Web Appendix:

A Simple and Successful Shrinkage Method for Weighting Estimators of Treatment Effects

Winfried Pohlmeier^a, Ruben Seiberlich^a, Selver Derya Uysal^{b,1}

^a*University of Konstanz, Department of Economics, Konstanz, Germany*

^b*IHS, Department of Economics and Finance, Vienna, Austria*

¹Corresponding author. Department of Economics and Finance, IHS, Vienna, Stumpergasse 56, A-1060, Vienna, Austria. Phone +43 1 59991 156, email:uysal@ihs.ac.at. The authors gratefully acknowledge financial support from the German Research Foundation (DFG) through research unit FOR 1882 “Psychoeconomics” and from the Oesterreichische Nationalbank (Anniversary Fund, project number: 14986). This paper benefited from helpful ideas and discussions with Nam-Huyan Kim, Bertrand Koebel, Fabian Krüger and Bernd Fitzenberger. Furthermore, we thank the participants at the DFH Workshop “Applied Econometrics” 2012, Königfeld, Germany, the participants at the Workshop of the German Statistical Association (DStatG) 2012, Vienna, Austria as well as the session participants at the European Meeting of the Econometric Society 2012, Málaga, Spain, for their helpful comments. We also like to thank two anonymous referees whose comments and suggestions clearly improved the paper.

Table A.1: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used instead of the conventional propensity scores, fixed valued λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	59.8 (-0.2)	60.9 (-0.3)	57.0 (-0.1)	56.4 (-6.3)	58.9 (-7.0)	52.1 (-8.5)	60.7 (-0.5)	61.6 (-0.7)	57.9 (-0.5)	58.4 (-11.5)	58.2 (-13.1)	49.5 (-17.1)	
	IPW 2	24.4 (-3.9)	26.7 (-4.6)	25.3 (-6.8)	26.8 (-1.0)	30.5 (-1.0)	33.8 (-0.5)	20.5 (-8.5)	22.6 (-10.0)	19.4 (-13.7)	26.0 (-1.4)	29.7 (-1.4)	33.3 (-0.8)	
	IPW 3	10.3 (-1.6)	9.0 (-1.6)	6.4 (-2.4)	11.4 (-0.4)	10.2 (-0.4)	8.6 (-0.1)	8.2 (-3.5)	6.9 (-3.7)	3.8 (-4.8)	11.1 (-0.6)	10.0 (-0.5)	8.5 (0.0)	
	DR	8.5 (0.0)	9.9 (0.0)	11.0 (0.0)	8.5 (0.0)	10.0 (0.0)	11.3 (0.0)	8.5 (0.1)	9.9 (0.0)	11.1 (0.0)	8.5 (-0.2)	10.0 (-0.3)	11.0 (-0.6)	
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	45.7 (-0.2)	48.1 (-0.3)	46.0 (-0.1)	43.9 (-5.0)	48.2 (-5.6)	42.9 (-6.8)	46.9 (-0.4)	49.2 (-0.5)	47.2 (-0.4)	48.3 (-9.7)	49.9 (-11.1)	42.7 (-14.2)	
	IPW 2	12.7 (-2.5)	14.5 (-3.2)	15.6 (-4.9)	14.2 (-0.6)	17.4 (-0.7)	21.9 (-0.4)	10.3 (-5.7)	11.9 (-7.0)	11.5 (-10.0)	13.7 (-0.9)	16.9 (-0.9)	21.6 (-0.5)	
	IPW 3	4.8 (-1.0)	4.4 (-1.1)	2.8 (-1.6)	5.5 (-0.3)	5.2 (-0.2)	4.3 (0.0)	3.5 (-2.2)	3.1 (-2.4)	1.1 (-3.3)	5.3 (-0.4)	5.1 (-0.3)	4.3 (0.0)	
	DR	5.5 (0.0)	6.5 (0.0)	7.2 (0.0)	5.6 (0.0)	6.6 (0.0)	7.4 (0.0)	5.5 (0.0)	6.5 (0.0)	7.3 (0.0)	5.7 (-0.1)	6.6 (-0.2)	7.2 (-0.4)	
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	55.9 (-0.4)	47.9 (-0.5)	38.1 (-1.0)	52.5 (-1.1)	43.2 (-1.6)	35.2 (-1.4)	56.1 (-0.3)	48.3 (-0.3)	38.7 (-0.7)	52.8 (-3.4)	43.1 (-4.6)	35.2 (-4.8)	
	IPW 2	20.6 (-2.0)	22.6 (-2.0)	22.0 (-2.6)	22.2 (-1.1)	23.8 (-1.5)	23.0 (-1.4)	18.8 (-3.9)	21.2 (-4.0)	20.6 (-4.9)	21.5 (-1.6)	22.9 (-2.1)	22.3 (-1.9)	
	IPW 3	8.6 (-0.9)	7.6 (-0.8)	6.7 (-1.0)	9.0 (-0.6)	7.6 (-0.7)	7.0 (-0.5)	7.6 (-1.8)	6.6 (-1.7)	5.7 (-1.9)	8.7 (-0.8)	7.3 (-1.0)	6.8 (-0.7)	
	DR	5.9 (0.0)	6.6 (0.0)	8.3 (0.0)	5.9 (0.0)	6.7 (0.0)	8.4 (0.0)	5.9 (0.0)	6.7 (0.0)	8.2 (0.0)	6.0 (0.0)	6.9 (0.0)	8.6 (0.0)	
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	40.6 (-0.3)	33.9 (-0.4)	27.4 (-0.7)	37.1 (-0.8)	29.3 (-1.1)	24.7 (-1.0)	41.0 (-0.2)	34.3 (-0.2)	27.9 (-0.5)	38.4 (-2.6)	30.1 (-3.4)	25.4 (-3.5)	
	IPW 2	10.7 (-1.3)	12.9 (-1.3)	13.8 (-1.8)	11.7 (-0.7)	13.7 (-1.0)	14.2 (-1.0)	9.6 (-2.5)	12.2 (-2.6)	12.9 (-3.4)	11.2 (-1.1)	13.2 (-1.4)	13.8 (-1.3)	
	IPW 3	3.6 (-0.6)	3.5 (-0.5)	3.5 (-0.6)	3.8 (-0.4)	3.6 (-0.4)	3.7 (-0.3)	3.0 (-1.2)	2.9 (-1.0)	2.8 (-1.3)	3.6 (-0.5)	3.4 (-0.6)	3.6 (-0.4)	
	DR	3.9 (0.0)	4.5 (0.0)	5.8 (0.0)	3.9 (0.0)	4.6 (0.0)	5.9 (0.0)	3.9 (0.0)	4.5 (0.0)	5.8 (0.0)	4.0 (0.0)	4.7 (0.0)	6.0 (0.0)	
Ratio 2:3			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	47.7 (-2.5)	65.5 (-2.0)	36.3 (-4.0)	46.8 (-9.2)	66.1 (-6.8)	33.0 (-14.6)	48.7 (-3.2)	66.5 (-2.6)	36.8 (-5.4)	48.1 (-15.4)	67.4 (-10.9)	31.6 (-24.6)	
	IPW 2	19.7 (-2.0)	21.9 (-2.3)	18.8 (-3.2)	21.6 (-0.1)	23.2 (-0.1)	21.7 (0.0)	17.0 (-5.2)	19.5 (-5.9)	15.8 (-7.6)	21.5 (-0.2)	23.2 (-0.1)	21.8 (0.0)	
	IPW 3	8.9 (-0.9)	7.5 (-0.9)	5.7 (-1.2)	9.7 (-0.1)	8.4 (0.0)	7.0 (0.0)	7.4 (-2.3)	6.0 (-2.4)	4.0 (-2.8)	9.6 (-0.1)	8.3 (0.0)	7.0 (0.1)	
	DR	6.2 (0.0)	6.3 (0.0)	7.3 (0.0)	6.2 (0.0)	6.4 (0.0)	7.4 (0.0)	6.2 (0.0)	6.3 (0.0)	7.3 (-0.1)	6.1 (-0.1)	6.3 (-0.3)	7.1 (-0.4)	
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	36.5 (-1.8)	54.8 (-1.7)	28.4 (-2.9)	37.1 (-7.1)	57.2 (-5.8)	27.0 (-10.9)	37.6 (-2.4)	56.3 (-2.2)	29.2 (-3.9)	40.2 (-12.5)	60.6 (-9.7)	27.3 (-19.6)	
	IPW 2	9.9 (-1.3)	11.8 (-1.5)	11.2 (-2.1)	11.0 (-0.1)	12.4 (-0.1)	13.2 (0.0)	8.3 (-3.3)	10.4 (-3.9)	9.3 (-5.2)	11.0 (-0.1)	12.4 (-0.1)	13.3 (0.0)	
	IPW 3	4.4 (-0.5)	3.7 (-0.6)	2.8 (-0.8)	4.9 (0.0)	4.2 (0.0)	3.7 (0.0)	3.5 (-1.4)	2.8 (-1.5)	1.8 (-1.8)	4.8 (0.0)	4.2 (0.0)	3.6 (0.0)	
	DR	4.0 (0.0)	4.1 (0.0)	5.0 (0.0)	4.0 (0.0)	4.2 (0.0)	5.0 (0.0)	4.0 (0.0)	4.1 (0.0)	5.0 (0.0)	4.0 (-0.1)	4.1 (-0.2)	4.8 (-0.3)	

Note: The percentage improvements in MSE of ATE estimates due to the shrunk propensity score for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.2: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used instead of the conventional propensity scores, $\text{MSE}(\hat{p}_i^s)$ -minimizing λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	60.9	66.3	66.3	57.5	63.3	58.4	61.6	67.3	66.3	58.1	64.6	56.9
		(-0.2)	(-0.3)	(-0.2)	(-6.2)	(-6.2)	(-7.3)	(-0.4)	(-0.6)	(-0.5)	(-11.8)	(-11.0)	(-13.9)
	IPW 2	24.6	26.5	31.3	27.7	29.0	34.3	20.5	22.5	28.0	27.0	28.3	33.8
		(-4.3)	(-3.9)	(-5.3)	(-0.9)	(-1.3)	(-0.9)	(-9.2)	(-8.9)	(-10.7)	(-1.3)	(-1.7)	(-1.3)
Ratio 1:1	IPW 3	9.9	9.3	7.3	11.4	10.0	8.7	7.6	7.3	5.3	11.2	9.8	8.6
		(-1.8)	(-1.4)	(-1.7)	(-0.4)	(-0.5)	(-0.3)	(-4.0)	(-3.2)	(-3.6)	(-0.5)	(-0.6)	(-0.3)
	DR	8.5	9.6	11.2	8.6	9.8	11.7	8.4	9.6	11.1	8.6	9.9	11.7
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.2)	(-0.2)	(-0.4)
	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
Ratio 1:1	IPW 1	46.4	54.1	56.5	44.8	52.6	49.7	47.5	55.5	56.8	47.9	56.1	50.2
		(-0.2)	(-0.3)	(-0.1)	(-4.8)	(-5.1)	(-6.1)	(-0.3)	(-0.5)	(-0.4)	(-9.7)	(-9.5)	(-12.2)
	IPW 2	11.9	15.8	21.4	13.7	17.2	23.2	9.5	13.4	19.7	13.3	16.8	22.8
		(-2.7)	(-2.6)	(-3.9)	(-0.6)	(-0.9)	(-0.7)	(-5.9)	(-5.9)	(-7.9)	(-0.9)	(-1.2)	(-0.9)
	IPW 3	4.1	4.5	3.9	5.0	4.9	5.0	2.7	3.3	2.5	4.9	4.8	4.9
Ratio 3:2		(-1.1)	(-0.8)	(-1.2)	(-0.3)	(-0.3)	(-0.2)	(-2.4)	(-2.0)	(-2.5)	(-0.3)	(-0.4)	(-0.2)
	DR	4.8	6.6	7.7	4.9	6.7	8.3	4.9	6.6	7.7	5.0	6.8	8.4
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)	(-0.3)
	homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	51.9	86.8	42.0	47.7	71.8	41.0	52.4	86.7	42.9	48.8	70.6	42.8
Ratio 3:2		(-0.5)	(-0.2)	(-0.7)	(-1.4)	(-0.7)	(-1.8)	(-0.4)	(-0.1)	(-0.5)	(-4.3)	(-2.4)	(-5.0)
	IPW 2	21.0	21.3	22.2	22.0	22.6	24.3	19.1	19.3	20.6	21.1	21.8	23.5
		(-2.4)	(-2.5)	(-2.0)	(-1.2)	(-1.4)	(-2.0)	(-4.7)	(-4.8)	(-4.1)	(-1.8)	(-2.0)	(-2.6)
	IPW 3	9.5	8.1	6.9	9.9	8.6	6.7	8.3	7.0	6.0	9.6	8.3	6.4
		(-1.2)	(-1.0)	(-0.6)	(-0.6)	(-0.6)	(-0.8)	(-2.3)	(-2.1)	(-1.4)	(-0.9)	(-0.9)	(-1.0)
Ratio 3:2	DR	6.1	6.7	8.3	6.2	6.7	8.5	6.1	6.6	8.3	6.3	6.9	8.8
		(0.0)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	36.1	79.4	30.5	32.0	59.6	29.5	36.6	79.3	31.3	34.2	59.1	31.9
		(-0.4)	(-0.2)	(-0.5)	(-1.0)	(-0.6)	(-1.3)	(-0.3)	(-0.1)	(-0.3)	(-3.1)	(-2.1)	(-3.8)
Ratio 2:3	IPW 2	10.1	11.8	13.9	10.7	12.9	15.7	9.0	10.5	12.8	10.1	12.4	15.1
		(-1.5)	(-1.7)	(-1.4)	(-0.8)	(-0.9)	(-1.4)	(-3.0)	(-3.3)	(-2.9)	(-1.2)	(-1.3)	(-1.8)
	IPW 3	3.8	3.9	3.7	4.1	4.2	3.6	3.1	3.1	3.1	3.8	4.0	3.4
		(-0.7)	(-0.7)	(-0.4)	(-0.4)	(-0.4)	(-0.5)	(-1.4)	(-1.4)	(-1.0)	(-0.6)	(-0.6)	(-0.7)
	DR	3.8	4.5	5.9	3.9	4.6	6.0	3.8	4.5	5.9	4.0	4.7	6.2
Ratio 2:3		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
	homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	72.5	56.0	38.6	74.2	56.0	33.9	73.5	57.1	38.8	75.6	56.9	34.5
		(-1.3)	(-2.6)	(-4.7)	(-4.9)	(-9.2)	(-16.0)	(-1.7)	(-3.4)	(-6.2)	(-7.9)	(-15.0)	(-25.2)
	IPW 2	21.3	21.7	24.5	23.6	24.0	24.8	18.3	18.7	22.9	23.5	23.9	25.0
Ratio 2:3		(-2.7)	(-2.6)	(-2.0)	(-0.1)	(-0.1)	(-0.1)	(-6.4)	(-6.5)	(-5.7)	(-0.1)	(-0.1)	(-0.1)
	IPW 3	9.2	8.0	6.5	10.5	9.1	7.1	7.3	6.3	5.1	10.5	9.0	7.1
		(-1.3)	(-1.1)	(-0.7)	(0.0)	(0.0)	(-0.1)	(-3.1)	(-2.7)	(-2.0)	(0.0)	(0.0)	(-0.1)
	DR	6.4	7.1	7.6	6.4	7.1	7.8	6.3	7.1	7.5	6.3	7.0	7.8
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)	(-0.2)	(-0.2)	(-0.2)
Ratio 2:3	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	61.1	44.9	29.9	64.9	46.6	27.1	62.7	46.3	30.3	68.7	49.7	29.1
		(-1.1)	(-2.0)	(-3.6)	(-4.2)	(-7.3)	(-12.6)	(-1.4)	(-2.6)	(-4.8)	(-7.1)	(-12.7)	(-21.2)
	IPW 2	9.7	11.8	15.6	11.1	13.2	15.5	8.1	10.1	15.1	11.1	13.2	15.7
		(-1.6)	(-1.6)	(-1.4)	(-0.1)	(-0.1)	(-0.1)	(-4.0)	(-4.1)	(-4.0)	(-0.1)	(-0.1)	(-0.1)
Ratio 2:3	IPW 3	3.8	3.7	3.2	4.6	4.3	3.6	2.7	2.6	2.4	4.6	4.3	3.6
		(-0.7)	(-0.7)	(-0.5)	(0.0)	(0.0)	(-0.1)	(-1.8)	(-1.7)	(-1.3)	(0.0)	(0.0)	(-0.1)
	DR	3.5	4.6	4.9	3.6	4.6	5.1	3.5	4.6	4.8	3.6	4.6	5.2
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.2)	(-0.1)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$ (in parenthesis). The tuning parameter λ is chosen according to the MSE minimizing tuning parameter method.

Table A.3: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used instead of the conventional propensity scores, cross validated λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	9.1	homogeneous, homoscedastic					9.1	heterogeneous, homoscedastic				
		(0.0)	6.4	1.9	7.7	4.9	1.7	(-0.1)	6.4	2.0	6.0	3.3	1.3
	IPW 2	7.0	(-0.1)	(0.0)	(-1.1)	(-1.2)	(-0.5)	(-0.1)	(-0.2)	(-0.1)	(-2.2)	(-2.1)	(-0.9)
		(-1.1)	4.8	3.5	8.1	5.8	4.5	5.6	3.5	2.8	8.1	5.6	4.5
	IPW 3	4.0	(-0.4)	(-0.4)	(-0.2)	(-0.3)	(-0.1)	(-2.3)	(-1.1)	(-0.9)	(-0.3)	(-0.4)	(-0.1)
Ratio 1:1	DR	(-0.6)	2.6	1.7	4.4	2.9	2.2	3.3	2.0	1.2	4.6	2.9	2.2
		(0.0)	(-0.2)	(-0.3)	(-0.1)	(-0.2)	(-0.1)	(-1.3)	(-0.6)	(-0.6)	(-0.1)	(-0.2)	(0.0)
		3.4	2.7	2.5	3.4	2.8	2.7	3.6	2.7	2.4	3.6	2.7	2.7
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.1)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
Ratio 1:1	IPW 1	7.4	5.2	1.8	6.4	4.0	1.5	7.5	5.2	1.8	5.3	2.9	1.2
		(0.0)	(-0.1)	(0.0)	(-0.9)	(-1.0)	(-0.4)	(-0.1)	(-0.1)	(-0.1)	(-1.9)	(-1.8)	(-0.8)
	IPW 2	3.1	2.3	2.2	3.9	2.9	2.8	2.2	1.5	1.8	4.0	2.8	2.7
		(-0.7)	(-0.3)	(-0.3)	(-0.1)	(-0.2)	(-0.1)	(-1.5)	(-0.7)	(-0.7)	(-0.2)	(-0.3)	(-0.1)
	IPW 3	1.6	1.2	1.0	1.9	1.3	1.3	1.2	0.8	0.7	2.1	1.3	1.2
Ratio 3:2	DR	(-0.4)	(-0.1)	(-0.2)	(-0.1)	(-0.1)	(0.0)	(-0.8)	(-0.4)	(-0.4)	(-0.1)	(-0.1)	(0.0)
		2.1	1.6	1.7	2.1	1.7	1.8	2.2	1.6	1.7	2.2	1.7	1.8
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	13.2	8.3	5.4	13.1	8.3	5.5	13.4	8.5	5.6	12.8	8.1	5.4
Ratio 3:2		(-0.1)	(0.0)	(-0.1)	(-0.5)	(-0.3)	(-0.2)	(-0.1)	(0.0)	(0.0)	(-1.5)	(-0.8)	(-0.5)
	IPW 2	7.6	4.9	3.0	8.0	5.1	3.1	6.7	4.3	2.5	7.7	4.9	2.9
		(-0.9)	(-0.4)	(-0.3)	(-0.4)	(-0.3)	(-0.1)	(-1.7)	(-0.8)	(-0.6)	(-0.6)	(-0.4)	(-0.2)
	IPW 3	4.5	2.8	1.7	4.7	2.8	1.7	4.0	2.5	1.5	4.6	2.7	1.7
	DR	(-0.5)	(-0.3)	(-0.2)	(-0.3)	(-0.2)	(-0.1)	(-1.0)	(-0.5)	(-0.4)	(-0.4)	(-0.3)	(-0.1)
Ratio 3:2		3.0	2.3	1.7	3.0	2.4	1.8	3.0	2.3	1.7	3.0	2.4	1.9
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	8.7	5.7	3.8	8.4	5.6	3.5	8.9	5.9	3.9	8.6	5.7	3.5
		(-0.1)	(0.0)	(0.0)	(-0.4)	(-0.2)	(-0.1)	(0.0)	(0.0)	(0.0)	(-1.1)	(-0.6)	(-0.4)
Ratio 2:3	IPW 2	3.2	2.4	1.8	3.4	2.5	1.6	2.7	2.0	1.5	3.2	2.3	1.4
		(-0.5)	(-0.3)	(-0.2)	(-0.2)	(-0.2)	(-0.1)	(-1.1)	(-0.5)	(-0.4)	(-0.4)	(-0.3)	(-0.1)
	IPW 3	1.6	1.2	1.0	1.7	1.2	0.8	1.3	1.0	0.9	1.6	1.1	0.7
		(-0.3)	(-0.2)	(-0.1)	(-0.2)	(-0.1)	(-0.1)	(-0.6)	(-0.3)	(-0.3)	(-0.2)	(-0.2)	(-0.1)
	DR	1.8	1.5	1.1	1.8	1.5	1.1	1.8	1.5	1.1	1.8	1.6	1.2
Ratio 2:3		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	9.7	6.4	3.8	6.2	2.9	0.1	9.2	6.0	3.4	3.6	0.2	-2.9
		(-0.3)	(-0.5)	(-0.3)	(-1.7)	(-1.8)	(-1.1)	(-0.4)	(-0.6)	(-0.4)	(-2.8)	(-2.9)	(-1.8)
	IPW 2	7.3	5.2	3.2	8.3	5.8	4.0	5.7	4.1	1.9	8.3	5.8	4.0
Ratio 2:3		(-0.8)	(-0.2)	(-0.4)	(0.0)	(-0.1)	(0.0)	(-2.0)	(-0.8)	(-0.8)	(0.0)	(-0.1)	(0.0)
	IPW 3	4.3	3.0	1.9	4.9	3.2	2.1	3.4	2.5	1.3	4.9	3.2	2.2
		(-0.5)	(-0.1)	(-0.2)	(0.0)	(0.0)	(0.0)	(-1.2)	(-0.5)	(-0.5)	(0.0)	(0.0)	(0.0)
	DR	2.9	2.3	2.0	2.9	2.4	2.0	2.9	2.3	1.9	2.8	2.3	1.9
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.1)
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	7.7	5.0	2.9	5.3	2.6	0.0	7.4	4.8	2.5	3.3	0.5	-2.5
		(-0.2)	(-0.4)	(-0.2)	(-1.3)	(-1.4)	(-0.8)	(-0.3)	(-0.5)	(-0.3)	(-2.3)	(-2.4)	(-1.5)
	IPW 2	2.9	2.5	1.8	3.6	2.9	2.3	2.0	1.8	1.0	3.6	2.9	2.3
		(-0.5)	(-0.1)	(-0.2)	(0.0)	(-0.1)	(0.0)	(-1.3)	(-0.5)	(-0.5)	(0.0)	(-0.1)	(0.0)
Ratio 2:3	IPW 3	1.7	1.4	1.0	2.0	1.6	1.2	1.2	1.1	0.7	2.0	1.6	1.2
		(-0.3)	(-0.1)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.7)	(-0.3)	(-0.3)	(0.0)	(0.0)	(0.0)
	DR	1.7	1.4	1.3	1.7	1.4	1.3	1.7	1.4	1.3	1.6	1.4	1.3
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.1)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the cross validated tuning parameter method.

Table A.4: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores, fixed valued λ

N		linear			nonlinear			linear			nonlinear		
		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	53.9	59.0	55.8	55.4	62.2	56.7	54.9	59.8	56.1	64.2	68.3	63.1
		(0.0)	(0.0)	(0.0)	(-1.3)	(-1.0)	(-0.7)	(-0.1)	(0.0)	(0.0)	(-1.2)	(-0.5)	(0.1)
	IPW 2	22.1	29.2	33.6	22.7	31.0	37.3	22.0	29.3	33.6	22.6	30.2	34.0
Ratio 1:1		(-0.7)	(-0.9)	(-0.7)	(-0.1)	(0.0)	(0.1)	(-1.6)	(-1.9)	(-1.5)	(0.1)	(-0.5)	(-3.1)
	IPW 3	11.2	15.7	17.8	11.8	16.7	18.8	10.5	14.8	16.6	11.8	15.6	14.2
		(-0.2)	(-0.4)	(-0.1)	(0.0)	(0.1)	(0.0)	(-0.5)	(-0.8)	(-0.3)	(0.0)	(-0.9)	(-4.9)
	DR	12.9	18.2	20.7	13.4	18.7	22.6	12.9	18.5	19.9	13.7	17.8	18.6
Ratio 1:1		(0.1)	(0.1)	(-0.1)	(0.0)	(0.0)	(0.2)	(0.2)	(0.3)	(-0.1)	(-0.6)	(-1.9)	(-5.6)
		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	38.2	43.8	42.2	40.5	48.5	43.9	39.6	45.0	43.0	51.2	56.7	51.9
		(0.0)	(0.0)	(0.0)	(-1.0)	(-0.8)	(-0.5)	(0.0)	(0.0)	(0.0)	(-1.0)	(-0.4)	(0.1)
Ratio 1:1	IPW 2	8.9	13.5	18.5	9.6	15.1	21.1	9.2	13.6	18.6	9.6	14.8	18.7
		(-0.5)	(-0.7)	(-0.6)	(-0.1)	(0.0)	(0.1)	(-1.1)	(-1.4)	(-1.2)	(0.1)	(-0.3)	(-2.4)
	IPW 3	2.1	4.6	5.3	2.7	5.3	5.7	1.8	3.8	4.5	2.7	4.7	2.5
		(-0.1)	(-0.3)	(-0.1)	(0.0)	(0.1)	(0.0)	(-0.4)	(-0.6)	(-0.3)	(0.0)	(-0.6)	(-3.4)
Ratio 1:1	DR	4.8	7.3	7.6	5.1	7.5	8.9	5.0	7.3	7.0	5.4	7.0	6.1
		(0.1)	(0.1)	(-0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.2)	(-0.1)	(-0.4)	(-1.3)	(-4.1)
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	51.8	45.1	42.9	46.9	38.5	37.2	50.4	42.8	39.0	50.5	43.4	42.6
		(-0.1)	(-0.2)	(-0.1)	(-2.0)	(-2.3)	(-2.1)	(-1.1)	(-2.0)	(-3.4)	(-1.8)	(-1.0)	(0.0)
	IPW 2	19.7	22.8	29.7	21.4	24.7	30.4	20.0	23.6	30.2	20.9	23.9	27.0
Ratio 3:2		(-0.6)	(-0.5)	(-0.6)	(-0.1)	(-0.1)	(-0.2)	(-0.2)	(0.0)	(0.0)	(0.1)	(-0.4)	(-3.3)
	IPW 3	10.9	10.9	19.0	11.7	11.9	19.3	11.1	10.8	17.8	11.1	10.7	14.8
		(-0.3)	(-0.2)	(-0.2)	(0.1)	(0.1)	(0.0)	(0.2)	(0.1)	(-0.4)	(-0.1)	(-0.7)	(-4.4)
	DR	12.5	12.6	21.2	12.6	12.9	21.4	11.8	11.1	18.0	11.4	10.7	15.4
Ratio 3:2		(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.5)	(-1.1)	(-2.6)	(-1.2)	(-2.3)	(-6.5)
		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	36.7	31.1	30.9	31.9	25.0	25.4	35.8	29.7	28.4	35.7	29.4	29.8
		(-0.1)	(-0.1)	(-0.1)	(-1.5)	(-1.6)	(-1.5)	(-0.8)	(-1.4)	(-2.5)	(-1.4)	(-0.7)	(0.0)
Ratio 3:2	IPW 2	7.1	10.9	17.9	7.9	12.0	17.0	7.5	11.8	18.7	7.6	11.4	14.4
		(-0.4)	(-0.4)	(-0.4)	(0.0)	(0.0)	(-0.1)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.3)	(-2.3)
	IPW 3	1.0	2.7	9.4	1.4	3.4	8.8	1.2	2.8	9.1	1.0	2.5	5.5
		(-0.2)	(-0.2)	(-0.1)	(0.0)	(0.1)	(0.0)	(0.1)	(0.1)	(-0.2)	(0.0)	(-0.5)	(-3.0)
Ratio 3:2	DR	2.1	4.0	10.3	2.2	4.2	10.5	1.7	3.1	8.5	1.4	2.7	6.2
		(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.3)	(-0.7)	(-1.7)	(-0.8)	(-1.6)	(-4.5)
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	45.2	66.2	41.9	50.3	70.7	46.5	46.6	67.4	40.9	58.0	75.7	53.7
		(0.2)	(0.1)	(0.0)	(-0.3)	(-0.2)	(-0.4)	(0.1)	(-0.2)	(-1.6)	(-0.5)	(-0.3)	(-0.1)
	IPW 2	18.2	23.2	26.2	18.7	23.3	27.2	16.3	20.6	20.5	18.8	23.2	27.2
Ratio 2:3		(-0.5)	(-0.7)	(-0.5)	(-0.1)	(0.0)	(0.0)	(-3.1)	(-4.5)	(-6.9)	(0.0)	(0.0)	(-0.2)
	IPW 3	10.6	12.3	16.6	10.9	13.0	17.6	8.6	9.0	9.8	11.0	12.8	17.3
		(-0.2)	(-0.3)	(-0.1)	(-0.1)	(0.0)	(0.0)	(-2.2)	(-3.6)	(-5.9)	(0.0)	(-0.1)	(-0.3)
	DR	12.5	14.3	18.9	12.6	14.5	19.7	12.7	13.9	15.8	13.1	14.8	19.8
Ratio 2:3		(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.7)	(-2.6)	(0.0)	(-0.2)	(-0.4)
		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	30.1	52.1	29.8	35.9	58.4	35.3	31.8	53.8	29.8	45.3	65.9	44.0
		(0.1)	(0.1)	(0.0)	(-0.2)	(-0.2)	(-0.3)	(0.1)	(-0.1)	(-1.1)	(-0.4)	(-0.2)	(-0.1)
Ratio 2:3	IPW 2	7.7	10.1	14.3	8.1	10.1	15.1	6.8	8.4	10.4	8.3	10.2	15.1
		(-0.3)	(-0.4)	(-0.3)	(-0.1)	(0.0)	(0.0)	(-2.0)	(-3.0)	(-4.5)	(0.0)	(0.0)	(-0.1)
	IPW 3	4.0	3.4	7.4	4.2	4.0	8.0	2.8	1.2	3.0	4.3	4.0	7.9
		(-0.1)	(-0.2)	(0.0)	(0.0)	(0.0)	(0.0)	(-1.4)	(-2.3)	(-3.6)	(0.0)	(0.0)	(-0.2)
Ratio 2:3	DR	8.1	6.1	10.0	8.0	6.3	10.2	8.3	5.6	8.2	8.4	6.7	10.4
		(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.4)	(-1.6)	(0.0)	(-0.1)	(-0.2)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.5: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 1, fixed valued λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	26.7 (0.0)	19.3 (-0.1)	17.0 (0.1)	29.4 (-2.2)	19.4 (-2.4)	13.7 (-1.4)	34.0 (-0.1)	24.3 (-0.1)	19.4 (0.1)	34.2 (-3.0)	24.7 (-0.8)	17.6 (2.1)
	IPW 2	15.0 (-1.0)	11.4 (-1.3)	10.5 (-1.7)	15.4 (-0.2)	12.3 (-0.1)	11.6 (0.2)	15.1 (-2.3)	10.8 (-2.8)	9.6 (-3.1)	16.7 (1.1)	14.2 (1.4)	11.3 (-0.3)
	IPW 3	13.9 (-0.5)	10.3 (-0.6)	8.8 (-0.8)	14.1 (-0.1)	10.9 (0.0)	9.6 (0.2)	14.5 (-1.1)	10.2 (-1.4)	8.6 (-1.5)	15.2 (1.1)	12.4 (1.2)	8.6 (-1.0)
	DR	10.2 (0.0)	7.0 (0.0)	7.2 (0.1)	9.9 (0.0)	7.1 (0.0)	7.7 (0.1)	11.1 (0.0)	7.5 (0.0)	7.7 (0.1)	10.3 (0.9)	7.8 (0.3)	5.3 (-2.7)
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	21.8 (0.0)	13.5 (0.0)	10.6 (0.1)	23.8 (-1.4)	14.1 (-1.5)	8.6 (-0.8)	27.0 (-0.1)	16.7 (-0.1)	12.0 (0.1)	27.8 (-2.0)	18.6 (-0.5)	12.0 (1.5)
	IPW 2	11.9 (-0.6)	6.3 (-0.8)	5.4 (-1.1)	12.1 (-0.1)	7.2 (-0.1)	6.1 (0.1)	12.1 (-1.4)	5.4 (-1.7)	4.4 (-2.0)	12.9 (0.7)	8.7 (0.9)	6.3 (-0.2)
	IPW 3	12.1 (-0.3)	6.4 (-0.4)	4.7 (-0.5)	12.2 (-0.1)	6.9 (0.0)	5.2 (0.1)	12.6 (-0.7)	5.8 (-0.8)	4.1 (-1.0)	12.8 (0.7)	8.2 (0.8)	4.9 (-0.7)
	DR	11.6 (0.0)	6.0 (0.0)	4.8 (0.0)	11.4 (0.0)	6.1 (0.0)	5.1 (0.1)	12.3 (0.0)	5.9 (0.0)	4.5 (0.0)	11.6 (0.6)	6.7 (0.2)	4.0 (-1.7)
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	23.7 (-0.2)	15.9 (-0.3)	15.0 (-0.2)	24.2 (-2.8)	14.9 (-3.2)	12.3 (-2.9)	28.1 (-1.5)	17.5 (-2.6)	11.9 (-4.8)	28.6 (-1.9)	20.1 (-0.7)	18.1 (1.3)
	IPW 2	15.0 (-0.7)	10.0 (-0.6)	10.6 (-0.8)	14.8 (-0.2)	10.7 (-0.3)	12.2 (-0.2)	16.7 (-0.3)	11.3 (0.1)	10.9 (0.0)	16.2 (1.2)	12.4 (0.6)	11.2 (-2.3)
	IPW 3	14.3 (-0.4)	8.9 (-0.3)	9.5 (-0.3)	14.1 (-0.1)	9.3 (-0.1)	10.4 (-0.1)	15.8 (0.0)	9.8 (0.2)	8.8 (-0.5)	15.1 (1.0)	10.5 (0.3)	8.4 (-3.1)
	DR	10.3 (0.0)	6.0 (0.0)	8.0 (0.0)	10.1 (0.0)	6.0 (0.0)	8.2 (0.0)	10.5 (-0.4)	5.0 (-1.0)	4.7 (-2.8)	10.1 (0.4)	5.5 (-0.9)	3.9 (-5.2)
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	19.0 (-0.1)	10.1 (-0.2)	8.0 (-0.1)	19.3 (-1.8)	9.5 (-1.9)	5.9 (-1.8)	22.1 (-1.0)	11.2 (-1.6)	6.2 (-3.1)	22.5 (-1.2)	12.9 (-0.3)	10.0 (0.9)
	IPW 2	11.0 (-0.4)	5.0 (-0.4)	3.7 (-0.5)	10.7 (-0.1)	5.5 (-0.1)	4.2 (-0.1)	12.0 (-0.2)	5.8 (0.0)	4.0 (0.0)	11.7 (0.7)	6.7 (0.4)	3.8 (-1.5)
	IPW 3	11.2 (-0.2)	4.8 (-0.2)	3.1 (-0.2)	11.0 (-0.1)	5.1 (-0.1)	3.3 (0.0)	12.1 (0.0)	5.4 (0.1)	2.8 (-0.3)	11.7 (0.7)	5.9 (0.2)	2.3 (-2.0)
	DR	10.2 (0.0)	4.2 (0.0)	2.4 (0.0)	10.1 (0.0)	4.3 (0.0)	2.5 (0.0)	10.3 (-0.2)	3.5 (-0.5)	0.3 (-1.7)	10.3 (0.3)	4.1 (-0.6)	0.0 (-3.4)
Ratio 2:3			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	23.9 (0.2)	16.3 (0.0)	16.7 (0.0)	28.1 (-0.5)	18.5 (-0.9)	15.8 (-0.7)	30.3 (-0.1)	20.7 (-0.6)	16.9 (-2.1)	33.1 (-1.8)	22.2 (-1.4)	17.5 (-0.2)
	IPW 2	13.4 (-0.6)	9.1 (-0.8)	11.1 (-0.7)	13.1 (-0.1)	9.6 (0.0)	11.2 (0.0)	11.7 (-3.2)	5.1 (-5.1)	3.4 (-8.2)	13.5 (0.4)	10.5 (0.8)	12.1 (1.0)
	IPW 3	12.7 (-0.3)	8.5 (-0.4)	10.3 (-0.3)	12.5 (-0.1)	8.9 (0.0)	10.3 (0.0)	11.8 (-2.2)	5.6 (-3.7)	4.3 (-6.2)	12.9 (0.5)	9.7 (0.7)	11.0 (0.9)
	DR	9.4 (0.0)	6.0 (0.0)	8.8 (0.1)	9.1 (0.0)	5.9 (0.0)	8.6 (0.1)	10.1 (-0.2)	5.7 (-0.8)	6.5 (-2.5)	9.4 (0.6)	6.4 (0.6)	9.0 (0.7)
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	19.1 (0.1)	10.1 (0.0)	11.2 (0.0)	22.3 (-0.3)	12.1 (-0.6)	11.1 (-0.5)	23.6 (-0.1)	13.1 (-0.4)	11.6 (-1.3)	26.6 (-1.2)	15.5 (-1.0)	13.1 (-0.2)
	IPW 2	11.2 (-0.4)	4.6 (-0.5)	6.3 (-0.4)	11.0 (-0.1)	5.3 (0.0)	6.3 (0.0)	10.3 (-1.8)	2.2 (-3.0)	1.6 (-4.8)	11.3 (0.3)	5.9 (0.5)	6.9 (0.6)
	IPW 3	11.5 (-0.2)	5.0 (-0.3)	6.1 (-0.2)	11.4 (0.0)	5.5 (0.0)	6.0 (0.0)	11.1 (-1.2)	3.1 (-2.2)	2.4 (-3.6)	11.6 (0.3)	6.1 (0.4)	6.5 (0.6)
	DR	11.8 (0.0)	5.1 (0.0)	5.9 (0.0)	11.6 (0.0)	5.1 (0.0)	5.7 (0.1)	12.3 (-0.1)	4.7 (-0.5)	4.5 (-1.4)	11.7 (0.4)	5.5 (0.4)	6.1 (0.5)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 1 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^S))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.6: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 2, fixed valued λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	24.0	18.0	10.2	24.7	18.5	9.9	25.4	19.0	11.0	30.1	26.1	19.6
		(-0.1)	(0.0)	(0.1)	(-2.8)	(-2.4)	(-1.3)	(-0.2)	(-0.1)	(0.1)	(-1.9)	(1.7)	(6.9)
	IPW 2	12.0	6.6	2.7	12.5	7.4	4.1	11.2	5.0	1.4	13.7	10.0	8.9
		(-1.1)	(-1.5)	(-2.0)	(-0.3)	(-0.1)	(0.2)	(-2.5)	(-3.2)	(-3.7)	(1.4)	(2.8)	(5.4)
Ratio 1:1	IPW 3	7.5	4.0	1.2	7.8	4.3	1.9	7.0	3.1	0.7	8.8	6.4	5.9
		(-0.5)	(-0.7)	(-1.0)	(-0.2)	(0.0)	(0.2)	(-1.3)	(-1.6)	(-1.8)	(1.2)	(2.3)	(4.4)
	DR	3.0	1.4	0.1	2.8	1.1	-0.1	3.2	1.4	0.3	3.1	2.0	2.1
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.7)	(1.2)	(2.3)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
Ratio 1:1	IPW 1	19.2	13.6	6.9	19.9	14.6	7.0	20.2	14.4	7.3	24.2	20.5	13.9
		(-0.1)	(0.0)	(0.1)	(-1.7)	(-1.4)	(-0.7)	(-0.1)	(0.0)	(0.1)	(-1.2)	(1.2)	(4.9)
	IPW 2	8.5	4.0	1.9	8.8	5.2	3.2	8.0	3.0	1.1	9.6	6.8	6.1
		(-0.7)	(-0.9)	(-1.2)	(-0.2)	(-0.1)	(0.2)	(-1.5)	(-1.9)	(-2.3)	(0.9)	(1.7)	(3.3)
	IPW 3	7.2	3.6	1.7	7.4	4.2	2.4	6.9	3.0	1.3	8.0	5.5	4.8
Ratio 3:2		(-0.3)	(-0.4)	(-0.6)	(-0.1)	(0.0)	(0.1)	(-0.8)	(-0.9)	(-1.1)	(0.7)	(1.4)	(2.7)
	DR	6.1	3.7	2.1	5.9	3.6	2.2	6.2	3.8	2.1	5.9	4.1	3.5
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.4)	(0.7)	(1.4)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	19.3	13.9	8.0	18.0	12.4	6.3	18.7	13.0	6.5	23.6	20.1	18.2
Ratio 3:2		(-0.2)	(-0.3)	(-0.2)	(-3.1)	(-3.4)	(-3.2)	(-1.0)	(-1.5)	(-1.6)	(-1.1)	(1.7)	(7.2)
	IPW 2	10.2	7.2	4.0	10.0	7.6	4.6	11.8	9.8	8.5	11.6	10.5	8.9
		(-0.7)	(-0.7)	(-0.8)	(-0.3)	(-0.3)	(-0.2)	(0.4)	(1.6)	(3.5)	(1.7)	(2.9)	(4.5)
	IPW 3	7.2	4.8	2.6	7.0	4.9	2.9	8.3	6.7	5.8	8.3	7.3	6.3
		(-0.4)	(-0.3)	(-0.4)	(-0.2)	(-0.2)	(-0.1)	(0.5)	(1.4)	(2.9)	(1.5)	(2.4)	(3.6)
Ratio 3:2	DR	2.6	1.8	0.8	2.6	1.8	0.7	2.8	2.3	1.6	3.1	2.9	2.1
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.3)	(0.8)	(0.7)	(1.2)	(1.4)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	15.0	10.1	5.9	14.2	9.2	5.0	14.7	9.4	5.2	18.1	14.2	13.0
		(-0.1)	(-0.2)	(-0.1)	(-1.9)	(-2.0)	(-1.9)	(-0.7)	(-0.9)	(-1.0)	(-0.7)	(1.3)	(4.7)
Ratio 2:3	IPW 2	6.1	4.6	1.4	5.9	5.0	1.8	7.0	6.2	4.2	6.9	6.8	4.5
		(-0.4)	(-0.4)	(-0.5)	(-0.2)	(-0.2)	(-0.1)	(0.2)	(0.8)	(2.2)	(1.0)	(1.8)	(2.7)
	IPW 3	5.1	3.9	1.1	4.9	4.1	1.2	5.7	5.0	3.0	5.7	5.5	3.4
		(-0.2)	(-0.2)	(-0.2)	(-0.1)	(-0.1)	(-0.1)	(0.3)	(0.8)	(1.7)	(0.9)	(1.5)	(2.2)
	DR	4.2	3.5	0.9	4.1	3.5	0.8	4.2	3.6	1.4	4.5	4.2	1.5
Ratio 2:3		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.5)	(0.5)	(0.8)	(0.9)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	21.0	14.6	11.1	23.0	16.0	11.7	22.6	16.3	12.6	26.9	19.6	15.0
		(0.0)	(0.0)	(0.0)	(-1.2)	(-0.9)	(-0.7)	(0.4)	(1.1)	(1.4)	(-1.8)	(-0.6)	(0.8)
	IPW 2	10.1	6.4	5.1	10.0	6.9	6.1	7.7	3.2	0.2	10.2	7.5	7.0
Ratio 2:3		(-0.6)	(-0.9)	(-0.9)	(-0.1)	(0.0)	(0.0)	(-3.2)	(-4.2)	(-5.6)	(0.1)	(0.6)	(1.0)
	IPW 3	6.7	4.3	4.1	6.6	4.6	4.7	5.2	2.3	1.1	6.7	5.0	5.5
		(-0.3)	(-0.5)	(-0.5)	(-0.1)	(0.0)	(0.0)	(-1.9)	(-2.4)	(-3.3)	(0.1)	(0.5)	(0.8)
	DR	2.4	1.7	2.9	2.2	1.6	3.0	2.7	2.2	3.5	2.1	1.7	3.2
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.5)	(0.6)	(0.1)	(0.3)	(0.3)
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	15.1	10.6	7.2	17.0	12.1	7.7	16.4	12.0	8.4	20.5	15.2	10.4
		(0.0)	(0.0)	(0.0)	(-0.7)	(-0.6)	(-0.5)	(0.3)	(0.7)	(0.9)	(-1.2)	(-0.4)	(0.5)
	IPW 2	6.0	3.2	2.2	6.2	3.9	2.5	4.5	1.3	-0.5	6.3	4.2	3.2
		(-0.4)	(-0.5)	(-0.5)	(-0.1)	(0.0)	(0.0)	(-1.9)	(-2.4)	(-3.2)	(0.1)	(0.4)	(0.6)
Ratio 2:3	IPW 3	5.1	2.9	2.1	5.2	3.4	2.3	4.2	1.8	0.5	5.3	3.7	2.8
		(-0.2)	(-0.3)	(-0.2)	(0.0)	(0.0)	(0.0)	(-1.1)	(-1.3)	(-1.8)	(0.1)	(0.3)	(0.5)
	DR	4.3	3.0	2.2	4.2	2.9	2.2	4.5	3.4	2.5	4.1	2.9	2.3
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.4)	(0.4)	(0.1)	(0.2)	(0.2)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 2 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.7: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 3, fixed valued λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	25.6	-9.0	2.2	58.3	37.6	16	34.1	5.7	2.5	79.2	62.4	32.7	
		(-0.1)	(7.5)	(0.5)	(60.7)	(40.8)	(15.0)	(39.6)	(14)	(1.8)	(73.8)	(57.6)	(28.8)	
	IPW 2	13.7	24.8	33	63.5	56.9	50	40.2	41	44	82.5	75.2	64.6	
		(-0.9)	(1.1)	(-1.5)	(52.1)	(26.3)	(7.5)	(23.7)	(2.1)	(-2.2)	(65.6)	(37.1)	(10.8)	
Ratio 1:1	IPW 3	12.8	-2.7	12	59	43.4	27	29.3	11	15	81	67.4	40.1	
		(-0.4)	(3.1)	(-1.1)	(59.6)	(35.4)	(7.5)	(33.5)	(6.1)	(-1.8)	(72.6)	(49.2)	(10.1)	
	DR	8.6	12	13	26.7	12.2	14	26.5	12	12	29.2	13.2	10.1	
		(0)	(0.1)	(-0.1)	(0)	(0)	(0.2)	(0)	(0.4)	(0.2)	(2.9)	(0.6)	(-4.8)	
			homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
Ratio 1:1	IPW 1	-5.8	-14.4	-2.6	43.0	22.2	7.5	18.6	-4.5	-2.3	69.6	49.0	21.9	
		(16.9)	(4.5)	(0.3)	(49.1)	(30.3)	(10.0)	(28.5)	(9.3)	(1.1)	(66.6)	(48.6)	(21.4)	
	IPW 2	0.4	7.4	18.2	47.0	38.7	33.7	22.9	22.4	28.1	72.0	61.5	49.8	
		(10.3)	(0.7)	(-1.1)	(42.4)	(20.9)	(5.7)	(17.3)	(1.5)	(-1.8)	(59.0)	(32.5)	(8.9)	
	IPW 3	-10.6	-12.1	2.3	42.7	25.5	13.0	13.5	-2.5	4.2	70.5	52.1	25.2	
Ratio 3:2		(13.7)	(1.9)	(-0.8)	(47.9)	(26.5)	(5.1)	(23.6)	(4.0)	(-1.3)	(65.2)	(41.5)	(7.3)	
	DR	33.5	6.1	4.1	33.5	6.5	4.9	33.6	5.9	3.4	34.7	7.4	2.4	
		(0.0)	(0.1)	(-0.1)	(0.0)	(0.0)	(0.1)	(0.0)	(0.2)	(0.1)	(1.7)	(0.4)	(-3.3)	
			homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	-9.7	1.0	13.8	-12.7	-21.1	3.8	-9.3	-4.6	7.3	28.0	-6.5	9.6	
Ratio 3:2		(16.0)	(17.1)	(6.3)	(-2.6)	(-4.7)	(-3.2)	(4.0)	(10.1)	(0.6)	(15.1)	(0.3)	(0.0)	
	IPW 2	7.2	19.4	21.5	12.9	15.2	20.7	17.6	26.8	26.4	44.8	31.9	25.8	
		(14.1)	(14.0)	(5.4)	(1.1)	(-0.3)	(-0.2)	(6.0)	(11.0)	(5.3)	(13.2)	(1.0)	(-3.3)	
	IPW 3	-5.1	9.7	15.4	-4.7	-7.2	7.7	0.9	12.0	15.4	33.4	6.2	5.0	
		(16.5)	(18.8)	(7.1)	(1.1)	(0.0)	(0.3)	(7.6)	(16.4)	(7.1)	(15.1)	(-0.4)	(-4.8)	
Ratio 3:2	DR	38.5	16.5	15.5	39.6	17.3	15.7	37.9	14.9	12.2	37.8	14.4	8.9	
		(0.0)	(0.4)	(0.3)	(1.8)	(1.0)	(0.2)	(-0.4)	(-0.8)	(-2.5)	(-0.5)	(-2.0)	(-6.9)	
			homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
	IPW 1	-4.1	0.7	7.8	-5.9	-11.1	0.4	-4.1	-2.4	4.0	19.1	-3.7	3.8	
		(8.8)	(9.9)	(4.1)	(-1.4)	(-2.4)	(-1.9)	(2.3)	(5.9)	(0.5)	(10.0)	(0.3)	(0.0)	
Ratio 2:3	IPW 2	2.5	10.4	11.3	5.8	7.5	9.5	9.3	16.0	15.5	30.1	19.6	13.4	
		(8.4)	(8.7)	(3.6)	(0.6)	(-0.2)	(-0.1)	(3.8)	(7.1)	(3.6)	(9.4)	(0.7)	(-2.3)	
	IPW 3	-3.9	5.4	7.4	-3.9	-4.5	1.6	-0.4	7.0	7.9	21.4	3.2	-0.3	
		(9.4)	(11.2)	(4.6)	(0.6)	(0.0)	(0.2)	(4.5)	(9.9)	(4.6)	(10.2)	(-0.3)	(-3.1)	
	DR	6.0	-1.8	3.1	7.6	-1.0	3.2	5.6	-2.8	1.2	5.9	-3.2	-1.6	
Ratio 2:3		(0.0)	(0.3)	(0.2)	(1.6)	(0.7)	(0.1)	(-0.3)	(-0.5)	(-1.6)	(-0.5)	(-1.6)	(-4.8)	
			homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	63.6	40.2	20.9	81.2	64.5	34.5	74.5	50.8	22.0	89.7	77.9	47.9	
		(68.2)	(43.7)	(13.1)	(79.6)	(61.6)	(26.7)	(72.9)	(49.8)	(14.6)	(84.7)	(70.7)	(38.6)	
	IPW 2	62.6	47.1	36.7	82.5	71.2	55.3	73.1	57.0	41.9	91.5	84.4	71.4	
Ratio 2:3		(62.1)	(30.6)	(6.3)	(75.5)	(48.3)	(16.1)	(65.5)	(30.8)	(2.0)	(81.5)	(55.9)	(21.3)	
	IPW 3	61.8	40.6	22.5	82.1	68.0	40.8	72.9	50.0	22.0	91.4	82.5	57.6	
		(66.3)	(38.4)	(6.8)	(78.9)	(57.2)	(17.1)	(70.5)	(41.6)	(2.7)	(84.3)	(66.0)	(24.4)	
	DR	39.2	15.4	13.2	40.2	15.9	13.7	39.3	15.4	10.3	45.4	19.9	14.7	
		(0.0)	(0.2)	(0.1)	(1.3)	(1.0)	(0.6)	(0.1)	(0.2)	(-2.2)	(9.0)	(5.1)	(1.3)	
Ratio 2:3			homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
	IPW 1	45.6	21.5	9.4	70.6	49.6	21.7	60.6	32.9	11.1	84.2	68.1	36.1	
		(58.3)	(33.2)	(8.9)	(73.5)	(52.6)	(19.6)	(65.2)	(39.9)	(10.2)	(81.4)	(64.8)	(31.2)	
	IPW 2	43.5	27.7	20.3	71.1	55.9	38.2	58.2	39.3	26.2	85.4	74.4	57.1	
		(52.2)	(23.6)	(4.5)	(69.2)	(41.5)	(12.5)	(57.8)	(25.1)	(1.6)	(78.0)	(51.4)	(18.2)	
Ratio 2:3	IPW 3	42.9	21.6	9.8	70.9	52.3	25.1	58.1	31.8	10.0	85.5	72.0	41.9	
		(56.0)	(29.0)	(4.6)	(72.5)	(48.6)	(12.4)	(62.6)	(33.0)	(2.0)	(80.9)	(60.2)	(19.3)	
	DR	58.3	17.0	7.3	58.5	17.5	7.7	58.3	16.7	5.6	60.0	19.9	8.5	
		(0.0)	(0.1)	(0.0)	(0.6)	(0.4)	(0.4)	(0.0)	(0.1)	(-1.3)	(3.9)	(3.0)	(1.0)	

