Supplementary Material to "Sample size calculation and blinded recalculation for analysis of covariance models with multiple random covariates"

In this supplementary material, we provide several tables containing the sample sizes and power values that were obtained by applying the exact and the four approximate fixed sample size calculation methods, respectively, which were discussed in the main body of the manuscript. At first, the total sample sizes were calculated by using each of those 5 methods. Then, the respective exact power values were determined following the method proposed by Shieh (2017). For details regarding the parameter specifications, the reader is referred to Section 3 of the manuscript. Tables 1–3 contain the results for balanced scenarios with 2 covariates, where the correlations between the covariates were set to 0.25, 0.5 and 0.75, respectively. Results for unbalanced settings with 2 covariates are provided in Table 4. Finally, Table 5 contains the results for balanced scenarios with 3 covariates. In Section 2 of the Supplementary Material, we present some results regarding the distribution of the final sample sizes of the blinded recalculation procedure. The different settings are described in detail in Section 3 of the manuscript.

1 Sample sizes and power for fixed sample size calculation settings

Table 1: Total sample sizes N and related exact power for the exact method as well as for the four approximate fixed sample size calculation formulas discussed in Section 2. An ANCOVA model with $c = 2$ covariates was considered, assuming $\gamma = 1$ (i.e., balanced design), $\sigma_Y^2 = \sigma_Z^2 = 1$, $\rho_Z = 0.25$. Exact: Exact method proposed by Shieh (2017), Appr (3): Basic approximate formula, Appr (4): Guenther-Schouten adjustment, Appr (5): Degrees-of-freedom adjustment, Appr (6): Combined Guenther-Schouten and degrees-of-freedom adjustment. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$. $n_{sim} = 1,000,000$.

Setting			Exact		Appr (3)		Appr (4)		Appr (5)		Appr (6)	
Δ	$\boldsymbol{\sigma}_{YZ}$	R^2	N	Power	N	Power	N	Power	N	Power	N	Power
0.25	c_1	0.10	456	0.8000	454	0.7982	456	0.8000	456	0.8000	458	0.8017
0.25	c_2	0.40	306	0.8008	302	0.7956	304	0.7982	304	0.7982	306	0.8008
0.25	c_3	0.90	56	0.8127	52	0.7811	54	0.7975	54	0.7975	56	0.8127
0.50	c_1	0.10	118	0.8034	114	0.7893	116	0.7964	116	0.7964	118	0.8034
0.50	c_2	0.40	80	0.8032	76	0.7817	78	0.7927	78	0.7927	80	0.8032
0.50	c_3	0.90	18	0.8283	14	0.6835	16	0.7652	16	0.7652	18	0.8283
0.75	c_1	0.10	56	0.8127	52	0.7811	54	0.7975	54	0.7975	56	0.8127
0.75	c_2	0.40	38	0.8040	34	0.7530	36	0.7797	36	0.7797	38	0.8040
0.75	c_3	0.90	12	0.8861	6	0.2527	8	0.5606	14	0.9464	16	0.9758
0.25	c_4	0.27	374	0.8020	370	0.7977	372	0.7998	372	0.7998	374	0.8020
0.25	c_5	0.57	222	0.8010	218	0.7937	220	0.7973	220	0.7973	222	0.8010
0.25	c_6	0.67	172	0.8018	168	0.7923	170	0.7971	170	0.7971	172	0.8018
0.50	c_4	0.27	98	0.8081	94	0.7910	96	0.7997	96	0.7997	98	0.8081
0.50	c_5	0.57	60	0.8109	56	0.7816	58	0.7967	58	0.7967	60	0.8109
0.50	c_6	0.67	46	0.8006	42	0.7600	44	0.7811	46	0.8006	46	0.8006
0.75	c_4	0.27	46	0.8091	42	0.7690	44	0.7898	44	0.7898	46	0.8091
0.75	c_5	0.57	30	0.8244	26	0.7572	28	0.7931	28	0.7931	30	0.8244
0.75	c_6	0.67	24	0.8218	20	0.7296	22	0.7798	22	0.7798	24	0.8218

Table 2: Total sample sizes N and related exact power for the exact method as well as for the four approximate fixed sample size calculation formulas discussed in Section 2. An ANCOVA model with $c = 2$ covariates was considered, assuming $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $\rho_Z = 0.5$. Exact: Exact method proposed by Shieh (2017), Appr (3): Basic approximate formula, Appr (4): Guenther-Schouten adjustment, Appr (5): Degrees-of-freedom adjustment, Appr (6): Combined Guenther-Schouten and degrees-of-freedom adjustment. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$. $n_{sim} = 1,000,000$.

