.73 \\ +1 & -1 & +1 & -1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & -1 & 0 & 0 & 1.73 \\ +1 & +1 & -1 & -1 & +1 & 0 & 1.63 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & +1 & +1 & -1 & -1 & 0 & 0 & 1.73 \\ +1 & +1 & +1 & +1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & +1 & -1 & 0 & 1.63 & -0.58 \\ +1 & +1 & +1 & -1 & -1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & +1 & -1 & 0 & 1.63 & -0.58 \end{bmatrix}$$

Covariance matrix of the managerial estimates under X_2 :

$$M_{..}(X_2'X_2)^{-1}.M' = \begin{bmatrix} 0.0469 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.0469 & -0.0156 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -0.0156 & 0.0469 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.0469 & 0 & 0 & 0 & 0 & -0.0111 & 0.0064 & -0.0090 & 0 \\ 0 & 0 & 0 & 0 & 0.0469 & 0 & 0 & 0 & 0 & 0.0128 & 0.0090 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.0550 & -0.0045 & 0.0064 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -0.0045 & 0.0599 & 0.0036 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.0064 & 0.0036 & 0.0573 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -0.0111 & 0 & 0 & 0 & 0 & 0.0472 & 0 & 0 & 0.0111 \\ 0 & 0 & 0 & 0.0064 & 0.0128 & 0 & 0 & 0 & 0 & 0.0469 & 0 & 0.0064 \\ 0 & 0 & 0 & -0.0090 & 0.0090 & 0 & 0 & 0 & 0 & 0 & 0.0469 & -0.0090 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.0111 & 0.0064 & -0.0090 & 0.0469 \end{bmatrix}$$

$$M_1\text{-error}(X_2) = 1.1673$$

Case 2: Different M and W

Managerial quantities:

Weights on managerial quantities:

$$M^{comb} = \begin{bmatrix} +1 & +1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 & -1 & -1 & -1 & 1.41 & -0.82 & -0.58 & -1.41 & 0.82 & 0.58 & -1 \\ +1 & +1 & -1 & +1 & +1 & 0 & 1.61 & -0.58 & -1 & -1 & -1 & 0 & 1.61 & -0.58 & 0 & -1.61 & 0.58 & -1 \\ +1 & +1 & -1 & +1 & +1 & 0 & 0 & 1.73 & -1 & -1 & -1 & 0 & 0 & 1.73 & 0 & 0 & -1.73 & -1 \\ +1 & +1 & -1 & +1 & +1 & -1.41 & -0.82 & -0.58 & -1 & -1 & -1 & -1.41 & -0.82 & -0.58 & 1.41 & 0.82 & 0.58 & -1 \\ +1 & -1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 & +1 & -1 & -1 & -1.41 & 0.82 & 0.58 & -1.41 & 0.82 & 0.58 & -1 \\ +1 & -1 & -1 & +1 & +1 & 0 & 1.61 & -0.58 & +1 & -1 & -1 & 0 & -1.61 & 0.58 & 0 & -1.61 & 0.58 & -1 \\ +1 & -1 & -1 & +1 & +1 & 0 & 0 & 1.73 & +1 & -1 & -1 & 0 & 0 & -1.73 & 0 & 0 & -1.73 & -1 \\ +1 & -1 & -1 & +1 & +1 & -1.41 & -0.82 & -0.58 & +1 & -1 & -1 & 1.41 & 0.82 & 0.58 & 1.41 & 0.82 & 0.58 & -1 \\ +1 & -1 & +1 & +1 & +1 & 1.41 & -0.82 & -0.58 & -1 & +1 & +1 & -1.41 & 0.82 & 0.58 & 1.41 & -0.82 & -0.58 & +1 \\ +1 & -1 & +1 & +1 & +1 & 0 & 1.61 & -0.58 & -1 & +1 & +1 & 0 & -1.61 & 0.58 & 0 & 1.61 & -0.58 & +1 \\ +1 & -1 & +1 & +1 & +1 & 0 & 0 & 1.73 & -1 & +1 & +1 & 0 & 0 & -1.73 & 0 & 0 & 1.73 & +1 \\ +1 & -1 & +1 & +1 & +1 & -1.41 & -0.82 & -0.58 & -1 & +1 & +1 & 1.41 & 0.82 & 0.58 & -1.41 & -0.82 & -0.58 & +1 \end{bmatrix}$$

$$W^{comb} = \begin{bmatrix} 3 \\ 1 \\ 1 \\ 1 \\ 3 \\ 1 \\ 1 \\ 1 \\ 3 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