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score with trimming rule 3 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.8: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores, $\text{MSE}(\hat{p}_i^s)$ -minimizing λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	55.2	64.1	66.9	55.8	64.9	64.5	55.7	64.9	66.9	62.8	71.7	70.2
		(-0.1)	(-0.1)	(0.0)	(-1.6)	(-1.3)	(-0.6)	(-0.1)	(-0.2)	(0.0)	(-1.7)	(-0.7)	(0.1)
	IPW 2	23.3	28.6	37.3	23.9	29.2	38.6	23.0	28.7	38.4	23.8	29.0	35.0
		(-0.8)	(-0.5)	(-1.2)	(-0.1)	(-0.2)	(0.0)	(-1.9)	(-1.3)	(-2.1)	(0.1)	(-0.1)	(-3.1)
Ratio 1:1	IPW 3	11.9	15.3	19.0	12.5	15.8	20.9	11.0	14.8	18.2	12.5	15.4	15.9
		(-0.3)	(-0.1)	(-0.5)	(0.0)	(0.0)	(0.0)	(-0.7)	(-0.3)	(-0.9)	(0.0)	(-0.3)	(-4.6)
	DR	13.8	17.6	22.6	14.5	18.4	24.1	13.5	17.6	22.7	14.9	18.3	19.5
		(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.1)	(0.3)	(0.1)	(-0.7)	(-1.2)	(-5.8)
	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
Ratio 1:1	IPW 1	38.1	50.3	53.0	39.9	52.2	50.4	39.1	51.6	53.3	48.9	61.0	58.0
		(-0.1)	(-0.1)	(0.0)	(-1.3)	(-1.1)	(-0.4)	(-0.1)	(-0.1)	(0.0)	(-1.4)	(-0.6)	(0.1)
	IPW 2	7.8	15.9	22.8	8.3	16.2	23.0	7.9	16.1	25.0	8.4	16.1	20.3
		(-0.5)	(-0.3)	(-1.0)	(-0.1)	(-0.1)	(0.0)	(-1.2)	(-0.9)	(-1.7)	(0.1)	(0.0)	(-2.4)
	IPW 3	1.1	6.0	7.0	1.6	6.3	8.4	0.6	5.6	6.9	1.7	6.1	5.1
Ratio 3:2		(-0.2)	(-0.1)	(-0.5)	(0.0)	(0.0)	(0.0)	(-0.4)	(-0.2)	(-0.7)	(0.0)	(-0.2)	(-3.4)
	DR	4.2	8.3	9.4	4.8	8.9	11.3	4.0	8.3	9.4	5.3	8.9	8.7
		(0.0)	(0.1)	(-0.1)	(0.0)	(0.0)	(-0.1)	(0.1)	(0.2)	(0.0)	(-0.4)	(-0.8)	(-4.3)
	homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	47.9	86.0	43.7	41.7	69.1	40.2	46.9	85.3	40.0	46.1	70.0	47.1
Ratio 3:2		(-0.1)	(0.0)	(-0.2)	(-2.4)	(-1.1)	(-2.4)	(-0.9)	(-0.4)	(-3.7)	(-2.6)	(-0.6)	(-0.1)
	IPW 2	20.8	22.0	28.3	21.5	23.4	31.1	21.5	22.7	28.8	20.9	22.5	28.2
		(-0.9)	(-0.7)	(-0.4)	(-0.2)	(-0.2)	(-0.2)	(-0.6)	(-0.1)	(-0.1)	(0.1)	(-0.5)	(-2.4)
	IPW 3	12.3	11.7	17.1	12.9	12.9	17.9	12.6	11.9	16.5	12.3	11.6	14.0
		(-0.4)	(-0.3)	(-0.2)	(0.0)	(0.0)	(0.2)	(0.0)	(0.2)	(-0.7)	(0.0)	(-0.8)	(-3.3)
Ratio 3:2	DR	12.8	12.8	19.5	13.1	13.3	20.1	12.3	11.7	16.6	11.8	11.1	15.1
		(0.0)	(0.1)	(0.2)	(0.0)	(0.0)	(0.1)	(-0.4)	(-1.0)	(-2.6)	(-1.1)	(-2.3)	(-5.3)
	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	31.9	78.0	31.0	26.5	55.8	28.4	31.4	77.3	28.7	31.1	57.1	35.0
		(0.0)	(0.0)	(-0.1)	(-1.6)	(-1.0)	(-1.7)	(-0.6)	(-0.4)	(-2.6)	(-1.8)	(-0.6)	(-0.1)
Ratio 2:3	IPW 2	6.4	8.6	15.9	7.0	9.8	18.5	7.0	9.3	16.3	6.5	9.2	16.3
		(-0.6)	(-0.5)	(-0.4)	(-0.1)	(-0.1)	(-0.1)	(-0.4)	(-0.1)	(-0.1)	(0.1)	(-0.3)	(-1.8)
	IPW 3	1.2	1.7	7.8	1.6	2.5	8.6	1.4	1.9	7.5	1.2	1.6	5.8
		(-0.3)	(-0.2)	(-0.2)	(0.0)	(0.0)	(0.1)	(0.0)	(0.1)	(-0.4)	(0.0)	(-0.5)	(-2.4)
	DR	1.9	2.7	10.1	2.1	3.1	10.4	1.6	2.0	8.2	1.3	1.7	6.9
Ratio 2:3		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(-0.2)	(-0.7)	(-1.7)	(-0.8)	(-1.5)	(-3.9)
	homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	71.1	55.9	44.6	75.9	61.0	48.2	72.2	57.0	43.7	80.3	67.1	56.7
		(0.0)	(0.0)	(0.4)	(-0.4)	(-0.6)	(-0.2)	(0.0)	(-0.2)	(-1.0)	(-0.7)	(-0.8)	(-0.2)
	IPW 2	20.3	23.0	29.7	21.3	24.1	29.1	17.8	19.7	24.9	21.3	24.2	28.8
Ratio 2:3		(-1.1)	(-0.8)	(-0.9)	(-0.1)	(-0.1)	(0.2)	(-4.5)	(-4.9)	(-7.7)	(0.0)	(0.0)	(-0.2)
	IPW 3	11.4	12.8	15.7	12.1	13.6	16.4	8.6	9.2	8.9	12.2	13.6	15.7
		(-0.6)	(-0.4)	(-0.6)	(0.0)	(0.0)	(0.1)	(-3.2)	(-3.8)	(-7.1)	(0.0)	(0.0)	(-0.5)
	DR	12.7	14.9	17.9	13.1	15.2	18.5	12.4	14.3	15.2	13.8	15.8	18.3
		(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.0)	(-0.2)	(-0.6)	(-2.3)	(0.0)	(-0.1)	(-1.0)
Ratio 2:3	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	57.0	42.1	29.6	64.1	48.3	33.7	59.0	43.7	29.2	71.2	56.5	43.8
		(0.0)	(0.0)	(0.3)	(-0.3)	(-0.5)	(-0.1)	(0.0)	(-0.1)	(-0.9)	(-0.6)	(-0.7)	(-0.1)
	IPW 2	7.4	12.3	17.8	7.9	12.8	16.9	6.0	10.5	15.4	8.0	12.9	16.8
		(-0.6)	(-0.5)	(-0.7)	(0.0)	(-0.1)	(0.1)	(-2.8)	(-3.1)	(-5.5)	(0.0)	(0.0)	(-0.2)
Ratio 2:3	IPW 3	2.9	5.9	6.8	3.3	6.2	7.2	1.3	3.8	2.6	3.4	6.3	6.9
		(-0.3)	(-0.2)	(-0.5)	(0.0)	(0.0)	(0.1)	(-1.9)	(-2.3)	(-4.8)	(0.0)	(0.0)	(-0.4)
	DR	6.9	8.7	8.4	7.1	8.9	9.5	6.7	8.5	6.4	7.5	9.3	9.8
		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.3)	(-1.7)	(0.0)	(0.0)	(-0.7)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^s))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the MSE minimizing tuning parameter method.

Table A.9: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 1, $\text{MSE}(\hat{p}_i^s)$ -minimizing λ

			linear			nonlinear				linear		nonlinear			
N		100	200	500	100	200	500	100	200	500	100	200	500		
Ratio 1:1			homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	28.6 (-0.1)	18.1 (-0.2)	18.6 (0.1)	30.4 (-2.6)	17.0 (-3.2)	18.1 (-1.5)	35.4 (-0.1)	23.2 (-0.3)	22.2 (0.0)	34.7 (-3.4)	20.9 (-2.4)	24.1 (1.7)		
	IPW 2	17.2 (-1.3)	10.7 (-0.8)	9.5 (-1.7)	17.8 (-0.2)	10.8 (-0.3)	11.7 (0.0)	16.7 (-2.8)	10.6 (-2.0)	9.5 (-3.1)	19.4 (1.4)	12.5 (1.0)	10.0 (-1.6)		
	IPW 3	16.5 (-0.6)	8.8 (-0.3)	8.3 (-0.9)	16.8 (-0.1)	8.8 (-0.2)	9.5 (0.0)	16.6 (-1.4)	9.3 (-0.8)	8.6 (-1.6)	18.1 (1.3)	10.2 (0.9)	7.1 (-2.2)		
	DR	12.5 (0.0)	4.8 (0.0)	7.4 (-0.1)	12.1 (0.0)	4.9 (0.0)	7.3 (-0.1)	13.2 (0.0)	5.7 (0.0)	8.7 (-0.1)	12.8 (1.0)	5.4 (0.2)	3.4 (-3.9)		
Ratio 1:1			homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	21.6 (-0.1)	11.7 (-0.1)	9.5 (0.0)	23.2 (-1.7)	11.2 (-2.0)	9.3 (-0.9)	26.4 (-0.1)	15.2 (-0.2)	12.7 (0.0)	26.7 (-2.3)	14.3 (-1.6)	14.1 (1.2)		
	IPW 2	12.4 (-0.7)	5.3 (-0.5)	2.8 (-1.2)	12.8 (-0.2)	5.5 (-0.2)	4.0 (0.0)	12.2 (-1.6)	5.3 (-1.2)	3.5 (-2.2)	13.8 (0.7)	6.6 (0.6)	2.8 (-1.3)		
	IPW 3	13.3 (-0.3)	4.9 (-0.2)	2.6 (-0.7)	13.4 (-0.1)	5.0 (-0.1)	3.4 (0.0)	13.3 (-0.8)	5.2 (-0.5)	3.4 (-1.1)	14.2 (0.7)	5.9 (0.5)	1.7 (-1.7)		
	DR	13.4 (0.0)	3.9 (0.0)	2.3 (-0.1)	13.2 (0.0)	4.1 (0.0)	2.4 (-0.1)	13.8 (0.0)	4.3 (0.0)	3.5 (-0.1)	13.5 (0.5)	4.5 (0.1)	-0.2 (-2.8)		
Ratio 3:2			homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	24.1 (-0.1)	16.0 (-0.2)	13.8 (-0.4)	24.4 (-3.1)	13.8 (-3.2)	10.1 (-3.6)	28.5 (-1.1)	17.7 (-2.2)	11.4 (-5.3)	28.4 (-2.7)	17.8 (-0.7)	15.9 (1.0)		
	IPW 2	15.2 (-1.1)	9.8 (-0.9)	8.7 (-0.5)	15.7 (-0.3)	9.8 (-0.3)	9.3 (-0.2)	16.3 (-0.9)	11.4 (-0.2)	10.1 (0.1)	17.1 (1.2)	11.1 (0.8)	7.9 (-2.0)		
	IPW 3	14.7 (-0.6)	8.8 (-0.5)	7.5 (-0.2)	15.0 (-0.2)	8.6 (-0.1)	7.7 (-0.1)	15.8 (-0.3)	10.0 (0.1)	7.9 (-0.5)	16.2 (1.1)	9.3 (0.5)	5.5 (-2.6)		
	DR	11.2 (0.0)	5.3 (0.0)	5.8 (0.0)	11.0 (0.0)	5.4 (0.0)	5.7 (0.0)	11.4 (-0.2)	4.8 (-0.9)	3.7 (-2.8)	11.0 (0.4)	4.6 (-0.8)	1.1 (-4.7)		
Ratio 3:2			homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	18.9 (-0.1)	11.1 (-0.1)	8.0 (-0.2)	19.1 (-1.8)	9.5 (-2.1)	5.7 (-2.2)	22.1 (-0.7)	12.5 (-1.4)	6.6 (-3.3)	21.8 (-1.7)	12.0 (-0.6)	9.5 (0.6)		
	IPW 2	10.4 (-0.6)	5.3 (-0.5)	3.4 (-0.4)	10.5 (-0.1)	5.0 (-0.2)	3.9 (-0.1)	11.2 (-0.5)	6.6 (-0.1)	4.4 (0.1)	11.3 (0.7)	5.6 (0.5)	3.0 (-1.5)		
	IPW 3	10.6 (-0.4)	5.1 (-0.3)	2.9 (-0.2)	10.6 (-0.1)	4.8 (-0.1)	3.2 (0.0)	11.3 (-0.2)	6.1 (0.1)	3.2 (-0.2)	11.2 (0.6)	5.1 (0.3)	1.7 (-1.9)		
	DR	9.6 (0.0)	4.0 (0.0)	2.6 (0.0)	9.5 (0.0)	4.1 (0.0)	2.6 (0.0)	9.8 (-0.1)	3.9 (-0.5)	1.2 (-1.6)	9.4 (0.2)	3.5 (-0.5)	-0.4 (-3.2)		
Ratio 2:3			homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	26.8 (0.1)	15.9 (0.1)	13.7 (0.0)	30.4 (-1.1)	16.9 (-1.3)	14.0 (-0.9)	33.0 (-0.2)	20.1 (-0.5)	14.3 (-2.1)	34.7 (-2.8)	19.4 (-2.5)	16.9 (-0.9)		
	IPW 2	15.1 (-1.2)	9.8 (-1.0)	9.6 (-1.3)	15.6 (-0.1)	10.1 (-0.1)	10.9 (0.0)	12.6 (-4.6)	5.8 (-5.7)	1.6 (-9.8)	16.0 (0.6)	10.7 (0.6)	11.4 (0.3)		
	IPW 3	14.9 (-0.7)	8.8 (-0.5)	8.5 (-0.7)	15.1 (0.0)	9.0 (0.0)	9.3 (0.0)	13.4 (-3.1)	6.0 (-4.0)	1.8 (-7.5)	15.5 (0.6)	9.6 (0.5)	9.6 (0.2)		
	DR	11.7 (0.0)	5.6 (0.0)	7.0 (0.0)	11.4 (0.0)	5.7 (0.0)	7.4 (0.0)	12.2 (-0.2)	5.4 (-0.7)	4.1 (-3.0)	11.5 (0.7)	6.2 (0.5)	7.4 (-0.2)		
Ratio 2:3			homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	19.7 (0.1)	11.1 (0.0)	8.2 (0.0)	22.5 (-0.7)	12.0 (-0.9)	8.6 (-0.5)	24.0 (-0.1)	14.1 (-0.3)	9.1 (-1.5)	26.3 (-1.9)	14.3 (-1.7)	11.2 (-0.6)		
	IPW 2	11.1 (-0.7)	5.7 (-0.6)	4.4 (-0.8)	11.3 (0.0)	5.7 (-0.1)	4.9 (0.0)	9.6 (-2.6)	3.5 (-3.3)	-0.2 (-6.3)	11.6 (0.3)	6.1 (0.3)	5.1 (0.2)		
	IPW 3	11.8 (-0.4)	5.8 (-0.3)	4.0 (-0.5)	11.9 (0.0)	5.8 (0.0)	4.4 (0.0)	10.9 (-1.8)	4.3 (-2.3)	0.3 (-4.8)	12.1 (0.3)	6.2 (0.3)	4.5 (0.1)		
	DR	12.6 (0.0)	5.7 (0.0)	3.6 (0.0)	12.4 (0.0)	5.8 (0.0)	3.9 (0.0)	12.9 (-0.1)	5.6 (-0.4)	2.2 (-2.0)	12.5 (0.4)	6.1 (0.3)	3.8 (-0.2)		

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 1 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the MSE minimizing tuning parameter method.

Table A.10: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 2, $\text{MSE}(\hat{p}_i^s)$ -minimizing λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	homogeneous, homoscedastic												
	IPW 1	24.6	14.4	12.4	24.6	13.3	13.0	25.7	15.0	13.4	29.4	19.6	23.1
		(-0.1)	(-0.3)	(0.1)	(-3.1)	(-3.6)	(-1.5)	(-0.2)	(-0.5)	(0.1)	(-2.3)	(-0.6)	(6.5)
	IPW 2	12.4	7.5	3.6	13.2	7.6	5.5	11.1	6.7	2.0	14.5	9.8	9.5
		(-1.4)	(-0.7)	(-1.8)	(-0.3)	(-0.4)	(0.1)	(-3.2)	(-2.0)	(-3.4)	(1.6)	(2.1)	(4.6)
Ratio 1:1	IPW 3	8.7	4.3	2.3	9.0	4.3	3.3	7.9	3.9	1.5	10.2	6.1	6.7
		(-0.7)	(-0.3)	(-0.9)	(-0.2)	(-0.2)	(0.1)	(-1.7)	(-0.9)	(-1.6)	(1.4)	(1.7)	(3.8)
	DR	4.0	0.9	1.6	3.7	1.0	1.2	4.1	0.9	1.8	4.0	1.8	2.8
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.8)	(0.8)	(1.9)
	heterogeneous, homoscedastic												
Ratio 1:1	homogeneous, heteroscedastic												
	IPW 1	18.3	11.0	9.2	18.7	10.7	9.7	19.2	11.4	9.9	22.5	15.2	17.0
		(-0.1)	(-0.2)	(0.1)	(-1.9)	(-2.2)	(-0.8)	(-0.1)	(-0.3)	(0.1)	(-1.6)	(-0.4)	(4.5)
	IPW 2	7.3	4.6	1.9	7.8	5.1	2.9	6.7	4.2	1.0	8.6	6.5	5.5
		(-0.7)	(-0.4)	(-1.2)	(-0.2)	(-0.2)	(0.1)	(-1.7)	(-1.2)	(-2.2)	(0.9)	(1.3)	(2.8)
Ratio 3:2	IPW 3	6.5	3.7	1.6	6.7	4.0	2.1	6.1	3.5	1.1	7.4	5.1	4.2
		(-0.4)	(-0.2)	(-0.6)	(-0.1)	(-0.1)	(0.1)	(-0.9)	(-0.5)	(-1.1)	(0.8)	(1.0)	(2.2)
	DR	6.1	3.4	1.6	5.9	3.5	1.3	6.2	3.4	1.6	6.1	4.0	2.2
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.4)	(0.5)	(1.0)
	heterogeneous, heteroscedastic												
Ratio 3:2	homogeneous, homoscedastic												
	IPW 1	21.5	13.4	9.4	20.0	11.7	7.3	21.3	12.7	7.5	24.8	19.1	20.3
		(-0.1)	(-0.2)	(-0.4)	(-3.3)	(-3.3)	(-3.8)	(-0.7)	(-1.3)	(-2.6)	(-1.8)	(1.7)	(7.6)
	IPW 2	10.4	6.1	2.8	10.8	6.7	3.0	11.7	8.6	6.8	12.5	9.4	8.4
		(-1.1)	(-1.0)	(-0.6)	(-0.3)	(-0.3)	(-0.4)	(-0.3)	(1.3)	(3.3)	(2.0)	(3.0)	(5.5)
Ratio 3:2	IPW 3	7.1	3.8	1.0	7.3	4.2	1.0	8.1	5.7	3.8	8.8	6.4	5.6
		(-0.7)	(-0.5)	(-0.2)	(-0.2)	(-0.2)	(-0.3)	(0.1)	(1.3)	(2.5)	(1.8)	(2.5)	(4.7)
	DR	2.5	1.0	-1.0	2.4	1.1	-1.3	2.9	1.6	-0.6	2.9	1.9	1.0
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.4)	(0.1)	(0.9)	(1.1)	(2.5)
	heterogeneous, heteroscedastic												
Ratio 3:2	homogeneous, heteroscedastic												
	IPW 1	16.0	9.8	6.5	15.2	8.7	5.3	16.1	9.4	5.4	18.5	13.6	14.1
		(-0.1)	(-0.1)	(-0.2)	(-1.9)	(-2.1)	(-2.2)	(-0.4)	(-0.8)	(-1.6)	(-1.1)	(1.0)	(5.3)
	IPW 2	6.2	3.0	1.2	6.4	3.3	1.5	7.0	4.5	3.7	7.4	5.0	4.9
		(-0.7)	(-0.5)	(-0.4)	(-0.2)	(-0.2)	(-0.2)	(-0.2)	(0.8)	(2.0)	(1.2)	(1.7)	(3.5)
Ratio 2:3	IPW 3	5.2	2.3	0.7	5.3	2.5	0.8	5.8	3.5	2.4	6.1	3.8	3.7
		(-0.4)	(-0.3)	(-0.2)	(-0.1)	(-0.1)	(-0.1)	(0.1)	(0.8)	(1.5)	(1.0)	(1.5)	(3.0)
	DR	4.6	2.1	0.6	4.5	2.1	0.5	4.9	2.4	0.8	4.8	2.6	1.8
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.3)	(0.1)	(0.5)	(0.6)	(1.5)
	heterogeneous, heteroscedastic												
Ratio 2:3	homogeneous, homoscedastic												
	IPW 1	21.2	13.9	9.1	23.3	15.4	10.0	23.2	15.8	10.4	27.2	18.9	13.3
		(0.0)	(0.0)	(0.0)	(-1.5)	(-1.5)	(-1.0)	(0.9)	(1.1)	(1.3)	(-2.5)	(-1.8)	(0.0)
	IPW 2	8.1	5.7	2.9	9.0	6.9	4.5	5.2	2.2	-2.3	9.2	7.4	5.6
		(-1.4)	(-1.1)	(-1.3)	(-0.1)	(-0.1)	(0.0)	(-4.8)	(-4.8)	(-6.4)	(0.3)	(0.5)	(1.2)
Ratio 2:3	IPW 3	5.4	3.5	2.0	5.9	4.1	2.8	3.6	1.4	-1.2	6.0	4.5	3.7
		(-0.8)	(-0.6)	(-0.7)	(0.0)	(-0.1)	(0.0)	(-2.9)	(-2.8)	(-3.6)	(0.3)	(0.5)	(1.0)
	DR	1.1	0.7	0.9	0.9	0.7	0.8	1.7	1.3	1.6	0.7	0.8	1.2
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.4)	(0.5)	(0.8)	(0.2)	(0.2)	(0.5)
	heterogeneous, heteroscedastic												
Ratio 2:3	homogeneous, heteroscedastic												
	IPW 1	15.6	10.3	6.7	17.2	11.5	7.6	17.1	11.7	7.7	20.5	14.4	10.3
		(0.0)	(0.0)	(0.0)	(-1.0)	(-1.0)	(-0.6)	(0.5)	(0.7)	(0.8)	(-1.7)	(-1.2)	(0.1)
	IPW 2	5.1	3.0	1.5	5.5	3.6	2.5	3.5	1.1	-1.8	5.6	4.0	3.1
		(-0.8)	(-0.6)	(-0.8)	(0.0)	(-0.1)	(0.0)	(-2.7)	(-2.7)	(-4.0)	(0.1)	(0.3)	(0.7)
Ratio 2:3	IPW 3	4.6	2.6	1.6	4.8	2.8	2.0	3.6	1.5	-0.4	4.8	3.2	2.6
		(-0.4)	(-0.3)	(-0.4)	(0.0)	(0.0)	(0.0)	(-1.6)	(-1.6)	(-2.3)	(0.1)	(0.3)	(0.6)
	DR	4.1	2.4	1.6	3.9	2.4	1.5	4.3	2.9	1.9	3.8	2.6	1.7
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.3)	(0.4)	(0.1)	(0.2)	(0.3)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 2 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the MSE minimizing tuning parameter method.

Table A.11: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 3, $\text{MSE}(\hat{p}_i^s)$ -minimizing λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	6.3 (24.6)	-15.7 (7.8)	2.9 (2.1)	58.0 (59.0)	33.4 (41.1)	21.0 (19.8)	34.8 (37.5)	-0.7 (14.7)	4.4 (4.3)	78.7 (72.6)	59.7 (58.1)	38.8 (34.2)	
	IPW 2	17.6 (13.5)	20.5 (2.1)	35.4 (-0.9)	64.1 (50.0)	54.6 (27.7)	54.1 (10.5)	41.6 (20.9)	37.8 (3.3)	46.7 (-1.2)	82.7 (63.9)	74.1 (38.8)	68.3 (14.0)	
	IPW 3	2.7 (19.8)	-6.9 (4.1)	10.2 (-0.8)	60.0 (57.9)	41.3 (36.5)	28.7 (11.0)	31.5 (30.9)	8.0 (7.4)	13.0 (-1.1)	81.4 (71.4)	66.4 (50.4)	43.5 (14.5)	
	DR	29.7 (0.1)	8.2 (0.3)	10.5 (0.5)	29.8 (0.0)	8.4 (0.0)	10.8 (-0.1)	29.7 (0.1)	8.0 (0.7)	10.0 (1.4)	32.7 (3.2)	9.5 (0.4)	6.1 (-6.1)	
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-7.9 (15.0)	-16.8 (5.1)	-3.5 (1.1)	40.3 (46.8)	20.0 (30.7)	9.4 (13.3)	15.9 (26.3)	-7.1 (9.8)	-2.6 (2.5)	67.7 (64.9)	46.9 (48.8)	25.0 (25.5)	
	IPW 2	-0.2 (8.4)	6.2 (1.7)	23.6 (-0.8)	45.3 (39.8)	37.6 (22.0)	40.2 (7.6)	21.6 (14.8)	21.2 (2.7)	34.4 (-1.1)	70.9 (56.9)	60.6 (33.8)	55.9 (11.0)	
	IPW 3	-11.0 (11.8)	-12.0 (2.8)	2.6 (-0.7)	41.1 (45.6)	25.5 (27.3)	16.4 (7.1)	12.3 (21.2)	-1.8 (5.2)	5.0 (-1.0)	69.5 (63.5)	51.9 (42.2)	29.8 (10.1)	
	DR	33.7 (0.0)	4.0 (0.3)	3.1 (0.2)	33.9 (0.0)	4.3 (0.0)	3.5 (-0.1)	33.6 (0.1)	3.9 (0.5)	2.6 (0.7)	35.3 (1.7)	4.9 (0.1)	0.7 (-4.1)	
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	-8.0 (18.1)	-2.0 (17.1)	11.7 (6.6)	-14.2 (-3.6)	-24.0 (-4.7)	0.1 (-4.0)	-7.7 (6.0)	-7.0 (10.5)	5.5 (0.5)	26.0 (13.1)	-9.3 (-0.1)	6.1 (-0.2)	
	IPW 2	7.8 (15.6)	17.1 (13.1)	21.2 (5.5)	11.6 (0.5)	14.5 (-0.3)	20.4 (-0.3)	17.9 (6.8)	25.5 (10.1)	26.4 (5.3)	44.0 (12.2)	32.3 (1.2)	25.5 (-2.5)	
	IPW 3	-5.7 (18.6)	6.7 (18.9)	15.2 (6.9)	-7.8 (0.6)	-9.9 (0.1)	7.0 (0.2)	-0.1 (9.0)	9.3 (16.6)	15.8 (6.8)	31.4 (14.2)	3.8 (-0.4)	4.5 (-3.8)	
	DR	36.8 (0.0)	11.3 (0.4)	10.2 (0.1)	37.8 (1.4)	12.2 (1.1)	10.2 (0.0)	36.4 (-0.3)	10.2 (-0.6)	7.6 (-3.0)	35.9 (-0.7)	9.1 (-2.2)	3.2 (-6.1)	
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-4.0 (10.1)	0.2 (9.2)	5.5 (4.8)	-7.7 (-1.9)	-11.0 (-2.6)	-1.4 (-2.2)	-4.0 (3.6)	-2.8 (5.4)	1.9 (1.0)	16.5 (8.2)	-3.8 (0.1)	2.7 (-0.1)	
	IPW 2	1.2 (9.3)	9.9 (7.6)	11.3 (4.0)	3.2 (0.3)	8.4 (-0.2)	11.5 (-0.1)	7.5 (4.4)	15.7 (6.1)	15.6 (4.0)	27.5 (8.2)	21.1 (1.0)	15.5 (-1.9)	
	IPW 3	-5.5 (10.5)	4.3 (10.6)	6.8 (4.9)	-7.3 (0.3)	-4.8 (0.0)	1.5 (0.3)	-2.6 (5.3)	5.8 (9.4)	7.4 (5.0)	18.0 (9.0)	2.8 (-0.1)	-0.3 (-2.5)	
	DR	4.5 (0.0)	-3.4 (0.4)	-0.1 (0.0)	6.0 (1.3)	-2.5 (0.9)	0.1 (0.0)	4.3 (-0.2)	-4.1 (-0.3)	-1.7 (-2.0)	4.1 (-0.6)	-4.7 (-1.4)	-5.0 (-4.4)	
Ratio 2:3			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	64.7 (67.6)	41.0 (45.5)	18.7 (15.5)	81.6 (79.1)	64.8 (62.7)	33.5 (29.7)	75.0 (72.3)	51.2 (51.3)	20.4 (17.6)	89.8 (84.3)	77.8 (71.5)	47.8 (41.7)	
	IPW 2	63.3 (61.1)	48.1 (32.8)	37.8 (7.2)	83.0 (74.9)	71.9 (50.4)	56.9 (17.1)	73.2 (64.2)	57.3 (32.8)	43.6 (2.7)	91.8 (81.0)	84.7 (57.8)	72.8 (22.2)	
	IPW 3	62.6 (65.6)	41.9 (40.4)	18.2 (7.7)	82.6 (78.5)	68.8 (58.6)	37.8 (18.7)	73.2 (69.7)	50.8 (43.2)	17.3 (3.1)	91.6 (84.0)	82.9 (67.0)	55.9 (26.1)	
	DR	39.8 (0.0)	15.0 (0.7)	9.0 (0.3)	40.7 (1.5)	15.0 (0.3)	9.6 (0.3)	39.5 (-0.1)	15.1 (1.2)	5.9 (-1.9)	45.9 (9.4)	18.4 (3.5)	10.8 (0.6)	
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	45.2 (56.8)	23.8 (34.9)	7.1 (9.9)	70.2 (72.5)	50.7 (53.7)	19.8 (21.3)	60.0 (64.0)	34.8 (41.3)	8.7 (11.6)	83.8 (80.7)	68.5 (65.5)	34.6 (33.1)	
	IPW 2	42.5 (50.4)	29.3 (25.7)	24.9 (4.6)	70.5 (68.1)	56.9 (43.5)	42.7 (12.7)	57.0 (56.0)	40.4 (27.1)	31.5 (1.5)	85.1 (77.2)	74.8 (53.3)	60.8 (18.1)	
	IPW 3	41.9 (54.4)	23.5 (31.0)	9.3 (4.5)	70.3 (71.6)	53.4 (50.2)	24.9 (12.7)	57.0 (61.0)	33.5 (34.7)	9.4 (1.4)	85.2 (80.3)	72.4 (61.3)	42.0 (19.5)	
	DR	57.5 (0.0)	17.3 (0.5)	5.6 (0.1)	57.8 (0.6)	17.1 (0.1)	6.4 (0.3)	57.3 (0.0)	17.4 (0.9)	3.4 (-1.5)	59.3 (4.0)	18.8 (1.8)	7.3 (0.5)	

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 3 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the MSE minimizing tuning parameter method.