Setting			Exact		Appr (3)		Appr (4)		Appr (5)		Appr (6)	
Δ	$\boldsymbol{\sigma}_{YZ}$	R^2	N	Power	N	Power	N	Power	N	Power	N	Power
0.25	c_1	0.08	466	0.8012	462	0.7978	464	0.7995	464	0.7995	466	0.8012
0.25	c_2	0.33	340	0.8012	336	0.7965	338	0.7988	338	0.7988	340	0.8012
0.25	c_3	0.75	130	0.8013	126	0.7886	128	0.7950	128	0.7950	130	0.8013
0.50	c_1	0.08	120	0.8029	116	0.7890	118	0.7960	118	0.7960	120	0.8029
0.50	c_2	0.33	88	0.8010	84	0.7816	86	0.7915	86	0.7915	88	0.8010
0.50	c_3	0.75	36	0.8052	32	0.7507	34	0.7794	34	0.7794	36	0.8052
0.75	c_1	0.08	56	0.8055	52	0.7735	54	0.7901	54	0.7901	56	0.8055
0.75	c_2	0.33	42	0.8065	38	0.7616	40	0.7851	40	0.7851	42	0.8065
0.75	c_3	0.75	20	0.8412	14	0.6391	16	0.7222	18	0.7888	20	0.8412
0.25	c_4	0.25	382	0.8014	378	0.7972	380	0.7993	380	0.7993	382	0.8014
0.25	c_5	0.58	214	0.8011	210	0.7935	212	0.7973	212	0.7973	214	0.8011
0.25	c_6	0.58	214	0.8011	210	0.7935	212	0.7973	212	0.7973	214	0.8011
0.50	c_4	0.25	100	0.8074	96	0.7907	98	0.7992	98	0.7992	100	0.8074
0.50	c_5	0.58	58	0.8113	54	0.7809	56	0.7966	56	0.7966	58	0.8113
0.50	c_6	0.58	58	0.8113	54	0.7809	56	0.7966	56	0.7966	58	0.8113
0.75	c_4	0.25	46	0.8002	42	0.7595	44	0.7806	46	0.8002	46	0.8002
0.75	c_5	0.58	28	0.8077	24	0.7322	26	0.7726	26	0.7726	28	0.8077
0.75	c_6	0.58	28	0.8077	24	0.7322	26	0.7726	26	0.7726	28	0.8077

Table 3: Total sample sizes N and related exact power for the exact method as well as for the four approximate fixed sample size calculation formulas discussed in Section 2. An ANCOVA model with $c = 2$ covariates was considered, assuming $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $\rho_Z = 0.75$. Exact: Exact method proposed by Shieh (2017), Appr (3): Basic approximate formula, Appr (4): Guenther-Schouten adjustment, Appr (5): Degrees-of-freedom adjustment, Appr (6): Combined Guenther-Schouten and degrees-of-freedom adjustment. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$. $n_{sim} = 1,000,000$.

Setting			Exact		Appr (3)		Appr (4)		Appr (5)		Appr (6)	
Δ	$\boldsymbol{\sigma}_{YZ}$	R^2	N	Power	N	Power	N	Power	N	Power	N	Power
0.25	c_1	0.07	472	0.8012	468	0.7978	470	0.7995	470	0.7995	472	0.8012
0.25	c_2	0.29	364	0.8015	360	0.7971	362	0.7993	362	0.7993	364	0.8015
0.25	c_3	0.64	184	0.8015	180	0.7927	182	0.7971	182	0.7971	184	0.8015
0.50	c_1	0.07	122	0.8045	118	0.7909	120	0.7978	120	0.7978	122	0.8045
0.50	c_2	0.29	94	0.8014	90	0.7833	92	0.7925	92	0.7925	94	0.8014
0.50	c_3	0.64	50	0.8091	46	0.7728	48	0.7916	48	0.7916	50	0.8091
0.75	c_1	0.07	56	0.8005	52	0.7682	54	0.7849	54	0.7849	56	0.8005
0.75	c_2	0.29	44	0.8002	40	0.7573	42	0.7796	44	0.8002	46	0.8190
0.75	c_3	0.64	26	0.8323	20	0.7002	22	0.7515	24	0.7953	26	0.8323
0.25	c_4	0.29	364	0.8015	360	0.7971	362	0.7993	362	0.7993	364	0.8015
0.25	c_5	0.79	112	0.8018	108	0.7869	110	0.7945	110	0.7945	112	0.8018
0.25	c_6	0.57	220	0.8010	216	0.7936	218	0.7973	218	0.7973	220	0.8010
0.50	c_4	0.29	94	0.8014	90	0.7833	92	0.7925	92	0.7925	94	0.8014
0.50	c_5	0.79	32	0.8129	28	0.7501	30	0.7834	30	0.7834	32	0.8129
0.50	c_6	0.57	58	0.8003	54	0.7694	56	0.7853	56	0.7853	58	0.8003
0.75	c_4	0.29	44	0.8002	40	0.7573	42	0.7796	44	0.8002	46	0.8190
0.75	c_5	0.79	18	0.8459	12	0.6007	14	0.7044	16	0.7850	18	0.8459
0.75	c_6	0.57	30	0.8278	24	0.7202	26	0.7610	28	0.7968	30	0.8278