Covariance matrix of the managerial estimates under X_I (from case 1):

$$M^{comb} (X_I' X_I)^{-1} M^{comb \prime} = \begin{bmatrix} 0.6875 & 0.3138 & 0.25 & 0.25 & 0.375 & 0.3737 & 0.1875 & 0.0625 & -0.0625 & 0.0617 & 0 & 0 \\ 0.3138 & 0.8044 & 0.312 & 0.3138 & 0.2503 & 0.6194 & 0.2495 & 0.1253 & -0.0625 & -0.0617 & -0.0622 & -0.0625 \\ 0.25 & 0.312 & 0.6875 & 0.25 & 0.1875 & 0.373 & 0.375 & 0.0625 & -0.0625 & -0.0005 & -0.125 & -0.0625 \\ 0.25 & 0.3138 & 0.25 & 0.6875 & 0.1875 & 0.3737 & 0.1875 & 0.25 & -0.0625 & -0.0008 & -0.0625 & -0.125 \\ 0.375 & 0.2503 & 0.1875 & 0.1875 & 1.125 & 0.5013 & 0.1875 & 0.1875 & 0 & -0.1247 & -0.1875 & -0.1875 \\ 0.3737 & 0.6194 & 0.373 & 0.3737 & 0.5013 & 1.4817 & 0.4974 & 0.2523 & -0.1245 & 0.1212 & -0.1253 & -0.1245 \\ 0.1875 & 0.2495 & 0.375 & 0.1875 & 0.1875 & 0.4974 & 1.125 & 0.1875 & 0 & 0.062 & 0.1875 & 0 \\ 0.0625 & 0.1253 & 0.0625 & 0.25 & 0.1875 & 0.2523 & 0.1875 & 0.875 & -0.125 & -0.0622 & -0.125 & 0.0625 \\ -0.0625 & -0.0625 & -0.0625 & -0.0625 & 0 & -0.1245 & 0 & -0.125 & 0.8125 & 0.3145 & 0.3125 & 0.3125 \\ 0.0617 & -0.0617 & -0.0005 & -0.0008 & -0.1247 & 0.1212 & 0.062 & -0.0622 & 0.3145 & 0.6809 & 0.2503 & 0.252 \\ 0 & -0.0622 & -0.125 & -0.0625 & -0.1875 & -0.1253 & 0.1875 & -0.125 & 0.3125 & 0.2503 & 0.6875 & 0.25 \\ 0 & -0.0625 & -0.0635 & -0.125 & -0.1875 & -0.1245 & 0 & 0.0625 & 0.3125 & 0.252 & 0.25 & 0.6875 \end{bmatrix}$$

$$M_1\text{-error}(X_I) = 20.7894$$

Managerial design obtained from the modified Federov algorithm, X_2^{comb} :

$$X_2^{comb} = \begin{bmatrix} +1 & -1 & -1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & -1 & +1 & -1 & -1 & 0 & 0 & 1.73 \\ +1 & -1 & +1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & +1 & +1 & +1 & -1 & 0 & 1.63 & -0.58 \\ +1 & -1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & +1 & -1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & 0 & 0 & 1.73 \\ +1 & +1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & 0 & 1.63 & -0.58 \\ +1 & +1 & -1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & -1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & +1 & +1 & -1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & +1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & +1 & +1 & -1 & 0 & 0 & 1.73 \\ +1 & +1 & -1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & -1 & -1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & +1 & -1 & -1 & -1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & +1 & 0 & 1.63 & -0.58 \\ +1 & -1 & -1 & +1 & +1 & 0 & 1.63 & -0.58 \\ +1 & +1 & +1 & +1 & +1 & 1.41 & -0.82 & -0.58 \\ +1 & -1 & +1 & +1 & -1 & 1.41 & -0.82 & -0.58 \end{bmatrix}$$