Table A.12: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores, cross validated λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	55.4 (0.0)	56.9 (0.1)	81.3 (0.1)	53.5 (0.0)	53.4 (0.2)	73.0 (0.1)	55.4 (0.0)	56.8 (0.2)	80.8 (0.1)	58.9 (0.4)	59.1 (0.6)	73.5 (-0.6)	
	IPW 2	18.2 (0.1)	24.1 (0.0)	41.0 (0.1)	19.4 (0.1)	22.7 (0.2)	36.9 (0.0)	18.9 (0.1)	25.5 (0.1)	42.0 (0.3)	18.5 (-0.6)	21.4 (-0.9)	32.9 (-3.8)	
	IPW 3	9.0 (0.1)	10.5 (0.1)	18.0 (0.4)	9.8 (0.1)	10.8 (0.3)	18.8 (0.0)	9.1 (0.3)	10.5 (0.3)	17.6 (0.7)	8.9 (-0.8)	9.4 (-1.2)	13.8 (-5.0)	
	DR	13.0 (0.0)	14.4 (0.2)	22.4 (0.0)	13.8 (0.0)	15.1 (0.0)	23.8 (0.0)	13.2 (0.1)	14.4 (0.4)	22.0 (0.1)	13.6 (-1.2)	14.6 (-1.9)	20.4 (-4.8)	
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	39.2 (0.0)	41.9 (0.1)	71.7 (0.1)	37.6 (-0.1)	38.8 (0.2)	61.4 (0.1)	39.6 (0.0)	42.2 (0.1)	71.5 (0.1)	45.0 (0.3)	46.3 (0.5)	63.4 (-0.6)	
	IPW 2	6.0 (0.1)	10.5 (0.0)	24.9 (0.1)	6.3 (0.0)	9.0 (0.1)	21.9 (0.0)	6.8 (0.2)	11.7 (0.0)	26.6 (0.2)	5.9 (-0.3)	8.2 (-0.6)	18.7 (-2.9)	
	IPW 3	-0.8 (0.1)	0.0 (0.0)	6.8 (0.2)	-0.6 (0.1)	0.0 (0.2)	7.8 (0.0)	-0.6 (0.3)	-0.1 (0.2)	6.8 (0.4)	-0.9 (-0.4)	-0.8 (-0.8)	4.2 (-3.5)	
	DR	1.8 (0.0)	2.7 (0.2)	10.0 (0.0)	2.4 (0.0)	3.2 (0.0)	11.6 (0.0)	2.0 (0.1)	2.7 (0.3)	9.9 (0.1)	2.6 (-0.7)	3.1 (-1.3)	9.4 (-3.5)	
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	35.8 (0.0)	39.6 (0.0)	35.3 (0.0)	32.4 (-1.0)	36.2 (-0.5)	28.3 (-0.1)	34.1 (-0.8)	37.9 (-1.3)	32.6 (-1.9)	36.1 (-0.2)	41.2 (-0.1)	27.8 (-3.5)	
	IPW 2	18.5 (-0.1)	23.3 (-0.1)	20.9 (-0.1)	20.0 (0.0)	24.1 (0.1)	21.1 (0.0)	19.1 (0.2)	23.5 (-0.1)	20.5 (-1.1)	18.8 (-0.3)	21.7 (-1.7)	12.8 (-7.5)	
	IPW 3	10.8 (0.0)	12.9 (0.0)	10.7 (0.0)	11.3 (0.1)	13.8 (0.2)	11.5 (0.1)	11.0 (0.3)	12.1 (-0.2)	9.4 (-1.2)	10.0 (-0.4)	11.1 (-2.1)	2.1 (-8.5)	
	DR	13.0 (0.0)	16.2 (0.1)	13.7 (0.0)	13.4 (0.0)	16.6 (0.0)	14.0 (0.0)	12.4 (-0.6)	14.6 (-1.1)	11.7 (-2.3)	11.8 (-1.5)	13.7 (-3.1)	4.7 (-9.1)	
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	20.2 (0.0)	23.9 (0.0)	19.7 (0.0)	17.6 (-0.7)	21.2 (-0.3)	13.8 (0.0)	19.2 (-0.7)	23.0 (-1.0)	17.8 (-1.4)	21.3 (-0.2)	26.5 (-0.1)	14.6 (-2.7)	
	IPW 2	4.6 (-0.1)	9.0 (-0.1)	6.7 (-0.1)	5.9 (0.0)	9.8 (0.1)	7.6 (0.0)	5.2 (0.2)	9.3 (-0.1)	6.5 (-0.7)	5.2 (-0.2)	8.2 (-1.1)	2.0 (-5.2)	
	IPW 3	-0.6 (0.0)	1.5 (0.0)	-1.1 (0.0)	-0.2 (0.0)	2.2 (0.1)	0.1 (0.0)	-0.5 (0.2)	1.1 (-0.1)	-2.1 (-0.8)	-0.9 (-0.2)	0.4 (-1.3)	-6.0 (-5.8)	
	DR	0.3 (0.0)	3.3 (0.1)	1.0 (0.0)	0.6 (0.0)	3.7 (0.0)	1.2 (0.0)	-0.1 (-0.4)	2.4 (-0.8)	-0.3 (-1.5)	-0.2 (-0.9)	1.8 (-1.9)	-5.0 (-6.3)	
Ratio 2:3			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	48.8 (0.1)	41.4 (0.2)	37.6 (0.0)	56.1 (-0.1)	46.3 (0.1)	42.1 (0.1)	50.4 (0.0)	42.1 (0.1)	35.7 (-2.2)	64.1 (0.0)	53.5 (0.4)	50.1 (0.0)	
	IPW 2	16.9 (-0.2)	19.1 (0.0)	24.5 (0.0)	17.8 (0.0)	20.0 (0.0)	24.8 (0.0)	15.6 (-2.1)	18.2 (-1.7)	22.6 (-3.8)	17.7 (0.0)	20.2 (0.1)	24.1 (-0.8)	
	IPW 3	9.7 (-0.1)	10.2 (0.0)	13.8 (0.1)	10.2 (0.0)	10.8 (0.0)	14.3 (0.0)	8.1 (-1.8)	8.4 (-1.5)	9.1 (-4.1)	10.1 (-0.1)	11.1 (0.1)	13.4 (-1.0)	
	DR	12.6 (0.0)	13.0 (0.2)	17.4 (0.0)	12.8 (0.0)	13.5 (0.0)	18.1 (0.1)	12.7 (-0.2)	12.7 (0.0)	14.3 (-3.1)	13.2 (-0.1)	14.3 (-0.1)	18.0 (-0.9)	
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	33.4 (0.0)	27.5 (0.1)	23.4 (0.0)	41.7 (-0.1)	33.0 (0.0)	28.3 (0.1)	35.6 (0.0)	28.6 (0.0)	22.4 (-1.7)	52.1 (0.0)	41.6 (0.3)	37.7 (0.0)	
	IPW 2	6.3 (-0.1)	7.8 (0.0)	13.0 (0.0)	6.8 (0.0)	8.2 (0.0)	13.7 (0.0)	5.9 (-1.2)	7.4 (-1.1)	12.4 (-2.6)	6.8 (0.0)	8.4 (0.0)	13.4 (-0.5)	
	IPW 3	2.0 (0.0)	1.4 (0.0)	5.9 (0.1)	2.1 (0.0)	1.8 (0.0)	6.6 (0.0)	1.2 (-1.0)	0.4 (-0.9)	3.2 (-2.6)	2.1 (0.0)	2.1 (0.0)	6.1 (-0.6)	
	DR	5.8 (0.0)	4.3 (0.1)	8.8 (0.0)	5.9 (0.0)	4.6 (0.0)	9.7 (0.0)	6.0 (-0.1)	4.2 (0.0)	6.9 (-2.0)	6.2 (0.0)	5.3 (-0.1)	9.9 (-0.5)	

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the cross validated tuning parameter method.

Table A.13: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 1, cross-validated λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	14.5	homogeneous, homoscedastic					22.1	heterogeneous, homoscedastic				
		(0.0)	11.2	8.8	17.6	13.4	7.5	(0.0)	16.5	11.9	21.6	16.6	7.1
	IPW 2	8.8	(0.0)	(0.0)	(-0.3)	(-0.3)	(0.0)	(0.0)	(-0.1)	(0.0)	(0.2)	(0.2)	(-1.9)
		(-0.3)	6.7	7.7	8.3	7.6	7.4	9.9	7.2	9.6	9.2	8.6	4.8
	IPW 3	9.9	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)	(-0.6)	(-0.1)	(0.0)	(1.0)	(0.1)	(-3.1)
Ratio 1:1	DR	(-0.2)	7.6	7.2	9.7	8.2	7.2	11.1	8.2	8.6	10.4	8.9	4.4
		(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.4)	(0.0)	(0.0)	(0.9)	(0.0)	(-3.1)
		8.3	6.7	6.2	8.0	6.4	6.6	9.4	7.7	7.4	8.2	6.6	3.9
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.7)	(-0.1)	(-3.1)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
Ratio 1:1	IPW 1	11.4	7.6	3.9	13.5	9.0	3.1	16.3	11.0	6.6	16.5	11.5	2.6
		(0.0)	(0.0)	(0.0)	(-0.3)	(-0.2)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(-1.5)
	IPW 2	7.5	4.9	3.7	7.4	5.3	3.8	8.2	5.1	5.7	8.1	6.0	1.7
		(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.3)	(-0.1)	(0.0)	(0.6)	(0.0)	(-2.1)
	IPW 3	8.5	5.4	3.8	8.5	5.6	4.0	9.2	5.6	5.3	9.1	6.1	1.8
Ratio 3:2	DR	(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.2)	(0.0)	(0.0)	(0.5)	(0.0)	(-2.1)
		8.9	5.0	3.5	8.8	4.9	3.9	9.5	5.4	4.8	9.1	5.1	1.8
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.4)	(-0.1)	(-2.1)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	16.6	9.4	7.9	17.8	9.9	6.7	21.4	12.2	7.7	21.3	12.2	3.2
Ratio 3:2		(0.0)	(-0.1)	(0.1)	(-1.2)	(-0.7)	(0.0)	(-1.0)	(-1.8)	(-2.7)	(0.5)	(1.3)	(-2.1)
	IPW 2	12.7	7.1	7.1	12.1	7.4	7.7	14.1	8.1	7.2	13.2	7.4	2.1
		(-0.3)	(-0.1)	(-0.1)	(-0.1)	(0.0)	(0.1)	(0.0)	(-0.2)	(-1.4)	(1.0)	(-0.5)	(-5.3)
	IPW 3	13.2	7.5	5.8	12.8	7.6	6.2	14.4	8.1	5.5	13.7	7.2	0.2
	DR	(-0.2)	(-0.1)	(0.0)	(-0.1)	(0.0)	(0.1)	(0.0)	(-0.3)	(-1.6)	(1.0)	(-0.6)	(-5.6)
Ratio 3:2		10.6	5.8	4.9	10.5	5.8	4.9	10.6	5.1	3.5	10.6	4.5	-2.0
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.5)	(-1.2)	(-2.5)	(0.5)	(-1.2)	(-6.4)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	12.2	4.8	1.0	12.7	5.3	0.4	15.3	6.8	0.9	14.7	7.0	-1.7
		(-0.1)	(0.0)	(0.1)	(-0.8)	(-0.4)	(0.0)	(-0.7)	(-1.1)	(-1.7)	(0.2)	(0.8)	(-1.4)
Ratio 2:3	IPW 2	9.1	2.6	0.8	8.4	3.0	1.8	10.0	3.2	0.9	9.0	3.1	-1.5
		(-0.1)	(-0.1)	(0.0)	(-0.1)	(0.0)	(0.1)	(0.0)	(-0.1)	(-0.8)	(0.5)	(-0.3)	(-3.4)
	IPW 3	9.5	3.0	0.0	9.1	3.3	0.7	10.3	3.4	-0.3	9.6	3.1	-2.9
		(-0.1)	(0.0)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.2)	(-1.0)	(0.5)	(-0.3)	(-3.5)
	DR	8.7	2.3	-0.2	8.7	2.3	-0.1	8.7	2.0	-1.2	8.7	1.6	-4.2
Ratio 2:3		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.3)	(-0.7)	(-1.6)	(0.2)	(-0.7)	(-4.0)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	16.4	10.1	7.1	20.6	12.5	8.0	22.9	14.6	6.9	25.4	15.8	10.4
		(0.1)	(0.1)	(0.0)	(-0.3)	(-0.1)	(0.0)	(-0.2)	(-0.3)	(-3.3)	(-0.7)	(-0.3)	(-0.2)
	IPW 2	9.7	6.1	6.7	9.4	6.0	6.6	8.7	4.9	3.5	9.9	6.7	6.4
Ratio 2:3		(-0.4)	(0.0)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-2.2)	(-1.8)	(-4.7)	(0.6)	(0.4)	(-0.1)
	IPW 3	10.5	6.3	5.9	10.3	6.3	6.0	9.9	5.6	2.3	10.7	6.9	5.7
		(-0.3)	(0.0)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-1.8)	(-1.5)	(-4.5)	(0.6)	(0.4)	(-0.2)
	DR	8.1	5.0	4.9	7.9	4.8	5.2	8.5	5.5	2.4	8.2	5.2	5.1
		(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.3)	(-0.5)	(-3.5)	(0.6)	(0.5)	(-0.1)
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	13.4	6.7	3.1	16.4	8.3	3.9	17.8	9.7	3.4	20.3	11.0	5.8
		(0.0)	(0.0)	(0.0)	(-0.2)	(-0.1)	(0.0)	(-0.1)	(-0.2)	(-2.1)	(-0.5)	(-0.2)	(-0.1)
	IPW 2	8.5	4.4	3.4	8.5	4.2	3.5	8.0	3.8	2.0	8.8	4.6	3.5
		(-0.2)	(0.0)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-1.2)	(-1.0)	(-2.8)	(0.3)	(0.3)	(0.0)
Ratio 2:3	IPW 3	9.4	4.6	3.2	9.4	4.5	3.5	9.2	4.2	1.5	9.7	4.9	3.4
		(-0.1)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.9)	(-0.8)	(-2.7)	(0.3)	(0.3)	(0.0)
	DR	9.9	4.3	3.0	9.8	4.1	3.4	10.2	4.5	1.9	10.1	4.4	3.4
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.3)	(-2.0)	(0.4)	(0.3)	(0.0)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 1 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the cross validated tuning parameter method.

Table A.14: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 2, cross-validated λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	11.5 (0.0)	homogeneous, homoscedastic					12.2 (0.0)	heterogeneous, homoscedastic				
	IPW 2	4.9 (-0.4)	7.2 (0.0)	2.2 (0.0)	13.0 (-0.4)	8.5 (-0.6)	3.6 (-0.1)	4.9 (-0.1)	7.6 (-0.1)	2.4 (0.0)	17.9 (1.8)	13.3 (2.1)	8.4 (3.2)
	IPW 3	2.6 (-0.3)	3.3 (0.0)	1.0 (0.0)	5.0 (0.0)	3.2 (-0.1)	1.4 (-0.1)	2.5 (-0.6)	3.2 (-0.1)	1.1 (0.0)	5.9 (1.1)	4.3 (1.0)	2.9 (1.5)
	DR	0.5 (0.0)	0.8 (0.0)	0.4 (0.0)	0.3 (0.0)	0.6 (0.0)	0.3 (0.0)	0.6 (0.0)	0.7 (0.0)	0.4 (0.0)	0.5 (0.4)	0.8 (0.4)	0.9 (0.6)
Ratio 1:1	IPW 1	8.2 (0.0)	homogeneous, heteroscedastic					8.7 (0.0)	heterogeneous, heteroscedastic				
	IPW 2	2.6 (-0.2)	5.3 (0.0)	2.6 (0.0)	9.4 (-0.4)	6.2 (-0.3)	3.2 (0.0)	2.5 (-0.4)	5.5 (-0.1)	2.7 (0.0)	13.1 (1.1)	9.7 (1.4)	6.4 (2.2)
	IPW 3	2.0 (-0.1)	2.1 (0.0)	1.4 (0.0)	2.7 (0.0)	2.2 (-0.1)	1.3 (0.0)	1.9 (-0.3)	2.0 (0.0)	1.5 (0.0)	3.3 (0.6)	2.8 (0.6)	2.0 (0.8)
	DR	1.8 (0.0)	1.6 (0.0)	1.1 (0.0)	2.1 (0.0)	1.7 (0.0)	1.0 (0.0)	1.8 (-0.3)	1.5 (0.0)	1.1 (0.0)	2.5 (0.5)	2.2 (0.4)	1.5 (0.6)
Ratio 3:2	IPW 1	12.6 (-0.1)	homogeneous, homoscedastic					12.3 (-0.4)	heterogeneous, homoscedastic				
	IPW 2	6.5 (-0.3)	6.0 (-0.1)	2.7 (0.0)	12.3 (-1.3)	5.7 (-0.7)	2.3 (0.0)	7.8 (0.8)	5.4 (-0.6)	1.9 (-0.5)	16.8 (1.3)	10.6 (3.3)	7.0 (4.7)
	IPW 3	4.2 (-0.2)	3.1 (-0.2)	2.3 (-0.2)	6.2 (-0.2)	2.9 (-0.1)	1.9 (0.0)	5.1 (0.8)	4.8 (1.3)	4.2 (1.3)	7.4 (1.4)	4.3 (1.6)	3.3 (1.8)
	DR	1.2 (0.0)	1.6 (-0.1)	1.4 (-0.1)	4.1 (-0.1)	1.6 (0.0)	1.2 (0.0)	1.4 (0.6)	2.6 (0.9)	2.6 (0.8)	5.0 (1.2)	2.7 (1.3)	2.4 (1.4)
Ratio 3:2	IPW 1	8.8 (0.0)	homogeneous, heteroscedastic					8.7 (-0.2)	heterogeneous, heteroscedastic				
	IPW 2	3.6 (-0.1)	4.4 (0.0)	2.2 (0.0)	8.5 (-0.8)	4.3 (-0.4)	1.8 (0.0)	4.5 (0.5)	4.1 (-0.3)	1.8 (-0.3)	11.2 (0.7)	7.2 (1.9)	4.6 (3.0)
	IPW 3	2.9 (-0.1)	1.9 (-0.1)	1.5 (-0.1)	3.3 (-0.1)	1.9 (0.0)	0.9 (0.0)	3.4 (0.4)	3.0 (0.8)	2.7 (0.8)	3.9 (0.8)	2.6 (0.8)	1.7 (1.0)
	DR	2.4 (0.0)	1.4 (-0.1)	1.0 (-0.1)	2.7 (-0.1)	1.4 (0.0)	0.6 (0.0)	2.5 (0.4)	2.0 (0.5)	1.8 (0.5)	3.2 (0.6)	1.9 (0.7)	1.2 (0.8)
Ratio 2:3	IPW 1	12.9 (0.0)	homogeneous, homoscedastic					14.3 (0.7)	heterogeneous, homoscedastic				
	IPW 2	5.4 (-0.5)	4.4 (0.1)	2.2 (-0.1)	8.5 (0.0)	4.3 (-0.1)	1.8 (0.0)	4.1 (-2.1)	4.1 (-1.3)	1.8 (-1.5)	11.2 (0.3)	7.2 (0.2)	4.6 (0.5)
	IPW 3	3.3 (-0.3)	1.4 (0.0)	1.0 (-0.1)	2.7 (0.0)	1.4 (-0.1)	0.6 (0.0)	3.4 (-1.3)	2.0 (-0.8)	1.8 (-0.9)	3.2 (0.3)	1.9 (0.1)	1.2 (0.4)
	DR	0.6 (0.0)	1.2 (0.0)	0.5 (0.0)	2.3 (0.0)	1.2 (0.0)	0.6 (0.0)	2.5 (0.1)	1.2 (0.1)	0.7 (0.1)	2.4 (0.2)	1.4 (0.2)	0.7 (0.3)
Ratio 2:3	IPW 1	9.0 (0.0)	homogeneous, heteroscedastic					10.0 (0.4)	heterogeneous, heteroscedastic				
	IPW 2	2.5 (-0.2)	7.0 (-0.1)	4.1 (0.1)	14.9 (-0.5)	8.3 (-0.6)	5.6 (0.2)	4.1 (-2.1)	7.9 (0.4)	5.1 (0.9)	18.8 (-0.1)	11.4 (-0.1)	8.9 (1.6)
	IPW 3	3.3 (-0.3)	3.3 (0.1)	2.1 (-0.1)	5.4 (0.0)	2.8 (-0.1)	1.7 (0.0)	2.5 (-1.2)	2.2 (-0.7)	0.9 (-1.0)	5.6 (0.2)	3.1 (0.1)	2.2 (0.2)
	DR	0.6 (0.0)	2.0 (0.0)	1.1 (0.0)	3.3 (0.0)	1.8 (0.0)	0.9 (0.0)	2.5 (0.3)	1.3 (0.2)	0.4 (0.4)	3.5 (0.1)	2.0 (0.1)	1.3 (0.2)
Ratio 2:3	IPW 1	9.0 (0.0)	homogeneous, homoscedastic					10.0 (0.4)	heterogeneous, homoscedastic				
	IPW 2	2.5 (-0.2)	6.0 (-0.1)	2.7 (0.0)	10.5 (-0.4)	6.9 (-0.4)	3.7 (0.1)	1.9 (-1.2)	6.7 (0.2)	3.3 (0.5)	13.6 (-0.2)	9.1 (-0.1)	6.1 (1.1)
	IPW 3	2.1 (-0.1)	2.5 (0.0)	1.1 (-0.1)	2.5 (0.0)	2.1 (-0.1)	0.9 (0.0)	1.6 (-1.2)	1.9 (-0.7)	0.4 (-1.0)	2.7 (0.2)	2.3 (0.1)	1.1 (0.2)
	DR	1.8 (0.0)	2.1 (0.0)	0.6 (0.0)	2.1 (0.0)	1.8 (0.0)	0.5 (0.0)	2.0 (-0.7)	1.7 (-0.4)	0.1 (-0.6)	2.2 (0.1)	1.9 (0.1)	0.7 (0.2)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 2 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the cross validated tuning parameter method.

Table A.15: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 3, cross-validated λ

N		100	linear		500	nonlinear		500	100	linear	500	100	nonlinear	500
			200			200				200			200	
Ratio 1:1			homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	-10.2 (24.8)	-26.1 (8.1)	-4.8 (2.1)	51.4 (60.4)	29.4 (43.4)	14.5 (21.1)	22.8 (37.6)		-9.7 (15.2)	-3.4 (4.1)	75.1 (73.7)	56.3 (59.3)	28.6 (32.1)
	IPW 2	9.9 (14.4)	18.6 (2.8)	37.0 (0.4)	60.7 (50.1)	53.5 (27.9)	54.1 (10.5)	37.1 (22.3)		37.2 (4.6)	49.7 (0.6)	80.9 (63.8)	73.0 (38.4)	67.9 (13.7)
	IPW 3	-4.5 (20.3)	-7.3 (4.4)	12.8 (0.2)	57.1 (58.0)	41.2 (36.6)	29.8 (11.0)	26.9 (31.7)		8.4 (8.2)	17.2 (0.4)	79.9 (71.2)	66.0 (49.9)	44.1 (14.3)
Ratio 1:1	DR	26.6 (0.1)	10.4 (0.3)	13.5 (0.6)	26.8 (0.0)	10.5 (0.0)	14.1 (0.0)	26.7 (0.1)		10.3 (0.7)	13.6 (1.4)	29.2 (2.6)	10.9 (-0.1)	10.5 (-4.9)
			homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
	IPW 1	-18.6 (15.6)	-24.5 (4.8)	-8.6 (1.4)	34.8 (48.4)	15.4 (31.8)	5.4 (14.7)	7.1 (26.9)		-14.5 (9.6)	-7.5 (2.7)	64.3 (66.2)	43.0 (49.4)	17.9 (24.4)
	IPW 2	-3.7 (9.4)	5.0 (1.9)	24.5 (0.3)	43.3 (40.2)	36.4 (21.6)	40.3 (8.0)	19.5 (16.3)		20.8 (3.4)	36.4 (0.5)	69.6 (57.0)	59.4 (33.0)	55.7 (11.3)
Ratio 3:2	IPW 3	-14.7 (12.6)	-13.0 (2.7)	3.7 (0.1)	39.1 (46.1)	24.3 (26.8)	17.1 (7.6)	9.8 (22.2)		-2.5 (5.3)	7.3 (0.2)	68.2 (63.5)	50.8 (41.3)	30.1 (10.6)
	DR	31.3 (0.0)	4.0 (0.2)	4.5 (0.4)	31.5 (0.0)	4.1 (0.0)	5.0 (0.0)	31.3 (0.0)		3.9 (0.4)	4.8 (0.9)	32.6 (1.3)	4.6 (-0.1)	2.3 (-3.5)
			homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	-13.4 (18.2)	-7.3 (17.3)	3.1 (7.0)	-18.3 (-0.6)	-28.4 (-0.9)	-6.5 (0.1)	-13.9 (6.2)		-12.2 (11.2)	-1.3 (3.3)	22.4 (16.3)	-17.4 (2.2)	-11.7 (-5.3)
Ratio 3:2	IPW 2	9.5 (16.4)	17.6 (13.8)	18.7 (5.8)	12.7 (0.7)	14.2 (0.0)	18.0 (0.0)	19.2 (7.6)		25.2 (10.2)	23.1 (4.1)	44.2 (11.9)	30.7 (0.0)	18.8 (-6.9)
	IPW 3	-2.7 (19.1)	8.5 (19.3)	13.0 (6.9)	-5.2 (0.7)	-8.3 (0.2)	5.0 (0.4)	2.5 (9.3)		10.3 (16.3)	13.0 (5.8)	32.7 (13.8)	3.5 (-1.9)	-2.5 (-8.7)
	DR	39.2 (0.0)	14.2 (0.4)	9.4 (0.1)	40.3 (1.4)	15.2 (1.1)	9.9 (0.0)	38.6 (-0.5)		12.8 (-0.8)	7.5 (-2.3)	38.3 (-0.9)	11.3 (-2.9)	-0.3 (-9.6)
			homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
Ratio 3:2	IPW 1	-7.8 (9.7)	-6.5 (9.8)	-3.7 (4.5)	-10.4 (-0.4)	-17.7 (-0.5)	-9.2 (0.0)	-8.3 (3.3)		-9.3 (6.4)	-6.6 (2.2)	13.8 (10.5)	-12.8 (1.3)	-11.8 (-3.5)
	IPW 2	3.6 (9.5)	8.2 (8.5)	7.4 (3.8)	5.7 (0.4)	5.9 (0.0)	7.8 (0.0)	9.9 (4.6)		13.7 (6.5)	11.0 (2.8)	29.4 (8.4)	17.8 (0.1)	9.5 (-4.8)
	IPW 3	-2.7 (10.5)	3.0 (11.3)	2.4 (4.5)	-4.1 (0.4)	-6.9 (0.1)	-2.7 (0.2)	0.1 (5.2)		4.2 (9.7)	2.3 (3.9)	20.4 (9.1)	-0.4 (-1.1)	-7.2 (-5.7)
	DR	7.7 (0.0)	-5.2 (0.3)	-3.9 (0.1)	9.4 (1.4)	-4.4 (0.8)	-3.6 (0.0)	7.2 (-0.5)		-6.1 (-0.6)	-5.2 (-1.5)	7.5 (-0.6)	-7.1 (-1.9)	-10.5 (-6.6)
Ratio 2:3			homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	59.8 (67.6)	35.5 (45.4)	13.7 (15.5)	79.1 (79.3)	61.8 (63.1)	30.0 (30.5)	71.5 (72.3)		46.7 (51.5)	14.5 (16.3)	88.4 (84.6)	76.1 (72.1)	44.5 (42.1)
	IPW 2	60.5 (61.4)	46.3 (33.4)	38.4 (8.0)	81.6 (74.9)	70.7 (50.3)	56.9 (17.1)	71.7 (64.9)		57.3 (34.7)	46.9 (5.6)	91.1 (81.0)	84.0 (57.8)	72.7 (22.0)
	IPW 3	60.1 (65.8)	40.4 (40.8)	19.6 (8.2)	81.4 (78.5)	67.9 (58.6)	38.8 (18.7)	71.8 (70.1)		50.8 (44.6)	21.3 (5.5)	91.1 (84.0)	82.4 (67.0)	56.3 (25.9)
Ratio 2:3	DR	36.8 (0.0)	14.0 (0.6)	11.6 (0.3)	37.9 (1.5)	14.0 (0.3)	12.5 (0.3)	36.6 (-0.1)		14.6 (1.4)	8.7 (-2.3)	43.3 (9.3)	17.6 (3.7)	13.5 (0.5)
			homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
	IPW 1	40.9 (57.1)	18.0 (34.2)	3.3 (10.5)	67.8 (72.9)	47.1 (53.6)	17.5 (22.5)	56.8 (64.2)		29.8 (40.9)	4.7 (11.4)	82.5 (81.1)	66.3 (65.8)	32.7 (34.1)
	IPW 2	40.5 (51.0)	27.2 (25.5)	24.3 (5.7)	69.4 (68.3)	55.4 (43.0)	42.2 (13.2)	56.0 (56.9)		39.8 (28.1)	33.1 (4.2)	84.5 (77.3)	74.0 (52.9)	60.3 (18.5)
Ratio 2:3	IPW 3	39.9 (55.0)	21.1 (30.6)	9.0 (5.4)	69.2 (71.8)	51.8 (49.7)	24.8 (13.3)	55.9 (61.7)		32.3 (35.3)	11.0 (3.7)	84.6 (80.4)	71.6 (61.0)	41.8 (20.0)
	DR	55.7 (0.0)	15.2 (0.4)	5.5 (0.2)	56.0 (0.5)	15.1 (0.1)	6.2 (0.2)	55.6 (0.0)		15.5 (0.8)	3.9 (-1.4)	57.6 (3.9)	17.2 (2.1)	6.9 (0.3)

Note: The percentage improvements in MSE of ATE estimates due to the shrunk propensity score combined with trimming rule 2 with respect to the conventional propensity score combined with trimming rule 3 for each estimation method and for each possible DGP are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the cross validated tuning parameter method.

Table A.16: Details for the simulations with many variables.

Empirical Variance-Covariance Matrix (Σ)															
2.56															
1.19	1.68														
-0.64	-0.79	38.61													
-0.30	-0.94	26.81	29.82												
-0.05	0.01	-0.29	-0.26	0.22											
-0.07	-0.05	-0.03	-0.10	-0.02	0.15										
-0.26	-0.13	0.83	0.69	-0.13	0.23	2.83									
0.27	0.25	0.01	0.09	0.04	-0.05	-0.20	2.52								
0.36	0.25	0.01	0.01	0.03	-0.07	-0.41	1.44	2.26							
0.53	0.42	0.20	0.23	0.03	-0.10	-0.38	1.04	1.13	2.70						
0.50	0.38	0.56	0.58	0.03	-0.11	-0.52	0.87	1.07	2.16	2.74					
0.43	0.29	0.13	0.06	0.00	-0.03	-0.16	0.22	0.27	0.29	0.29	1.11				
-1.07	-0.62	-0.21	-0.33	0.02	0.05	0.36	-0.30	-0.40	-0.45	-0.47	-0.34	2.86			
-0.07	-0.03	0.02	-0.08	0.00	0.02	0.13	0.32	0.25	0.00	0.03	-0.01	0.14	2.10		
-0.27	-0.20	0.10	0.08	-0.01	0.04	0.20	0.30	0.21	-0.11	-0.12	-0.10	0.24	0.78	1.28	
0.26	0.27	0.46	0.09	-0.01	-0.05	-0.09	-0.06	0.15	0.39	0.18	-0.11	-0.04	0.08	-0.15	9.85

Note: Details for the simulations with many variables. The sample variance-covariance matrix is from the data based on NCDS and used as the variance matrix for the X vector in Eq. (17) drawn from multivariate normal.

Table A.17: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used instead of the conventional propensity scores, fixed valued λ for many X

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	38.9 (-1.4)	27.3 (-0.5)	14.8 (1.7)	40.6 (-4.3)	28.6 (-2.4)	18.1 (3.1)	39.2 (-3.0)	28.4 (-1.1)	16.0 (2.2)	40.3 (-10.3)	30.5 (-6.0)	20.4 (2.3)
	IPW 2	19.0 (-1.0)	14.6 (-0.4)	3.6 (-2.9)	19.8 (-0.1)	14.8 (-0.1)	9.0 (1.5)	18.4 (-2.0)	14.4 (-0.9)	1.1 (-5.0)	19.6 (-0.1)	14.7 (-0.2)	9.2 (1.8)
	IPW 3	9.7 (-0.4)	5.8 (-0.2)	0.8 (-2.1)	10.0 (0.0)	5.9 (-0.1)	3.8 (0.8)	9.1 (-0.9)	5.6 (-0.4)	-0.5 (-3.4)	10.0 (0.0)	5.8 (-0.1)	4.1 (1.0)
	DR	2.3 (0.0)	1.6 (0.0)	1.1 (0.0)	2.3 (0.0)	1.6 (0.0)	1.0 (0.0)	2.3 (0.0)	1.6 (0.0)	1.1 (0.0)	2.3 (0.0)	1.6 (0.0)	0.8 (-0.2)
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	29.9 (-0.9)	18.1 (0.0)	8.9 (0.9)	31.5 (-2.9)	19.6 (-1.1)	11.0 (1.6)	30.4 (-2.0)	19.1 (-0.3)	9.7 (1.1)	32.6 (-7.4)	22.3 (-3.4)	12.7 (0.9)
	IPW 2	13.6 (-0.6)	7.5 (-0.5)	1.3 (-1.7)	14.0 (0.0)	7.9 (0.0)	4.4 (0.7)	13.3 (-1.2)	7.2 (-1.0)	-0.1 (-2.9)	13.9 (-0.1)	7.9 (0.0)	4.5 (0.8)
	IPW 3	7.4 (-0.3)	3.2 (-0.3)	0.2 (-1.2)	7.5 (0.0)	3.4 (0.0)	2.0 (0.3)	7.1 (-0.5)	3.0 (-0.5)	-0.5 (-2.0)	7.5 (0.0)	3.4 (0.0)	2.1 (0.4)
	DR	1.2 (0.0)	0.8 (0.0)	0.5 (0.0)	1.2 (0.0)	0.9 (0.0)	0.5 (0.0)	1.2 (0.0)	0.8 (0.0)	0.5 (0.0)	1.2 (0.0)	0.9 (0.0)	0.4 (-0.2)
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	42.5 (-0.1)	35.6 (0.2)	11.0 (-1.2)	42.9 (0.0)	34.0 (-0.2)	15.9 (2.6)	43.9 (0.1)	36.0 (0.2)	12.1 (-0.6)	44.2 (-1.6)	34.0 (-1.6)	19.0 (4.1)
	IPW 2	20.4 (-0.8)	18.8 (0.3)	6.2 (-2.1)	20.8 (-0.2)	17.2 (-0.4)	13.0 (2.7)	19.5 (-1.6)	18.7 (0.2)	4.8 (-3.5)	20.6 (-0.4)	16.9 (-0.7)	13.3 (3.0)
	IPW 3	11.0 (-0.4)	6.2 (0.2)	1.5 (-1.8)	11.3 (-0.1)	5.7 (-0.3)	4.6 (1.3)	10.7 (-0.7)	6.2 (0.2)	0.5 (-2.7)	11.1 (-0.1)	5.5 (-0.5)	5.0 (1.6)
	DR	1.8 (0.0)	1.6 (0.0)	1.6 (0.1)	1.8 (0.0)	1.6 (0.0)	1.6 (0.2)	1.8 (0.0)	1.6 (0.0)	1.5 (0.1)	1.8 (0.0)	1.6 (0.0)	1.5 (0.0)
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	29.2 (-0.1)	21.1 (0.0)	6.2 (-1.0)	29.6 (-0.1)	20.0 (-0.2)	9.4 (1.4)	30.7 (0.1)	21.7 (0.0)	6.9 (-0.5)	31.6 (-1.3)	20.9 (-1.0)	11.5 (2.3)
	IPW 2	12.1 (-0.5)	9.1 (0.0)	3.1 (-1.5)	12.2 (-0.2)	8.4 (-0.3)	7.7 (1.5)	11.5 (-1.0)	8.9 (-0.2)	2.2 (-2.4)	12.1 (-0.3)	8.3 (-0.4)	8.0 (1.7)
	IPW 3	6.9 (-0.2)	2.8 (0.0)	0.4 (-1.2)	6.9 (-0.1)	2.7 (-0.2)	2.4 (0.7)	6.7 (-0.4)	2.8 (-0.1)	-0.2 (-1.7)	6.9 (-0.1)	2.6 (-0.3)	2.6 (0.9)
	DR	1.4 (0.0)	0.5 (0.0)	0.9 (0.0)	1.3 (0.0)	0.5 (0.0)	0.9 (0.1)	1.4 (0.0)	0.5 (0.0)	0.8 (0.0)	1.3 (0.0)	0.5 (0.0)	0.8 (0.0)
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	39.1 (-6.4)	27.3 (-1.8)	14.0 (1.3)	38.4 (-11.8)	29.2 (-5.3)	14.8 (-1.0)	38.0 (-9.6)	27.8 (-3.2)	14.6 (0.8)	34.4 (-20.7)	29.9 (-11.6)	14.3 (-6.5)
	IPW 2	19.8 (-1.1)	12.4 (-1.1)	3.7 (-2.5)	20.8 (0.0)	13.9 (0.1)	6.6 (0.3)	18.6 (-2.5)	11.6 (-2.2)	1.9 (-4.5)	20.8 (0.0)	13.9 (0.1)	6.7 (0.3)
	IPW 3	9.5 (-0.5)	4.3 (-0.6)	2.1 (-1.6)	10.1 (0.0)	5.0 (0.1)	4.0 (0.2)	8.9 (-1.1)	3.9 (-1.1)	0.9 (-2.7)	10.1 (0.0)	5.0 (0.1)	4.0 (0.2)
	DR	1.5 (0.0)	1.3 (0.0)	0.9 (0.0)	1.5 (0.0)	1.3 (0.0)	0.9 (0.0)	1.5 (0.0)	1.3 (0.0)	1.0 (0.1)	1.5 (0.0)	1.3 (0.0)	0.7 (-0.2)
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	35.2 (-4.1)	21.6 (-0.6)	10.5 (0.4)	34.9 (-8.2)	23.4 (-3.0)	11.1 (-1.3)	34.6 (-6.4)	22.2 (-1.5)	11.0 (0.1)	32.1 (-15.9)	24.8 (-7.9)	10.9 (-5.3)
	IPW 2	16.8 (-0.6)	8.4 (-0.8)	2.3 (-1.5)	17.2 (0.0)	9.3 (0.2)	4.1 (0.1)	16.3 (-1.4)	8.0 (-1.6)	1.2 (-2.7)	17.2 (0.0)	9.4 (0.2)	4.1 (0.1)
	IPW 3	9.1 (-0.3)	3.4 (-0.4)	1.2 (-0.9)	9.3 (0.0)	3.9 (0.1)	2.4 (0.1)	8.7 (-0.6)	3.1 (-0.8)	0.5 (-1.6)	9.3 (0.0)	3.9 (0.1)	2.4 (0.1)
	DR	0.8 (0.0)	1.0 (0.0)	0.7 (0.0)	0.7 (0.0)	1.0 (0.0)	0.6 (0.0)	0.8 (0.0)	1.0 (0.0)	0.7 (0.0)	0.7 (0.0)	1.0 (0.0)	0.5 (-0.1)

Note: The percentage improvements in MSE of ATE estimates due to the shrunk propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.18: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used instead of the conventional propensity scores, $\text{MSE}(\hat{p}_i^s)$ -minimizing λ , for many X .