Table 4: Total sample sizes N and related exact power for the exact method as well as for the four approximate fixed sample size calculation formulas discussed in Section 2. An ANCOVA model with $c = 2$ covariates was considered, assuming $\gamma = 2$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $\rho_Z = 0.5$. Exact: Exact method proposed by Shieh (2017), Appr (3): Basic approximate formula, Appr (4): Guenther-Schouten adjustment, Appr (5): Degrees-of-freedom adjustment, Appr (6): Combined Guenther-Schouten and degrees-of-freedom adjustment. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$. $n_{sim} = 1,000,000$.

Setting			Exact		Appr (3)		Appr (4)		Appr (5)		Appr (6)	
Δ	$\boldsymbol{\sigma}_{YZ}$	R^2	N	Power	N	Power	N	Power	N	Power	N	Power
0.25	c_1	0.08	525	0.8021	519	0.7976	522	0.7999	522	0.7999	522	0.7999
0.25	c_2	0.33	381	0.8001	378	0.7970	381	0.8001	381	0.8001	381	0.8001
0.25	c_3	0.75	147	0.8048	144	0.7965	144	0.7965	144	0.7965	147	0.8048
0.50	c_1	0.08	135	0.8044	132	0.7953	132	0.7953	132	0.7953	135	0.8044
0.50	c_2	0.33	99	0.8031	96	0.7905	99	0.8031	99	0.8031	99	0.8031
0.50	c_3	0.75	42	0.8264	36	0.7580	39	0.7946	39	0.7946	42	0.8264
0.75	c_1	0.08	63	0.8090	60	0.7885	60	0.7885	60	0.7885	63	0.8090
0.75	c_2	0.33	48	0.8180	42	0.7593	45	0.7904	45	0.7904	48	0.8180
0.75	c_3	0.75	21	0.8218	18	0.7415	18	0.7415	21	0.8218	21	0.8218
0.25	c_4	0.25	429	0.8011	426	0.7983	426	0.7983	426	0.7983	429	0.8011
0.25	c_5	0.58	240	0.8006	237	0.7956	240	0.8006	240	0.8006	240	0.8006
0.25	c_6	0.58	240	0.8006	237	0.7956	240	0.8006	240	0.8006	240	0.8006
0.50	c_4	0.25	111	0.8038	108	0.7926	108	0.7926	111	0.8038	111	0.8038
0.50	c_5	0.58	63	0.8001	60	0.7793	63	0.8001	63	0.8001	63	0.8001
0.50	c_6	0.58	63	0.8001	60	0.7793	63	0.8001	63	0.8001	63	0.8001
0.75	c_4	0.25	54	0.8222	48	0.7718	51	0.7984	51	0.7984	54	0.8222
0.75	c_5	0.58	33	0.8357	27	0.7429	30	0.7937	30	0.7937	33	0.8357
0.75	c_6	0.58	33	0.8357	27	0.7429	30	0.7937	30	0.7937	33	0.8357

Table 5: Total sample sizes N and related exact power for the exact method as well as for the four approximate fixed sample size calculation formulas discussed in Section 2. An ANCOVA model with $c = 3$ covariates was considered, assuming $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = Cov(Z_2, Z_3) = 0.5$, $Cov(Z_1, Z_3) = 0.25$. Exact: Exact method proposed by Shieh (2017), Appr (3): Basic approximate formula, Appr (4): Guenther-Schouten adjustment, Appr (5): Degrees-of-freedom adjustment, Appr (6): Combined Guenther-Schouten and degrees-of-freedom adjustment. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.25, 0.5)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.5, 0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.75, 0.75, 0.5)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.5, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.75, 0.5)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.5, 0.75, 0.5)$. $n_{sim} = 1,000,000$.