Covariance matrix of the managerial estimates under X_2^{comb} :

$$M^{comb} \cdot (X_2^{comb \top} X_2^{comb})^{-1} \cdot M^{comb \top} = \begin{bmatrix} 0.4239 & 0.026 & 0.0402 & 0.0244 & 0.1076 & -0.0239 & -0.0402 & -0.0244 & -0.0519 & 0.0241 & -0.0229 & 0.0244 \\ 0.026 & 0.807 & 0.068 & 0.0725 & -0.0269 & 0.1767 & -0.068 & -0.0684 & 0.073 & -0.1765 & 0.0737 & 0.0684 \\ 0.0402 & 0.068 & 0.8111 & 0.0681 & -0.054 & -0.0680 & 0.1889 & -0.0681 & 0.0501 & 0.0680 & -0.1612 & 0.0681 \\ 0.0244 & 0.0725 & 0.0681 & 0.8196 & -0.0274 & -0.0684 & -0.0681 & 0.1804 & 0.0735 & 0.0686 & 0.0741 & -0.1804 \\ 0.1076 & -0.0269 & -0.054 & -0.0274 & 0.3392 & 0.0287 & 0.054 & 0.0274 & 0.0052 & -0.0273 & 0.0523 & -0.0274 \\ -0.0239 & 0.1767 & -0.068 & -0.0684 & 0.0287 & 0.8071 & 0.068 & 0.0725 & -0.0731 & 0.1765 & -0.0736 & -0.0684 \\ -0.0402 & -0.0680 & 0.1889 & -0.0681 & 0.054 & 0.068 & 0.8111 & 0.0681 & -0.0501 & -0.0680 & 0.1612 & -0.0681 \\ -0.0244 & -0.0684 & -0.0681 & 0.1804 & 0.0274 & 0.0725 & 0.0681 & 0.8196 & -0.0735 & -0.0686 & -0.0741 & 0.1804 \\ -0.0519 & 0.073 & 0.0501 & 0.0735 & 0.0052 & -0.0731 & -0.0501 & -0.0735 & 0.4192 & 0.0749 & 0.1435 & 0.0735 \\ 0.0241 & -0.1765 & 0.068 & 0.0686 & -0.0273 & 0.1765 & -0.068 & -0.0686 & 0.0749 & 0.8074 & 0.0744 & 0.0727 \\ -0.0229 & 0.0737 & -0.1612 & 0.0741 & 0.0523 & -0.0736 & 0.1612 & -0.0741 & 0.1435 & 0.0744 & 0.7800 & 0.0741 \\ 0.0244 & 0.0684 & 0.0681 & -0.1804 & -0.0274 & -0.0684 & -0.0681 & 0.1804 & 0.0735 & 0.0727 & 0.0741 & 0.8196 \end{bmatrix}$$

$$M_1\text{-error}(X_2^{comb}) = 14.4396$$

Technical appendix 3 : Choice-Based Experiment Example

We obtain choice designs from metric designs by cyclically generating alternatives as in Arora and Huber (2001) and Huber and Zwerina (1996). For ease of exposition, we use a diagonal matrix P , which is equivalent to assuming that all the parameters are zero. If prior knowledge is available on the parameters, the correct formulation follows Huber and Zwerina (1996) and Arora and Huber (2001).

Managerial quantities:

$$M_{WTP} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & -0.33 \\ 0 & 1 & 0 & 0 & 0 & -0.33 \\ 0 & 0 & 1 & 0 & 0 & -0.33 \\ 0 & 0 & 0 & 1 & 0 & -0.33 \\ 0 & 0 & 0 & 0 & 1 & -0.33 \end{bmatrix}$$

Probability-centered D-efficient design based on X (from the main appendix), Z :