	N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	54.6 (-1.9)	34.0 (-1.9)	20.7 (-1.5)	49.3 (-9.8)	26.4 (-13.1)	10.3 (-13.9)	54.2 (-4.0)	34.0 (-3.6)	20.3 (-2.7)	41.3 (-23.2)	14.9 (-30.7)	-5.6 (-33.1)
	IPW 2	30.5 (-3.1)	16.6 (-2.3)	11.9 (-1.5)	32.4 (-0.4)	18.3 (-1.1)	13.6 (-1.3)	27.1 (-6.9)	12.8 (-6.2)	8.4 (-5.0)	32.0 (-0.8)	17.7 (-1.7)	12.9 (-1.9)
	DR	22.4 (-2.3)	13.4 (-1.3)	9.0 (-0.6)	24.4 (-0.2)	14.2 (-0.8)	8.6 (-0.9)	19.7 (-5.1)	10.8 (-3.9)	7.0 (-2.8)	24.1 (-0.5)	13.8 (-1.2)	8.2 (-1.3)
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	42.2 (-1.1)	23.5 (-1.1)	13.9 (-0.8)	39.0 (-6.4)	18.9 (-8.3)	8.5 (-7.6)	42.6 (-2.5)	23.7 (-2.2)	14.1 (-1.4)	34.5 (-16.4)	11.6 (-20.5)	-0.1 (-18.8)
	IPW 2	20.4 (-1.9)	8.6 (-1.5)	5.5 (-0.9)	21.3 (-0.2)	9.6 (-0.6)	6.7 (-0.7)	18.7 (-4.1)	6.3 (-4.0)	3.5 (-2.9)	21.0 (-0.4)	9.2 (-1.0)	6.3 (-1.0)
	DR	15.3 (-1.4)	7.5 (-0.9)	4.3 (-0.5)	16.4 (-0.1)	7.9 (-0.4)	4.0 (-0.5)	13.9 (-3.0)	5.9 (-2.5)	3.3 (-1.6)	16.2 (-0.2)	7.6 (-0.7)	3.7 (-0.7)
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	67.9 (-4.8)	52.8 (-0.3)	24.8 (-0.2)	65.1 (-0.8)	47.9 (-2.0)	22.0 (-2.8)	68.8 (0.0)	53.6 (0.1)	25.5 (0.1)	62.4 (-5.3)	43.5 (-8.3)	16.5 (-10.1)
	IPW 2	29.2 (-3.3)	26.1 (-2.0)	14.5 (-1.2)	31.3 (-0.8)	25.4 (-2.3)	13.6 (-2.8)	26.3 (-6.1)	23.6 (-4.6)	12.1 (-3.5)	30.5 (-1.6)	24.0 (-3.6)	12.3 (-4.2)
	DR	23.6 (-0.7)	17.1 (-1.2)	11.2 (-0.5)	25.9 (-0.5)	17.0 (-1.8)	9.8 (-1.9)	21.5 (-4.5)	15.3 (-3.1)	9.6 (-1.9)	25.4 (-1.0)	15.9 (-2.8)	8.8 (-2.9)
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	48.4 (-0.2)	33.8 (-0.4)	14.3 (0.0)	45.2 (-0.5)	29.9 (-1.3)	12.5 (-1.6)	49.5 (0.0)	34.6 (-0.1)	14.8 (0.1)	44.2 (-4.0)	27.7 (-5.8)	9.5 (-6.0)
	IPW 2	17.0 (-2.0)	13.2 (-1.5)	7.2 (-0.6)	17.5 (-0.5)	13.0 (-1.4)	6.5 (-1.7)	15.4 (-3.7)	11.4 (-3.3)	5.9 (-1.8)	16.9 (-0.9)	12.1 (-2.2)	5.7 (-2.4)
	DR	13.5 (-1.4)	8.3 (-0.9)	5.1 (-0.2)	14.4 (-0.3)	8.2 (-1.0)	4.1 (-1.1)	12.3 (-2.7)	7.0 (-2.2)	4.3 (-0.9)	14.1 (-0.6)	7.6 (-1.6)	3.5 (-1.7)
Ratio 3:5			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	56.0 (-10.1)	28.3 (-11.4)	12.4 (-7.5)	52.3 (-20.2)	7.5 (-33.7)	-5.5 (-29.5)	54.8 (-13.8)	22.7 (-16.4)	10.1 (-11.0)	46.5 (-31.9)	-21.8 (-67.5)	-34.9 (-65.0)
	IPW 2	34.7 (-2.5)	26.7 (-1.8)	4.8 (-5.1)	36.5 (-0.1)	27.4 (-0.1)	10.4 (0.2)	31.1 (-6.5)	24.0 (-6.0)	-0.9 (-11.6)	36.4 (-0.1)	27.5 (-0.1)	10.6 (0.2)
	DR	27.1 (-1.8)	13.0 (-1.2)	4.3 (-3.4)	28.5 (0.0)	14.3 (-0.2)	7.5 (0.2)	24.3 (-4.6)	9.8 (-4.2)	0.4 (-7.5)	28.5 (0.0)	14.2 (-0.2)	7.6 (0.2)
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	48.2 (-6.7)	27.1 (-6.5)	11.3 (-3.9)	46.5 (-14.8)	12.7 (-20.4)	1.6 (-16.2)	48.0 (-9.7)	23.1 (-9.5)	10.5 (-5.9)	43.0 (-25.8)	-9.7 (-44.6)	-15.3 (-37.8)
	IPW 2	26.5 (-1.3)	18.9 (-1.2)	0.8 (-2.8)	27.2 (0.0)	19.1 (0.0)	3.9 (0.1)	24.8 (-3.5)	17.7 (-3.8)	-2.3 (-6.4)	27.2 (0.0)	19.2 (0.0)	3.9 (0.1)
	DR	21.6 (-0.9)	8.8 (-0.8)	1.7 (-1.8)	22.2 (0.0)	9.5 (-0.1)	3.2 (0.1)	20.4 (-2.4)	7.2 (-2.5)	-0.3 (-4.1)	22.2 (0.0)	9.5 (-0.1)	3.2 (0.1)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.19: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used instead of the conventional propensity scores, cross validated λ , for many X .

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	53.0	43.7	29.9	49.2	34.0	27.6	53.0	43.8	31.3	41.6	18.4	13.8
		(0.2)	(-0.4)	(2.9)	(-8.5)	(-13.8)	(-1.2)	(0.3)	(-0.9)	(3.3)	(-19.8)	(-34.3)	(-19.0)
	IPW 2	28.6	22.1	1.9	35.4	28.1	20.6	20.4	13.8	-10.3	34.3	27.1	21.1
		(-7.0)	(-6.6)	(-14.2)	(-0.8)	(-1.2)	(3.9)	(-15.5)	(-15.0)	(-26.3)	(-1.8)	(-2.3)	(4.5)
Ratio 1:1	IPW 3	25.4	16.1	0.3	31.6	21.4	14.4	17.4	8.8	-8.5	30.7	20.6	15.0
		(-6.3)	(-5.5)	(-11.4)	(-0.7)	(-1.0)	(3.0)	(-14.1)	(-12.6)	(-20.4)	(-1.6)	(-1.9)	(3.7)
	DR	8.7	4.5	3.0	8.7	4.5	3.0	8.7	4.5	3.0	8.7	4.5	2.2
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.9)
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
Ratio 1:1	IPW 1	38.7	28.6	18.6	37.3	22.7	17.0	39.3	29.1	19.7	33.6	12.8	8.0
		(0.1)	(-0.1)	(1.4)	(-5.4)	(-8.7)	(-1.6)	(0.3)	(-0.4)	(1.6)	(-13.8)	(-23.4)	(-13.6)
	IPW 2	17.8	9.8	-1.2	21.9	13.9	9.6	13.2	4.5	-8.2	21.3	13.3	9.9
		(-4.4)	(-4.7)	(-8.7)	(-0.4)	(-0.5)	(1.8)	(-9.4)	(-10.2)	(-15.8)	(-0.9)	(-1.1)	(2.2)
	IPW 3	16.3	7.2	-1.0	20.0	10.6	6.8	11.9	2.7	-6.1	19.5	10.2	7.2
Ratio 3:2		(-3.9)	(-3.8)	(-6.8)	(-0.3)	(-0.4)	(1.4)	(-8.4)	(-8.3)	(-12.0)	(-0.8)	(-0.8)	(1.7)
	DR	3.4	1.7	1.4	3.4	1.8	1.4	3.4	1.7	1.4	3.5	1.8	1.0
		(0.0)	(0.0)	(-0.1)	(0.0)	(0.0)	(-0.1)	(0.0)	(0.0)	(-0.1)	(-0.1)	(-0.1)	(-0.5)
	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	54.8	51.0	20.7	55.9	48.8	32.4	55.5	51.2	22.9	52.2	41.2	31.6
Ratio 3:2		(-2.0)	(-1.3)	(-6.1)	(-2.1)	(-3.1)	(5.5)	(-1.8)	(-0.9)	(-4.5)	(-8.6)	(-12.1)	(2.9)
	IPW 2	31.3	29.3	7.4	36.1	30.0	25.8	25.0	24.1	-0.3	34.0	27.6	25.8
		(-6.3)	(-4.0)	(-11.5)	(-2.1)	(-3.2)	(5.5)	(-12.3)	(-9.1)	(-19.5)	(-4.1)	(-5.7)	(5.7)
	IPW 3	29.1	20.0	3.9	33.6	21.2	17.1	23.6	15.3	-2.3	31.6	19.1	17.4
		(-5.6)	(-3.4)	(-9.6)	(-1.9)	(-3.0)	(4.4)	(-10.9)	(-7.9)	(-15.9)	(-3.7)	(-5.2)	(4.9)
Ratio 3:2	DR	6.8	5.2	4.7	6.7	5.2	4.9	6.8	5.2	4.5	6.7	5.2	4.4
		(0.0)	(0.1)	(0.4)	(0.0)	(0.1)	(0.5)	(0.0)	(0.1)	(0.2)	(0.0)	(0.2)	(0.0)
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	36.8	30.0	10.6	37.7	28.9	18.1	37.9	30.4	12.2	36.4	24.4	17.8
		(-1.4)	(-1.4)	(-4.5)	(-1.6)	(-2.1)	(3.0)	(-1.3)	(-1.0)	(-3.4)	(-6.4)	(-8.5)	(1.0)
Ratio 2:3	IPW 2	16.3	12.4	1.3	19.2	13.9	13.5	12.2	8.6	-3.7	17.8	12.5	13.5
		(-4.1)	(-3.5)	(-8.1)	(-1.5)	(-2.0)	(3.0)	(-8.0)	(-7.1)	(-13.4)	(-2.8)	(-3.5)	(3.1)
	IPW 3	15.2	7.4	-0.4	17.8	9.1	7.9	11.6	4.0	-4.3	16.5	7.9	8.0
		(-3.7)	(-2.9)	(-6.5)	(-1.3)	(-1.7)	(2.3)	(-7.2)	(-5.9)	(-10.6)	(-2.5)	(-3.0)	(2.6)
	DR	3.8	1.3	2.2	3.7	1.3	2.3	3.8	1.3	2.1	3.8	1.3	2.1
Ratio 2:3		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(-0.1)
	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	54.9	38.5	25.4	47.1	22.3	2.4	54.8	36.9	23.6	37.7	-0.9	-36.6
		(-1.7)	(-6.1)	(-3.2)	(-14.3)	(-28.2)	(-29.3)	(-1.4)	(-8.3)	(-6.3)	(-25.9)	(-57.2)	(-74.0)
	IPW 2	30.4	19.7	4.6	37.8	28.4	18.1	20.4	9.6	-8.1	37.7	28.5	18.4
Ratio 2:3		(-7.3)	(-7.8)	(-12.9)	(0.1)	(0.3)	(1.1)	(-17.5)	(-18.4)	(-26.3)	(0.0)	(0.3)	(1.3)
	IPW 3	26.9	13.9	4.4	33.8	21.4	14.6	17.5	5.4	-4.7	33.7	21.5	14.9
		(-6.7)	(-6.7)	(-9.8)	(0.1)	(0.3)	(0.9)	(-16.1)	(-15.4)	(-19.3)	(0.1)	(0.3)	(1.0)
	DR	5.8	3.9	3.2	5.6	4.0	3.0	5.8	3.9	3.3	5.5	3.8	2.3
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.2)	(0.0)	(0.0)	(0.2)	(-0.2)	(-0.2)	(-1.0)
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	45.7	31.1	19.9	40.9	19.4	4.9	45.9	30.2	19.0	34.4	1.3	-21.5
		(-1.0)	(-3.7)	(-2.8)	(-9.7)	(-19.6)	(-20.3)	(-0.9)	(-5.2)	(-4.8)	(-19.6)	(-43.3)	(-51.7)
	IPW 2	24.4	12.7	1.5	28.4	18.0	9.8	19.1	6.8	-6.4	28.3	18.1	10.0
		(-4.3)	(-5.0)	(-8.1)	(0.1)	(0.4)	(0.4)	(-10.0)	(-11.8)	(-16.5)	(0.1)	(0.5)	(0.5)
Ratio 2:3	IPW 3	23.3	9.7	1.9	27.1	14.1	7.9	18.4	4.6	-3.7	27.1	14.3	8.0
		(-3.8)	(-4.2)	(-6.1)	(0.1)	(0.4)	(0.3)	(-8.9)	(-9.6)	(-11.9)	(0.1)	(0.5)	(0.4)
	DR	1.8	2.1	2.1	1.7	2.3	2.0	1.8	2.1	2.2	1.6	2.2	1.6
		(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(-0.1)	(0.0)	(0.1)	(0.1)	(-0.1)	(-0.1)	(-0.5)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.20: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores, fixed valued λ , many X

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	33.2	homogeneous, homoscedastic					18.1	34.8	heterogeneous, homoscedastic			
		(-0.1)	27.7	13.9	38.7	29.6				28.6	15.0	46.0	33.5
	IPW 2	15.0	(-0.5)	(0.7)	(-0.6)	(-1.7)	(2.3)	(-0.4)	(-0.9)	(1.1)	(-1.2)	(-3.4)	(2.4)
	DR	5.0	(-0.2)	(-0.1)	(-3.0)	(0.0)	(0.0)	(0.5)	(-0.3)	(-0.4)	(-4.7)	(0.0)	(-0.2)
Ratio 1:1	IPW 1	21.9	16.5	5.5	26.7	18.2	7.5	23.8	17.3	6.1	34.1	22.4	9.7
		(0.0)	(-0.1)	(0.2)	(-0.2)	(-0.7)	(1.1)	(-0.1)	(-0.3)	(0.4)	(-0.7)	(-1.8)	(1.2)
	IPW 2	7.1	6.5	-0.5	8.1	6.7	1.9	7.2	6.3	-1.5	8.3	6.6	1.3
	DR	1.0	(-0.2)	(-2.0)	(0.0)	(0.0)	(0.0)	(-0.3)	(-0.5)	(-2.9)	(0.0)	(0.0)	(-0.4)
Ratio 3:2	IPW 1	32.5	35.7	12.0	31.9	33.2	14.8	31.0	34.2	13.5	35.6	34.3	15.8
		(-0.7)	(-0.2)	(3.2)	(-2.3)	(-1.2)	(4.8)	(-3.1)	(-1.5)	(5.0)	(-3.7)	(-1.5)	(4.4)
	IPW 2	17.1	21.6	7.4	18.1	21.2	13.2	16.7	21.6	9.0	18.2	21.2	10.3
	DR	15.3	(0.1)	(0.3)	(0.8)	(0.0)	(0.4)	(3.3)	(0.3)	(2.5)	(0.0)	(0.7)	(0.9)
Ratio 3:2	IPW 1	16.5	15.8	6.3	16.6	14.0	8.2	16.0	14.9	7.7	20.8	16.1	8.7
		(-0.6)	(-0.1)	(1.4)	(-1.7)	(-0.7)	(2.5)	(-2.3)	(-0.9)	(2.6)	(-2.7)	(-0.9)	(2.2)
	IPW 2	-1.6	3.3	3.0	-0.8	3.4	7.1	-1.9	3.0	4.6	-0.7	3.5	4.9
	DR	-14.3	(0.0)	(-0.1)	(-0.3)	(0.0)	(0.1)	(1.5)	(0.0)	(0.8)	(0.0)	(0.2)	(-0.2)
Ratio 2:3	IPW 1	40.6	24.8	10.2	47.7	29.3	11.0	43.3	25.6	8.0	55.7	34.5	12.8
		(1.3)	(0.1)	(-0.1)	(2.4)	(-0.1)	(0.6)	(1.9)	(0.0)	(-1.6)	(3.9)	(-0.6)	(0.4)
	IPW 2	17.8	11.1	6.2	18.0	12.1	6.9	17.2	10.1	2.1	18.0	12.0	6.5
	DR	13.3	(0.0)	(-0.3)	(-2.4)	(0.0)	(0.2)	(-0.4)	(-0.9)	(-7.1)	(0.0)	(0.1)	(-0.8)
Ratio 2:3	IPW 1	30.4	15.0	11.4	36.2	17.6	12.7	32.8	15.2	10.3	44.5	21.7	15.0
		(0.7)	(0.2)	(0.0)	(1.5)	(0.2)	(0.3)	(1.1)	(0.0)	(-0.8)	(2.9)	(-0.2)	(0.1)
	IPW 2	17.1	9.0	5.9	17.0	9.0	6.5	17.0	8.9	2.8	17.0	9.0	6.3
	DR	18.9	(0.0)	(-0.2)	(-1.3)	(0.0)	(0.3)	(-0.2)	(-1.4)	(-4.1)	(0.0)	(0.2)	(-0.5)
		(0.0)	(0.1)	(-1.0)	(0.0)	(0.3)	(-0.3)	(-0.5)	(-0.9)	(-3.4)	(0.0)	(0.2)	(-0.5)
		(0.0)	(0.0)	(-0.3)	(0.1)	(0.1)	(0.0)	(-0.2)	(-0.6)	(-2.0)	(0.2)	(0.1)	(-0.2)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.21: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 1, fixed valued λ , many X

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	29.3	homogeneous, homoscedastic					33.2	heterogeneous, homoscedastic				
		(-0.4)	14.7	6.9	32.5	17.2	10.2	(-0.9)	18.7	10.0	36.1	19.9	14.1
	IPW 2	15.7	(-0.5)	(0.4)	(-1.3)	(-2.0)	(2.0)	(-0.9)	(-1.0)	(0.8)	(-3.1)	(-4.1)	(3.4)
	DR	14.0	5.7	-1.4	15.8	5.9	1.8	14.8	5.7	-2.7	15.6	5.9	2.7
Ratio 1:1	IPW 1	25.4	(-0.3)	(-0.2)	(-3.6)	(0.0)	(-0.1)	(-0.6)	(-0.4)	(-5.2)	(0.1)	(0.0)	(1.1)
		(-0.2)	14.7	4.6	-1.5	14.8	4.9	0.8	14.1	4.8	-2.3	14.5	4.8
	IPW 2	14.7	(-0.2)	(0.0)	(-3.0)	(0.0)	(0.0)	(-0.4)	(-0.2)	(-4.2)	(0.1)	(0.0)	(0.6)
	DR	14.0	0.7	-1.9	13.7	0.4	-2.0	13.7	1.2	-1.5	13.6	0.1	-1.7
Ratio 1:1	IPW 1	25.4	(0.0)	(0.0)	(-1.5)	(0.0)	(-1.6)	(0.0)	(0.0)	(-1.5)	(0.1)	(0.0)	(-1.0)
		(-0.2)	16.2	6.4	27.4	18.8	8.1	28.3	19.3	8.0	30.4	21.9	10.3
	IPW 2	14.7	(-0.1)	(0.5)	(-0.7)	(-0.8)	(1.3)	(-0.4)	(-0.3)	(0.8)	(-1.8)	(-1.9)	(2.1)
	DR	14.0	6.3	1.5	14.6	7.4	3.2	14.7	6.0	0.7	14.8	7.5	3.8
Ratio 3:2	IPW 1	22.5	(-0.2)	(-0.3)	(-1.5)	(0.0)	(0.3)	(-0.4)	(-0.5)	(-2.4)	(0.1)	(0.1)	(1.0)
		(-0.1)	13.2	5.7	1.7	13.2	6.6	2.9	13.3	5.6	1.2	13.2	6.6
	IPW 2	18.0	(-0.2)	(-1.2)	(0.0)	(0.0)	(0.1)	(-0.2)	(-0.3)	(-1.8)	(0.1)	(0.1)	(0.7)
	DR	14.0	5.4	2.2	13.9	5.0	2.3	14.0	5.8	2.3	13.8	4.7	2.6
Ratio 3:2	IPW 1	22.5	(0.0)	(0.0)	(-0.4)	(0.0)	(-0.5)	(0.0)	(0.0)	(-0.4)	(0.0)	(0.0)	(-0.1)
		(-1.1)	11.7	2.9	23.3	11.3	4.8	23.4	13.0	5.9	25.1	12.8	6.5
	IPW 2	18.0	(-0.5)	(0.4)	(-2.7)	(-2.0)	(2.0)	(-3.6)	(-2.2)	(1.5)	(-4.0)	(-2.3)	(3.5)
	DR	18.0	6.0	-1.1	18.3	5.1	1.2	18.5	6.8	0.9	18.5	5.2	0.6
Ratio 3:2	IPW 1	21.9	(-0.2)	(0.0)	(-1.7)	(0.0)	(-0.3)	(1.2)	(0.1)	(-0.7)	(0.2)	(0.2)	(1.1)
		(-0.1)	13.2	5.5	-1.1	18.4	4.7	0.7	18.5	6.2	0.9	18.5	4.6
	IPW 2	18.0	(-0.1)	(0.0)	(-1.2)	(0.0)	(-0.2)	(1.0)	(0.0)	(-0.1)	(0.1)	(0.2)	(0.7)
	DR	31.1	3.0	0.7	30.9	2.8	0.5	31.2	2.9	2.5	30.6	2.4	-1.0
Ratio 3:2	IPW 1	21.9	(0.1)	(0.0)	(0.5)	(0.1)	(0.0)	(0.5)	(0.2)	(-0.4)	(1.6)	(-0.2)	(0.1)
		(-0.6)	13.2	3.0	22.7	13.4	3.9	22.7	14.3	5.2	24.0	14.5	4.3
	IPW 2	14.7	(-0.1)	(0.1)	(-1.6)	(-0.7)	(1.1)	(-2.2)	(-0.9)	(0.9)	(-2.5)	(-0.8)	(2.1)
	DR	12.4	(-0.1)	(-1.2)	(0.0)	(0.0)	(0.6)	(0.0)	(0.0)	(-0.6)	(0.1)	(0.1)	(0.5)
Ratio 2:3	IPW 1	24.9	7.0	0.3	13.2	6.8	1.1	13.1	7.5	1.9	13.2	6.7	0.1
		(-0.1)	12.8	7.0	0.3	13.2	6.8	1.1	13.1	7.5	1.9	13.2	6.7
	IPW 2	14.6	(-0.1)	(-0.9)	(0.0)	(0.0)	(0.5)	(0.0)	(0.0)	(-0.2)	(0.1)	(0.1)	(0.3)
	DR	30.4	4.8	0.8	12.0	4.7	0.8	12.6	4.9	2.3	11.6	4.3	-0.7
Ratio 2:3	IPW 1	24.9	(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.1)	(0.9)	(-0.1)	(0.0)	(-0.6)
		(0.0)	14.9	10.8	28.9	16.7	12.2	30.0	18.1	12.4	34.2	19.4	14.8
	IPW 2	15.6	(0.1)	(2.2)	(0.0)	(-0.1)	(3.2)	(-0.1)	(0.3)	(1.9)	(-0.2)	(-0.5)	(4.3)
	DR	14.6	7.2	3.0	15.5	7.5	4.1	15.8	6.0	-1.2	15.7	7.5	4.6
Ratio 2:3	IPW 1	23.7	(-0.2)	(-0.6)	(-2.0)	(0.1)	(0.0)	(0.2)	(-0.9)	(-2.0)	(0.2)	(0.2)	(0.9)
		(-0.1)	16.2	6.3	3.1	14.4	6.4	3.7	14.9	5.5	-0.4	14.6	6.3
	IPW 2	16.0	(-0.4)	(-1.5)	(0.1)	(0.0)	(0.2)	(-0.7)	(-1.6)	(-4.9)	(0.2)	(0.2)	(0.9)
	DR	38.0	5.0	-0.2	30.5	4.6	-0.5	30.6	5.1	-1.8	30.7	4.6	-0.1
Ratio 2:3	IPW 1	23.7	(0.0)	(0.2)	(0.0)	(0.0)	(0.1)	(-0.1)	(-0.3)	(-1.6)	(0.1)	(0.2)	(0.7)
		(0.0)	15.1	9.7	26.6	16.8	9.5	27.6	17.4	9.8	30.8	19.2	10.1
	IPW 2	16.2	(0.1)	(1.3)	(0.0)	(0.1)	(1.8)	(0.0)	(0.2)	(1.2)	(-0.1)	(0.0)	(2.5)
	DR	16.0	8.0	6.3	16.0	8.8	6.4	16.8	7.2	3.4	15.9	8.9	6.5
Ratio 2:3	IPW 1	23.7	(-0.6)	(-1.0)	(0.1)	(-0.1)	(0.1)	(-0.5)	(-1.6)	(-3.3)	(0.2)	(0.1)	(0.6)
		(0.0)	16.0	7.8	6.1	15.7	8.3	6.0	16.7	7.2	3.4	15.7	8.4
	IPW 2	16.2	(-0.5)	(-0.7)	(0.1)	(-0.1)	(0.1)	(-0.3)	(-1.3)	(-2.7)	(0.2)	(0.0)	(0.5)
	DR	38.0	9.4	2.6	38.0	9.2	2.5	38.2	9.6	0.9	38.1	9.1	2.7
Ratio 2:3	IPW 1	23.7	(-0.1)	(0.1)	(0.0)	(-0.1)	(0.1)	(-0.1)	(-0.5)	(-0.8)	(0.0)	(0.0)	(0.5)
		(0.0)	15.1	9.7	26.6	16.8	9.5	27.6	17.4	9.8	30.8	19.2	10.1
	IPW 2	16.2	(0.1)	(1.3)	(0.0)	(0.1)	(1.8)	(0.0)	(0.2)	(1.2)	(-0.1)	(0.0)	(2.5)
	DR	16.0	8.0	6.3	16.0	8.8	6.4	16.8	7.2	3.4	15.9	8.9	6.5

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.22: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 2, fixed valued λ , many X

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	22.4	homogeneous, homoscedastic					23.5	heterogeneous, homoscedastic				
		(-0.4)	11.3	10.0	23.8	12.0	13.2	23.5	12.3	11.0	26.4	13.8	16.8
	IPW 2	11.0	(-0.5)	(1.7)	(-1.3)	(-2.1)	(3.7)	(-0.9)	(-1.0)	(2.2)	(-2.9)	(-4.4)	(5.4)
		(-0.4)	2.8	2.2	11.1	2.7	6.6	10.7	2.6	0.2	11.3	2.7	7.5
	IPW 3	6.8	(-0.1)	(-2.6)	(0.0)	(-0.1)	(1.3)	(-0.7)	(-0.4)	(-4.5)	(0.1)	(-0.1)	(2.3)
Ratio 1:1	DR	5.4	0.7	2.3	6.8	0.8	5.2	6.6	0.4	0.9	7.0	0.7	6.1
		(-0.2)	(0.0)	(-1.9)	(0.0)	(0.0)	(0.9)	(-0.4)	(-0.2)	(-3.2)	(0.1)	(0.0)	(1.8)
		(0.0)	5.4	-2.1	3.1	5.2	-2.2	3.0	5.3	-2.1	3.2	5.3	-2.3
		(0.0)	(0.0)	(-0.1)	(0.0)	(0.0)	(-0.2)	(0.0)	(0.0)	(-0.1)	(0.1)	(0.0)	(0.1)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
Ratio 1:1	IPW 1	20.2	9.0	9.3	21.0	10.4	11.6	20.8	10.1	10.1	22.7	12.6	14.5
		(-0.1)	(-0.2)	(1.1)	(-0.6)	(-0.9)	(2.1)	(-0.4)	(-0.4)	(1.3)	(-1.6)	(-2.1)	(3.0)
	IPW 2	11.1	0.7	2.3	11.4	1.6	4.8	11.0	0.3	0.9	11.5	1.7	5.4
		(-0.3)	(-0.3)	(-1.3)	(0.0)	(0.0)	(0.8)	(-0.5)	(-0.5)	(-2.3)	(0.1)	(0.1)	(1.4)
	IPW 3	7.6	-0.1	2.5	7.8	0.7	4.2	7.5	-0.5	1.6	7.9	0.8	4.8
Ratio 3:2	DR	(-0.2)	(-0.2)	(-0.9)	(0.0)	(0.0)	(0.7)	(-0.3)	(-0.3)	(-1.6)	(0.1)	(0.0)	(1.1)
		4.7	-0.5	3.4	4.6	-0.6	3.2	4.6	-0.4	3.5	4.6	-0.8	3.3
		(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.2)	(0.1)	(0.0)	(0.4)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	18.9	11.0	3.9	18.8	9.7	5.6	17.3	10.1	3.4	20.6	10.4	8.9
Ratio 3:2		(-1.2)	(-0.4)	(0.5)	(-2.9)	(-1.8)	(2.2)	(-3.7)	(-1.2)	(0.3)	(-4.2)	(-2.4)	(5.7)
	IPW 2	11.1	6.1	1.7	11.2	4.8	5.1	11.9	7.3	1.7	11.2	4.9	6.5
		(-0.2)	(0.1)	(-2.0)	(0.0)	(-0.2)	(0.8)	(0.5)	(1.1)	(-2.6)	(0.2)	(0.1)	(2.5)
	IPW 3	8.1	3.9	1.3	8.2	3.2	3.9	8.8	4.8	1.2	8.2	3.3	5.2
		(-0.1)	(0.1)	(-1.4)	(0.0)	(-0.1)	(0.6)	(0.4)	(0.9)	(-1.9)	(0.1)	(0.2)	(2.2)
Ratio 3:2	DR	4.7	0.7	1.1	4.7	0.7	1.2	5.1	1.1	0.9	4.6	0.5	2.0
		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(0.3)	(0.3)	(-0.3)	(-0.1)	(0.1)	(1.0)
			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	21.6	6.2	3.4	21.4	5.0	4.5	20.5	5.4	3.1	22.4	4.9	6.6
		(-0.7)	(-0.1)	(0.3)	(-1.6)	(-0.8)	(1.4)	(-2.1)	(-0.6)	(0.2)	(-2.4)	(-0.9)	(3.7)
Ratio 2:3	IPW 2	13.8	3.3	2.3	13.8	2.3	4.4	14.2	4.1	2.3	13.9	2.4	5.4
		(-0.1)	(-0.1)	(-1.2)	(0.0)	(0.0)	(0.6)	(0.2)	(0.4)	(-1.6)	(0.1)	(0.2)	(1.7)
	IPW 3	10.6	2.1	2.2	10.6	1.6	3.9	10.9	2.7	2.2	10.6	1.7	4.8
		(-0.1)	(-0.1)	(-0.8)	(0.0)	(0.0)	(0.5)	(0.2)	(0.3)	(-1.2)	(0.1)	(0.2)	(1.5)
	DR	6.6	0.5	2.6	6.6	0.6	2.7	6.9	0.8	2.4	6.4	0.6	3.4
Ratio 2:3		(0.0)	(0.0)	(0.3)	(0.0)	(0.0)	(0.2)	(0.1)	(0.2)	(-0.1)	(-0.1)	(0.1)	(0.9)
			homogeneous, homoscedastic						heterogeneous, homoscedastic				
	IPW 1	19.8	11.1	4.9	22.1	12.9	8.7	22.3	13.0	7.6	26.2	15.6	14.1
		(0.4)	(0.5)	(1.5)	(0.6)	(0.4)	(2.5)	(1.4)	(1.6)	(3.2)	(0.8)	(0.1)	(3.1)
	IPW 2	10.3	3.4	-3.2	10.6	3.6	-0.6	10.3	2.4	-4.8	10.7	3.6	-0.3
Ratio 2:3		(-0.3)	(-0.6)	(-2.7)	(0.1)	(0.1)	(-0.2)	(-1.1)	(-1.4)	(-4.4)	(0.2)	(0.2)	(0.1)
	IPW 3	6.3	2.3	-3.4	6.3	2.3	-1.6	6.5	1.6	-4.4	6.5	2.4	-1.2
		(-0.2)	(-0.4)	(-2.1)	(0.1)	(0.1)	(-0.3)	(-0.6)	(-0.9)	(-3.1)	(0.2)	(0.2)	(-0.1)
	DR	20.6	-0.8	-3.0	21.1	-1.0	-2.9	21.1	-0.6	-2.3	22.1	-1.0	-2.7
		(0.0)	(0.1)	(-0.5)	(0.0)	(0.1)	(-0.5)	(0.0)	(0.4)	(0.2)	(0.0)	(0.1)	(-0.5)
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic				
	IPW 1	17.2	11.6	4.2	19.3	13.1	6.7	19.2	13.1	6.0	23.0	15.3	10.7
		(0.2)	(0.6)	(0.6)	(0.3)	(0.7)	(1.2)	(0.7)	(1.4)	(1.7)	(0.5)	(0.7)	(1.5)
	IPW 2	7.9	4.0	-2.0	8.1	4.2	-1.0	7.7	3.4	-3.2	8.1	4.2	-0.8
		(-0.3)	(-0.4)	(-1.6)	(0.0)	(0.1)	(-0.3)	(-0.8)	(-0.9)	(-2.8)	(0.1)	(0.3)	(-0.1)
Ratio 2:3	IPW 3	5.7	3.3	-2.0	5.7	3.4	-1.3	5.7	2.9	-2.7	5.8	3.4	-1.2
		(-0.2)	(-0.3)	(-1.3)	(0.0)	(0.1)	(-0.3)	(-0.5)	(-0.6)	(-2.0)	(0.1)	(0.2)	(-0.2)
	DR	4.7	1.1	-1.2	5.0	0.9	-1.3	5.1	1.4	-1.0	5.5	0.8	-1.2
		(0.0)	(0.1)	(-0.3)	(0.0)	(0.1)	(-0.4)	(0.0)	(0.3)	(0.0)	(0.0)	(0.1)	(-0.4)

Note: The percentage improvements in MSE of ATE estimates due to the shrunk propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$. (in parenthesis). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.23: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 2 instead of the conventional propensity scores with trimming rule 3, fixed valued λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	29.6 (33.7)	1.2 (2.3)	0.5 (-1.1)	51.1 (44.5)	10.8 (7.1)	2.8 (0.3)	54.1 (48.1)	6.7 (4.9)	0.8 (-0.8)	75.5 (62.1)	26.7 (15.9)	4.1 (0.5)
	IPW 2	32.1 (24.4)	14.4 (2.4)	-3.0 (-5.5)	56.1 (35.7)	30.2 (7.8)	3.4 (-2.3)	55.1 (36.7)	25.8 (4.3)	-3.2 (-7.4)	78.9 (53.5)	50.2 (14.9)	6.0 (-3.6)
	IPW 3	26.5 (31.1)	1.5 (1.6)	-0.6 (-3.2)	52.2 (43.2)	15.6 (6.7)	2.5 (-1.0)	52.8 (45.4)	9.2 (3.3)	-1.9 (-4.4)	78.1 (61.2)	35.6 (14.3)	1.9 (-2.2)
	DR	39.3 (0.0)	2.8 (0.1)	-1.5 (-1.7)	39.3 (0.0)	2.6 (0.1)	-0.5 (-1.4)	39.1 (0.0)	3.1 (0.1)	-1.9 (-1.8)	39.4 (0.0)	2.2 (0.0)	-1.5 (-2.5)
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	8.0 (23.5)	1.0 (1.1)	-1.4 (-0.8)	31.3 (34.6)	7.4 (3.9)	-0.3 (0.0)	34.4 (37.9)	4.4 (2.5)	-1.1 (-0.6)	62.9 (54.8)	19.1 (10.1)	0.5 (0.1)
	IPW 2	8.3 (16.6)	7.9 (0.9)	-2.8 (-3.2)	34.2 (27.4)	19.4 (4.4)	0.6 (-1.5)	33.1 (28.2)	15.8 (1.9)	-2.3 (-4.3)	64.4 (46.6)	36.3 (9.7)	3.0 (-2.2)
	IPW 3	2.6 (21.3)	-1.8 (0.4)	-3.2 (-2.0)	29.6 (33.0)	7.6 (3.4)	-2.1 (-0.8)	30.2 (35.0)	2.9 (1.2)	-4.0 (-2.7)	63.3 (53.5)	22.6 (8.7)	-2.8 (-1.4)
	DR	42.6 (0.0)	4.9 (0.0)	-2.5 (-1.1)	42.4 (0.0)	4.8 (0.0)	-2.0 (-1.0)	42.5 (0.0)	4.9 (0.0)	-2.9 (-1.2)	42.4 (0.1)	4.6 (-0.1)	-2.5 (-1.6)
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	-24.6 (9.3)	-0.9 (9.1)	6.4 (4.2)	-20.5 (-1.6)	-8.7 (1.3)	6.7 (4.1)	-24.8 (-4.9)	-5.5 (5.2)	7.8 (6.0)	6.8 (-0.8)	-10.0 (-1.8)	6.7 (3.4)
	IPW 2	-1.2 (10.4)	8.4 (8.0)	5.6 (1.6)	8.6 (2.1)	7.3 (2.1)	8.4 (2.5)	10.1 (1.8)	11.7 (6.4)	8.1 (3.2)	34.6 (2.8)	14.2 (0.7)	6.8 (-0.4)
	IPW 3	-17.0 (11.1)	4.1 (11.2)	5.6 (1.7)	-8.6 (2.4)	-1.0 (4.5)	5.8 (2.2)	-8.6 (1.5)	4.7 (10.1)	7.4 (3.6)	21.4 (3.8)	2.2 (2.8)	2.7 (-0.6)
	DR	70.4 (0.1)	14.5 (0.2)	4.9 (0.4)	71.0 (0.2)	14.7 (0.4)	4.9 (0.2)	70.3 (0.0)	14.0 (-0.3)	6.8 (2.3)	70.8 (0.0)	14.2 (0.2)	1.2 (-3.2)
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-19.0 (4.8)	-1.7 (5.7)	2.0 (2.2)	-16.3 (-1.0)	-6.4 (1.4)	2.2 (2.2)	-18.9 (-2.9)	-4.7 (3.7)	3.4 (3.4)	1.0 (-0.3)	-7.4 (-0.3)	2.3 (1.8)
	IPW 2	-10.3 (5.8)	1.5 (4.9)	1.7 (0.5)	-3.4 (1.1)	0.7 (1.5)	3.7 (1.1)	-2.5 (1.0)	3.0 (4.1)	4.0 (1.5)	17.1 (2.1)	4.6 (0.5)	2.8 (-0.7)
	IPW 3	-20.7 (6.0)	-0.6 (6.9)	1.3 (0.5)	-15.4 (1.3)	-3.9 (3.0)	1.3 (0.9)	-15.6 (0.8)	-0.7 (6.4)	2.9 (1.8)	5.4 (2.5)	-2.7 (1.8)	-1.1 (-1.0)
	DR	7.8 (0.0)	-2.9 (0.1)	-2.7 (-0.5)	8.4 (0.1)	-2.6 (0.3)	-2.7 (-0.6)	7.7 (-0.1)	-3.5 (-0.1)	-0.9 (0.8)	7.9 (-0.2)	-2.8 (-0.1)	-5.6 (-3.1)
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	73.7 (76.8)	36.0 (32.9)	8.0 (-1.4)	83.3 (81.9)	54.2 (46.4)	8.7 (-0.1)	82.5 (81.5)	47.3 (40.6)	6.1 (-2.8)	91.0 (86.9)	70.3 (57.9)	10.8 (1.5)
	IPW 2	71.5 (71.9)	41.8 (27.1)	12.3 (-4.3)	83.7 (77.9)	61.8 (39.4)	19.3 (-2.6)	81.4 (76.8)	53.7 (31.7)	12.5 (-8.7)	92.4 (83.9)	78.2 (49.0)	30.5 (-2.6)
	IPW 3	72.5 (75.3)	37.5 (29.5)	7.7 (-3.4)	84.1 (81.0)	58.5 (43.1)	11.7 (-2.5)	82.3 (80.2)	49.0 (35.4)	5.2 (-7.7)	92.6 (86.4)	75.9 (54.0)	18.3 (-3.1)
	DR	67.6 (0.1)	9.6 (0.0)	1.3 (-0.6)	67.5 (0.4)	9.3 (0.4)	2.5 (0.3)	67.6 (-0.1)	9.3 (-0.6)	-2.8 (-3.9)	67.6 (1.1)	9.7 (1.2)	2.5 (0.2)
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	56.5 (70.6)	21.6 (23.2)	9.2 (-0.6)	72.5 (77.7)	40.1 (36.4)	10.8 (0.2)	71.0 (77.0)	32.6 (30.4)	8.3 (-1.3)	85.8 (84.6)	59.5 (50.1)	13.6 (1.3)
	IPW 2	52.6 (64.5)	28.9 (18.4)	8.9 (-2.4)	71.6 (72.8)	48.9 (30.3)	13.9 (-1.3)	68.2 (71.4)	40.8 (23.0)	8.6 (-5.1)	86.3 (81.1)	68.4 (41.5)	22.4 (-1.2)
	IPW 3	54.1 (68.5)	24.3 (20.2)	4.6 (-1.9)	72.3 (76.4)	44.9 (33.2)	6.4 (-1.3)	69.7 (75.3)	35.4 (25.7)	2.2 (-4.5)	86.8 (83.9)	65.3 (45.9)	10.0 (-1.7)
	DR	79.4 (0.1)	22.5 (-0.1)	2.3 (-0.2)	79.3 (0.2)	22.3 (0.3)	2.8 (0.3)	79.4 (0.0)	22.2 (-0.6)	-0.2 (-1.9)	79.3 (0.5)	22.5 (0.7)	2.7 (0.3)

Note: The percentage improvements in MSE of ATE estimates due to the shrunken propensity score for each estimation method and for each possible DGP with multidimensional covariate vector X are reported along with the percentage change which is due to the bias introduced by shrinkage, i.e., $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$, (in parentheses). The tuning parameter λ is chosen according to the fixed tuning parameter method.