Setting			Exact		Appr (3)		Appr (4)		Appr (5)		Appr (6)	
Δ	$\boldsymbol{\sigma}_{YZ}$	R^2	N	Power	N	Power	N	Power	N	Power	N	Power
0.25	c_1	0.27	372	0.8009	368	0.7977	370	0.7998	370	0.7998	372	0.8020
0.25	c_2	0.42	298	0.8002	294	0.7962	296	0.7989	298	0.8016	298	0.8016
0.25	c_3	0.77	122	0.8065	116	0.7894	118	0.7965	120	0.8033	122	0.8099
0.50	c_1	0.27	98	0.8060	92	0.7842	94	0.7932	96	0.8019	98	0.8102
0.50	c_2	0.42	80	0.8090	74	0.7819	76	0.7932	78	0.8040	80	0.8143
0.50	c_3	0.77	36	0.8254	30	0.7559	32	0.7865	34	0.8138	36	0.8380
0.75	c_1	0.27	46	0.8012	42	0.7712	44	0.7920	46	0.8111	48	0.8288
0.75	c_2	0.42	38	0.8027	34	0.7649	36	0.7912	38	0.8150	40	0.8364
0.75	c_3	0.77	20	0.8450	14	0.6761	16	0.7582	18	0.8219	20	0.8705
0.25	c_4	0.33	340	0.8000	336	0.7965	338	0.7988	338	0.7988	340	0.8012
0.25	c_5	0.60	204	0.8002	200	0.7942	202	0.7982	202	0.7982	204	0.8022
0.25	c_6	0.60	204	0.8002	200	0.7942	202	0.7982	202	0.7982	204	0.8022
0.50	c_4	0.33	90	0.8055	84	0.7816	86	0.7915	88	0.8010	90	0.8101
0.50	c_5	0.60	56	0.8088	50	0.7678	52	0.7852	54	0.8014	56	0.8166
0.50	c_6	0.60	56	0.8088	50	0.7678	52	0.7852	54	0.8014	56	0.8166
0.75	c_4	0.33	44	0.8160	38	0.7616	40	0.7851	42	0.8065	44	0.8261
0.75	c_5	0.60	28	0.8094	24	0.7537	26	0.7932	26	0.7932	28	0.8271
0.75	c_6	0.60	28	0.8094	24	0.7537	26	0.7932	26	0.7932	28	0.8271

2 Final sample sizes resulting from the recalculation procedure

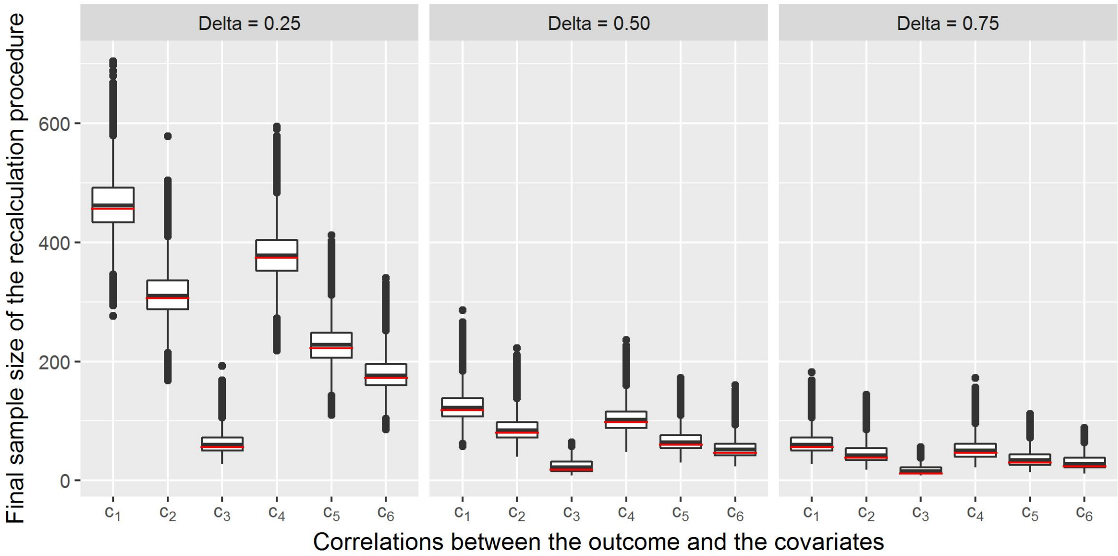

Figure 1: Distribution of the final sample sizes of the recalculation procedure, with the corresponding exact fixed sample size as reference (red line). We assumed $c = 2$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.25$ (*i.e.,* covariance matrix scenario *Cov 1*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