$$Z = \begin{bmatrix} +1 & -1 & -1 & -1 & -1 & -1 \\ -1 & +1 & +1 & +1 & +1 & +1 \\ -1 & +1 & -1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 & -1 & -1 \\ +1 & +1 & +1 & -1 & +1 & +1 \\ -1 & -1 & -1 & +1 & -1 & -1 \\ -1 & -1 & +1 & +1 & -1 & +1 \\ +1 & +1 & -1 & -1 & +1 & -1 \\ +1 & +1 & -1 & +1 & +1 & -1 \\ -1 & -1 & +1 & -1 & -1 & +1 \\ +1 & -1 & +1 & -1 & +1 & +1 \\ -1 & +1 & -1 & +1 & -1 & -1 \\ +1 & -1 & -1 & -1 & +1 & -1 \\ -1 & +1 & +1 & -1 & +1 & -1 \\ -1 & -1 & -1 & -1 & +1 & -1 \\ +1 & +1 & +1 & +1 & -1 & +1 \\ -1 & +1 & -1 & -1 & -1 & +1 \\ +1 & -1 & +1 & +1 & +1 & -1 \\ -1 & +1 & +1 & -1 & -1 & -1 \\ +1 & -1 & -1 & +1 & +1 & +1 \\ +1 & +1 & +1 & +1 & -1 & -1 \\ -1 & -1 & -1 & -1 & +1 & +1 \\ -1 & -1 & +1 & +1 & +1 & -1 \\ +1 & +1 & -1 & -1 & -1 & +1 \end{bmatrix}$$

Covariance matrix of the managerial estimates under Z :

$$M_{WTP} \cdot (Z' P Z)^{-1} \cdot M_{WTP}' = \begin{bmatrix} 0.0924 & 0.0091 & 0.0091 & 0.0091 & 0.0091 \\ 0.0091 & 0.0924 & 0.0091 & 0.0091 & 0.0091 \\ 0.0091 & 0.0091 & 0.0924 & 0.0091 & 0.0091 \\ 0.0091 & 0.0091 & 0.0091 & 0.0924 & 0.0091 \\ 0.0091 & 0.0091 & 0.0091 & 0.0091 & 0.0924 \end{bmatrix}$$

$$M_A\text{-error}(Z) = 0.0924$$

$$M_D\text{-error}(Z) = 0.0909$$

Probability-centered M-efficient design matrix based on X_{WTP} (from the main appendix), Z_{WTP} :

$$Z_{WTP} = \begin{bmatrix} +1 & -1 & -1 & -1 & -1 & 0.98 \\ -1 & +1 & +1 & +1 & +1 & -0.98 \\ -1 & +1 & -1 & +1 & +1 & -0.32 \\ +1 & -1 & +1 & -1 & -1 & 0.32 \\ +1 & +1 & +1 & -1 & +1 & -0.98 \\ -1 & -1 & -1 & +1 & -1 & 0.98 \\ -1 & -1 & +1 & +1 & -1 & 0.34 \\ +1 & +1 & -1 & -1 & +1 & -0.34 \\ +1 & +1 & -1 & +1 & +1 & -1.00 \\ -1 & -1 & +1 & -1 & -1 & 1.00 \\ +1 & -1 & +1 & -1 & +1 & -0.32 \\ -1 & +1 & -1 & +1 & -1 & 0.32 \\ +1 & -1 & -1 & +1 & -1 & 0.34 \\ -1 & +1 & +1 & -1 & +1 & -0.34 \\ -1 & -1 & -1 & -1 & +1 & 0.98 \\ +1 & +1 & +1 & +1 & -1 & -0.98 \\ -1 & +1 & -1 & -1 & -1 & 1.00 \\ +1 & -1 & +1 & +1 & +1 & -1.00 \\ -1 & +1 & +1 & -1 & -1 & 0.32 \\ +1 & -1 & -1 & +1 & +1 & -0.32 \\ +1 & +1 & +1 & +1 & -1 & -1.00 \\ -1 & -1 & -1 & -1 & +1 & 1 \\ -1 & -1 & +1 & +1 & +1 & -0.34 \\ +1 & +1 & -1 & -1 & -1 & 0.34 \end{bmatrix}$$

Covariance matrix of the managerial estimates under Z_{WTP} :

$$M_{WTP} \cdot (Z' P Z)^{-1} \cdot M_{WTP}' = \begin{bmatrix} 0.0833 & 0 & 0 & 0 & 0 \\ 0 & 0.0833 & 0 & 0 & 0 \\ 0 & 0 & 0.0833 & 0 & 0 \\ 0 & 0 & 0 & 0.0833 & 0 \\ 0 & 0 & 0 & 0 & 0.0833 \end{bmatrix}$$

$$M_A\text{-error}(Z_{WTP}) = 0.0833$$

$$M_D\text{-error}(Z_{WTP}) = 0.0833$$