Table A.24: MSE of ATE estimators based on conventional propensity score

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	131.9	75.7	30.4	145.6	88.3	33.4	138.7	79.7	31.9	199.7	116.6	43.7
	IPW 2	80.0	43.5	19.2	79.4	43.8	19.8	82.4	45.2	20.0	79.9	43.9	19.8
	IPW 3	71.9	37.0	15.5	72.0	37.2	15.5	72.7	37.4	15.7	72.6	37.4	15.6
	DR	78.0	39.4	16.3	78.8	39.9	16.7	78.3	39.7	16.3	80.7	40.8	17.3
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	169.7	95.9	38.8	183.2	108.8	41.8	176.5	99.9	40.3	237.0	137.5	52.4
	IPW 2	120.8	63.6	26.9	120.6	63.8	27.4	123.4	65.0	27.6	121.0	63.9	27.5
	IPW 3	112.8	57.6	23.1	113.1	57.6	23.0	113.7	57.8	23.2	113.5	57.7	23.2
	DR	118.3	59.3	23.6	119.0	59.5	23.8	118.8	59.5	23.6	120.8	60.3	24.4
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	122.1	53.7	21.5	114.0	49.2	20.0	124.2	54.6	21.9	125.6	54.3	22.1
	IPW 2	74.2	37.5	16.8	75.3	38.2	16.7	75.2	38.2	17.1	75.3	38.3	16.7
	IPW 3	68.0	33.0	14.7	68.5	33.3	14.6	68.6	33.2	14.8	68.6	33.4	14.7
	DR	73.2	34.9	15.3	73.6	35.1	15.4	73.6	35.1	15.4	74.2	35.5	15.6
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	160.7	74.3	29.5	152.2	69.3	27.8	162.7	75.2	29.9	163.8	74.4	29.9
	IPW 2	113.8	57.8	24.6	114.7	58.2	24.3	114.8	58.5	25.0	114.8	58.2	24.3
	IPW 3	107.1	53.0	22.3	107.6	53.3	22.2	107.7	53.2	22.4	107.8	53.3	22.2
	DR	109.8	54.3	22.7	110.2	54.4	22.8	110.1	54.6	22.8	110.9	54.7	23.0
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	108.5	90.6	21.6	130.2	114.4	25.8	115.2	97.6	22.7	177.5	160.7	35.0
	IPW 2	72.3	38.7	16.1	72.4	38.2	16.0	74.0	39.9	16.6	72.7	38.3	16.1
	IPW 3	67.4	34.3	14.3	67.6	34.3	14.3	68.0	34.5	14.3	67.9	34.4	14.3
	DR	72.9	36.1	14.8	73.3	36.3	14.9	73.4	36.4	14.9	74.3	36.8	15.2
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	148.3	110.7	29.9	170.0	134.5	34.3	155.1	117.7	31.1	217.1	180.8	43.7
	IPW 2	114.6	58.7	24.1	114.9	58.2	24.1	116.5	59.9	24.6	115.2	58.3	24.1
	IPW 3	110.5	54.7	22.3	110.8	54.7	22.2	111.2	54.9	22.3	111.1	54.8	22.3
	DR	117.7	56.4	22.8	118.1	56.6	22.9	118.3	56.7	22.9	119.0	57.1	23.1

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.25: MSE of ATE estimators based on propensity score trimmed by trimming rule 1

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	82.9	38.4	16.2	91.9	41.4	16.7	94.7	42.3	17.4	108.7	49.1	19.6
	IPW 2	73.2	34.8	14.2	72.6	34.5	14.0	75.7	35.8	14.7	74.2	35.7	14.7
	IPW 3	74.1	34.8	14.0	74.0	34.8	14.0	76.0	35.5	14.3	75.5	36.0	14.7
	DR	75.6	34.7	13.9	75.8	34.9	14.0	76.7	35.0	14.1	77.7	36.4	14.9
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	134.1	62.3	25.1	143.1	65.3	25.6	146.2	65.9	26.1	160.1	73.1	28.7
	IPW 2	124.8	58.7	23.2	124.1	58.3	23.0	127.5	59.4	23.5	125.6	59.6	23.9
	IPW 3	125.5	58.7	23.0	125.3	58.6	22.9	127.7	59.1	23.1	126.7	59.9	23.7
	DR	127.4	58.5	22.9	127.5	58.6	22.9	128.7	58.7	23.0	129.3	60.1	23.9
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	77.1	35.1	14.4	79.8	35.5	14.3	85.8	37.8	15.2	87.1	38.5	15.5
	IPW 2	70.0	32.2	13.2	69.5	32.2	13.3	72.2	32.9	13.4	71.1	33.3	13.8
	IPW 3	70.6	32.3	13.1	70.4	32.4	13.2	72.5	32.9	13.3	71.8	33.3	13.6
	DR	71.4	32.5	13.1	71.6	32.5	13.2	72.6	32.9	13.3	73.2	33.5	13.7
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	125.7	57.0	22.2	128.4	57.4	22.1	134.1	59.5	22.9	135.9	60.4	23.4
	IPW 2	118.8	54.2	21.0	118.4	54.2	21.0	120.7	54.8	21.1	120.1	55.3	21.6
	IPW 3	119.4	54.2	20.9	119.2	54.3	20.9	121.0	54.7	21.0	120.8	55.3	21.5
	DR	119.8	54.5	20.9	119.9	54.4	20.9	120.7	54.7	21.0	121.8	55.4	21.5
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	78.2	36.6	15.0	90.0	41.1	16.4	88.3	40.2	16.2	111.4	50.3	19.7
	IPW 2	68.3	32.7	13.3	67.7	32.4	13.1	70.1	33.4	13.7	68.3	32.9	13.3
	IPW 3	69.0	32.8	13.3	68.8	32.8	13.1	70.5	33.3	13.5	69.3	33.2	13.3
	DR	70.4	32.9	13.2	70.5	33.0	13.1	71.3	33.2	13.4	71.2	33.5	13.4
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	128.1	59.0	23.7	140.2	63.6	25.0	138.5	62.6	24.7	161.8	72.9	28.2
	IPW 2	119.0	55.4	22.1	118.6	55.3	21.8	121.1	56.0	22.4	119.1	55.7	22.0
	IPW 3	120.0	55.6	21.9	119.8	55.6	21.8	121.7	56.0	22.1	120.3	56.0	22.0
	DR	122.7	55.8	21.8	122.8	55.9	21.8	123.7	56.1	22.0	123.5	56.4	22.0

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is trimmed according to the first rule explained in the text. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.26: MSE of ATE estimators based on propensity score trimmed by trimming rule 2

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	80.0	37.8	14.9	86.2	41.0	16.0	83.8	39.6	15.7	102.3	50.1	20.1
	IPW 2	70.7	33.0	13.1	70.2	32.7	12.9	72.4	33.7	13.4	71.7	34.0	14.4
	IPW 3	69.0	32.5	12.9	68.9	32.4	12.9	70.0	32.9	13.2	70.2	33.7	14.3
	DR	70.0	32.7	12.9	70.3	32.8	12.9	70.4	32.8	13.1	71.9	34.2	14.4
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	129.8	62.3	24.1	136.1	65.7	25.2	133.8	64.1	24.8	152.5	74.8	29.3
	IPW 2	120.2	57.3	22.4	119.6	57.1	22.3	121.8	57.9	22.7	121.1	58.4	23.8
	IPW 3	118.9	57.0	22.3	118.7	56.9	22.3	119.8	57.4	22.5	120.0	58.2	23.7
	DR	119.8	57.1	22.2	120.0	57.1	22.2	120.2	57.4	22.4	121.5	58.4	23.7
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	73.0	34.3	13.3	73.8	34.5	13.4	75.8	35.8	14.3	81.4	38.5	15.5
	IPW 2	66.3	31.2	12.3	65.8	31.1	12.2	68.2	32.4	13.1	67.4	32.5	13.4
	IPW 3	65.2	30.9	12.2	65.0	30.9	12.2	66.5	31.8	12.9	66.5	32.2	13.3
	DR	65.8	31.1	12.2	66.0	31.2	12.2	66.9	32.0	12.8	67.9	32.6	13.5
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	119.8	57.0	21.7	120.8	57.2	21.9	122.4	58.4	22.6	128.6	61.3	24.1
	IPW 2	112.7	54.0	20.5	112.2	53.9	20.5	114.2	55.0	21.2	114.0	55.3	21.8
	IPW 3	111.7	53.7	20.4	111.5	53.7	20.5	112.7	54.5	21.0	113.2	55.0	21.7
	DR	112.2	54.1	20.5	112.4	54.0	20.5	113.0	54.8	21.2	114.4	55.5	21.8
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	75.3	35.9	14.1	84.0	39.9	15.7	79.6	38.0	15.4	101.9	48.6	19.1
	IPW 2	65.8	31.7	12.5	65.4	31.5	12.4	67.1	32.7	13.2	65.7	31.8	12.6
	IPW 3	64.6	31.4	12.4	64.5	31.3	12.4	65.6	32.1	13.1	64.8	31.5	12.5
	DR	65.4	31.5	12.4	65.5	31.5	12.4	65.8	32.0	13.0	66.0	31.9	12.6
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	122.1	59.3	22.6	131.2	63.6	24.1	126.6	61.8	23.9	149.3	72.6	27.3
	IPW 2	112.5	54.6	21.2	112.5	54.4	21.0	113.7	55.6	21.9	112.8	54.7	21.1
	IPW 3	111.8	54.4	21.0	112.0	54.4	21.0	112.8	55.3	21.7	112.3	54.6	21.1
	DR	113.1	54.6	21.0	113.3	54.6	21.0	113.6	55.4	21.5	113.7	54.9	21.2

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is trimmed according to the second rule explained in the text. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.27: MSE of ATE estimators based on propensity score trimmed by trimming rule by HLW

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	81.7	28.5	13.7	155.5	53.6	17.2	94.9	34.0	14.4	344.0	98.3	24.0
	IPW 2	72.1	40.9	19.0	168.1	70.2	24.9	107.4	54.4	23.6	352.4	123.7	36.9
	IPW 3	73.1	30.4	14.5	155.0	54.9	17.2	91.9	35.9	15.3	336.9	96.7	22.4
	DR	74.3	36.6	14.8	93.1	36.9	15.0	92.7	36.8	14.8	98.4	38.6	15.6
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	99.2	47.1	21.8	191.4	72.1	25.3	131.0	52.5	22.5	380.1	116.6	32.3
	IPW 2	110.4	59.4	26.8	205.8	88.3	32.6	145.3	72.4	31.2	390.3	141.3	44.5
	IPW 3	99.8	49.0	22.4	191.9	73.2	25.0	129.1	54.3	23.2	374.0	114.8	30.2
	DR	169.2	58.5	22.7	170.0	58.8	22.9	169.8	58.6	22.7	175.1	60.5	23.5
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	53.7	29.8	14.2	53.7	25.0	13.1	56.4	29.8	14.4	86.3	28.9	14.0
	IPW 2	64.2	35.9	15.1	68.0	34.0	14.7	73.0	39.9	16.3	107.9	42.8	16.5
	IPW 3	57.6	32.6	14.1	57.8	27.4	12.8	61.6	33.7	14.3	91.5	31.8	13.1
	DR	104.2	36.6	14.3	106.5	37.0	14.4	104.7	36.7	14.4	105.8	37.0	14.5
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	97.8	51.6	22.1	97.8	46.8	20.9	100.3	51.7	22.3	130.2	50.7	21.8
	IPW 2	108.5	57.5	22.8	112.1	55.3	22.3	117.1	61.4	24.0	151.8	64.1	24.0
	IPW 3	102.0	54.5	21.8	102.2	49.3	20.5	105.9	55.6	22.2	135.8	53.7	20.9
	DR	114.4	51.3	21.0	116.6	51.6	21.1	114.7	51.4	21.1	116.1	51.5	21.2
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	163.5	51.2	15.8	343.5	94.6	21.1	241.0	64.7	17.2	724.5	176.7	31.1
	IPW 2	158.1	56.2	18.7	335.4	101.8	26.0	230.1	73.6	22.8	696.3	188.2	40.9
	IPW 3	157.6	50.5	15.4	336.0	93.3	19.9	229.6	62.8	16.6	703.5	171.0	28.0
	DR	104.9	36.6	13.8	107.2	36.9	13.9	105.5	37.0	14.0	118.3	39.1	14.3
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	190.7	67.6	23.2	371.0	111.0	28.4	268.5	81.0	24.6	752.2	193.1	38.4
	IPW 2	187.3	73.1	25.9	364.9	118.7	33.1	259.6	90.4	29.8	726.1	204.9	47.7
	IPW 3	185.8	67.4	22.9	364.5	110.3	27.3	258.1	79.6	24.0	732.1	187.9	35.3
	DR	259.3	63.9	22.1	261.5	64.3	22.2	260.0	64.2	22.2	272.4	66.5	22.6

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is trimmed according to the rule by HLW. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.28: MSE of ATE estimators based on shrunk propensity score with fixed valued λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	53.0	29.6	13.1	63.5	36.3	16.0	54.5	30.6	13.4	83.0	48.7	22.1
	IPW 2	60.4	31.9	14.3	58.2	30.4	13.1	65.5	35.0	16.1	59.2	30.8	13.2
	IPW 3	64.5	33.7	14.6	63.8	33.4	14.2	66.7	34.9	15.1	64.5	33.6	14.3
	DR	71.4	35.5	14.5	72.1	35.9	14.8	71.7	35.8	14.5	73.8	36.7	15.4
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	92.1	49.8	20.9	102.7	56.4	23.9	93.8	50.8	21.3	122.4	68.9	30.1
	IPW 2	105.5	54.4	22.7	103.5	52.7	21.4	110.7	57.3	24.4	104.4	53.0	21.6
	IPW 3	107.3	55.0	22.5	106.9	54.6	22.0	109.7	56.1	23.0	107.5	54.7	22.2
	DR	111.7	55.4	21.9	112.4	55.6	22.1	112.2	55.6	21.9	113.9	56.3	22.6
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	53.9	28.0	13.3	54.1	27.9	12.9	54.5	28.2	13.4	59.2	30.9	14.3
	IPW 2	58.9	29.1	13.1	58.6	29.1	12.9	61.1	30.1	13.6	59.2	29.5	13.0
	IPW 3	62.1	30.5	13.7	62.4	30.8	13.6	63.4	31.0	13.9	62.7	31.0	13.7
	DR	68.9	32.6	14.1	69.3	32.8	14.1	69.3	32.8	14.2	69.8	33.0	14.2
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	95.5	49.1	21.4	95.7	49.0	21.0	96.0	49.4	21.6	100.9	52.0	22.3
	IPW 2	101.7	50.3	21.2	101.3	50.3	20.8	103.8	51.3	21.7	101.9	50.6	21.0
	IPW 3	103.3	51.2	21.6	103.4	51.4	21.4	104.5	51.7	21.8	103.8	51.5	21.4
	DR	105.5	51.9	21.4	105.8	51.9	21.4	105.8	52.1	21.5	106.4	52.1	21.6
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	56.7	31.3	13.7	69.3	38.8	17.3	59.1	32.7	14.4	92.1	52.5	24.0
	IPW 2	58.0	30.2	13.1	56.7	29.3	12.5	61.4	32.1	14.0	57.1	29.4	12.6
	IPW 3	61.4	31.7	13.5	61.0	31.4	13.3	62.9	32.5	13.8	61.3	31.5	13.3
	DR	68.4	33.8	13.7	68.7	33.9	13.8	68.9	34.1	13.8	69.8	34.5	14.1
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	94.2	50.0	21.4	106.9	57.5	25.1	96.8	51.4	22.0	129.8	71.3	31.8
	IPW 2	103.3	51.8	21.4	102.2	51.0	20.9	106.8	53.6	22.3	102.6	51.1	20.9
	IPW 3	105.7	52.7	21.6	105.4	52.4	21.4	107.3	53.4	21.9	105.7	52.5	21.5
	DR	113.1	54.1	21.7	113.4	54.2	21.7	113.6	54.3	21.7	114.3	54.7	22.0

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the fixed valued λ . The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.29: MSE of ATE estimators based on shrunk propensity score with MSE-minimizing λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	51.7	30.4	13.5	61.9	37.1	16.7	53.6	31.5	14.1	81.1	49.2	22.7
	IPW 2	59.1	32.5	14.3	56.4	31.5	13.6	64.8	35.5	16.1	57.2	31.9	13.6
	IPW 3	62.7	34.5	15.0	61.9	34.5	14.9	65.4	35.8	15.7	62.4	34.7	14.9
	DR	69.3	36.8	15.1	70.2	37.2	15.5	69.9	37.2	15.4	72.0	37.9	15.9
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	93.7	51.8	20.8	104.1	58.5	23.8	95.5	52.9	21.3	123.4	70.7	29.8
	IPW 2	107.9	56.5	22.5	105.4	55.5	21.7	113.4	59.5	24.4	106.2	55.9	21.9
	IPW 3	109.3	57.6	22.8	108.6	57.5	22.8	111.9	58.7	23.5	109.1	57.7	22.8
	DR	113.7	58.3	22.5	114.6	58.7	22.9	114.2	58.6	22.7	116.2	59.4	23.5
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	53.1	29.1	12.9	53.4	28.8	12.8	53.7	29.3	13.0	58.9	31.8	14.2
	IPW 2	58.6	30.7	13.3	57.8	30.4	13.5	61.0	32.0	13.9	58.6	30.7	13.6
	IPW 3	61.8	32.1	13.9	61.7	32.2	14.1	63.2	32.8	14.2	62.1	32.4	14.2
	DR	68.4	34.1	14.4	68.8	34.3	14.6	68.7	34.3	14.4	69.4	34.7	14.8
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	97.5	49.0	20.9	97.9	48.7	20.8	98.2	49.3	21.0	103.2	51.5	22.2
	IPW 2	104.9	51.3	21.2	104.2	51.0	21.4	107.3	52.7	21.8	104.9	51.3	21.5
	IPW 3	106.5	52.1	21.7	106.5	52.2	21.8	108.0	52.9	21.9	106.9	52.3	22.0
	DR	109.0	52.6	21.7	109.4	52.8	21.9	109.4	52.8	21.8	110.1	53.1	22.1
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	54.1	30.7	13.9	66.9	38.4	17.7	56.7	32.2	14.7	89.9	52.2	24.7
	IPW 2	56.7	30.3	12.8	54.9	29.4	12.5	60.8	32.5	13.9	55.2	29.5	12.5
	IPW 3	59.6	31.8	13.3	58.9	31.5	13.3	61.8	32.8	13.8	59.2	31.7	13.3
	DR	66.0	34.0	13.7	66.6	34.2	13.9	66.6	34.4	14.0	67.9	34.7	14.1
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	93.8	50.9	20.9	106.6	58.5	24.7	96.3	52.3	21.6	129.8	72.3	31.6
	IPW 2	104.5	53.9	20.9	102.7	53.0	20.6	108.5	56.0	22.0	103.1	53.1	20.7
	IPW 3	106.2	54.8	21.1	105.5	54.5	21.2	108.3	55.7	21.6	105.7	54.6	21.2
	DR	112.7	56.2	21.3	113.1	56.4	21.5	113.3	56.5	21.4	114.3	56.9	21.8

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the MSE-minimizing λ . The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.30: MSE of ATE estimators based on shrunk propensity score with data driven λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	142.4	76.9	75.0	147.8	76.7	56.0	148.8	80.0	76.5	193.1	100.7	68.3
	IPW 2	74.8	40.6	20.8	74.2	39.2	19.2	78.7	42.8	21.8	74.6	39.4	19.3
	IPW 3	69.5	35.2	15.2	69.5	35.2	15.3	71.4	35.9	15.4	69.8	35.3	15.4
	DR	75.7	37.2	16.0	76.7	37.6	16.3	76.4	37.6	16.1	78.6	38.5	16.9
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	182.4	97.1	81.8	187.3	96.9	62.9	188.6	100.1	83.2	232.1	120.9	74.9
	IPW 2	120.8	62.3	28.5	119.9	60.7	27.2	124.8	64.4	29.6	120.3	60.9	27.3
	IPW 3	114.4	56.3	23.2	114.1	56.3	23.4	116.2	57.0	23.4	114.5	56.5	23.6
	DR	118.2	57.9	23.8	119.3	58.3	24.2	118.9	58.2	23.8	121.1	59.2	24.9
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	81.6	49.2	20.2	79.3	47.1	18.3	83.3	50.1	20.4	88.7	54.4	20.4
	IPW 2	65.3	37.6	15.5	66.1	37.7	15.5	67.2	38.5	15.9	66.4	37.9	15.5
	IPW 3	62.2	33.8	14.0	62.5	34.1	14.1	63.3	34.1	14.1	62.8	34.3	14.1
	DR	68.1	35.9	14.5	68.5	36.1	14.6	68.5	36.1	14.6	69.2	36.5	14.7
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	122.8	69.7	27.2	120.6	67.7	25.4	124.5	70.7	27.5	130.2	75.2	27.5
	IPW 2	107.6	58.4	22.7	108.6	58.6	22.9	109.4	59.4	23.1	109.0	58.8	22.9
	IPW 3	103.7	54.5	21.2	104.1	54.8	21.4	104.7	54.9	21.3	104.4	55.0	21.4
	DR	105.9	55.5	21.6	106.3	55.8	21.6	106.4	55.7	21.7	106.9	56.1	21.7
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	114.3	53.8	20.5	151.3	66.7	25.2	124.0	57.2	21.7	222.1	92.2	35.8
	IPW 2	68.9	36.1	15.2	68.3	36.1	15.1	72.0	37.6	16.1	68.5	36.2	15.1
	IPW 3	65.8	33.4	13.5	65.5	33.5	13.5	67.3	33.9	13.7	65.8	33.6	13.6
	DR	71.8	35.4	14.1	72.2	35.7	14.2	72.6	35.7	14.2	73.3	36.2	14.5
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	156.1	74.8	27.8	192.9	87.6	32.5	165.8	78.1	29.0	263.6	113.2	42.9
	IPW 2	115.8	57.9	23.2	115.0	57.8	23.3	119.0	59.3	24.2	115.3	57.9	23.4
	IPW 3	112.1	54.7	21.6	111.7	54.9	21.7	113.6	55.2	21.8	112.0	55.0	21.8
	DR	118.3	56.8	22.2	118.6	57.0	22.5	119.1	57.0	22.3	119.7	57.6	22.8

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the data-driven λ . The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.31: MSE of ATE estimators based on shrunk propensity score with trimming rule 2, fixed valued λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	60.8	31.0	13.4	64.9	33.4	14.4	62.5	32.0	14.0	71.5	37.0	16.2
	IPW 2	62.2	30.8	12.7	61.4	30.2	12.4	64.3	32.0	13.2	61.8	30.6	13.1
	IPW 3	63.8	31.2	12.8	63.5	31.0	12.6	65.0	31.9	13.1	64.0	31.6	13.4
	DR	67.9	32.2	12.9	68.3	32.4	12.9	68.2	32.4	13.1	69.6	33.5	14.1
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	104.9	53.9	22.4	109.0	56.1	23.4	106.7	54.9	23.0	115.6	59.5	25.2
	IPW 2	110.0	55.0	21.9	109.1	54.1	21.6	112.0	56.2	22.4	109.4	54.4	22.4
	IPW 3	110.4	54.9	21.9	110.0	54.5	21.7	111.6	55.6	22.2	110.4	54.9	22.6
	DR	112.6	55.0	21.8	113.0	55.0	21.7	112.8	55.2	21.9	114.3	56.1	22.9
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	58.9	29.5	12.3	60.5	30.3	12.6	61.6	31.2	13.4	62.1	30.8	12.7
	IPW 2	59.6	29.0	11.8	59.2	28.8	11.6	60.2	29.2	12.0	59.6	29.1	12.2
	IPW 3	60.5	29.4	11.9	60.5	29.4	11.8	61.1	29.6	12.1	61.0	29.9	12.5
	DR	64.1	30.5	12.1	64.3	30.6	12.1	65.0	31.2	12.6	65.8	31.7	13.2
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	101.8	51.2	20.4	103.6	51.9	20.8	104.4	52.9	21.4	105.3	52.6	21.0
	IPW 2	105.8	51.5	20.2	105.6	51.2	20.2	106.2	51.6	20.3	106.1	51.6	20.8
	IPW 3	106.0	51.6	20.2	106.1	51.5	20.2	106.3	51.7	20.4	106.7	52.0	21.0
	DR	107.5	52.2	20.4	107.7	52.1	20.4	108.3	52.8	20.9	109.3	53.2	21.5
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	59.5	30.6	12.5	64.7	33.5	13.8	61.6	31.8	13.4	74.5	39.1	16.2
	IPW 2	59.1	29.7	11.9	58.8	29.3	11.6	61.9	31.7	13.2	59.1	29.4	11.7
	IPW 3	60.2	30.0	11.9	60.2	29.8	11.8	62.2	31.4	12.9	60.4	30.0	11.8
	DR	63.8	30.9	12.0	64.1	31.0	12.0	64.1	31.3	12.5	64.5	31.3	12.2
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	103.7	53.0	21.0	108.9	56.0	22.2	105.8	54.4	21.8	118.7	61.6	24.5
	IPW 2	105.8	52.8	20.7	105.5	52.3	20.4	108.6	54.8	22.0	105.7	52.4	20.5
	IPW 3	106.1	52.8	20.6	106.2	52.6	20.5	108.1	54.3	21.6	106.3	52.6	20.5
	DR	108.2	53.0	20.5	108.6	53.0	20.5	108.5	53.5	21.0	109.0	53.3	20.7

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the fixed valued λ combined with the second trimming rule. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.32: MSE of ATE estimators based on shrunk propensity score with trimming rule 2, MSE-minimizing λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	59.4	32.5	13.3	64.4	35.4	14.2	61.8	33.8	13.9	72.1	39.3	15.7
	IPW 2	60.2	31.6	13.1	59.4	31.4	12.7	62.7	32.7	13.8	59.7	31.5	13.4
	IPW 3	61.3	32.2	13.1	61.1	32.3	12.9	63.0	32.9	13.5	61.5	32.5	13.7
	DR	65.3	33.5	13.2	65.7	33.6	13.3	66.0	33.9	13.4	67.0	34.4	14.5
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	108.3	56.1	22.4	113.3	59.0	23.4	110.8	57.4	23.0	121.1	62.9	25.1
	IPW 2	112.9	56.5	22.1	112.0	56.2	21.8	115.4	57.6	22.8	112.2	56.3	22.6
	IPW 3	112.8	56.7	22.1	112.5	56.7	21.9	114.4	57.3	22.5	112.7	56.9	22.8
	DR	114.4	57.3	22.1	114.7	57.3	22.2	115.2	57.6	22.3	115.8	58.0	23.4
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	57.5	30.8	12.6	59.5	31.7	13.0	59.9	32.4	13.6	62.0	32.4	13.1
	IPW 2	58.7	30.4	12.3	58.2	30.0	12.3	59.2	30.6	12.4	58.7	30.4	12.8
	IPW 3	59.9	30.9	12.4	59.6	30.7	12.4	60.2	31.0	12.6	60.3	31.2	13.1
	DR	63.5	31.9	12.6	63.8	31.9	12.7	64.2	32.5	13.1	65.4	33.1	13.8
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	103.9	52.4	20.7	105.8	53.3	21.1	106.3	54.1	21.8	108.2	54.0	21.2
	IPW 2	109.1	53.2	20.7	108.5	52.8	20.7	109.7	53.4	20.9	109.1	53.2	21.2
	IPW 3	109.4	53.3	20.7	109.2	53.1	20.7	109.8	53.5	20.9	109.9	53.6	21.4
	DR	111.2	53.6	20.8	111.5	53.6	20.8	111.9	54.2	21.3	113.1	54.8	21.9
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	56.9	30.8	12.5	62.4	34.0	13.9	59.4	32.2	13.5	72.8	39.9	16.3
	IPW 2	57.3	29.8	11.9	56.5	29.4	11.8	61.1	32.0	13.5	56.8	29.4	11.9
	IPW 3	58.2	30.2	12.0	57.8	30.0	12.0	60.9	31.8	13.2	58.1	30.1	12.1
	DR	61.5	31.2	12.2	61.9	31.2	12.3	62.3	31.7	12.8	62.4	31.4	12.5
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	103.6	53.5	21.0	109.2	56.7	22.5	106.1	54.8	22.0	119.7	62.5	25.1
	IPW 2	107.2	53.6	20.3	106.5	53.2	20.3	110.9	55.8	21.9	106.7	53.3	20.4
	IPW 3	107.2	53.5	20.4	106.9	53.4	20.4	109.9	55.1	21.6	107.1	53.5	20.5
	DR	108.8	53.8	20.5	109.1	53.9	20.5	109.5	54.3	21.1	109.6	54.1	20.8

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the MSE-minimizing λ combined with the second trimming rule. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.33: MSE of ATE estimators based on shrunk propensity score with trimming rule 2, data driven λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	69.8	35.4	14.3	74.4	37.6	15.4	73.0	36.9	15.0	84.3	42.6	18.3
	IPW 2	65.8	32.3	12.7	65.1	32.2	12.7	67.6	33.0	13.0	66.2	32.8	13.6
	IPW 3	65.9	32.3	12.7	65.5	32.3	12.7	67.1	32.8	12.9	66.7	32.9	13.6
	DR	68.2	32.8	12.7	68.5	32.9	12.8	68.7	33.0	12.8	70.5	33.8	13.8
Ratio 1:1	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	119.8	59.5	23.6	124.7	61.8	24.6	123.1	61.1	24.2	134.8	66.9	27.8
	IPW 2	117.3	57.0	21.9	116.9	56.9	21.9	119.0	57.7	22.1	117.8	57.6	22.8
	IPW 3	117.1	57.0	21.8	117.1	57.1	21.9	118.3	57.5	21.9	118.0	57.7	22.9
	DR	118.6	57.2	21.8	118.9	57.4	21.8	119.2	57.6	21.8	120.6	58.4	23.0
Ratio 3:2	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	60.4	32.4	13.8	61.6	32.8	13.9	63.3	34.0	14.6	65.0	34.8	15.6
	IPW 2	57.6	30.3	12.7	57.5	30.1	12.6	58.2	30.8	13.0	58.4	31.2	13.9
	IPW 3	58.1	30.3	12.7	58.2	30.2	12.7	58.6	30.7	13.0	59.2	31.3	14.0
	DR	61.1	30.8	12.8	61.2	30.8	12.8	61.9	31.5	13.2	62.9	32.3	14.3
Ratio 3:2	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	107.2	56.2	22.7	108.6	56.5	22.7	110.3	57.8	23.5	112.1	58.6	24.3
	IPW 2	105.9	54.5	21.6	105.8	54.2	21.5	106.6	55.0	21.9	106.6	55.3	22.7
	IPW 3	106.0	54.3	21.6	106.1	54.2	21.6	106.6	54.8	22.0	107.0	55.3	22.8
	DR	107.5	54.5	21.6	107.5	54.5	21.6	108.4	55.2	22.0	109.1	56.0	23.0
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	64.8	33.7	13.3	70.8	36.9	14.6	67.8	35.2	14.4	82.8	43.0	17.4
	IPW 2	61.7	30.8	11.8	61.2	30.7	11.8	64.4	32.0	12.7	61.5	30.7	12.0
	IPW 3	62.1	30.9	11.8	61.8	30.9	11.8	64.1	31.8	12.6	62.2	30.9	12.0
	DR	64.6	31.5	11.9	64.8	31.6	11.9	65.3	31.9	12.4	65.4	31.8	12.1
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	112.6	57.0	22.0	118.7	60.2	23.3	115.4	58.6	23.1	130.5	66.4	26.1
	IPW 2	111.8	54.7	20.6	111.3	54.6	20.6	114.2	55.9	21.4	111.5	54.6	20.7
	IPW 3	111.8	54.8	20.5	111.6	54.7	20.5	113.6	55.6	21.3	111.9	54.8	20.7
	DR	113.3	55.1	20.5	113.5	55.2	20.6	113.9	55.4	21.0	114.1	55.3	20.8

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the data-driven λ combined with the second trimming rule. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.34: MSE of ATE estimators based on shrunk propensity score with trimming rule 1, fixed valued λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	75.3	34.8	13.6	86.9	40.1	15.5	90.7	40.4	15.3	104.7	47.0	18.1
	IPW 2	67.0	31.7	12.7	65.2	31.5	12.3	70.6	33.2	13.5	66.6	32.2	12.6
	IPW 3	68.9	32.8	13.0	67.8	32.9	12.9	71.8	33.8	13.5	69.4	33.6	13.3
Ratio 1:1	DR	73.0	34.1	13.1	73.1	34.1	13.2	74.6	34.8	13.4	75.5	35.3	13.9
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	128.8	59.3	22.5	140.7	64.7	24.5	144.1	64.8	24.4	158.7	71.5	27.1
	IPW 2	124.2	57.9	22.0	122.9	58.0	21.7	127.7	59.4	23.0	124.5	58.5	22.0
Ratio 3:2	IPW 3	125.6	58.7	22.2	124.9	58.9	22.1	128.3	59.6	22.8	126.6	59.5	22.5
	DR	129.0	59.2	22.0	129.2	59.2	22.1	130.4	59.8	22.4	131.7	60.3	22.9
	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	67.1	32.5	13.3	71.2	33.6	13.3	77.6	36.2	14.3	78.3	35.9	13.9
Ratio 3:2	IPW 2	61.6	30.5	12.8	60.8	30.2	12.6	63.4	31.3	13.2	62.1	30.9	12.9
	IPW 3	63.3	31.1	13.0	62.7	31.0	12.9	64.8	31.8	13.3	64.2	31.8	13.3
	DR	67.2	32.1	13.1	67.3	32.1	13.1	68.2	32.6	13.3	69.3	33.2	13.7
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
Ratio 3:2	IPW 1	117.5	56.2	21.6	121.2	57.5	21.6	127.8	60.0	22.6	127.8	59.8	22.1
	IPW 2	114.3	54.6	21.3	113.1	54.5	21.1	116.2	55.4	21.8	114.4	55.1	21.4
	IPW 3	115.2	55.0	21.4	114.4	55.0	21.3	116.7	55.7	21.7	115.7	55.7	21.6
	DR	116.7	55.1	21.3	116.9	55.2	21.3	117.7	55.7	21.5	118.8	56.1	21.9
Ratio 2:3	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	72.4	34.1	12.9	86.8	40.6	15.3	84.8	38.6	14.3	110.8	50.5	19.0
	IPW 2	64.1	30.5	11.9	62.8	30.1	11.6	67.2	32.0	12.7	63.4	30.3	11.7
	IPW 3	65.7	31.3	12.0	64.9	31.2	12.0	68.2	32.4	12.6	65.5	31.3	12.1
Ratio 2:3	DR	69.3	32.5	12.1	69.3	32.5	12.2	70.3	33.1	12.4	70.3	32.9	12.5
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	124.4	57.3	21.2	138.8	63.8	23.6	136.7	61.7	22.6	162.9	73.6	27.2
	IPW 2	119.8	55.5	20.8	118.7	55.2	20.5	122.7	57.0	21.7	119.4	55.3	20.7
Ratio 2:3	IPW 3	121.0	56.1	20.8	120.4	56.0	20.8	123.5	57.1	21.4	121.1	56.2	21.0
	DR	124.9	56.9	20.8	125.0	56.8	20.9	125.9	57.3	21.0	126.1	57.1	21.2

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the fixed valued λ combined with the first trimming rule. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.35: MSE of ATE estimators based on shrunken propensity score with trimming rule 1, MSE-minimizing λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	75.2	34.9	13.6	87.0	40.1	15.6	90.7	40.5	15.3	104.9	47.1	18.1
	IPW 2	66.9	31.7	12.7	65.0	31.5	12.4	70.5	33.3	13.5	66.4	32.2	12.7
	IPW 3	68.8	32.8	13.0	67.7	32.9	12.9	71.7	33.8	13.5	69.2	33.6	13.3
	DR	73.0	34.1	13.1	73.1	34.1	13.2	74.5	34.8	13.4	75.5	35.3	13.9
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	128.8	59.3	22.6	140.8	64.7	24.5	144.3	64.8	24.4	159.0	71.6	27.0
	IPW 2	124.3	58.0	22.1	122.8	58.0	21.7	127.8	59.5	23.0	124.5	58.6	22.0
	IPW 3	125.5	58.7	22.2	124.8	58.9	22.1	128.4	59.6	22.8	126.5	59.6	22.6
	DR	128.9	59.2	22.0	129.2	59.2	22.2	130.4	59.8	22.4	131.7	60.3	22.9
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	66.9	32.3	13.3	71.3	33.5	13.3	77.6	36.1	14.3	78.6	35.9	13.9
	IPW 2	61.2	30.3	12.8	60.3	30.0	12.6	63.0	31.2	13.2	61.5	30.7	12.8
	IPW 3	62.8	31.0	13.0	62.2	30.9	12.9	64.3	31.7	13.3	63.5	31.6	13.2
	DR	67.0	32.0	13.1	67.1	32.0	13.1	68.0	32.5	13.3	69.1	33.1	13.7
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	117.3	56.1	21.6	121.3	57.5	21.5	128.0	60.0	22.6	128.2	59.8	22.0
	IPW 2	114.3	54.6	21.4	112.9	54.4	21.1	116.2	55.4	21.8	114.1	55.0	21.4
	IPW 3	115.0	54.9	21.4	114.1	55.0	21.3	116.6	55.6	21.7	115.4	55.6	21.6
	DR	116.6	55.1	21.3	116.7	55.1	21.3	117.6	55.7	21.5	118.7	56.1	21.9
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	72.1	34.0	12.9	87.0	40.7	15.3	84.9	38.5	14.2	111.7	50.9	19.1
	IPW 2	63.7	30.3	11.8	62.3	29.9	11.6	67.1	31.9	12.7	62.9	30.1	11.7
	IPW 3	65.2	31.1	12.0	64.4	31.0	11.9	68.0	32.3	12.5	65.0	31.2	12.1
	DR	69.2	32.5	12.1	69.2	32.4	12.2	70.3	33.0	12.4	70.2	32.8	12.4
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	124.2	57.1	21.2	139.1	63.8	23.6	136.9	61.6	22.6	163.8	74.0	27.3
	IPW 2	119.8	55.5	20.8	118.6	55.1	20.5	123.0	57.0	21.7	119.3	55.2	20.6
	IPW 3	120.9	56.0	20.8	120.2	55.9	20.8	123.6	57.1	21.5	120.9	56.1	20.9
	DR	124.8	56.8	20.8	125.0	56.8	20.9	125.9	57.3	21.0	126.1	57.1	21.2

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunken with the MSE-minimizing λ combined with the first trimming rule. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.36: MSE of ATE estimators based on shrunk propensity score with trimming rule 1, data-driven λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	78.4	38.5	15.3	87.6	42.1	16.3	91.7	43.1	16.7	103.3	48.7	18.9
	IPW 2	69.8	33.8	13.5	68.6	33.9	13.4	72.7	34.7	14.1	70.3	34.8	13.9
	IPW 3	71.6	34.4	13.6	71.0	34.6	13.6	74.0	35.2	14.0	72.7	35.5	14.0
	DR	73.9	34.9	13.5	74.0	34.9	13.6	75.5	35.6	13.8	76.4	36.1	14.3
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	132.0	63.0	24.1	141.4	66.6	25.1	145.1	67.5	25.5	157.1	73.1	27.7
	IPW 2	125.8	59.4	22.5	125.1	59.6	22.5	128.5	60.3	23.2	126.8	60.5	23.0
	IPW 3	127.3	59.9	22.6	127.1	60.1	22.7	129.7	60.6	23.1	128.8	61.0	23.1
	DR	129.8	60.0	22.5	130.1	60.1	22.6	131.3	60.6	22.8	132.4	61.3	23.3
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	69.5	34.6	14.6	72.9	35.3	14.5	78.9	37.9	15.5	79.4	37.7	15.4
	IPW 2	63.7	31.8	13.4	63.0	31.7	13.4	65.2	32.4	13.7	64.5	32.6	13.9
	IPW 3	65.3	32.2	13.4	64.9	32.2	13.4	66.6	32.8	13.6	66.4	33.1	13.9
	DR	67.8	32.5	13.3	67.9	32.5	13.4	68.8	33.0	13.6	69.9	33.6	13.9
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	119.2	57.9	22.6	122.4	58.7	22.5	128.6	61.2	23.5	128.4	61.1	23.3
	IPW 2	115.4	55.4	21.6	114.5	55.4	21.7	117.0	56.1	21.9	115.8	56.3	22.2
	IPW 3	116.3	55.7	21.5	115.9	55.7	21.7	117.8	56.3	21.8	117.2	56.7	22.1
	DR	117.3	55.6	21.5	117.4	55.6	21.5	118.4	56.1	21.7	119.2	56.7	22.1
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	74.5	36.2	14.0	86.7	41.0	15.6	85.9	40.1	15.1	108.0	49.3	18.8
	IPW 2	66.1	32.0	12.5	65.2	31.8	12.4	68.7	33.0	13.0	65.8	32.0	12.5
	IPW 3	67.7	32.4	12.4	67.2	32.4	12.4	69.9	33.3	12.8	67.8	32.6	12.6
	DR	69.9	33.0	12.4	70.0	33.0	12.4	71.0	33.5	12.7	70.9	33.3	12.7
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	127.2	59.7	22.3	139.5	64.4	23.9	138.4	63.6	23.5	160.9	72.7	27.1
	IPW 2	121.2	56.7	21.1	120.5	56.4	21.1	123.6	57.7	21.8	121.1	56.7	21.3
	IPW 3	122.7	57.0	21.1	122.4	56.9	21.2	124.7	57.9	21.5	123.0	57.2	21.3
	DR	125.4	57.3	21.1	125.6	57.3	21.2	126.4	57.8	21.3	126.5	57.7	21.4

Note: Reported values are Monte Carlo MSE $\times 10^4$ of ATE estimators based on the four different propensity score methods method: IPW1, IPW2, IPW3 and DR which are explained in detailed in Section 2. Propensity score is shrunk with the data-driven λ combined with the first trimming rule. The ATE is estimated for 10000, 5000 and 2000 Monte Carlo samples with sample sizes 100, 200 and 500, respectively. Ratio refers to the treated-to-control ratio. Linear and nonlinear refer to the relation between propensity score and outcome variable. Homogeneous or heterogenous describes treatment homogeneity or heterogeneity. Homoscedastic and heteroscedastic describe the error term structure of the outcome variable.