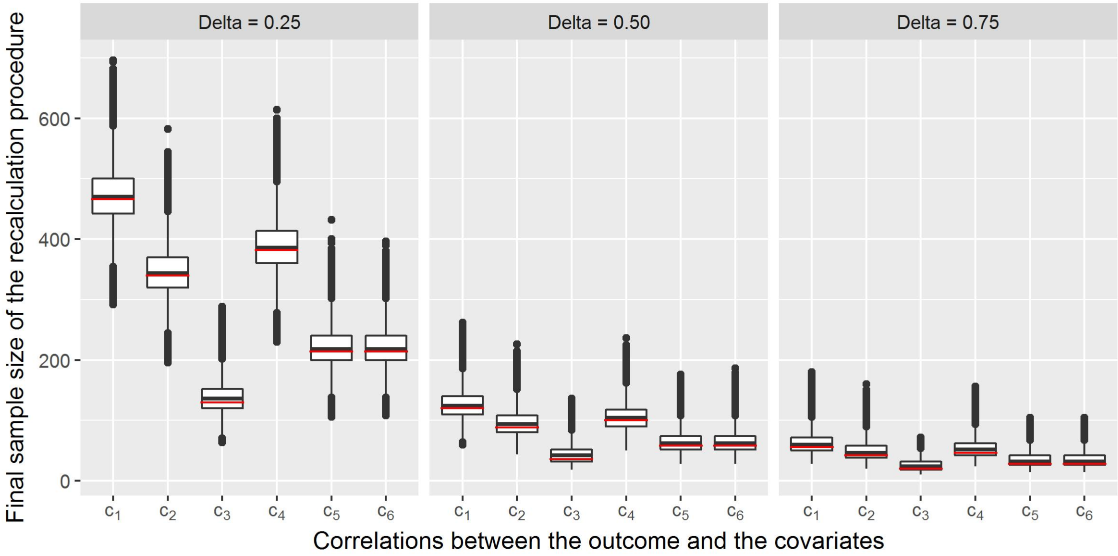

Figure 2: Distribution of the final sample sizes of the recalculation procedure, with the corresponding exact fixed sample size as reference (red line). We assumed $c = 2$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.5$ (*i.e.,* covariance matrix scenario *Cov 2*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

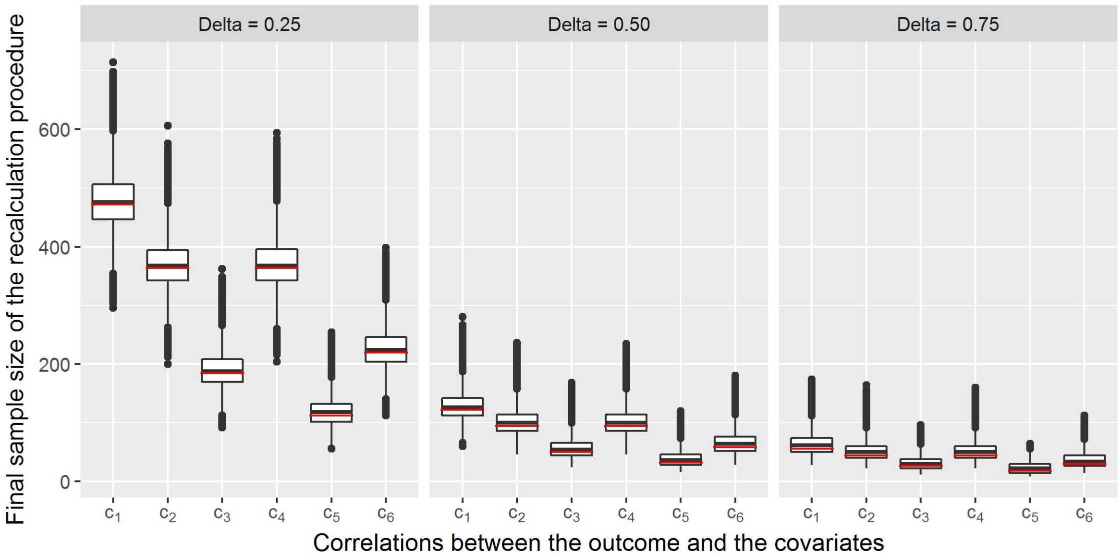

Figure 3: Distribution of the final sample sizes of the recalculation procedure, with the corresponding exact fixed sample size as reference (red line). We assumed $c = 2$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.75$ (*i.e.,* covariance matrix scenario *Cov 3*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

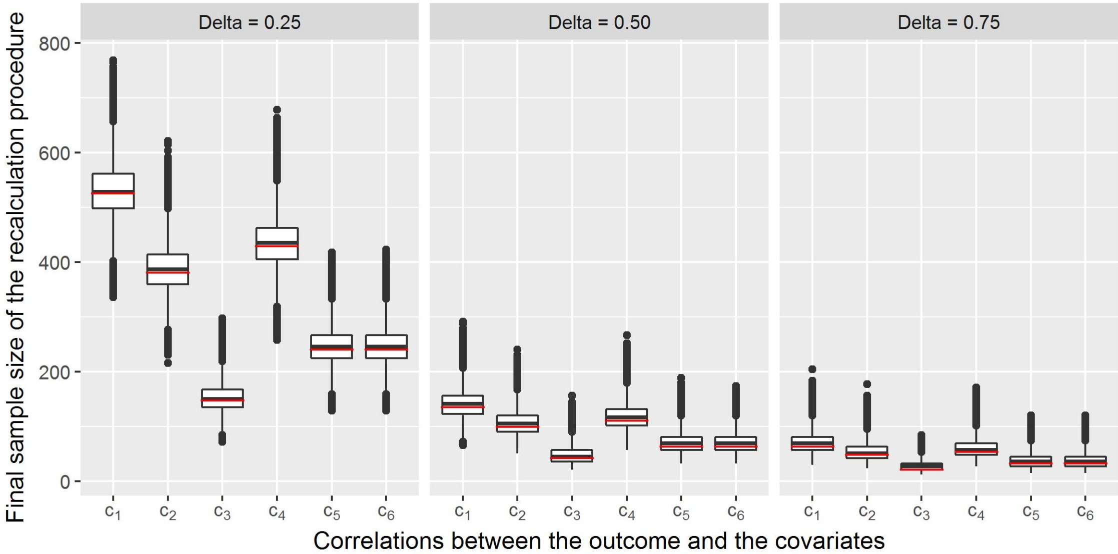

Figure 4: Distribution of the final sample sizes of the recalculation procedure, with the corresponding exact fixed sample size as reference (red line). We assumed $c = 2$ covariates, $\gamma = 2$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.5$ (*i.e.,* covariance matrix scenario *Cov 2*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

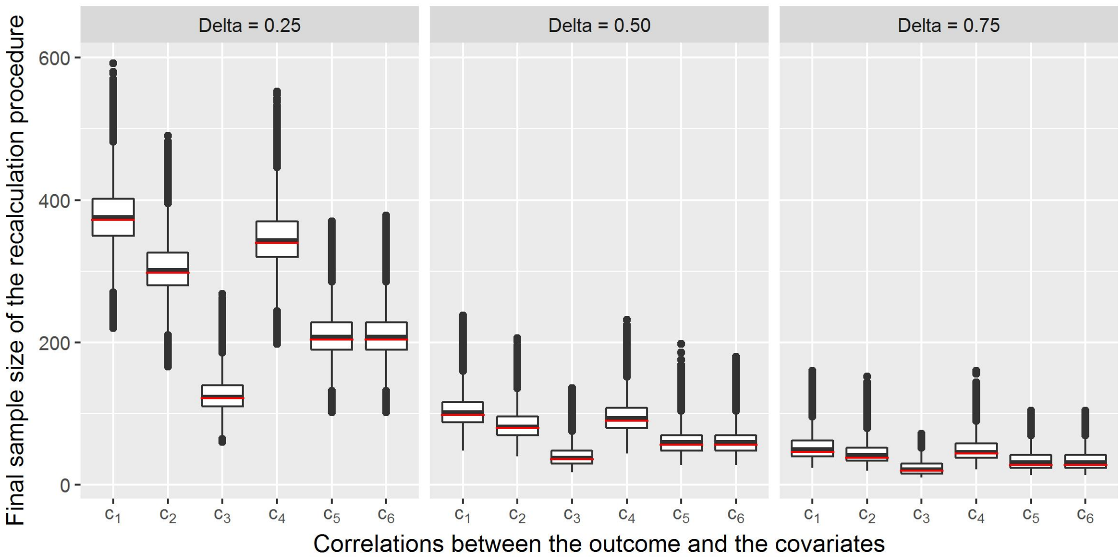

Figure 5: Distribution of the final sample sizes of the recalculation procedure, with the corresponding exact fixed sample size as reference (red line). We assumed an ANCOVA model with $c = 3$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = Cov(Z_2, Z_3) = 0.5$, $Cov(Z_1, Z_3) = 0.25$. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.25, 0.5)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.5, 0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.75, 0.75, 0.5)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.5, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.75, 0.5)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.5, 0.75, 0.5)$.

The following tables show information on the distribution of the final sample sizes from the recalculation procedure and on the corresponding exact sample sizes (denoted by N_{Ex}) for the fixed setting (calculated by using the approach that was proposed by Shieh, 2017). The distribution of the recalculated sample sizes was summarized by providing the average, median, minimum and maximum final sample sizes, denoted by N_{Avg}, N_{Med}, N_{Min} and N_{Max}, respectively. Moreover, the excess over the exact sample size was analyzed by determining how often the final sample sizes resulting from the recalculation procedure exceeded $l \cdot N_{Ex}$, $l \in \{2, 3, 4\}$ (the results are given as the percentage within $n_{sim} = 1,000,000$ simulation runs).