Table A.37: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores, fixed λ

N		linear			nonlinear			linear			nonlinear		
		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	IPW 1	homogeneous, homoscedastic						heterogeneous, homoscedastic					
		42.1	55.4	54.7	39.2	56.6	54.6	34.1	51.2	51.8	46.9	61.3	60.5
		(-0.1)	(0.0)	(0.0)	(-1.3)	(-1.1)	(-1.9)	(-0.2)	(0.0)	(0.0)	(-0.4)	(-0.4)	(-1.4)
	IPW 2	15.4	26.7	31.3	16.1	28.9	36.6	14.2	25.8	29.5	15.1	27.0	34.6
		(-0.4)	(-1.1)	(-1.8)	(-0.1)	(-0.1)	(0.0)	(-0.9)	(-2.3)	(-3.7)	(-0.3)	(-0.7)	(-1.1)
Ratio 1:1	IPW 3	3.2	11.4	13.8	4.0	12.7	15.5	0.9	9.6	11.4	3.0	10.4	12.5
		(0.0)	(-0.4)	(-0.6)	(0.0)	(0.1)	(0.0)	(-0.2)	(-1.0)	(-1.2)	(-0.6)	(-1.2)	(-2.5)
		4.9	14.7	17.5	5.7	15.2	19.1	3.8	14.5	16.2	5.5	13.3	16.4
		(0.1)	(0.1)	(-0.1)	(0.0)	(0.0)	(0.1)	(0.2)	(0.3)	(-0.1)	(-1.5)	(-2.5)	(-3.7)
		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
Ratio 1:1	IPW 1	24.6	40.3	42.0	23.6	43.4	42.8	18.8	37.9	40.6	33.4	50.3	50.3
		(0.0)	(0.0)	(0.0)	(-1.0)	(-0.8)	(-1.5)	(-0.1)	(0.0)	(0.0)	(-0.3)	(-0.3)	(-1.1)
		-1.1	10.4	16.3	-0.2	12.0	20.0	-1.7	10.2	15.5	-0.8	10.7	18.3
		(-0.3)	(-0.8)	(-1.4)	(0.0)	(0.0)	(0.0)	(-0.7)	(-1.7)	(-2.7)	(-0.2)	(-0.5)	(-0.9)
		-9.1	0.3	2.4	-8.3	0.9	3.3	-10.5	-0.6	1.3	-8.8	-0.7	0.9
Ratio 3:2	IPW 2	(-0.1)	(-0.3)	(-0.4)	(0.0)	(0.1)	(0.0)	(-0.2)	(-0.7)	(-0.9)	(-0.4)	(-0.8)	(-1.7)
		-6.7	3.2	5.3	-6.1	3.4	6.2	-7.4	3.3	4.9	-6.1	2.0	4.0
		(0.1)	(0.1)	(-0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.2)	(-0.1)	(-1.1)	(-1.7)	(-2.7)
		homogeneous, homoscedastic						heterogeneous, homoscedastic					
		41.1	41.0	41.5	33.3	33.3	36.2	33.2	35.6	38.4	34.0	35.8	39.3
Ratio 3:2	IPW 2	(0.0)	(0.0)	(-0.1)	(-0.7)	(-0.9)	(-0.9)	(-0.1)	(-0.1)	(0.0)	(-0.1)	(-0.1)	(-0.2)
		11.7	19.9	27.4	14.1	21.5	27.1	10.2	19.5	27.4	12.8	19.9	25.7
		(-0.3)	(-0.5)	(-0.8)	(0.0)	(-0.3)	(-0.5)	(-0.1)	(-0.4)	(-0.9)	(-0.3)	(-0.1)	(-0.2)
		1.6	7.0	14.7	3.1	7.7	14.2	-0.1	6.1	14.1	1.7	5.9	12.2
		(-0.1)	(-0.2)	(-0.2)	(0.1)	(0.0)	(-0.2)	(0.2)	(0.0)	(0.0)	(-0.5)	(-0.3)	(-0.6)
Ratio 3:2	IPW 3	3.9	8.7	16.7	4.3	9.0	16.8	2.8	8.1	16.3	2.8	7.1	14.3
		(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.2)	(-0.2)	(-1.6)	(-1.6)	(-2.0)
		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
		24.9	27.5	30.6	17.9	20.8	25.6	19.2	24.0	28.7	19.5	23.6	28.4
		(0.0)	(0.0)	(-0.1)	(-0.5)	(-0.6)	(-0.7)	(-0.1)	(-0.1)	(0.0)	(0.0)	(-0.1)	(-0.2)
Ratio 2:3	IPW 2	-2.1	8.2	17.7	-0.7	9.1	16.5	-2.8	8.2	18.1	-1.7	8.0	15.1
		(-0.2)	(-0.3)	(-0.6)	(0.0)	(-0.1)	(-0.3)	(-0.1)	(-0.3)	(-0.6)	(-0.2)	(-0.1)	(-0.2)
		-9.4	-0.5	8.4	-8.6	-0.1	7.5	-10.3	-0.9	8.4	-9.5	-1.3	5.8
		(-0.1)	(-0.1)	(-0.2)	(0.1)	(0.0)	(-0.1)	(0.1)	(0.0)	(0.0)	(-0.4)	(-0.2)	(-0.4)
		-8.1	0.7	9.6	-7.9	0.9	9.7	-8.7	0.6	9.7	-8.9	-0.5	7.7
Ratio 2:3	IPW 3	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)	(-0.1)	(-1.2)	(-1.1)	(-1.3)
		homogeneous, homoscedastic						heterogeneous, homoscedastic					
		32.4	63.3	37.7	32.4	65.8	39.7	25.9	61.8	35.6	37.0	69.6	45.8
		(-0.2)	(-0.2)	(-0.7)	(-1.4)	(-1.1)	(-3.5)	(0.1)	(0.0)	(-0.4)	(-1.1)	(-1.0)	(-3.9)
		11.1	21.3	22.2	12.4	21.7	24.5	9.3	20.1	20.1	12.2	21.0	23.9
Ratio 2:3	IPW 3	(-0.3)	(-0.7)	(-1.2)	(0.0)	(0.0)	(0.0)	(-1.8)	(-2.8)	(-4.0)	(-0.3)	(-0.4)	(-0.6)
		2.7	9.0	10.9	3.6	9.7	12.6	0.3	7.1	8.0	3.3	8.9	11.8
		(-0.2)	(-0.3)	(-0.5)	(0.0)	(0.0)	(0.0)	(-1.2)	(-1.7)	(-2.2)	(-0.3)	(-0.5)	(-0.8)
		4.7	10.7	13.6	5.0	11.0	14.5	4.1	10.6	12.5	5.3	10.7	13.8
		(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.1)	(-0.2)	(-0.6)	(-0.9)	(-1.3)
Ratio 2:3	IPW 1	homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
		16.9	50.1	27.1	18.8	54.4	30.4	12.6	49.6	26.2	25.3	60.7	37.7
		(-0.1)	(-0.1)	(-0.5)	(-1.0)	(-0.9)	(-2.7)	(0.1)	(0.0)	(-0.3)	(-0.8)	(-0.9)	(-3.1)
		-2.2	8.0	10.9	-1.2	7.9	12.6	-3.1	7.5	9.5	-1.3	7.5	12.2
		(-0.3)	(-0.5)	(-0.8)	(0.0)	(0.0)	(0.0)	(-1.2)	(-1.9)	(-2.7)	(-0.2)	(-0.3)	(-0.4)
Ratio 2:3	IPW 2	-6.7	0.3	3.2	-6.0	0.7	4.3	-8.3	-0.8	1.3	-6.2	0.2	3.8
		(-0.1)	(-0.2)	(-0.3)	(0.0)	(0.0)	(0.0)	(-0.8)	(-1.1)	(-1.4)	(-0.2)	(-0.4)	(-0.5)
		-3.6	2.4	6.0	-3.4	2.5	6.5	-3.9	2.3	5.6	-3.2	2.4	6.0
		(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.2)	(-0.4)	(-0.6)	(-0.8)

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^*))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$ is given in brackets.

Table A.38: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 1 instead of the conventional propensity scores with trimming rule 1, fixed λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	IPW 1	7.9	homogeneous, homoscedastic						heterogeneous, homoscedastic					
		(-0.1)	(0.0)	(0.1)	(-2.2)	(-2.6)	(-3.9)	(-0.2)	(-0.1)	(0.0)	(-1.6)	(-0.7)	(-1.1)	
		7.6	8.2	7.3	8.2	9.6	10.7	6.5	6.3	4.0	8.6	10.4	12.1	
	IPW 2	(-0.7)	(-1.5)	(-3.1)	(-0.2)	(-0.2)	(0.1)	(-1.6)	(-3.2)	(-6.1)	(0.6)	(1.2)	(2.4)	
		6.1	5.8	4.3	6.5	6.5	6.0	5.3	4.7	2.9	6.7	7.0	6.8	
Ratio 1:1	IPW 3	(-0.3)	(-0.7)	(-1.3)	(-0.1)	(-0.1)	(0.2)	(-0.8)	(-1.5)	(-2.5)	(0.5)	(0.8)	(1.5)	
		DR	1.9	3.1	3.5	1.9	3.1	3.6	1.8	3.0	3.4	1.7	2.7	2.8
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(-0.1)	(-0.3)	(-0.5)	
	IPW 1	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
		4.6	8.1	10.2	2.1	5.6	6.9	2.0	5.8	8.2	1.4	6.5	9.0	
(-0.1)		(0.0)	(0.1)	(-1.4)	(-1.6)	(-2.4)	(-0.1)	(0.0)	(0.0)	(-1.0)	(-0.4)	(-0.6)		
Ratio 3:2	IPW 2	2.1	2.8	2.8	2.6	3.8	4.8	1.6	1.7	0.8	2.9	4.3	5.8	
		(-0.4)	(-0.9)	(-2.0)	(-0.1)	(-0.1)	(0.1)	(-1.0)	(-2.0)	(-3.9)	(0.4)	(0.7)	(1.5)	
		IPW 3	2.0	2.1	1.7	2.3	2.6	2.7	1.6	1.5	0.9	2.5	3.0	3.3
	DR	(-0.2)	(-0.4)	(-0.8)	(-0.1)	(0.0)	(0.1)	(-0.5)	(-1.0)	(-1.6)	(0.3)	(0.5)	(0.9)	
		0.9	2.0	2.3	1.0	2.0	2.3	0.9	1.9	2.3	0.9	1.8	1.9	
Ratio 3:2	IPW 1	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.2)	(-0.3)	
		homogeneous, homoscedastic						heterogeneous, homoscedastic						
		6.9	9.7	12.7	4.7	7.7	10.8	3.4	7.0	11.0	4.9	9.5	13.4	
	IPW 2	(0.0)	(0.0)	(-0.2)	(-1.0)	(-1.3)	(-1.3)	(-0.1)	(0.1)	(0.2)	(0.6)	(0.6)	(1.0)	
		6.5	6.5	7.6	7.0	6.9	8.1	6.4	6.5	7.3	7.6	7.9	9.6	
Ratio 3:2	IPW 3	(-0.4)	(-0.5)	(-1.1)	(-0.2)	(-0.5)	(-0.6)	(-0.3)	(-0.3)	(-1.1)	(0.8)	(1.0)	(1.4)	
		5.3	4.9	4.6	5.7	5.0	4.6	5.3	5.0	4.7	6.1	5.6	5.6	
		(-0.2)	(-0.2)	(-0.4)	(-0.1)	(-0.3)	(-0.3)	(-0.1)	(0.1)	(-0.1)	(0.6)	(0.7)	(1.0)	
	DR	1.5	1.8	2.8	1.5	1.9	2.8	1.5	1.8	2.7	1.4	1.7	2.6	
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.2)	
Ratio 3:2	IPW 1	homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
		4.0	5.4	7.6	2.7	4.4	6.2	1.9	4.0	6.6	2.9	5.8	8.2	
		(0.0)	(0.0)	(-0.1)	(-0.6)	(-0.8)	(-0.8)	(-0.1)	(0.0)	(0.1)	(0.4)	(0.5)	(0.7)	
	IPW 2	2.1	2.1	3.4	2.4	2.4	3.5	2.2	2.1	3.2	2.8	3.1	4.5	
		(-0.3)	(-0.3)	(-0.7)	(-0.1)	(-0.3)	(-0.4)	(-0.2)	(-0.2)	(-0.7)	(0.5)	(0.6)	(0.9)	
Ratio 2:3	IPW 3	1.8	1.7	2.0	2.0	1.8	1.9	1.9	1.8	2.1	2.3	2.2	2.6	
		(-0.2)	(-0.1)	(-0.2)	(-0.1)	(-0.1)	(-0.2)	(-0.1)	(0.1)	(-0.1)	(0.4)	(0.5)	(0.6)	
		DR	0.9	1.0	1.7	0.9	1.0	1.7	0.9	1.0	1.6	0.9	0.9	1.5
	IPW 1	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)	
		homogeneous, homoscedastic						heterogeneous, homoscedastic						
6.2		9.3	10.7	2.2	4.8	5.2	3.3	7.1	9.5	-0.4	2.8	3.4		
Ratio 2:3	IPW 2	(-0.3)	(-0.6)	(-1.0)	(-2.1)	(-3.3)	(-5.7)	(-0.2)	(-0.2)	(-0.4)	(-2.6)	(-3.8)	(-7.0)	
		5.9	6.8	6.4	6.4	7.7	7.9	4.4	4.6	3.0	6.5	7.9	8.1	
		(-0.5)	(-0.8)	(-1.5)	(0.0)	(0.0)	(0.0)	(-1.8)	(-3.0)	(-4.6)	(0.2)	(0.3)	(0.5)	
	IPW 3	5.0	5.1	4.1	5.3	5.6	4.9	3.8	3.6	2.4	5.4	5.6	5.1	
		(-0.3)	(-0.4)	(-0.7)	(0.0)	(0.0)	(0.1)	(-1.2)	(-1.7)	(-2.2)	(0.1)	(0.2)	(0.4)	
Ratio 2:3	DR	1.2	2.1	2.8	1.2	2.1	2.7	1.2	2.1	2.8	1.2	1.9	2.3	
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(-0.1)	(-0.2)	(-0.3)	
		homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	3.8	6.4	7.8	1.5	3.7	4.5	2.1	5.2	7.2	-0.3	2.5	3.4	
		(-0.2)	(-0.4)	(-0.7)	(-1.3)	(-2.1)	(-3.8)	(-0.1)	(-0.1)	(-0.3)	(-1.7)	(-2.6)	(-4.9)	
Ratio 2:3	IPW 2	1.6	2.4	2.7	1.9	3.0	3.6	0.8	1.1	0.6	2.0	3.1	3.8	
		(-0.3)	(-0.5)	(-0.9)	(0.0)	(0.0)	(0.0)	(-1.1)	(-1.8)	(-2.8)	(0.1)	(0.2)	(0.3)	
	IPW 3	1.7	2.0	1.8	1.9	2.3	2.3	1.0	1.2	0.8	2.0	2.4	2.4	
		(-0.2)	(-0.2)	(-0.4)	(0.0)	(0.0)	(0.0)	(-0.7)	(-1.0)	(-1.4)	(0.1)	(0.1)	(0.2)	
DR	0.6	1.3	1.8	0.6	1.3	1.7	0.6	1.3	1.9	0.6	1.2	1.5		
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.1)	(-0.2)		

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.39: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 1 instead of the conventional propensity scores used with trimming rule 2, fixed λ

		linear						nonlinear		linear		nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500	
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	4.4 (-0.2)	10.6 (0.0)	7.9 (0.1)	-2.7 (-2.8)	6.6 (-2.6)	5.4 (-3.9)	-9.1 (-0.4)	1.7 (0.0)	2.2 (0.0)	-3.7 (-0.4)	10.0 (1.8)	14.0 (3.8)	
	IPW 2	4.4 (-0.7)	3.2 (-1.6)	-0.8 (-3.6)	5.1 (-0.3)	4.6 (-0.2)	3.1 (0.2)	2.2 (-1.7)	0.2 (-3.6)	-4.8 (-7.0)	5.4 (0.8)	5.9 (2.6)	9.7 (8.2)	
	IPW 3	-0.8 (-0.4)	-0.8 (-0.7)	-3.6 (-1.6)	-0.4 (-0.2)	-0.3 (-0.1)	-2.0 (0.2)	-2.9 (-1.0)	-2.8 (-1.7)	-5.5 (-2.9)	-0.2 (0.5)	0.7 (2.0)	4.1 (7.0)	
	DR	-6.0 (0.0)	-2.8 (0.0)	-3.9 (0.0)	-5.8 (0.0)	-3.2 (0.0)	-4.6 (0.0)	-6.9 (0.0)	-3.4 (0.0)	-4.4 (0.0)	-6.2 (-0.4)	-3.3 (0.5)	-0.6 (4.5)	
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	1.4 (-0.1)	8.2 (0.0)	6.5 (0.1)	-2.9 (-1.7)	6.2 (-1.5)	5.2 (-2.4)	-7.1 (-0.2)	3.2 (0.0)	3.4 (0.0)	-3.5 (-0.1)	8.6 (1.3)	11.0 (2.9)	
	IPW 2	-1.6 (-0.5)	0.5 (-1.0)	-0.7 (-2.2)	-1.1 (-0.1)	1.7 (-0.1)	1.8 (0.1)	-3.0 (-1.1)	-0.8 (-2.2)	-2.6 (-4.2)	-0.7 (0.5)	2.3 (1.5)	5.7 (5.1)	
	IPW 3	-3.4 (-0.2)	-0.8 (-0.5)	-1.3 (-1.0)	-3.1 (-0.1)	-0.2 (0.0)	-0.1 (0.1)	-4.9 (-0.6)	-1.4 (-1.0)	-2.0 (-1.8)	-2.9 (0.3)	0.1 (1.2)	3.2 (4.3)	
	DR	-5.3 (0.0)	-0.4 (0.0)	-0.4 (0.0)	-5.3 (0.0)	-0.7 (0.0)	-0.7 (0.0)	-6.0 (0.0)	-0.3 (0.0)	-0.1 (0.0)	-5.5 (-0.2)	-1.0 (0.3)	1.3 (2.8)	
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	1.6 (0.0)	7.6 (0.0)	5.6 (-0.2)	-3.0 (-1.1)	5.0 (-1.4)	4.8 (-1.4)	-9.3 (0.5)	1.9 (1.3)	5.6 (3.6)	-1.8 (1.6)	9.5 (3.0)	13.6 (6.9)	
	IPW 2	1.2 (-0.5)	3.7 (-0.6)	0.8 (-1.2)	1.7 (-0.2)	3.7 (-0.6)	0.1 (-0.7)	1.0 (0.5)	4.9 (1.2)	4.8 (2.4)	2.5 (1.3)	5.9 (3.3)	7.2 (8.3)	
	IPW 3	-2.6 (-0.3)	0.6 (-0.2)	-2.7 (-0.4)	-2.2 (-0.2)	0.3 (-0.3)	-3.3 (-0.3)	-3.2 (0.5)	1.7 (1.4)	1.5 (3.3)	-1.4 (1.0)	2.3 (2.9)	3.5 (7.8)	
	DR	-6.9 (0.0)	-2.5 (-0.1)	-4.9 (0.0)	-6.7 (0.0)	-2.5 (-0.1)	-5.1 (0.0)	-7.0 (0.6)	-1.0 (1.3)	-0.5 (3.7)	-6.2 (0.2)	-1.1 (2.0)	0.8 (6.6)	
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	-0.8 (0.0)	5.4 (0.0)	5.4 (-0.1)	-3.5 (-0.6)	4.1 (-0.8)	5.3 (-0.8)	-7.4 (0.3)	2.1 (0.7)	5.6 (2.3)	-2.6 (1.1)	7.2 (2.1)	11.2 (4.5)	
	IPW 2	-3.2 (-0.3)	1.7 (-0.3)	1.1 (-0.7)	-2.9 (-0.1)	1.9 (-0.3)	1.1 (-0.4)	-3.3 (0.2)	2.4 (0.6)	3.5 (1.5)	-2.4 (0.8)	3.2 (2.1)	5.2 (5.1)	
	IPW 3	-4.9 (-0.2)	0.8 (-0.1)	-0.1 (-0.2)	-4.7 (-0.1)	0.7 (-0.2)	-0.2 (0.2)	-5.3 (0.2)	1.4 (0.7)	2.3 (2.0)	-4.3 (0.6)	1.8 (1.8)	3.7 (4.8)	
	DR	-5.8 (0.0)	0.2 (0.0)	0.1 (0.0)	-5.7 (0.0)	0.2 (0.0)	-0.1 (0.0)	-5.9 (0.3)	1.1 (0.7)	2.7 (2.2)	-5.6 (0.1)	1.0 (1.3)	3.0 (4.2)	
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic						
	IPW 1	2.6 (-0.6)	7.4 (-0.6)	4.7 (-1.1)	-4.8 (-2.9)	2.0 (-3.4)	0.6 (-5.9)	-7.3 (0.3)	1.9 (1.5)	4.8 (3.1)	-9.8 (-2.7)	-0.5 (-3.0)	0.4 (-6.1)	
	IPW 2	2.3 (-0.5)	4.1 (-0.9)	0.0 (-1.7)	3.1 (0.0)	5.0 (0.0)	2.5 (0.0)	0.1 (-1.8)	2.6 (-2.1)	-0.3 (-2.0)	2.9 (-0.2)	4.8 (0.1)	2.8 (0.5)	
	IPW 3	-1.6 (-0.3)	0.6 (-0.4)	-2.5 (-0.9)	-1.0 (0.0)	1.0 (0.0)	-1.0 (0.0)	-3.4 (-0.9)	0.2 (-0.3)	-0.8 (0.8)	-1.3 (-0.2)	0.8 (0.0)	-0.8 (0.2)	
	DR	-6.4 (0.0)	-2.4 (0.0)	-3.4 (0.0)	-6.2 (0.0)	-2.4 (0.0)	-3.3 (-0.1)	-6.9 (0.4)	-1.6 (1.4)	-0.3 (3.3)	-6.7 (-0.6)	-3.0 (-0.5)	-3.9 (-0.7)	
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic						
	IPW 1	-0.9 (-0.3)	6.8 (-0.3)	3.6 (-0.7)	-5.3 (-1.7)	3.7 (-2.1)	0.8 (-3.9)	-7.2 (0.3)	3.9 (1.0)	3.8 (1.9)	-8.7 (-1.7)	2.2 (-2.0)	0.4 (-4.3)	
	IPW 2	-4.1 (-0.3)	1.0 (-0.5)	-1.6 (-1.0)	-3.4 (0.0)	1.5 (0.0)	-0.4 (0.0)	-5.6 (-1.1)	0.3 (-1.2)	-1.5 (-1.2)	-3.5 (-0.1)	1.4 (0.1)	-0.1 (0.3)	
	IPW 3	-5.5 (-0.2)	-0.2 (-0.2)	-2.4 (-0.5)	-4.9 (0.0)	0.0 (0.0)	-1.6 (0.0)	-6.7 (-0.5)	-0.2 (-0.2)	-1.2 (0.5)	-5.1 (-0.1)	-0.2 (0.0)	-1.5 (0.1)	
	DR	-7.8 (0.0)	-0.9 (0.0)	-2.1 (0.0)	-7.7 (0.0)	-1.0 (0.0)	-2.0 (-0.1)	-8.3 (0.3)	-0.1 (0.9)	-0.2 (1.9)	-8.0 (-0.4)	-1.5 (-0.3)	-2.4 (-0.5)	

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$ is given in brackets.

Table A.40: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores used with trimming rule by HLW, fixed λ

		linear			nonlinear			linear			nonlinear		
N		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	6.4 (-0.2)	-18.7 (7.6)	-0.3 (0.5)	43.1 (60.7)	28.5 (40.7)	11.8 (12.2)	3.7 (39.5)	-14.4 (14.5)	-7.2 (1.6)	69.2 (74.2)	54.2 (57.7)	28.0 (26.2)
	IPW 2	6.2 (-0.6)	22.0 (1.0)	30.8 (-2.6)	60.4 (52.1)	55.6 (26.3)	49.8 (7.5)	34.1 (24.2)	38.2 (1.8)	40.3 (-4.1)	80.8 (65.4)	74.1 (37.0)	64.9 (11.9)
	IPW 3	4.9 (-0.3)	-7.9 (3.0)	7.5 (-1.6)	55.4 (59.7)	40.7 (35.4)	23.5 (7.5)	21.7 (33.8)	5.7 (5.9)	9.2 (-2.7)	79.1 (72.5)	65.4 (49.1)	39.0 (11.7)
	DR	0.2 (0.0)	8.3 (0.1)	9.3 (-0.1)	20.1 (0.0)	8.4 (0.0)	10.3 (0.1)	18.8 (0.0)	7.8 (0.3)	8.0 (0.2)	22.4 (2.1)	8.5 (0.1)	7.7 (-2.7)
Ratio 1:1		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-29.1 (16.8)	-21.5 (4.6)	-3.1 (0.3)	26.8 (49.1)	14.6 (30.2)	5.7 (8.3)	-9.3 (28.4)	-18.2 (9.3)	-6.7 (1.0)	58.5 (67.0)	41.4 (48.6)	19.2 (19.5)
	IPW 2	-10.6 (10.5)	4.0 (0.6)	16.0 (-1.9)	41.3 (42.4)	36.4 (20.9)	32.8 (5.7)	13.7 (17.7)	19.3 (1.3)	25.3 (-3.2)	68.8 (58.9)	59.6 (32.4)	49.5 (9.8)
	IPW 3	-23.2 (13.8)	-17.2 (1.8)	-0.7 (-1.1)	36.2 (47.9)	22.1 (26.5)	10.8 (5.1)	2.7 (23.8)	-7.2 (3.9)	1.0 (-1.9)	67.0 (65.1)	49.4 (41.3)	24.0 (8.6)
	DR	25.4 (0.0)	2.0 (0.1)	1.7 (-0.1)	25.7 (0.0)	2.3 (0.0)	2.1 (0.1)	24.9 (0.0)	1.8 (0.2)	1.2 (0.1)	26.8 (1.2)	2.5 (0.0)	0.2 (-1.9)
Ratio 3:2		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	-33.9 (16.4)	-6.2 (17.4)	11.5 (6.3)	-41.6 (0.1)	-31.4 (-2.0)	2.2 (-1.3)	-47.1 (6.1)	-17.9 (13.5)	6.4 (5.8)	4.0 (17.7)	-20.7 (2.1)	4.4 (-0.3)
	IPW 2	-2.0 (14.4)	16.3 (14.1)	18.9 (5.1)	4.9 (1.1)	11.7 (-0.5)	17.0 (-0.5)	7.5 (6.1)	22.9 (10.6)	23.4 (4.4)	39.1 (13.0)	28.4 (1.3)	24.4 (-0.2)
	IPW 3	-16.1 (16.7)	5.7 (18.9)	10.9 (7.1)	-15.0 (1.1)	-12.4 (-0.2)	1.8 (0.1)	-11.5 (7.6)	7.3 (16.3)	11.5 (7.4)	26.3 (14.8)	1.1 (0.1)	2.1 (-0.5)
	DR	32.5 (0.0)	12.8 (0.4)	10.8 (0.3)	33.8 (1.8)	13.6 (1.0)	10.8 (0.2)	31.6 (-0.1)	12.1 (0.1)	10.3 (0.1)	31.8 (-0.8)	11.0 (-1.3)	7.8 (-2.1)
Ratio 3:2		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-23.5 (9.0)	-4.4 (10.1)	7.3 (4.1)	-27.8 (0.1)	-17.4 (-1.0)	0.7 (-0.8)	-31.1 (3.5)	-10.6 (7.8)	4.4 (3.8)	-1.3 (11.7)	-12.2 (1.2)	1.8 (-0.2)
	IPW 2	-7.2 (8.5)	7.7 (8.8)	11.1 (3.4)	-3.1 (0.7)	4.4 (-0.3)	8.8 (-0.3)	-0.8 (3.8)	12.6 (6.9)	14.8 (3.0)	23.1 (9.1)	16.5 (0.9)	14.1 (-0.1)
	IPW 3	-14.8 (9.5)	2.3 (11.3)	6.3 (4.6)	-14.3 (0.6)	-8.2 (-0.1)	0.1 (0.1)	-12.1 (4.4)	3.5 (9.9)	7.2 (4.8)	13.1 (9.9)	-0.6 (0.0)	0.0 (-0.3)
	DR	-3.8 (0.0)	-5.2 (0.3)	2.4 (0.2)	-1.9 (1.6)	-4.5 (0.7)	2.4 (0.1)	-4.3 (-0.1)	-5.4 (0.1)	2.4 (0.0)	-4.0 (-0.9)	-6.7 (-1.0)	0.0 (-1.5)
Ratio 2:3		homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	55.1 (68.0)	35.2 (43.3)	15.2 (12.1)	74.4 (79.1)	58.6 (60.6)	26.2 (22.8)	64.6 (72.9)	42.3 (50.0)	15.0 (16.1)	84.6 (84.5)	72.4 (70.1)	38.9 (34.4)
	IPW 2	59.3 (62.2)	45.8 (30.6)	33.3 (5.8)	81.1 (75.5)	70.6 (48.3)	53.5 (16.1)	70.9 (65.9)	56.7 (31.7)	41.7 (4.1)	90.8 (81.4)	83.9 (55.8)	70.2 (21.2)
	IPW 3	58.4 (66.4)	38.3 (38.5)	17.2 (6.5)	80.6 (78.9)	66.9 (57.2)	37.3 (17.1)	70.5 (70.9)	48.9 (42.7)	20.5 (6.0)	90.7 (84.3)	81.7 (65.9)	54.8 (24.1)
	DR	33.7 (0.0)	11.8 (0.2)	7.5 (0.0)	35.1 (1.3)	12.5 (0.9)	8.2 (0.5)	33.3 (0.2)	12.1 (0.9)	6.8 (0.3)	40.5 (8.6)	16.0 (4.4)	8.4 (0.4)
Ratio 2:3		homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	35.4 (58.1)	18.2 (32.9)	6.0 (8.2)	62.8 (73.1)	44.8 (51.7)	15.9 (16.8)	49.5 (65.2)	26.7 (40.0)	6.6 (11.2)	78.4 (81.3)	63.2 (64.2)	29.0 (27.7)
	IPW 2	37.5 (52.2)	26.0 (23.6)	17.2 (4.1)	68.1 (69.2)	54.8 (41.5)	36.4 (12.6)	53.7 (58.2)	38.7 (25.9)	25.4 (3.1)	83.9 (77.9)	73.7 (51.3)	55.7 (18.1)
	IPW 3	36.5 (56.0)	19.1 (29.0)	5.7 (4.3)	67.8 (72.6)	50.7 (48.6)	22.1 (12.4)	53.3 (62.8)	30.4 (33.8)	8.5 (4.1)	83.9 (80.9)	70.9 (60.1)	39.3 (19.0)
	DR	53.0 (0.0)	13.7 (0.1)	3.2 (0.0)	53.3 (0.6)	14.3 (0.6)	3.8 (0.3)	52.7 (0.1)	13.7 (0.5)	2.9 (0.1)	54.9 (3.7)	16.3 (2.6)	4.1 (0.3)

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.41: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores, mse-minizing λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500							
Ratio 1:1	IPW 1	42.3	homogeneous, homoscedastic				heterogeneous, homoscedastic				62.6	65.6	39.2	62.0	34.3	59.6	63.1	45.0	67.5	67.2	
		(-0.1)	(0.0)	(0.0)	(-1.5)	(-0.9)	(-1.4)	(-0.2)	(0.0)	(0.0)	(-0.7)	(-0.3)	(-0.9)								
		13.9	27.7	36.8	14.7	29.8	39.1	13.2	26.7	37.1	13.6	27.9	36.8								
		(-0.3)	(-1.1)	(-2.2)	(-0.2)	(0.0)	(0.0)	(-0.8)	(-2.4)	(-3.9)	(-0.4)	(-0.6)	(-1.2)								
		0.3	13.7	16.9	1.3	15.1	19.4	-1.6	12.3	15.9	0.1	12.8	16.0								
Ratio 1:1	IPW 2	(0.0)	(-0.5)	(-1.1)	(-0.1)	(0.2)	(0.0)	(-0.1)	(-1.1)	(-1.8)	(-0.6)	(-1.1)	(-2.5)								
		2.1	17.5	21.1	3.3	18.0	22.8	1.4	17.4	21.0	3.1	15.9	19.6								
		(0.0)	(0.2)	(-0.1)	(0.0)	(0.0)	(-0.2)	(0.1)	(0.3)	(0.0)	(-1.5)	(-2.5)	(-4.2)								
		homogeneous, heteroscedastic				heterogeneous, heteroscedastic				49.2	52.6	25.7	50.0	49.4	21.2	47.7	51.3	33.3	57.5	56.3	
		(-0.1)	(0.0)	(0.0)	(-1.1)	(-0.7)	(-1.1)	(-0.1)	(0.0)	(0.0)	(-0.5)	(-0.2)	(-0.7)								
Ratio 3:2	IPW 2	0.2	14.9	21.2	1.1	16.3	22.5	-0.2	14.8	23.2	0.5	14.9	20.4								
		(-0.3)	(-0.9)	(-1.9)	(-0.1)	(0.0)	(0.0)	(-0.6)	(-1.8)	(-3.2)	(-0.3)	(-0.5)	(-1.0)								
		-7.9	4.6	4.7	-7.0	5.6	6.8	-9.3	4.0	5.0	-7.6	4.0	4.1								
		(0.0)	(-0.4)	(-0.9)	(0.0)	(0.2)	(0.0)	(-0.1)	(-0.9)	(-1.4)	(-0.4)	(-0.8)	(-1.9)								
		-5.6	8.1	8.2	-4.8	8.6	10.3	-6.2	8.2	8.6	-4.8	7.2	8.2								
Ratio 3:2	IPW 3	(0.0)	(0.1)	(-0.1)	(0.0)	(0.0)	(-0.2)	(0.1)	(0.2)	(0.0)	(-1.0)	(-1.8)	(-3.2)								
		homogeneous, homoscedastic				heterogeneous, homoscedastic				35.2	85.7	43.8	25.4	68.0	41.3	26.5	84.1	40.8	27.8	67.8	45.8
		(0.0)	(0.0)	(-0.1)	(-0.9)	(-0.5)	(-0.9)	(-0.1)	(0.0)	(-0.2)	(0.0)	(0.0)	(-0.2)	(-0.1)	(-0.3)						
		12.2	23.1	28.9	13.4	23.9	31.6	10.9	22.5	28.9	12.2	22.5	30.3								
		(-0.4)	(-0.5)	(-0.9)	(-0.1)	(-0.4)	(-0.3)	(-0.3)	(-0.4)	(-1.1)	(-0.3)	(-0.2)	(-0.1)								
Ratio 3:2	DR	2.7	12.6	16.4	3.8	13.0	17.2	0.9	11.7	16.2	2.7	11.4	15.5								
		(-0.2)	(-0.1)	(-0.4)	(0.0)	(-0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(-0.3)	(-0.5)	(-0.3)	(-0.3)							
		3.6	12.9	18.8	4.1	13.4	19.6	2.4	12.4	18.2	2.9	11.6	17.8								
		(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.1)	(-0.2)	(-0.3)	(0.0)	(-1.6)	(-1.5)	(-1.8)								
		homogeneous, heteroscedastic				heterogeneous, heteroscedastic				20.9	77.4	31.9	13.1	54.5	29.8	15.0	76.0	30.1	15.7	54.8	34.1
Ratio 2:3	IPW 1	(0.0)	(0.0)	(-0.1)	(-0.6)	(-0.4)	(-0.6)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-0.1)	(-0.1)	(-0.1)							
		0.3	8.8	17.8	1.1	9.8	19.9	-0.1	8.9	18.0	0.1	8.7	18.6								
		(-0.3)	(-0.4)	(-0.8)	(-0.1)	(-0.2)	(-0.2)	(-0.2)	(-0.4)	(-0.9)	(-0.2)	(-0.2)	(-0.1)								
		-5.7	1.7	9.1	-5.0	2.3	9.5	-6.5	1.6	9.2	-6.0	1.1	7.9								
		(-0.1)	(-0.1)	(-0.3)	(0.0)	(-0.1)	(0.1)	(0.0)	(0.0)	(-0.2)	(-0.3)	(-0.3)	(-0.3)								
Ratio 2:3	IPW 2	-4.7	2.2	11.3	-4.3	2.7	11.6	-5.1	2.1	11.2	-5.3	1.4	9.9								
		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(-0.1)	(-0.1)	(0.0)	(-1.2)	(-1.2)	(-1.4)								
		homogeneous, homoscedastic				heterogeneous, homoscedastic				62.9	52.8	40.6	66.0	55.1	41.8	60.0	50.4	38.9	69.5	59.5	49.2
		(-0.2)	(-0.3)	(-0.4)	(-0.9)	(-1.7)	(-3.4)	(0.0)	(-0.1)	(-0.1)	(-0.8)	(-1.7)	(-3.8)								
		11.2	21.6	26.6	12.4	23.1	27.5	9.9	20.1	26.3	12.2	22.5	27.1								
Ratio 2:3	IPW 3	(-0.4)	(-0.7)	(-1.3)	(-0.1)	(0.0)	(0.2)	(-2.1)	(-3.0)	(-4.1)	(-0.3)	(-0.4)	(-0.4)								
		0.7	10.2	11.0	1.8	11.3	13.1	-1.5	8.4	9.3	1.6	10.6	12.2								
		(-0.1)	(-0.3)	(-0.8)	(0.0)	(0.0)	(0.1)	(-1.4)	(-1.8)	(-2.7)	(-0.3)	(-0.5)	(-0.8)								
		1.5	12.0	14.0	2.4	12.5	15.2	1.0	12.1	14.0	3.0	12.2	14.6								
		(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.2)	(-0.5)	(-0.9)	(-1.6)								
Ratio 2:3	DR	homogeneous, heteroscedastic				heterogeneous, heteroscedastic				48.9	40.3	26.9	54.5	44.2	29.6	47.4	39.2	26.3	60.7	50.4	38.7
		(-0.1)	(-0.2)	(-0.2)	(-0.7)	(-1.2)	(-2.5)	(0.0)	(-0.1)	(0.0)	(-0.6)	(-1.3)	(-3.1)								
		-1.3	11.5	13.0	-0.5	12.3	13.8	-2.2	10.7	13.8	-0.6	11.9	13.6								
		(-0.3)	(-0.6)	(-1.0)	(0.0)	(0.0)	(0.1)	(-1.5)	(-2.1)	(-3.1)	(-0.2)	(-0.3)	(-0.4)								
		-6.8	4.1	1.3	-6.2	4.7	3.0	-8.4	3.1	0.6	-6.3	4.3	2.6								
Ratio 2:3	IPW 3	(-0.1)	(-0.3)	(-0.6)	(0.0)	(0.0)	(0.0)	(-0.9)	(-1.3)	(-2.0)	(-0.2)	(-0.4)	(-0.6)								
		-4.3	6.6	4.2	-3.9	6.8	5.7	-4.7	6.6	4.2	-3.5	6.7	5.7								
		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(-0.1)	(0.1)	(0.0)	(0.1)	(-0.4)	(-0.7)	(-1.2)								

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.42: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores with trimming rule 1, mse-minimizing λ

N		100	linear			nonlinear			100	linear			nonlinear		
			200	500		100	200	500		200	500		100	200	500
Ratio 1:1	IPW 1	homogeneous, homoscedastic													
		8.2	14.7	15.3	4.2	10.2	12.2	4.2	11.7	13.3	3.5	9.2	16.2		
		(-0.2)	(0.1)	(0.0)	(-2.4)	(-2.2)	(-3.5)	(-0.3)	(0.0)	(-0.1)	(-1.6)	(-1.3)	(-0.9)		
		7.1	9.5	8.7	7.9	11.5	12.4	6.0	8.1	7.6	8.6	11.1	12.5		
		(-0.7)	(-1.5)	(-3.2)	(-0.2)	(0.0)	(0.0)	(-1.6)	(-3.4)	(-5.8)	(0.9)	(0.4)	(1.1)		
Ratio 1:1	IPW 2	homogeneous, homoscedastic													
		5.6	7.0	6.0	6.1	8.1	7.8	4.8	6.7	6.0	6.6	7.4	7.2		
		(-0.4)	(-0.7)	(-1.5)	(-0.2)	(0.1)	(0.0)	(-0.9)	(-1.6)	(-2.5)	(0.7)	(0.0)	(0.1)		
		0.6	4.6	5.6	0.6	4.4	5.7	1.0	5.5	6.6	0.7	2.7	3.4		
		(0.0)	(0.1)	(-0.1)	(0.0)	(0.1)	(-0.2)	(0.0)	(0.1)	(-0.1)	(0.1)	(-1.3)	(-1.9)		
Ratio 1:1	IPW 3	homogeneous, heteroscedastic													
		7.4	9.7	8.7	5.0	7.2	7.5	4.7	8.2	8.9	4.3	6.6	10.8		
		(-0.1)	(0.1)	(0.0)	(-1.4)	(-1.3)	(-2.1)	(-0.1)	(0.1)	(0.0)	(-1.0)	(-0.8)	(-0.4)		
		5.2	4.3	0.8	5.9	5.6	3.4	4.5	3.7	1.2	6.3	5.3	2.9		
		(-0.4)	(-1.1)	(-2.3)	(-0.1)	(0.0)	(0.0)	(-1.0)	(-2.3)	(-4.2)	(0.4)	(0.1)	(0.5)		
Ratio 3:2	IPW 1	homogeneous, homoscedastic													
		5.6	14.1	14.0	3.3	10.9	11.9	1.0	10.9	12.6	4.0	11.8	13.7		
		(0.0)	(0.0)	(-0.2)	(-1.2)	(-1.5)	(-1.3)	(-0.1)	(-0.1)	(0.3)	(0.4)	(0.7)	(0.7)		
		5.9	11.2	9.5	6.9	10.4	10.0	5.0	11.1	10.2	8.0	11.1	10.7		
		(-0.6)	(-0.6)	(-1.2)	(-0.2)	(-0.5)	(-0.5)	(-0.5)	(-0.5)	(-1.1)	(0.8)	(1.2)	(1.0)		
Ratio 3:2	IPW 2	homogeneous, heteroscedastic													
		5.4	9.6	6.7	6.1	8.8	6.9	4.6	9.8	7.7	7.0	9.1	7.1		
		(-0.3)	(-0.2)	(-0.4)	(-0.2)	(-0.3)	(-0.2)	(-0.2)	(0.0)	(0.0)	(0.6)	(0.9)	(0.6)		
		1.9	5.4	5.0	1.9	5.5	5.2	1.4	5.6	5.6	2.1	5.1	4.2		
		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(0.0)	(-0.1)	(0.2)	(-0.1)	(0.1)	(-0.6)		
Ratio 2:3	IPW 1	homogeneous, homoscedastic													
		5.9	8.8	9.2	4.3	7.0	7.5	3.4	7.6	8.5	4.4	7.4	8.2		
		(0.0)	(0.0)	(-0.2)	(-0.7)	(-0.8)	(-0.7)	(-0.1)	(0.0)	(0.2)	(0.3)	(0.5)	(0.5)		
		4.5	5.5	5.7	4.8	5.0	5.6	4.4	6.1	6.3	5.1	5.1	5.5		
		(-0.4)	(-0.5)	(-0.9)	(-0.1)	(-0.2)	(-0.2)	(-0.3)	(-0.4)	(-0.8)	(0.4)	(0.6)	(0.5)		
Ratio 2:3	IPW 2	homogeneous, heteroscedastic													
		4.3	5.1	4.2	4.6	4.6	4.2	4.2	5.8	5.0	4.8	4.5	3.8		
		(-0.2)	(-0.2)	(-0.3)	(-0.1)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-0.1)	(0.3)	(0.4)	(0.3)		
		3.6	3.5	3.9	3.6	3.7	3.9	3.6	4.0	4.4	3.3	3.2	2.8		
		(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.2)	(-0.2)	(-0.2)	(-0.6)		
Ratio 2:3	IPW 3	homogeneous, homoscedastic													
		6.0	9.8	7.5	1.6	4.3	3.3	3.5	7.8	7.0	-1.0	0.9	2.5		
		(-0.5)	(-0.6)	(-1.2)	(-2.7)	(-3.6)	(-6.2)	(-0.2)	(-0.3)	(-0.8)	(-3.2)	(-4.5)	(-7.9)		
		5.4	8.0	5.6	6.0	9.0	8.9	4.1	6.2	3.4	6.2	8.8	9.2		
		(-0.5)	(-1.0)	(-1.7)	(-0.1)	(0.0)	(0.0)	(-2.1)	(-3.5)	(-5.2)	(0.4)	(0.1)	(0.1)		
Ratio 2:3	IPW 1	homogeneous, heteroscedastic													
		4.6	6.0	3.4	5.2	6.6	5.7	3.8	5.2	2.3	5.3	6.4	5.8		
		(-0.3)	(-0.5)	(-0.9)	(0.0)	(0.0)	(0.0)	(-1.4)	(-2.0)	(-2.7)	(0.3)	(0.0)	(-0.2)		
		0.3	2.5	2.6	0.4	2.7	3.6	0.9	3.0	2.8	0.4	2.2	3.2		
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.1)	(-0.1)	(-0.2)	(0.1)	(-0.4)	(-1.0)		
Ratio 2:3	IPW 2	homogeneous, homoscedastic													
		4.6	8.4	4.7	1.7	4.9	3.0	2.6	7.1	5.3	-0.4	2.4	3.3		
		(-0.2)	(-0.3)	(-0.6)	(-1.5)	(-2.2)	(-3.8)	(-0.1)	(-0.1)	(-0.4)	(-2.1)	(-2.9)	(-5.2)		
		2.7	4.8	-1.1	3.2	5.2	1.3	1.7	3.8	-2.1	3.3	5.1	1.4		
		(-0.4)	(-0.6)	(-1.2)	(0.0)	(0.0)	(0.0)	(-1.3)	(-2.2)	(-3.5)	(0.1)	(0.0)	(-0.1)		
Ratio 2:3	IPW 3	homogeneous, heteroscedastic													
		3.0	4.1	-1.6	3.3	4.3	0.1	2.1	3.6	-1.7	3.4	4.2	0.1		
		(-0.2)	(-0.3)	(-0.6)	(0.0)	(0.0)	(0.0)	(-0.9)	(-1.3)	(-1.9)	(0.1)	(0.0)	(-0.2)		
		2.1	3.5	-0.8	2.1	3.7	-0.1	2.2	3.7	-0.1	2.0	3.4	-0.6		
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)	(-0.1)	(-0.2)	(0.0)	(-0.4)	(-0.8)		

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.43: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores used with trimming rule 2, mse-minizing λ

N		100	linear			nonlinear			100	linear			nonlinear		
			200	500		100	200	500		200	500		100	200	500
Ratio 1:1	IPW 1	homogeneous, homoscedastic													
		3.1	10.9	8.9	-3.9	6.2	6.8	-10.1		2.1	3.5	-4.3	7.6	15.1	
		(-0.2)	(0.0)	(0.1)	(-2.9)	(-2.7)	(-3.6)	(-0.4)		(-0.1)	(0.0)	(-0.4)	(0.4)	(3.8)	
		1.7	6.3	2.7	2.7	8.3	6.3	-0.2		4.0	0.0	3.1	8.3	12.0	
		(-0.8)	(-1.5)	(-3.4)	(-0.3)	(-0.1)	(0.1)	(-1.9)		(-3.5)	(-6.3)	(1.0)	(1.4)	(7.3)	
Ratio 1:1	IPW 2	heterogeneous, homoscedastic													
		-3.4	2.5	-0.2	-2.7	3.6	1.4	-5.2		1.1	-1.3	-2.5	3.3	6.7	
		(-0.4)	(-0.7)	(-1.5)	(-0.2)	(0.0)	(0.1)	(-1.0)		(-1.7)	(-2.7)	(0.8)	(0.8)	(6.2)	
		-9.0	0.6	-0.3	-8.9	0.5	-0.5	-9.3		0.7	-0.4	-9.3	-1.0	2.9	
		(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.0)		(0.1)	(0.0)	(-0.2)	(-0.7)	(3.9)	
Ratio 1:1	IPW 1	homogeneous, heteroscedastic													
		3.5	9.1	8.4	-0.6	6.7	7.8	-4.6		4.1	6.0	-1.2	7.7	13.8	
		(-0.1)	(0.0)	(0.1)	(-1.7)	(-1.5)	(-2.0)	(-0.2)		(0.0)	(0.0)	(-0.2)	(0.5)	(2.9)	
		-0.3	3.6	-0.1	0.5	5.2	2.2	-1.5		2.6	-1.4	0.7	5.1	5.6	
		(-0.5)	(-1.1)	(-2.3)	(-0.1)	(0.0)	(0.1)	(-1.2)		(-2.3)	(-4.2)	(0.5)	(0.7)	(4.4)	
Ratio 3:2	IPW 2	heterogeneous, heteroscedastic													
		-1.9	2.3	-0.8	-1.4	3.3	0.3	-3.1		1.9	-0.9	-1.4	3.0	3.2	
		(-0.3)	(-0.5)	(-1.1)	(-0.1)	(0.0)	(0.1)	(-0.6)		(-1.2)	(-1.9)	(0.4)	(0.4)	(3.7)	
		-3.5	3.2	0.3	-3.5	3.2	0.2	-3.8		3.4	0.8	-3.9	2.2	1.7	
		(0.0)	(0.0)	(-0.1)	(0.0)	(0.0)	(-0.1)	(0.0)		(0.0)	(-0.1)	(-0.2)	(-0.6)	(2.2)	
Ratio 3:2	IPW 1	homogeneous, homoscedastic													
		2.3	11.4	9.6	-2.3	8.8	9.1	-9.0		5.5	8.8	-0.8	13.1	18.2	
		(0.0)	(0.0)	(-0.2)	(-1.3)	(-1.6)	(-1.4)	(0.4)		(1.0)	(3.1)	(1.5)	(3.2)	(7.3)	
		0.6	7.5	3.6	1.5	7.4	3.7	-0.3		8.3	6.9	2.8	9.4	11.1	
		(-0.6)	(-0.6)	(-1.3)	(-0.3)	(-0.6)	(-0.7)	(0.1)		(0.9)	(2.1)	(1.6)	(3.3)	(8.5)	
Ratio 3:2	IPW 2	heterogeneous, homoscedastic													
		-3.0	4.7	0.1	-2.4	4.3	0.2	-4.2		5.5	3.5	-1.2	6.2	7.3	
		(-0.4)	(-0.2)	(-0.4)	(-0.2)	(-0.4)	(-0.3)	(0.2)		(1.2)	(3.0)	(1.3)	(2.9)	(8.0)	
		-7.7	1.2	-1.9	-7.7	1.1	-1.8	-8.1		2.3	1.4	-6.9	2.4	4.1	
		(0.0)	(-0.1)	(0.0)	(0.0)	(-0.1)	(0.0)	(0.5)		(1.2)	(3.2)	(0.4)	(1.9)	(6.5)	
Ratio 3:2	IPW 1	homogeneous, heteroscedastic													
		2.5	7.4	7.7	-0.3	6.1	7.1	-4.0		4.3	7.4	0.4	9.1	13.0	
		(0.0)	(0.0)	(-0.2)	(-0.7)	(-0.8)	(-0.8)	(0.3)		(0.7)	(1.9)	(1.0)	(2.0)	(5.1)	
		0.0	3.2	3.6	0.4	3.3	3.2	-0.1		4.1	5.7	1.0	4.4	7.5	
		(-0.4)	(-0.5)	(-0.9)	(-0.1)	(-0.3)	(-0.3)	(0.0)		(0.5)	(1.0)	(0.9)	(1.9)	(5.5)	
Ratio 2:3	IPW 2	heterogeneous, heteroscedastic													
		-1.4	2.3	2.1	-1.1	2.3	1.8	-1.7		3.2	4.2	-0.7	3.3	5.8	
		(-0.2)	(-0.2)	(-0.3)	(-0.1)	(-0.2)	(-0.1)	(0.1)		(0.7)	(1.6)	(0.7)	(1.6)	(5.1)	
		-1.7	1.5	1.9	-1.7	1.6	1.8	-1.6		2.5	4.1	-1.6	2.3	4.9	
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.3)		(0.8)	(1.9)	(0.1)	(1.0)	(4.1)	
Ratio 2:3	IPW 1	homogeneous, homoscedastic													
		-1.2	7.7	2.5	-8.4	2.6	-1.3	-10.5		2.8	2.8	-12.6	0.2	-1.7	
		(-0.6)	(-0.7)	(-1.2)	(-3.2)	(-3.9)	(-6.5)	(0.8)		(1.3)	(2.7)	(-2.9)	(-3.8)	(-7.2)	
		-2.4	3.9	-1.4	-1.2	5.7	2.3	-4.0		2.7	-0.4	-1.4	5.4	3.2	
		(-0.6)	(-1.0)	(-1.8)	(-0.1)	(0.0)	(0.0)	(-2.1)		(-2.5)	(-1.6)	(0.0)	(0.1)	(0.9)	
Ratio 2:3	IPW 2	heterogeneous, homoscedastic													
		-6.0	0.5	-3.4	-5.1	1.5	-1.1	-7.0		0.5	-0.6	-5.3	1.1	-0.3	
		(-0.4)	(-0.5)	(-0.9)	(0.0)	(0.0)	(0.0)	(-0.9)		(-0.7)	(1.3)	(-0.1)	(-0.1)	(0.6)	
		-11.6	-2.7	-3.8	-11.4	-2.5	-3.3	-11.0		-1.2	0.2	-11.8	-3.4	-3.3	
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.7)		(1.2)	(3.6)	(-0.5)	(-0.7)	(-0.3)	
Ratio 2:3	IPW 1	homogeneous, heteroscedastic													
		-0.3	7.6	3.2	-4.9	4.3	1.8	-6.3		4.5	3.9	-8.4	2.5	2.3	
		(-0.3)	(-0.3)	(-0.6)	(-1.8)	(-2.3)	(-3.9)	(0.5)		(0.9)	(1.9)	(-1.8)	(-2.4)	(-4.6)	
		-3.8	2.1	-4.2	-3.1	3.1	-1.3	-4.9		1.4	-3.7	-3.3	3.0	-0.7	
		(-0.4)	(-0.7)	(-1.2)	(0.0)	(0.0)	(0.0)	(-1.3)		(-1.6)	(-1.1)	(-0.1)	(0.0)	(0.5)	
Ratio 2:3	IPW 2	heterogeneous, heteroscedastic													
		-5.0	0.7	-4.2	-4.5	1.3	-2.4	-5.9		0.7	-2.5	-4.7	1.1	-1.9	
		(-0.3)	(-0.4)	(-0.6)	(0.0)	(0.0)	(0.0)	(-0.7)		(-0.5)	(0.7)	(-0.1)	(-0.1)	(0.3)	
		-7.5	0.1	-2.9	-7.4	0.2	-2.6	-7.4		0.9	-0.3	-7.7	-0.3	-2.8	
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.3)		(0.7)	(2.2)	(-0.3)	(-0.5)	(-0.3)	

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.44: Percentage improvement in MSE for the ATE if the shrunken propensity scores are used with trimming rule 1 instead of the conventional propensity scores used with trimming rule by HLW, mse-minimizing λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	-20.6 (24.5)	-20.5 (8.2)	-1.0 (2.1)	42.1 (59.0)	28.0 (41.8)	15.4 (17.9)	3.3 (37.3)	-15.9 (15.2)	-6.5 (4.2)	68.6 (73.2)	53.7 (58.6)	32.4 (32.1)	
	IPW 2	7.5 (14.1)	19.5 (1.4)	34.8 (-2.0)	59.8 (50.0)	54.9 (27.9)	54.5 (10.5)	34.2 (21.7)	36.1 (2.3)	45.6 (-2.8)	80.4 (63.8)	73.7 (38.6)	69.1 (14.9)	
	IPW 3	-10.1 (20.2)	-9.0 (3.6)	7.9 (-1.4)	54.9 (57.9)	40.8 (36.6)	27.3 (11.0)	21.7 (31.4)	5.3 (6.5)	10.5 (-2.1)	78.8 (71.2)	65.4 (50.1)	43.5 (15.9)	
	DR	20.2 (0.0)	8.0 (0.4)	8.8 (0.5)	20.6 (0.0)	7.9 (0.0)	9.2 (-0.2)	19.8 (0.1)	7.8 (0.7)	8.0 (1.4)	23.3 (2.5)	6.9 (-1.0)	6.1 (-4.2)	
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-27.4 (15.0)	-19.3 (5.3)	-4.4 (1.1)	26.2 (47.0)	16.4 (31.4)	7.5 (12.1)	-8.9 (26.3)	-15.9 (10.2)	-7.1 (2.5)	57.8 (65.5)	42.2 (49.3)	22.0 (24.0)	
	IPW 2	-8.5 (8.6)	5.1 (1.1)	22.0 (-1.7)	41.0 (39.8)	37.7 (22.2)	39.8 (7.6)	14.7 (15.3)	19.9 (1.8)	32.8 (-2.5)	68.3 (56.8)	60.0 (33.5)	56.0 (11.8)	
	IPW 3	-21.1 (12.0)	-13.6 (2.4)	0.2 (-1.1)	36.0 (45.6)	24.9 (27.4)	14.9 (7.1)	3.6 (21.5)	-3.5 (4.5)	3.0 (-1.7)	66.6 (63.3)	50.9 (41.9)	29.0 (11.2)	
	DR	26.9 (0.0)	3.8 (0.3)	1.8 (0.1)	27.2 (0.0)	4.0 (0.0)	2.4 (-0.2)	26.5 (0.0)	3.9 (0.6)	1.8 (0.7)	28.4 (1.3)	3.1 (-1.0)	0.1 (-2.9)	
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	-34.3 (18.3)	-4.3 (17.3)	11.9 (6.8)	-46.1 (-0.7)	-28.2 (-2.2)	2.1 (-1.4)	-49.2 (7.5)	-15.9 (13.3)	6.8 (6.4)	0.8 (16.3)	-17.3 (1.8)	3.7 (-0.4)	
	IPW 2	-2.3 (16.1)	18.4 (13.4)	21.8 (4.9)	2.5 (0.6)	15.0 (-0.6)	21.0 (-0.5)	6.8 (7.2)	25.2 (9.8)	26.4 (4.3)	37.8 (11.9)	32.3 (1.5)	27.7 (-0.1)	
	IPW 3	-17.3 (18.9)	7.6 (19.1)	14.4 (6.7)	-19.2 (0.6)	-9.7 (-0.2)	6.2 (0.1)	-13.4 (9.1)	9.1 (16.5)	15.5 (7.2)	23.9 (13.8)	3.7 (0.0)	6.2 (-0.5)	
	DR	30.1 (0.0)	11.4 (0.4)	9.4 (0.1)	31.4 (1.4)	12.3 (1.0)	9.7 (0.1)	29.2 (-0.1)	10.8 (0.1)	9.4 (-0.1)	29.4 (-1.0)	9.6 (-1.3)	6.3 (-2.1)	
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	-20.7 (10.1)	-2.4 (9.3)	6.7 (4.8)	-27.4 (-0.4)	-14.2 (-1.0)	0.6 (-0.7)	-29.0 (4.4)	-8.6 (7.1)	3.9 (4.6)	-2.1 (10.3)	-9.2 (1.4)	1.3 (-0.2)	
	IPW 2	-5.3 (9.6)	10.1 (7.7)	13.4 (3.6)	-3.0 (0.3)	8.4 (-0.2)	13.0 (-0.2)	0.5 (4.6)	15.3 (5.8)	17.4 (3.2)	22.5 (8.0)	20.7 (1.1)	17.8 (-0.2)	
	IPW 3	-12.8 (10.7)	4.3 (10.7)	8.0 (4.8)	-14.5 (0.3)	-5.0 (-0.1)	2.5 (0.2)	-10.8 (5.4)	5.5 (9.3)	9.1 (5.1)	12.1 (8.7)	2.3 (0.1)	1.9 (-0.3)	
	DR	-1.9 (0.0)	-3.9 (0.4)	1.2 (0.0)	-0.2 (1.3)	-3.0 (0.9)	1.4 (0.0)	-2.3 (-0.1)	-4.0 (0.3)	1.6 (-0.1)	-2.3 (-1.0)	-5.0 (-1.0)	-1.7 (-1.6)	
Ratio 2:3			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	54.7 (67.4)	36.8 (45.0)	12.9 (14.4)	74.0 (78.7)	59.5 (61.7)	25.1 (25.6)	64.0 (72.3)	43.7 (51.4)	13.6 (18.8)	84.2 (84.2)	72.7 (71.0)	38.8 (37.3)	
	IPW 2	59.1 (61.4)	47.1 (32.9)	35.1 (6.9)	81.0 (74.9)	71.6 (50.4)	55.9 (17.1)	70.6 (64.9)	57.5 (33.8)	44.6 (5.4)	90.8 (80.9)	84.4 (57.7)	72.2 (22.1)	
	IPW 3	58.1 (65.8)	40.1 (40.5)	13.6 (7.5)	80.6 (78.5)	68.0 (58.6)	35.4 (18.7)	70.2 (70.2)	50.4 (44.2)	17.7 (7.1)	90.6 (84.0)	82.2 (66.9)	54.1 (25.9)	
	DR	32.0 (0.0)	12.1 (0.7)	4.7 (0.2)	33.4 (1.5)	12.2 (0.3)	5.9 (0.2)	31.6 (0.1)	12.9 (1.7)	4.6 (0.9)	39.1 (9.0)	14.9 (2.8)	6.7 (-0.2)	
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	34.8 (56.6)	21.5 (34.6)	3.6 (9.3)	62.2 (72.2)	46.7 (53.0)	14.8 (18.5)	48.7 (64.0)	29.6 (41.4)	4.9 (12.6)	78.0 (80.7)	64.2 (65.1)	28.7 (29.7)	
	IPW 2	37.1 (50.6)	28.6 (25.6)	20.5 (4.3)	67.8 (68.1)	56.6 (43.6)	40.5 (12.7)	53.2 (56.6)	40.6 (27.8)	30.2 (3.4)	83.7 (77.2)	74.5 (53.2)	59.2 (18.0)	
	IPW 3	36.1 (54.5)	22.1 (30.9)	4.0 (4.4)	67.4 (71.6)	52.7 (50.2)	21.5 (12.7)	52.8 (61.5)	33.0 (35.4)	7.6 (4.1)	83.7 (80.2)	71.9 (61.2)	39.3 (19.4)	
	DR	52.4 (0.0)	15.3 (0.5)	1.2 (0.0)	52.8 (0.6)	15.2 (0.1)	2.5 (0.2)	52.1 (0.1)	15.7 (1.1)	1.2 (0.3)	54.4 (3.9)	16.5 (1.2)	3.1 (0.0)	

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.45: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores, data driven λ

		N	100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	49.9 (0.0)	53.1 (0.1)	80.0 (0.0)	45.3 (-0.2)	47.7 (0.0)	71.5 (-0.1)	44.0 (0.0)	49.5 (0.1)	78.7 (0.0)	49.7 (0.4)	53.2 (0.6)	72.7 (0.2)	
	IPW 2	13.3 (0.1)	20.8 (-0.1)	37.3 (0.0)	15.0 (0.0)	18.5 (0.2)	33.2 (0.0)	12.8 (0.1)	21.7 (-0.2)	36.9 (0.1)	13.5 (-1.2)	16.5 (-0.7)	31.3 (-1.4)	
	IPW 3	1.2 (0.2)	4.6 (0.1)	12.5 (0.3)	2.3 (0.1)	4.4 (0.3)	13.4 (0.0)	-0.2 (0.4)	3.9 (0.2)	10.7 (0.6)	0.8 (-1.5)	2.3 (-1.0)	11.0 (-2.0)	
	DR	5.6 (0.0)	8.7 (0.3)	17.9 (0.0)	6.8 (0.0)	9.8 (0.0)	19.0 (0.0)	4.7 (0.1)	7.9 (0.4)	16.4 (0.1)	6.3 (-2.0)	9.0 (-1.9)	17.6 (-2.3)	
Ratio 1:1			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	33.0 (0.0)	38.5 (0.1)	71.1 (0.0)	29.3 (-0.2)	34.0 (0.0)	60.7 (0.0)	28.8 (0.0)	36.1 (0.1)	69.9 (0.0)	35.9 (0.4)	41.3 (0.5)	63.5 (0.2)	
	IPW 2	-0.8 (0.1)	6.7 (-0.1)	22.8 (0.0)	-0.3 (0.0)	4.7 (0.1)	19.5 (0.0)	-0.7 (0.1)	7.8 (-0.1)	22.8 (0.0)	-1.2 (-0.7)	3.5 (-0.5)	18.3 (-1.0)	
	IPW 3	-9.6 (0.1)	-5.1 (0.0)	3.5 (0.2)	-9.2 (0.1)	-5.3 (0.2)	4.4 (0.0)	-10.2 (0.3)	-5.5 (0.1)	2.0 (0.4)	-10.2 (-0.8)	-6.7 (-0.6)	3.1 (-1.3)	
	DR	-7.5 (0.0)	-2.0 (0.2)	7.2 (0.0)	-6.8 (0.0)	-1.4 (0.0)	8.5 (0.0)	-8.0 (0.1)	-2.4 (0.3)	5.8 (0.1)	-6.8 (-1.2)	-1.8 (-1.2)	8.1 (-1.6)	
Ratio 3:2			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	26.1 (0.1)	35.6 (0.0)	31.5 (0.0)	20.1 (-0.4)	31.3 (-0.2)	25.0 (0.0)	17.9 (-0.1)	30.9 (-0.1)	28.4 (0.0)	22.1 (0.0)	36.4 (-0.1)	28.7 (-0.8)	
	IPW 2	9.9 (-0.1)	19.5 (-0.1)	16.5 (-0.3)	12.3 (0.0)	20.1 (0.1)	16.1 (0.0)	9.4 (0.1)	19.3 (0.0)	16.3 (0.0)	10.3 (-0.8)	18.1 (-0.9)	13.1 (-2.1)	
	IPW 3	-0.1 (0.0)	7.4 (0.0)	6.1 (-0.1)	1.1 (0.2)	8.3 (0.2)	6.6 (0.0)	-1.1 (0.3)	6.3 (0.2)	5.3 (0.3)	-1.0 (-1.0)	6.1 (-1.2)	3.2 (-2.6)	
	DR	3.3 (0.1)	11.6 (0.1)	9.7 (0.0)	3.8 (0.0)	12.0 (0.0)	10.0 (-0.1)	2.6 (-0.1)	10.6 (-0.1)	8.9 (0.0)	2.0 (-2.0)	10.0 (-2.0)	6.9 (-3.2)	
Ratio 3:2			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	11.3 (0.0)	21.7 (0.0)	20.1 (-0.1)	7.1 (-0.4)	18.2 (-0.1)	14.5 (0.0)	5.8 (-0.1)	18.5 (-0.1)	17.9 (0.0)	9.9 (0.0)	23.4 (-0.1)	18.2 (-0.6)	
	IPW 2	-3.8 (0.0)	7.4 (-0.1)	6.6 (-0.2)	-1.8 (0.0)	7.8 (0.0)	6.5 (0.0)	-4.1 (0.1)	7.5 (0.0)	6.6 (0.0)	-2.9 (-0.4)	6.4 (-0.6)	4.5 (-1.6)	
	IPW 3	-10.4 (0.0)	-1.0 (0.0)	-0.7 (-0.1)	-9.5 (0.1)	-0.6 (0.1)	-0.3 (0.0)	-11.0 (0.2)	-1.7 (0.1)	-1.2 (0.2)	-10.5 (-0.5)	-2.0 (-0.7)	-2.5 (-1.8)	
	DR	-8.8 (0.0)	1.4 (0.1)	1.5 (0.0)	-8.5 (0.0)	1.8 (0.0)	1.6 (-0.1)	-9.3 (-0.1)	0.8 (0.0)	1.1 (0.0)	-9.4 (-1.1)	0.6 (-1.2)	-0.5 (-2.3)	
Ratio 2:3			homogeneous, homoscedastic						heterogeneous, homoscedastic					
	IPW 1	41.1 (0.0)	37.1 (-0.1)	34.5 (0.0)	46.3 (-0.3)	40.3 (-0.5)	38.2 (-0.3)	37.1 (0.1)	34.0 (0.2)	32.6 (0.1)	53.1 (0.1)	46.6 (0.0)	45.8 (0.1)	
	IPW 2	11.0 (-0.1)	16.2 (-0.1)	20.5 (0.0)	12.4 (0.0)	17.1 (0.0)	21.0 (0.0)	9.9 (-1.0)	15.7 (-0.7)	20.6 (-0.6)	11.9 (-0.5)	16.8 (-0.2)	20.5 (-0.6)	
	IPW 3	1.5 (0.0)	5.8 (0.0)	9.4 (0.1)	2.4 (0.0)	6.5 (0.1)	9.8 (0.0)	-0.2 (-0.6)	4.3 (-0.4)	7.5 (-0.3)	2.0 (-0.6)	6.2 (-0.3)	9.2 (-0.8)	
	DR	5.5 (0.0)	9.0 (0.2)	13.7 (0.0)	5.9 (0.0)	9.7 (0.0)	14.2 (0.1)	5.0 (0.0)	8.1 (0.5)	12.8 (0.0)	5.9 (-0.7)	10.1 (-0.6)	14.1 (-0.8)	
Ratio 2:3			homogeneous, heteroscedastic						heterogeneous, heteroscedastic					
	IPW 1	24.8 (0.0)	24.1 (0.0)	22.2 (0.0)	31.5 (-0.2)	28.3 (-0.4)	26.4 (-0.2)	22.7 (0.1)	22.4 (0.1)	20.9 (0.1)	41.0 (0.1)	36.1 (0.0)	35.2 (0.1)	
	IPW 2	-1.6 (-0.1)	4.5 (-0.1)	10.7 (0.0)	-1.0 (0.0)	5.1 (0.0)	11.3 (0.0)	-1.8 (-0.6)	4.3 (-0.5)	11.0 (-0.5)	-1.3 (-0.3)	4.9 (-0.2)	11.1 (-0.4)	
	IPW 3	-7.6 (0.0)	-2.7 (0.0)	3.3 (0.1)	-7.3 (0.0)	-2.1 (0.1)	3.7 (0.0)	-8.5 (-0.4)	-3.6 (-0.3)	2.0 (-0.2)	-7.6 (-0.3)	-2.2 (-0.2)	3.4 (-0.5)	
	DR	-4.3 (0.0)	0.4 (0.1)	6.4 (0.0)	-4.1 (0.0)	0.9 (0.0)	7.0 (0.0)	-4.4 (0.0)	0.0 (0.3)	5.5 (-0.1)	-4.0 (-0.4)	1.3 (-0.4)	7.2 (-0.6)	

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.46: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores with trimming rule 1, data-driven λ

N		linear			nonlinear			linear			nonlinear		
		100	200	500	100	200	500	100	200	500	100	200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	3.9	3.4	2.6	3.0	2.9	2.1	2.2	2.3	1.9	4.0	4.6	4.3
		(0.0)	(-0.1)	(-0.1)	(-0.6)	(-0.7)	(-0.6)	(0.0)	(-0.1)	(-0.1)	(0.2)	(0.3)	(0.8)
	IPW 2	3.2	2.6	1.9	3.4	2.6	2.0	3.1	2.6	1.8	3.7	3.0	2.5
		(-0.3)	(-0.1)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-0.6)	(-0.4)	(-0.3)	(0.4)	(0.3)	(0.4)
Ratio 1:1	IPW 3	2.1	1.5	1.0	2.2	1.5	1.1	2.0	1.5	0.9	2.4	1.7	1.3
		(-0.2)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.3)	(-0.1)	(-0.1)	(0.3)	(0.2)	(0.2)
	DR	0.6	0.6	0.7	0.6	0.6	0.7	0.6	0.6	0.7	0.5	0.5	0.6
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)
		homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
Ratio 1:1	IPW 1	2.3	2.2	1.7	1.9	1.9	1.4	1.4	1.5	1.3	2.6	3.2	3.0
		(0.0)	(0.0)	(0.0)	(-0.4)	(-0.5)	(-0.4)	(0.0)	(-0.1)	(-0.1)	(0.1)	(0.2)	(0.6)
	IPW 2	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.9	1.1	1.2	1.2
		(-0.2)	(-0.1)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.3)	(-0.2)	(-0.2)	(0.2)	(0.2)	(0.3)
	IPW 3	0.5	0.6	0.5	0.6	0.6	0.5	0.5	0.5	0.4	0.7	0.7	0.6
Ratio 3:2		(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.2)	(-0.1)	(-0.1)	(0.1)	(0.1)	(0.2)
	DR	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5	0.2	0.3	0.4
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)
		homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	4.1	3.5	2.6	2.8	3.0	2.5	2.1	2.3	2.0	4.0	5.1	4.5
Ratio 3:2		(0.0)	(0.0)	(0.0)	(-0.5)	(-0.3)	(0.0)	(-0.1)	(-0.1)	(0.0)	(0.9)	(1.3)	(1.5)
	IPW 2	3.5	2.6	1.8	3.6	2.5	1.8	3.8	3.0	2.3	4.1	3.1	2.4
		(-0.3)	(-0.2)	(-0.3)	(-0.1)	(-0.1)	(0.1)	(-0.2)	(0.0)	(-0.1)	(0.5)	(0.5)	(0.7)
	IPW 3	2.6	1.7	1.0	2.7	1.7	1.0	2.8	2.0	1.2	3.1	2.0	1.3
		(-0.2)	(-0.1)	(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.4)	(0.4)	(0.4)
Ratio 3:2	DR	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.4
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
		homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
	IPW 1	2.4	2.0	1.4	1.6	1.7	1.2	1.2	1.4	1.1	2.4	3.1	2.6
		(0.0)	(0.0)	(0.0)	(-0.4)	(-0.2)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.4)	(0.8)	(1.1)
Ratio 2:3	IPW 2	1.0	0.9	0.8	0.9	0.8	0.7	1.2	1.2	1.1	1.2	1.2	1.1
		(-0.1)	(-0.1)	(-0.2)	(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.3)	(0.3)	(0.4)
	IPW 3	0.7	0.6	0.4	0.7	0.5	0.3	0.9	0.8	0.6	1.0	0.8	0.5
		(-0.1)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.2)	(0.3)
	DR	0.3	0.4	0.2	0.3	0.4	0.2	0.3	0.4	0.2	0.3	0.3	0.2
Ratio 2:3		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
		homogeneous, homoscedastic							heterogeneous, homoscedastic				
	IPW 1	3.8	3.4	2.4	2.8	2.7	1.9	2.3	2.7	2.3	2.7	3.4	2.8
		(-0.1)	(-0.2)	(-0.1)	(-0.7)	(-1.1)	(-0.6)	(0.0)	(-0.1)	(0.1)	(-0.6)	(-0.9)	(0.1)
	IPW 2	3.3	2.7	1.7	3.4	2.6	1.8	2.6	2.0	1.0	3.5	2.8	1.9
Ratio 2:3		(-0.3)	(-0.1)	(-0.1)	(0.0)	(0.0)	(0.0)	(-1.0)	(-0.7)	(-0.7)	(0.1)	(0.1)	(0.1)
	IPW 3	2.4	1.8	1.1	2.5	1.8	1.1	1.8	1.3	0.6	2.6	1.9	1.2
		(-0.2)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.6)	(-0.3)	(-0.4)	(0.1)	(0.1)	(0.1)
	DR	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.5
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.1)
Ratio 2:3		homogeneous, heteroscedastic							heterogeneous, heteroscedastic				
	IPW 1	2.2	2.3	1.6	1.7	1.9	1.3	1.4	1.9	1.5	1.8	2.5	1.9
		(0.0)	(-0.1)	(-0.1)	(-0.4)	(-0.7)	(-0.3)	(0.0)	(-0.1)	(0.1)	(-0.4)	(-0.6)	(0.1)
	IPW 2	0.8	0.9	0.8	0.9	0.9	0.8	0.5	0.6	0.4	0.9	1.0	0.9
		(-0.1)	(-0.1)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.5)	(-0.4)	(-0.4)	(0.1)	(0.1)	(0.1)
Ratio 2:3	IPW 3	0.6	0.6	0.5	0.6	0.7	0.5	0.3	0.4	0.3	0.7	0.7	0.5
		(-0.1)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.4)	(-0.2)	(-0.2)	(0.1)	(0.0)	(0.0)
	DR	0.2	0.4	0.4	0.2	0.4	0.5	0.2	0.4	0.4	0.2	0.4	0.4
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$ is given in brackets.

Table A.47: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores used with trimming rule 2, data-driven λ

N		100	linear 200	500	100	nonlinear 200	500	100	linear 200	500	100	nonlinear 200	500
Ratio 1:1	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	0.6	-0.9	-4.6	-2.4	-2.7	-2.0	-10.2	-8.2	-8.6	-0.5	0.8	5.6
		(0.0)	(-0.1)	(-0.1)	(-0.7)	(-1.1)	(-0.7)	(0.0)	(-0.2)	(-0.2)	(1.8)	(2.1)	(6.0)
	IPW 2	-0.9	-1.0	-5.2	-0.1	-2.0	-4.3	-2.3	-1.6	-7.6	0.1	-1.7	0.6
		(-0.4)	(-0.1)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-0.9)	(-0.4)	(-0.4)	(0.5)	(1.3)	(5.0)
Ratio 1:1	IPW 3	-5.8	-4.7	-6.1	-5.3	-5.3	-5.8	-7.5	-5.6	-7.9	-5.2	-5.0	-1.2
		(-0.2)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.5)	(-0.1)	(-0.2)	(0.2)	(1.0)	(4.6)
	DR	-7.9	-5.7	-5.4	-7.7	-5.6	-5.9	-9.2	-6.9	-6.8	-7.9	-5.6	-2.6
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.5)	(0.4)	(3.8)
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
Ratio 1:1	IPW 1	-1.1	-0.2	0.5	-2.8	-1.1	1.6	-7.6	-4.5	-2.7	-1.3	1.2	6.7
		(0.0)	(-0.1)	(0.0)	(-0.5)	(-0.7)	(-0.4)	(0.0)	(-0.1)	(-0.1)	(1.1)	(1.4)	(4.1)
	IPW 2	-4.5	-2.0	-1.5	-4.1	-2.4	-1.6	-5.3	-2.3	-3.6	-4.1	-2.2	1.6
		(-0.2)	(-0.1)	(-0.1)	(0.0)	(-0.1)	(0.0)	(-0.5)	(-0.2)	(-0.2)	(0.3)	(0.7)	(3.1)
	IPW 3	-6.6	-3.4	-2.3	-6.3	-3.6	-2.6	-7.5	-3.9	-4.0	-6.4	-3.5	0.4
Ratio 3:2		(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.2)	(-0.1)	(-0.1)	(0.1)	(0.6)	(2.9)
	DR	-7.5	-3.2	-2.0	-7.5	-3.1	-2.5	-8.2	-3.6	-3.4	-7.8	-3.3	-0.2
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(-0.3)	(0.3)	(2.4)
	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	-0.5	-0.2	-2.9	-3.7	-1.5	-2.1	-9.2	-5.3	-4.1	-1.6	3.3	8.2
Ratio 3:2		(0.0)	(0.0)	(-0.1)	(-0.6)	(-0.3)	(0.1)	(0.6)	(1.3)	(2.3)	(1.7)	(3.3)	(8.2)
	IPW 2	-3.4	-1.7	-3.1	-2.8	-2.2	-4.4	-3.3	-0.5	-0.9	-2.4	-0.1	3.6
		(-0.3)	(-0.2)	(-0.4)	(-0.1)	(-0.1)	(0.0)	(0.7)	(1.5)	(2.6)	(0.9)	(2.6)	(7.7)
	IPW 3	-7.5	-4.5	-3.6	-7.0	-4.7	-4.3	-7.8	-3.9	-1.9	-6.7	-2.7	3.5
		(-0.2)	(-0.1)	(-0.2)	(0.0)	(0.0)	(0.0)	(0.6)	(1.3)	(2.4)	(0.6)	(2.3)	(7.3)
Ratio 3:2	DR	-9.8	-5.4	-4.0	-9.8	-5.4	-4.0	-9.7	-4.6	-2.4	-9.7	-3.6	3.5
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.8)	(1.4)	(2.7)	(-0.1)	(1.8)	(6.8)
	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	-1.4	1.6	2.6	-3.2	0.6	2.5	-6.4	-1.5	2.0	-1.7	3.3	8.6
		(0.0)	(0.0)	(-0.1)	(-0.4)	(-0.2)	(0.0)	(0.4)	(0.8)	(1.4)	(1.0)	(1.9)	(5.3)
Ratio 2:3	IPW 2	-5.0	0.2	1.4	-4.7	-0.4	-0.3	-4.9	1.0	2.9	-4.3	0.7	4.2
		(-0.1)	(-0.1)	(-0.3)	(-0.1)	(0.0)	(0.0)	(0.5)	(0.9)	(1.5)	(0.5)	(1.4)	(4.7)
	IPW 3	-6.6	-1.1	1.4	-6.3	-1.4	0.2	-6.7	-0.7	2.6	-6.1	-0.4	4.5
		(-0.1)	(-0.1)	(-0.2)	(0.0)	(0.0)	(0.0)	(0.4)	(0.8)	(1.5)	(0.3)	(1.2)	(4.4)
	DR	-6.6	-0.8	1.0	-6.7	-0.8	0.9	-6.4	-0.4	2.1	-6.6	0.1	5.0
Ratio 2:3		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.4)	(0.8)	(1.7)	(0.0)	(0.9)	(4.1)
	homogeneous, homoscedastic							heterogeneous, homoscedastic					
	IPW 1	-0.2	0.1	-0.7	-4.1	-1.9	-0.8	-8.6	-4.9	0.4	-5.9	-1.6	1.2
		(-0.1)	(-0.5)	(0.0)	(-1.0)	(-1.6)	(-0.4)	(1.0)	(0.6)	(4.3)	(-0.1)	(-0.8)	(1.9)
	IPW 2	-1.3	-0.2	-3.1	-0.9	-0.6	-3.3	-2.4	-0.8	-1.6	-1.0	-1.0	-2.5
Ratio 2:3		(-0.3)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.8)	(-0.1)	(2.6)	(-0.2)	(-0.2)	(0.8)
	IPW 3	-5.4	-2.7	-3.9	-5.0	-2.9	-4.2	-6.3	-3.1	-1.4	-5.2	-3.3	-3.5
		(-0.2)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.5)	(3.4)	(-0.3)	(-0.2)	(0.7)
	DR	-7.6	-4.1	-4.1	-7.5	-4.0	-4.4	-7.7	-4.4	-1.2	-8.0	-4.5	-4.3
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.6)	(0.7)	(3.9)	(-0.6)	(-0.5)	(0.3)
Ratio 2:3	homogeneous, heteroscedastic							heterogeneous, heteroscedastic					
	IPW 1	-2.7	1.5	1.2	-5.2	0.4	1.0	-7.9	-1.4	1.5	-6.4	0.5	2.2
		(-0.1)	(-0.2)	(0.0)	(-0.6)	(-1.0)	(-0.3)	(0.5)	(0.4)	(2.7)	(-0.1)	(-0.5)	(1.3)
	IPW 2	-5.7	-0.9	-1.6	-5.6	-1.2	-2.0	-6.2	-1.3	-1.2	-5.7	-1.4	-1.6
		(-0.2)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.5)	(-0.1)	(1.4)	(-0.1)	(-0.1)	(0.3)
Ratio 2:3	IPW 3	-7.5	-2.0	-2.2	-7.4	-2.1	-2.6	-8.0	-2.3	-1.1	-7.5	-2.4	-2.2
		(-0.1)	(0.0)	(-0.1)	(0.0)	(0.0)	(0.0)	(-0.1)	(0.2)	(1.9)	(-0.2)	(-0.1)	(0.3)
	DR	-8.7	-2.2	-2.2	-8.7	-2.2	-2.5	-8.9	-2.3	-0.9	-9.0	-2.5	-2.5
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.3)	(0.4)	(2.2)	(-0.4)	(-0.3)	(0.0)

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{p})) - \text{bias}^2(\text{ATE}(\hat{p}^s))}{\text{bias}^2(\text{ATE}(\hat{p})) + \text{Var}(\text{ATE}(\hat{p}))} \right)$ is given in brackets.