Table 6: Final sample sizes from the recalculation procedure and corresponding exact sample sizes for the fixed setting (N_{Ex}), assuming $c = 2$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.25$ (*i.e.,* covariance matrix scenario *Cov 1*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

Δ	$\boldsymbol{\sigma}_{YZ}$	N_{Ex}	N_{Avg}	N_{Med}	N_{Min}	N_{Max}	$> 2N_{Ex}[\%]$	$> 3N_{Ex}[\%]$	$> 4N_{Ex}[\%]$
0.25	c_1	456	463	462	276	704	0.00	0.00	0.00
0.25	c_2	306	312	310	168	578	0.00	0.00	0.00
0.25	c_3	56	61	60	28	192	0.43	0.00	0.00
0.50	c_1	118	124	122	58	286	0.00	0.00	0.00
0.50	c_2	80	86	84	40	222	0.08	0.00	0.00
0.50	c_3	18	24	22	8	64	15.26	2.50	0.00
0.75	c_1	56	61	60	28	182	0.44	0.00	0.00
0.75	c_2	38	45	42	18	144	2.98	0.03	0.00
0.75	c_3	12	18	16	8	56	15.97	1.88	0.14
0.25	c_4	374	379	378	218	594	0.00	0.00	0.00
0.25	c_5	222	229	228	110	412	0.00	0.00	0.00
0.25	c_6	172	178	176	86	340	0.00	0.00	0.00
0.50	c_4	98	103	102	48	236	0.01	0.00	0.00
0.50	c_5	60	65	64	30	172	0.32	0.00	0.00
0.50	c_6	46	53	52	24	160	1.27	0.00	0.00
0.75	c_4	46	52	50	22	172	1.35	0.00	0.00
0.75	c_5	30	36	34	14	112	4.70	0.13	0.00
0.75	c_6	24	30	28	12	88	7.66	0.39	0.00

Table 7: Final sample sizes from the recalculation procedure and corresponding exact sample sizes for the fixed setting (N_{Ex}), assuming $c = 2$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.5$ (*i.e.*, covariance matrix scenario *Cov 2*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

Δ	$\boldsymbol{\sigma}_{YZ}$	N_{Ex}	N_{Avg}	N_{Med}	N_{Min}	N_{Max}	$> 2N_{Ex}[\%]$	$> 3N_{Ex}[\%]$	$> 4N_{Ex}[\%]$
0.25	c_1	466	471	470	292	696	0.00	0.00	0.00
0.25	c_2	340	346	344	196	582	0.00	0.00	0.00
0.25	c_3	130	136	136	64	288	0.00	0.00	0.00
0.50	c_1	120	126	124	60	262	0.00	0.00	0.00
0.50	c_2	88	95	94	44	226	0.04	0.00	0.00
0.50	c_3	36	43	42	18	136	3.06	0.03	0.00
0.75	c_1	56	62	60	28	180	0.54	0.00	0.00
0.75	c_2	42	48	46	20	160	2.01	0.01	0.00
0.75	c_3	20	26	24	10	72	9.90	0.80	0.00
0.25	c_4	382	388	386	230	614	0.00	0.00	0.00
0.25	c_5	214	220	218	106	432	0.00	0.00	0.00
0.25	c_6	214	220	218	108	396	0.00	0.00	0.00
0.50	c_4	100	105	104	50	236	0.01	0.00	0.00
0.50	c_5	58	63	62	28	176	0.43	0.00	0.00
0.50	c_6	58	63	62	28	186	0.45	0.00	0.00
0.75	c_4	46	53	52	24	156	1.27	0.00	0.00
0.75	c_5	28	35	32	14	104	6.00	0.19	0.00
0.75	c_6	28	35	32	14	104	6.07	0.19	0.00

Table 8: Final sample sizes from the recalculation procedure and corresponding exact sample sizes for the fixed setting (N_{Ex}), assuming $c = 2$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.75$ (*i.e.*, covariance matrix scenario *Cov 3*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

Δ	$\boldsymbol{\sigma}_{YZ}$	N_{Ex}	N_{Avg}	N_{Med}	N_{Min}	N_{Max}	$> 2N_{Ex}[\%]$	$> 3N_{Ex}[\%]$	$> 4N_{Ex}[\%]$
0.25	c_1	472	477	476	296	714	0.00	0.00	0.00
0.25	c_2	364	370	368	200	606	0.00	0.00	0.00
0.25	c_3	184	190	188	92	362	0.00	0.00	0.00
0.50	c_1	122	128	126	60	280	0.00	0.00	0.00
0.50	c_2	94	101	100	46	236	0.03	0.00	0.00
0.50	c_3	50	56	54	24	168	0.95	0.00	0.00
0.75	c_1	56	63	62	28	174	0.62	0.00	0.00
0.75	c_2	44	51	50	22	164	1.68	0.01	0.00
0.75	c_3	26	31	30	12	96	6.46	0.29	0.00
0.25	c_4	364	370	368	204	594	0.00	0.00	0.00
0.25	c_5	112	119	118	56	254	0.01	0.00	0.00
0.25	c_6	220	226	224	112	398	0.00	0.00	0.00
0.50	c_4	94	101	100	46	234	0.03	0.00	0.00
0.50	c_5	32	38	36	16	120	3.96	0.07	0.00
0.50	c_6	58	65	64	28	180	0.60	0.00	0.00
0.75	c_4	44	51	50	22	160	1.70	0.01	0.00
0.75	c_5	18	24	22	8	64	13.96	2.08	0.00
0.75	c_6	30	35	34	14	112	4.43	0.12	0.00

Table 9: Final sample sizes from the recalculation procedure and corresponding exact sample sizes for the fixed setting (N_{Ex}), assuming $c = 2$ covariates, $\gamma = 2$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = 0.5$ (*i.e.*, covariance matrix scenario *Cov 2*). $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.25)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.75, 0.75)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.25, 0.75)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}) = (0.5, 0.75)$.

Δ	$\boldsymbol{\sigma}_{YZ}$	N_{Ex}	N_{Avg}	N_{Med}	N_{Min}	N_{Max}	$> 2N_{Ex}[\%]$	$> 3N_{Ex}[\%]$	$> 4N_{Ex}[\%]$
0.25	c_1	525	529	528	336	768	0.00	0.00	0.00
0.25	c_2	381	388	387	216	621	0.00	0.00	0.00
0.25	c_3	147	153	150	72	297	0.00	0.00	0.00
0.50	c_1	135	141	141	66	291	0.00	0.00	0.00
0.50	c_2	99	106	105	51	240	0.01	0.00	0.00
0.50	c_3	42	47	45	21	156	1.18	0.00	0.00
0.75	c_1	63	69	69	30	204	0.32	0.00	0.00
0.75	c_2	48	53	51	24	177	0.78	0.00	0.00
0.75	c_3	21	28	27	12	84	8.53	0.44	0.00
0.25	c_4	429	435	435	258	678	0.00	0.00	0.00
0.25	c_5	240	247	246	129	417	0.00	0.00	0.00
0.25	c_6	240	247	246	129	423	0.00	0.00	0.00
0.50	c_4	111	117	117	57	267	0.01	0.00	0.00
0.50	c_5	63	70	69	33	189	0.29	0.00	0.00
0.50	c_6	63	70	69	33	174	0.29	0.00	0.00
0.75	c_4	54	59	57	27	171	0.39	0.00	0.00
0.75	c_5	33	38	36	15	120	3.13	0.05	0.00
0.75	c_6	33	38	36	15	120	3.14	0.05	0.00

Table 10: Final sample sizes from the recalculation procedure and corresponding exact sample sizes for the fixed setting (N_{Ex}), assuming an ANCOVA model with $c = 3$ covariates, $\gamma = 1$, $\sigma_Y^2 = \sigma_Z^2 = 1$, $Cov(Z_1, Z_2) = Cov(Z_2, Z_3) = 0.5$, $Cov(Z_1, Z_3) = 0.25$. $c_1 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.25, 0.5)$, $c_2 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.5, 0.5, 0.5)$, $c_3 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.75, 0.75, 0.5)$, $c_4 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.5, 0.5)$, $c_5 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.25, 0.75, 0.5)$, $c_6 : (\sigma_{YZ_1}, \sigma_{YZ_2}, \sigma_{YZ_3}) = (0.5, 0.75, 0.5)$

Δ	$\boldsymbol{\sigma}_{YZ}$	N_{Ex}	N_{Avg}	N_{Med}	N_{Min}	N_{Max}	$> 2N_{Ex}[\%]$	$> 3N_{Ex}[\%]$	$> 4N_{Ex}[\%]$
0.25	c_1	372	377	376	220	592	0.00	0.00	0.00
0.25	c_2	298	304	302	166	490	0.00	0.00	0.00
0.25	c_3	122	126	124	60	268	0.00	0.00	0.00
0.50	c_1	98	103	102	48	238	0.02	0.00	0.00
0.50	c_2	80	84	82	40	206	0.05	0.00	0.00
0.50	c_3	36	40	38	18	136	2.02	0.01	0.00
0.75	c_1	46	52	50	24	160	1.12	0.00	0.00
0.75	c_2	38	44	42	20	152	2.17	0.01	0.00
0.75	c_3	20	25	22	10	72	9.10	0.83	0.00
0.25	c_4	340	346	344	198	552	0.00	0.00	0.00
0.25	c_5	204	210	208	102	370	0.00	0.00	0.00
0.25	c_6	204	210	208	102	378	0.00	0.00	0.00
0.50	c_4	90	95	94	44	232	0.03	0.00	0.00
0.50	c_5	56	61	60	28	198	0.45	0.00	0.00
0.50	c_6	56	61	60	28	180	0.44	0.00	0.00
0.75	c_4	44	48	46	22	160	1.09	0.00	0.00
0.75	c_5	28	34	32	14	104	5.51	0.19	0.00
0.75	c_6	28	34	32	14	104	5.53	0.19	0.00