Table A.48: Percentage improvement in MSE for the ATE if the shrunk propensity scores are used with trimming rule 1 instead of the conventional propensity scores used with trimming rule by HLW, data-driven λ

N		100	linear			nonlinear			100	linear			nonlinear		
			200	500	100	200	500			200	500	100	200	500	
Ratio 1:1	homogeneous, homoscedastic														
	IPW 1	-23.8 (24.8)	-37.1 (8.1)	-12.0 (2.0)	42.8 (60.2)	20.8 (43.0)	9.5 (20.6)	3.1 (37.6)		-28.3 (15.1)	-15.2 (4.0)	69.5 (73.7)	50.0 (59.4)	26.4 (34.2)	
	IPW 2	4.4 (14.4)	15.0 (2.7)	33.1 (0.3)	58.6 (50.1)	51.0 (27.9)	51.4 (10.5)	32.3 (22.3)		34.1 (4.4)	45.3 (0.4)	79.7 (63.6)	71.4 (38.5)	67.1 (14.9)	
	IPW 3	-13.6 (20.3)	-14.3 (4.4)	6.9 (0.2)	53.6 (58.0)	37.0 (36.6)	25.2 (11.0)	19.4 (31.7)		1.7 (8.1)	10.2 (0.3)	78.1 (71.1)	63.3 (50.0)	42.3 (16.3)	
	DR	20.5 (0.1)	4.5 (0.3)	8.4 (0.6)	20.9 (0.0)	4.9 (0.0)	8.7 (0.0)	19.6 (0.1)		3.4 (0.7)	7.3 (1.4)	23.2 (2.0)	5.1 (-0.1)	7.4 (-2.0)	
Ratio 1:1	homogeneous, heteroscedastic														
	IPW 1	-30.7 (15.6)	-31.8 (4.8)	-11.0 (1.3)	26.1 (48.3)	8.8 (31.5)	3.7 (14.4)	-9.5 (26.8)		-26.6 (9.6)	-13.5 (2.6)	58.4 (66.2)	37.7 (49.4)	18.2 (26.1)	
	IPW 2	-11.2 (9.3)	1.0 (1.8)	22.3 (0.2)	39.3 (40.2)	33.4 (21.6)	38.6 (8.0)	13.1 (16.2)		17.2 (3.2)	33.2 (0.4)	67.3 (56.9)	57.3 (33.0)	55.4 (12.3)	
	IPW 3	-24.7 (12.6)	-18.8 (2.7)	0.3 (0.1)	33.9 (46.1)	20.3 (26.8)	14.1 (7.6)	1.1 (22.3)		-8.0 (5.3)	2.5 (0.2)	65.3 (63.4)	48.0 (41.4)	29.3 (12.2)	
	DR	24.8 (0.0)	-0.7 (0.2)	1.5 (0.4)	25.0 (0.0)	-0.4 (0.0)	1.6 (0.0)	24.3 (0.0)		-1.2 (0.4)	0.4 (0.9)	26.0 (1.0)	-0.2 (-0.1)	1.0 (-1.4)	
Ratio 3:2	homogeneous, homoscedastic														
	IPW 1	-30.5 (18.3)	-14.4 (17.3)	-2.5 (6.9)	-39.9 (0.4)	-38.2 (-0.4)	-11.4 (0.1)	-41.9 (7.5)		-24.9 (13.4)	-7.6 (6.2)	5.2 (16.7)	-27.0 (2.2)	-10.2 (-1.2)	
	IPW 2	-0.1 (16.4)	13.5 (13.8)	14.1 (5.6)	4.2 (0.8)	9.7 (-0.1)	12.8 (0.0)	9.5 (7.5)		21.1 (10.3)	19.0 (5.2)	38.4 (11.6)	27.5 (0.8)	19.1 (-1.9)	
	IPW 3	-15.3 (19.1)	2.7 (19.3)	8.5 (6.8)	-17.4 (0.8)	-15.2 (0.2)	-0.3 (0.4)	-10.7 (9.3)		4.3 (16.7)	9.0 (7.3)	24.4 (13.4)	-1.9 (-0.9)	-1.3 (-2.5)	
	DR	32.5 (0.0)	9.5 (0.4)	5.3 (0.1)	33.7 (1.4)	10.5 (1.1)	5.7 (0.0)	31.7 (-0.1)		8.6 (0.3)	4.7 (0.2)	31.4 (-1.2)	7.6 (-1.8)	2.1 (-3.4)	
Ratio 3:2	homogeneous, heteroscedastic														
	IPW 1	-19.9 (9.7)	-9.6 (9.9)	-3.2 (4.4)	-24.4 (0.1)	-22.2 (-0.2)	-8.3 (0.1)	-26.3 (4.0)		-15.7 (7.7)	-6.4 (4.0)	1.3 (10.8)	-17.5 (1.3)	-7.1 (-0.8)	
	IPW 2	-4.9 (9.5)	6.6 (8.5)	7.3 (3.7)	-2.1 (0.4)	3.8 (0.0)	6.8 (0.0)	1.0 (4.6)		11.9 (6.6)	11.1 (3.5)	23.3 (8.2)	16.2 (0.6)	11.8 (-1.4)	
	IPW 3	-12.7 (10.5)	0.5 (11.3)	2.8 (4.4)	-13.7 (0.4)	-9.9 (0.1)	-3.1 (0.2)	-10.3 (5.2)		1.5 (9.9)	3.1 (4.8)	12.8 (8.9)	-2.8 (-0.5)	-3.6 (-1.7)	
	DR	-0.8 (0.0)	-7.3 (0.3)	-3.4 (0.0)	1.1 (1.4)	-6.5 (0.8)	-3.2 (0.0)	-1.3 (-0.1)		-7.9 (0.2)	-3.7 (0.1)	-1.0 (-0.8)	-8.5 (-1.2)	-5.8 (-2.4)	
Ratio 2:3	homogeneous, homoscedastic														
	IPW 1	53.7 (67.6)	30.8 (45.2)	9.3 (15.4)	74.4 (79.2)	57.6 (62.7)	25.3 (30.0)	63.8 (72.4)		39.3 (51.6)	10.3 (19.3)	84.9 (84.6)	72.6 (71.9)	39.8 (42.2)	
	IPW 2	57.7 (61.5)	44.3 (33.4)	35.1 (8.0)	80.3 (74.9)	69.6 (50.4)	54.7 (17.1)	69.8 (65.3)		56.0 (35.2)	45.6 (7.8)	90.4 (80.9)	83.4 (57.7)	71.3 (22.1)	
	IPW 3	56.5 (65.9)	37.5 (40.8)	15.5 (8.2)	79.8 (78.5)	66.3 (58.6)	35.6 (18.7)	69.2 (70.4)		48.6 (45.2)	19.9 (8.8)	90.3 (84.0)	81.4 (66.9)	54.2 (26.0)	
	DR	31.6 (0.0)	10.0 (0.7)	7.6 (0.3)	32.9 (1.5)	10.2 (0.3)	8.3 (0.3)	31.0 (0.1)		10.1 (1.9)	7.0 (0.9)	38.6 (8.9)	13.5 (3.3)	9.3 (0.5)	
Ratio 2:3	homogeneous, heteroscedastic														
	IPW 1	33.2 (57.1)	14.1 (34.0)	1.8 (10.5)	62.1 (72.8)	43.4 (53.2)	15.3 (22.2)	48.1 (64.3)		23.7 (40.9)	2.8 (13.5)	78.4 (81.1)	63.1 (65.6)	29.9 (34.2)	
	IPW 2	35.5 (51.1)	24.6 (25.5)	22.2 (5.6)	66.9 (68.3)	53.9 (43.1)	40.6 (13.2)	52.3 (57.2)		37.9 (28.5)	32.0 (5.8)	83.2 (77.3)	73.0 (52.9)	59.2 (18.5)	
	IPW 3	34.0 (55.0)	17.8 (30.6)	6.5 (5.4)	66.3 (71.8)	49.9 (49.7)	22.4 (13.3)	51.5 (62.0)		29.6 (35.7)	9.8 (5.9)	83.1 (80.3)	70.3 (60.9)	40.1 (20.1)	
	DR	51.0 (0.0)	11.8 (0.4)	3.0 (0.2)	51.3 (0.5)	11.9 (0.2)	3.4 (0.2)	50.7 (0.1)		11.9 (1.1)	2.4 (0.6)	52.9 (3.7)	13.7 (1.9)	4.1 (0.3)	

Note: Percentage change which is due to the bias $\left(\frac{\text{bias}^2(\text{ATE}(\hat{\rho})) - \text{bias}^2(\text{ATE}(\hat{\rho}^*))}{\text{bias}^2(\text{ATE}(\hat{\rho})) + \text{Var}(\text{ATE}(\hat{\rho}))} \right)$ is given in brackets.

Table A.49: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, fixed λ

	Conventional PS			Conventional Ps+ Trim1			Shrinkage+Trim2 vs.others			Conventional PS+ Trim2			Conventional PS+ HLW			
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Cons	54.2 (2.3)	23.6 (0.6)	12.2 (0.6)	14.9 (0.6)	28.3 (0.5)	15.7 (0.5)	15.0 (0.5)	12.1 (0.5)	21.8 (0.7)	9.8 (0.6)	6.5 (0.4)	2.9 (0.3)	24.7 (5.5)	35.4 (3.7)	24.7 (5.2)	33.1 (3.3)
Set2	2.8 (2.2)	-1.0 (0.5)	-1.6 (0.6)	-1.2 (0.6)	3.8 (0.5)	-0.2 (0.5)	-0.2 (0.5)	-0.5 (0.5)	3.5 (0.7)	0.7 (0.5)	0.7 (0.4)	0.5 (0.3)	10.7 (5.1)	13.6 (3.5)	11.7 (4.9)	0.4 (3.1)
Set3	-13.7 (2.2)	-13.1 (0.5)	-9.6 (0.6)	-9.4 (0.6)	-5.6 (0.5)	-4.6 (0.5)	-3.7 (0.5)	-1.2 (0.5)	-3.9 (0.7)	-2.9 (0.5)	-1.1 (0.4)	1.5 (0.3)	-8.6 (5.1)	-13.7 (3.5)	-10.9 (4.9)	-5.3 (3.1)
Set4	-10.0 (2.2)	-13.7 (0.5)	-10.6 (0.6)	-10.2 (0.6)	-2.7 (0.5)	-4.7 (0.5)	-3.8 (0.5)	-1.5 (0.5)	-1.3 (0.7)	-2.4 (0.5)	-0.6 (0.4)	1.8 (0.3)	5.1 (5.1)	3.5 (3.5)	4.9 (4.9)	3.1 (3.1)
Curve2	4.1 (1.5)	1.0 (0.4)	0.7 (0.4)	0.2 (0.4)	0.9 (0.3)	1.3 (0.4)	0.8 (0.3)	0.0 (0.3)	2.8 (0.5)	1.6 (0.4)	1.1 (0.3)	0.1 (0.2)	20.2 (3.6)	21.0 (2.5)	21.9 (3.5)	1.3 (2.2)
Design2	-14.7 (1.9)	-3.3 (0.5)	-0.5 (0.5)	-2.4 (0.5)	-4.1 (0.4)	-0.7 (0.4)	-0.8 (0.4)	-1.6 (0.4)	-4.4 (0.6)	0.1 (0.5)	0.2 (0.3)	-0.3 (0.2)	-22.7 (4.5)	-23.8 (3.0)	-20.4 (4.3)	-3.1 (2.7)
Design3	-3.3 (1.9)	-5.5 (0.5)	-0.8 (0.5)	-0.3 (0.5)	-1.5 (0.4)	-1.9 (0.4)	-1.2 (0.4)	-0.2 (0.4)	-2.3 (0.6)	-1.6 (0.5)	-0.8 (0.3)	-0.1 (0.2)	26.2 (4.5)	15.8 (3.0)	24.8 (4.3)	10.5 (2.7)
Nnr2	6.6 (1.9)	4.4 (0.5)	1.5 (0.5)	1.4 (0.5)	-9.5 (0.4)	-4.9 (0.4)	-5.2 (0.4)	-5.0 (0.4)	-5.4 (0.6)	-3.0 (0.5)	-2.2 (0.3)	-1.1 (0.2)	-16.1 (4.5)	-4.5 (3.0)	-11.2 (4.3)	-22.4 (2.7)
Nnr3	-2.9 (1.9)	9.0 (0.5)	4.8 (0.5)	5.1 (0.5)	-12.8 (0.4)	-5.4 (0.4)	-6.2 (0.4)	-5.2 (0.4)	-10.6 (0.6)	-5.1 (0.5)	-3.7 (0.3)	-2.0 (0.2)	-23.4 (4.5)	-9.5 (3.0)	-19.7 (4.3)	-25.0 (2.7)
R ²	0.74	0.96	0.91	0.90	0.96	0.86	0.87	0.79	0.90	0.79	0.73	0.66	0.76	0.84	0.75	0.69

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.50: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, mse-minimizing λ

	Conventional PS			Conventional PS+ Trim1			Conventional PS+ Trim2			Conventional PS+ HLW		
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Shrinkage+Trim2 vs.others												
Cons	59.7 (4.1)	24.5 (0.6)	12.8 (0.6)	15.3 (0.6)	29.7 (0.6)	16.8 (0.5)	16.4 (0.5)	13.4 (0.5)	21.8 (0.7)	9.9 (0.6)	7.0 (0.4)	3.4 (0.3)
Set2	2.7 (3.9)	-0.9 (0.6)	-1.5 (0.6)	-1.1 (0.6)	3.8 (0.5)	-0.4 (0.5)	-0.3 (0.4)	-0.5 (0.5)	3.5 (0.7)	0.6 (0.5)	0.7 (0.4)	0.6 (0.3)
Set3	-13.7 (3.9)	-13.3 (0.6)	-9.8 (0.6)	-9.4 (0.6)	-6.1 (0.5)	-5.2 (0.5)	-4.1 (0.4)	-1.5 (0.5)	-3.9 (0.7)	-3.0 (0.5)	-1.1 (0.4)	1.7 (0.3)
Set4	-10.1 (3.9)	-13.7 (0.6)	-10.7 (0.6)	-10.0 (0.6)	-3.2 (0.5)	-5.3 (0.5)	-4.2 (0.4)	-1.8 (0.5)	-1.4 (0.7)	-2.6 (0.5)	-0.7 (0.4)	2.0 (0.3)
Curve2	1.8 (2.8)	0.7 (0.4)	0.9 (0.4)	0.5 (0.4)	0.4 (0.4)	1.1 (0.3)	0.6 (0.3)	-0.3 (0.3)	2.5 (0.5)	1.9 (0.4)	1.2 (0.3)	0.0 (0.2)
Design2	-7.6 (3.4)	-5.2 (0.5)	-1.4 (0.5)	-3.6 (0.5)	-4.5 (0.5)	-0.9 (0.4)	-0.9 (0.4)	-1.5 (0.4)	-3.1 (0.6)	-0.6 (0.5)	-0.6 (0.3)	-1.1 (0.2)
Design3	-2.0 (3.4)	-4.9 (0.5)	-1.4 (0.5)	-1.2 (0.5)	-2.1 (0.5)	-1.5 (0.4)	-0.9 (0.4)	0.2 (0.4)	-2.1 (0.6)	-2.7 (0.5)	-1.9 (0.3)	-1.2 (0.2)
Nnr2	10.0 (3.4)	4.1 (0.5)	2.0 (0.5)	2.0 (0.5)	-11.1 (0.5)	-6.0 (0.4)	-6.8 (0.4)	-6.9 (0.4)	-7.5 (0.6)	-3.0 (0.5)	-2.7 (0.3)	-1.8 (0.2)
Nnr3	-6.0 (3.4)	10.6 (0.5)	4.7 (0.5)	5.3 (0.5)	-13.6 (0.5)	-7.5 (0.4)	-8.6 (0.4)	-7.8 (0.4)	-10.1 (0.6)	-5.2 (0.5)	-4.2 (0.3)	-2.6 (0.2)
R^2	0.46	0.96	0.92	0.92	0.96	0.91	0.93	0.89	0.88	0.81	0.81	0.81
									0.75	0.84	0.74	0.78

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.51: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, data-driven λ

	Conventional PS				Conventional PS+ Trim1				Shrinkage+Trim2 vs.others				Conventional PS+ Trim2				Conventional PS+ HLW			
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Cons	61.0 (3.1)	23.4 (1.5)	11.5 (0.9)	15.3 (1.0)	18.8 (0.6)	11.5 (0.6)	12.6 (0.6)	11.3 (0.6)	11.0 (0.5)	4.6 (0.3)	2.8 (0.2)	0.9 (0.1)	14.0 (5.8)	33.8 (3.7)	22.3 (5.3)	36.1 (2.9)				
Set2	2.0 (2.9)	-1.1 (1.4)	-1.8 (0.9)	-1.4 (0.9)	3.0 (0.6)	-0.2 (0.5)	-0.4 (0.5)	-0.6 (0.5)	2.3 (0.4)	0.5 (0.3)	0.4 (0.2)	0.2 (0.1)	11.9 (5.5)	14.0 (3.5)	12.7 (5.0)	-0.7 (2.7)				
Set3	-14.4 (2.9)	-13.1 (1.4)	-10.1 (0.9)	-10.9 (0.9)	-4.4 (0.6)	-3.0 (0.5)	-2.9 (0.5)	-1.6 (0.5)	-2.0 (0.4)	-1.4 (0.3)	-0.5 (0.2)	0.9 (0.1)	-6.7 (5.5)	-13.1 (3.5)	-10.4 (5.0)	-6.8 (2.7)				
Set4	-11.4 (2.9)	-13.6 (1.4)	-11.2 (0.9)	-11.7 (0.9)	-2.3 (0.6)	-3.1 (0.5)	-3.1 (0.5)	-1.9 (0.5)	-0.4 (0.4)	-1.1 (0.3)	-0.3 (0.2)	1.0 (0.1)	4.7 (5.5)	1.2 (3.5)	1.8 (5.0)	-7.5 (2.7)				
Curve2	1.9 (2.0)	-0.9 (1.0)	0.1 (0.6)	0.2 (0.7)	0.5 (0.4)	-0.2 (0.4)	-0.2 (0.4)	-0.4 (0.4)	2.4 (0.3)	0.1 (0.2)	0.2 (0.1)	0.0 (0.1)	22.6 (3.9)	20.9 (2.5)	22.3 (3.6)	0.4 (1.9)				
Design2	-29.2 (2.5)	-6.4 (1.2)	-2.0 (0.7)	-4.1 (0.8)	-2.3 (0.5)	-0.3 (0.5)	-1.0 (0.5)	-1.9 (0.5)	-1.1 (0.4)	0.8 (0.2)	0.6 (0.2)	0.1 (0.1)	-22.2 (4.7)	-25.2 (3.0)	-21.4 (4.4)	-5.9 (2.3)				
Design3	-16.0 (2.5)	-5.3 (1.2)	-0.2 (0.7)	-0.5 (0.8)	0.4 (0.5)	-0.7 (0.5)	-0.9 (0.5)	-0.7 (0.5)	0.8 (0.4)	-0.3 (0.2)	-0.1 (0.2)	-0.1 (0.1)	31.3 (4.7)	16.6 (3.0)	25.1 (4.4)	8.7 (2.3)				
Nnr2	-1.0 (2.5)	3.3 (1.2)	0.9 (0.7)	1.1 (0.8)	-6.9 (0.5)	-3.9 (0.5)	-4.4 (0.5)	-4.4 (0.5)	-4.8 (0.4)	-1.6 (0.2)	-1.1 (0.2)	-0.4 (0.1)	-16.6 (4.7)	-4.8 (3.0)	-10.7 (4.4)	-24.6 (2.3)				
Nnr3	2.5 (2.5)	8.4 (1.2)	2.9 (0.7)	3.5 (0.8)	-12.2 (0.5)	-5.1 (0.5)	-6.6 (0.5)	-6.1 (0.5)	-8.1 (0.4)	-2.7 (0.2)	-1.9 (0.2)	-0.7 (0.1)	-24.3 (4.7)	-6.3 (3.0)	-18.7 (4.4)	-27.6 (2.3)				
R ²	0.75	0.80	0.82	0.83	0.93	0.76	0.81	0.77	0.91	0.80	0.77	0.68	0.76	0.84	0.75	0.78				

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.52: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, fixed λ

	Shrinkage vs.others												Conventional PS+ HLW			
	Conventional PS				Conventional Ps+ Trim1				Conventional PS+ Trim2				Conventional PS+ HLW			
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Cons	60.3 (2.2)	23.6 (0.7)	9.1 (0.3)	8.6 (0.1)	37.9 (2.1)	15.1 (0.9)	11.6 (0.6)	5.1 (0.5)	31.8 (1.9)	9.0 (1.3)	2.7 (0.9)	-4.6 (0.8)	34.0 (4.9)	34.8 (3.5)	21.3 (5.2)	27.3 (3.1)
Set2	0.4 (2.1)	-1.7 (0.6)	-0.9 (0.3)	0.0 (0.1)	-1.7 (2.0)	-1.1 (0.8)	0.6 (0.5)	1.0 (0.5)	-1.9 (1.8)	-0.1 (1.2)	1.8 (0.9)	2.2 (0.8)	8.0 (4.6)	13.2 (3.3)	12.9 (4.9)	1.8 (2.9)
Set3	-11.4 (2.1)	-10.3 (0.6)	-4.3 (0.3)	-2.6 (0.1)	-1.9 (2.0)	-1.3 (0.8)	2.0 (0.5)	6.5 (0.5)	-0.1 (1.8)	0.6 (1.2)	5.1 (0.9)	9.7 (0.8)	-5.9 (4.6)	-11.0 (3.3)	-6.0 (4.9)	1.5 (2.9)
Set4	-10.0 (2.1)	-11.4 (0.6)	-4.8 (0.3)	-2.6 (0.1)	-3.1 (2.0)	-1.9 (0.8)	2.4 (0.5)	7.0 (0.5)	-1.5 (1.8)	0.6 (1.2)	6.0 (0.9)	10.9 (0.8)	2.6 (4.6)	2.2 (3.3)	6.3 (4.9)	1.8 (2.9)
Curve2	-2.1 (1.5)	3.3 (0.4)	1.3 (0.2)	0.1 (0.1)	-10.1 (1.4)	4.1 (0.6)	1.5 (0.4)	-0.2 (0.4)	-8.5 (1.3)	4.5 (0.8)	1.8 (0.6)	-0.1 (0.5)	12.1 (3.3)	22.7 (2.4)	23.0 (3.5)	1.3 (2.1)
Design2	-13.1 (1.8)	-3.7 (0.5)	-1.0 (0.2)	-2.3 (0.1)	-0.6 (1.7)	-1.0 (0.7)	-1.3 (0.5)	-1.4 (0.4)	-0.9 (1.6)	-0.1 (1.0)	-0.2 (0.8)	-0.1 (0.7)	-20.2 (4.0)	-24.1 (2.9)	-21.2 (4.3)	-2.5 (2.5)
Design3	-6.8 (1.8)	-5.0 (0.5)	-0.8 (0.2)	-2.7 (0.1)	-7.0 (1.7)	-1.2 (0.7)	-1.1 (0.5)	-2.5 (0.4)	-8.3 (1.6)	-0.8 (1.0)	-0.7 (0.8)	-2.4 (0.7)	21.9 (4.0)	16.3 (2.9)	25.6 (4.3)	9.0 (2.5)
Nnr2	4.2 (1.8)	2.2 (0.5)	-0.8 (0.2)	0.7 (0.1)	-14.0 (1.7)	-7.2 (0.7)	-7.6 (0.5)	-5.9 (0.4)	-10.0 (1.6)	-5.5 (1.0)	-4.7 (0.8)	-2.0 (0.7)	-19.5 (4.0)	-5.9 (2.9)	-13.1 (4.3)	-24.1 (2.5)
Nnr3	-10.0 (1.8)	2.3 (0.5)	-1.9 (0.2)	1.8 (0.1)	-23.4 (1.7)	-13.2 (0.7)	-13.4 (0.5)	-9.3 (0.4)	-21.6 (1.6)	-13.3 (1.0)	-11.3 (0.8)	-6.2 (0.7)	-34.2 (4.0)	-14.9 (2.9)	-26.1 (4.3)	-30.0 (2.5)
R ²	0.73	0.92	0.91	0.96	0.81	0.86	0.93	0.93	0.81	0.75	0.83	0.87	0.77	0.85	0.78	0.74

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.53: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, mse-minimizing λ

	Conventional PS						Shrinkage vs.others												Conventional PS+ HLW					
	Conventional PS			Conventional PS+ Trim1			Conventional PS+ Trim2			Conventional PS+ Trim3			Conventional PS+ Trim4			Conventional PS+ Trim5			Conventional PS+ HLW			Conventional PS+ HLW		
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Cons	65.6 (4.0)	24.6 (0.5)	9.3 (0.3)	8.4 (0.2)	38.7 (2.1)	16.2 (0.8)	12.5 (0.6)	5.8 (0.5)	31.2 (2.2)	9.3 (1.1)	2.7 (0.8)	-4.8 (0.8)	30.3 (5.2)	34.4 (3.6)	18.5 (5.5)	29.2 (2.7)								
Set2	0.6 (3.8)	-1.6 (0.5)	-0.9 (0.3)	0.0 (0.1)	-1.6 (2.0)	-1.2 (0.7)	0.5 (0.5)	0.8 (0.5)	-1.9 (2.1)	-0.1 (1.0)	1.7 (0.8)	2.1 (0.7)	9.3 (4.9)	13.2 (3.4)	13.9 (5.2)	0.7 (2.6)								
Set3	-11.1 (3.8)	-10.6 (0.5)	-4.6 (0.3)	-2.8 (0.1)	-1.7 (2.0)	-1.9 (0.7)	1.5 (0.5)	6.0 (0.5)	0.7 (2.1)	0.4 (1.0)	4.9 (0.8)	9.7 (0.7)	-4.1 (4.9)	-10.5 (3.4)	-4.7 (5.2)	1.4 (2.6)								
Set4	-9.5 (3.8)	-11.6 (0.5)	-5.2 (0.3)	-2.8 (0.1)	-2.7 (2.0)	-2.6 (0.7)	1.7 (0.5)	6.4 (0.5)	-0.6 (2.1)	0.3 (1.0)	5.7 (0.8)	10.8 (0.7)	4.6 (4.9)	2.8 (3.4)	7.6 (5.2)	1.6 (2.6)								
Curve2	-3.5 (2.7)	2.5 (0.4)	1.3 (0.2)	0.2 (0.1)	-10.2 (1.4)	3.3 (0.5)	1.0 (0.4)	-0.6 (0.4)	-8.6 (1.5)	4.2 (0.7)	1.6 (0.6)	-0.3 (0.5)	13.0 (3.5)	22.6 (2.4)	23.6 (3.7)	0.4 (1.8)								
Design2	-5.9 (3.3)	-5.3 (0.4)	-0.7 (0.2)	-2.2 (0.1)	0.3 (1.7)	-0.8 (0.6)	-0.2 (0.5)	0.1 (0.4)	1.8 (1.8)	-0.5 (0.9)	0.1 (0.7)	0.5 (0.6)	-18.4 (4.3)	-25.2 (2.9)	-21.2 (4.5)	-4.0 (2.2)								
Design3	-5.7 (3.3)	-4.6 (0.4)	-0.7 (0.2)	-2.5 (0.1)	-7.7 (1.7)	-0.8 (0.6)	0.0 (0.5)	-0.8 (0.4)	-8.0 (1.8)	-1.9 (0.9)	-1.0 (0.7)	-2.3 (0.6)	23.3 (4.3)	16.5 (2.9)	26.4 (4.5)	9.3 (2.2)								
Nnr2	7.0 (3.3)	1.7 (0.4)	-0.6 (0.2)	1.0 (0.1)	-14.6 (1.7)	-8.5 (0.6)	-9.5 (0.5)	-8.3 (0.4)	-11.2 (1.8)	-5.7 (0.9)	-5.5 (0.7)	-3.1 (0.6)	-18.6 (4.3)	-6.1 (2.9)	-12.6 (4.5)	-27.6 (2.2)								
Nnr3	-12.6 (3.3)	5.2 (0.4)	-1.6 (0.2)	2.2 (0.1)	-24.1 (1.7)	-14.0 (0.6)	-15.4 (0.5)	-11.8 (0.4)	-21.0 (1.8)	-12.0 (0.9)	-11.3 (0.7)	-6.6 (0.6)	-33.1 (4.3)	-10.7 (2.9)	-24.7 (4.5)	-33.8 (2.2)								
R^2	0.48	0.95	0.92	0.96	0.81	0.90	0.95	0.94	0.77	0.78	0.85	0.88	0.74	0.85	0.76	0.83								

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.54: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, data-driven λ

	Shrinkage vs.others												Conventional PS+ HLW			
	Conventional PS				Conventional Ps+ Trim1				Conventional PS+ Trim2				Conventional PS+ HLW			
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Cons	9.7 (0.5)	6.6 (0.3)	3.7 (0.2)	3.3 (0.1)	-111.4 (18.1)	-10.3 (2.1)	4.4 (0.7)	-2.0 (0.8)	-128.1 (19.8)	-18.5 (2.7)	-6.1 (1.1)	-13.4 (1.2)	-123.9 (21.9)	18.3 (4.0)	14.8 (5.6)	25.1 (2.7)
Set2	-0.7 (0.4)	-0.6 (0.3)	-0.3 (0.2)	0.0 (0.1)	-2.5 (17.1)	0.6 (2.0)	1.4 (0.6)	1.1 (0.8)	-4.4 (18.6)	1.6 (2.6)	2.2 (1.0)	2.0 (1.1)	20.5 (20.6)	17.7 (3.8)	15.2 (5.3)	0.8 (2.6)
Set3	-1.6 (0.4)	-2.8 (0.3)	-1.7 (0.2)	-1.0 (0.1)	34.4 (17.1)	10.8 (2.0)	6.0 (0.6)	9.6 (0.8)	40.5 (18.6)	13.3 (2.6)	9.0 (1.0)	13.0 (1.1)	29.0 (20.6)	-4.5 (3.8)	-2.9 (5.3)	2.9 (2.6)
Set4	-2.1 (0.4)	-3.2 (0.3)	-1.9 (0.2)	-1.0 (0.1)	29.9 (17.1)	10.9 (2.0)	6.7 (0.6)	10.2 (0.8)	34.8 (18.6)	13.9 (2.6)	10.1 (1.0)	13.9 (1.1)	42.2 (20.6)	11.1 (3.8)	10.1 (5.3)	3.2 (2.6)
Curve2	-1.9 (0.3)	0.9 (0.2)	0.4 (0.1)	0.1 (0.0)	1.2 (12.1)	2.4 (1.4)	0.1 (0.5)	-0.7 (0.5)	5.5 (13.2)	3.0 (1.8)	0.6 (0.7)	-0.3 (0.8)	52.3 (14.6)	25.5 (2.7)	23.6 (3.8)	0.4 (1.8)
Design2	2.9 (0.4)	-0.3 (0.2)	0.0 (0.1)	-0.5 (0.1)	106.0 (14.8)	9.2 (1.8)	1.2 (0.6)	2.3 (0.7)	112.4 (16.1)	10.9 (2.2)	2.9 (0.9)	4.5 (1.0)	80.2 (17.9)	-22.6 (3.3)	-20.3 (4.6)	-1.6 (2.2)
Design3	-0.9 (0.4)	-0.1 (0.2)	0.2 (0.1)	-0.5 (0.1)	76.5 (14.8)	7.6 (1.8)	-0.3 (0.6)	-0.3 (0.7)	80.1 (16.1)	8.6 (2.2)	0.5 (0.9)	0.4 (1.0)	134.5 (17.9)	23.4 (3.3)	26.8 (4.6)	9.8 (2.2)
Nnr2	-3.1 (0.4)	-1.6 (0.2)	-1.0 (0.1)	-0.5 (0.1)	-11.1 (14.8)	-10.2 (1.8)	-6.5 (0.6)	-6.3 (0.7)	-7.9 (16.1)	-7.9 (2.2)	-3.2 (0.9)	-2.2 (1.0)	-33.4 (17.9)	-9.3 (3.3)	-12.6 (4.6)	-27.9 (2.2)
Nnr3	-5.9 (0.4)	-2.6 (0.2)	-1.6 (0.1)	-0.8 (0.1)	-70.2 (14.8)	-20.9 (1.8)	-11.8 (0.6)	-11.6 (0.7)	-66.2 (16.1)	-19.1 (2.2)	-7.2 (0.9)	-6.2 (1.0)	-100.8 (17.9)	-16.0 (3.3)	-23.1 (4.6)	-34.3 (2.2)
R ²	0.88	0.87	0.86	0.94	0.58	0.79	0.91	0.91	0.56	0.71	0.78	0.83	0.63	0.85	0.75	0.83

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.55: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, fixed λ

	Conventional PS						Shrinkage+ Trim 1 vs.others						Conventional PS+ HLW					
	Conventional PS			Conventional PS+ Trim1			Conventional PS+ Trim2			Conventional PS+ HLW			Conventional PS+ HLW					
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR		
Cons	39.3 (2.7)	15.1 (0.7)	2.1 (0.6)	5.1 (0.6)	7.1 (0.6)	6.7 (0.4)	5.3 (0.2)	2.1 (0.1)	-1.1 (1.2)	0.4 (0.8)	-4.0 (0.6)	-7.8 (0.5)	5.1 (6.9)	28.6 (4.1)	16.4 (5.8)	25.3 (3.5)		
Set2	-0.1 (2.5)	-1.2 (0.6)	-1.7 (0.6)	-1.0 (0.6)	-1.5 (0.5)	-0.4 (0.3)	-0.2 (0.2)	-0.2 (0.1)	-2.4 (1.1)	0.6 (0.7)	0.8 (0.6)	0.9 (0.6)	8.0 (6.5)	14.3 (3.9)	12.6 (5.4)	0.9 (3.3)		
Set3	-13.3 (2.5)	-13.8 (0.6)	-9.7 (0.6)	-9.7 (0.6)	-2.8 (0.5)	-4.7 (0.3)	-3.3 (0.2)	-0.9 (0.1)	-1.0 (1.1)	-3.0 (0.7)	-0.5 (0.6)	1.9 (0.4)	-6.9 (6.5)	-14.1 (3.9)	-10.9 (5.4)	-5.0 (3.3)		
Set4	-11.9 (2.5)	-14.5 (0.6)	-10.8 (0.6)	-10.3 (0.6)	-3.6 (0.5)	-4.9 (0.3)	-3.3 (0.2)	-1.0 (0.1)	-2.2 (1.1)	-2.6 (0.7)	0.0 (0.6)	2.4 (0.4)	3.0 (6.5)	0.7 (3.9)	2.0 (5.4)	-5.3 (3.3)		
Curve2	3.1 (1.8)	1.4 (0.4)	0.8 (0.4)	0.2 (0.4)	-1.8 (0.4)	1.8 (0.2)	0.9 (0.1)	-0.1 (0.1)	0.1 (0.8)	2.1 (0.5)	1.2 (0.4)	0.0 (0.3)	22.3 (4.6)	22.6 (2.7)	23.6 (3.9)	1.3 (2.4)		
Design2	-13.5 (2.2)	-3.3 (0.5)	-0.1 (0.5)	-1.5 (0.5)	-0.4 (0.5)	-0.6 (0.3)	-0.3 (0.2)	-0.6 (0.1)	-0.6 (0.9)	0.2 (0.6)	0.7 (0.5)	0.7 (0.4)	-23.6 (5.7)	-24.9 (3.3)	-21.5 (4.7)	-2.3 (2.9)		
Design3	-4.1 (2.2)	-5.1 (0.5)	-0.2 (0.5)	-0.7 (0.5)	-2.5 (0.5)	-1.4 (0.3)	-0.7 (0.2)	-0.6 (0.1)	-3.4 (0.9)	-1.1 (0.6)	-0.3 (0.5)	-0.5 (0.4)	30.7 (5.7)	17.3 (3.3)	26.9 (4.7)	11.1 (2.9)		
Nnr2	17.8 (2.2)	10.2 (0.5)	7.4 (0.5)	7.4 (0.5)	3.3 (0.5)	0.6 (0.3)	0.0 (0.2)	0.7 (0.1)	9.0 (0.9)	2.9 (0.6)	3.4 (0.5)	5.1 (0.4)	-6.9 (5.7)	-0.9 (3.3)	-7.7 (4.7)	-19.0 (2.9)		
Nnr3	10.8 (2.2)	15.7 (0.5)	11.5 (0.5)	12.1 (0.5)	5.5 (0.5)	1.0 (0.3)	-0.4 (0.2)	1.2 (0.1)	9.3 (0.9)	1.7 (0.6)	2.6 (0.5)	5.0 (0.4)	-9.7 (5.7)	-5.3 (3.3)	-15.9 (4.7)	-21.0 (2.9)		
R ²	0.72	0.97	0.94	0.94	0.81	0.88	0.91	0.93	0.70	0.57	0.53	0.82	0.66	0.82	0.73	0.60		

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.56: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, mse-minimizing λ

	Shrinkage+ Trim 1 vs.others												
	Conventional PS			Conventional PS+ Trim1			Conventional PS+ Trim2			Conventional PS+ HLW			
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	
Cons	46.1 (4.7)	15.7 (0.6)	2.1 (0.6)	4.8 (0.7)	8.3 (0.7)	7.5 (0.6)	6.2 (0.4)	2.9 (0.5)	-1.5 (1.2)	0.1 (0.6)	-4.1 (0.5)	-8.1 (0.5)	27.7 (3.2)
Set2	0.3 (4.4)	-0.9 (0.6)	-1.4 (0.6)	-0.8 (0.7)	-1.4 (0.7)	-0.3 (0.5)	-0.2 (0.4)	-0.1 (0.5)	-2.3 (1.1)	0.7 (0.6)	0.9 (0.5)	1.0 (0.5)	-0.2 (3.0)
Set3	-12.6 (4.4)	-13.0 (0.6)	-9.0 (0.6)	-8.7 (0.7)	-2.3 (0.7)	-4.5 (0.5)	-3.0 (0.4)	-0.4 (0.5)	0.2 (1.1)	-2.3 (0.6)	0.1 (0.5)	3.0 (0.5)	-4.5 (3.0)
Set4	-10.9 (4.4)	-13.5 (0.6)	-9.8 (0.6)	-9.1 (0.7)	-3.0 (0.7)	-4.7 (0.5)	-3.1 (0.4)	-0.5 (0.5)	-1.0 (1.1)	-1.9 (0.6)	0.7 (0.5)	3.5 (0.5)	-4.8 (3.0)
Curve2	1.0 (3.1)	0.9 (0.4)	1.0 (0.4)	0.4 (0.5)	-2.0 (0.5)	1.5 (0.4)	0.7 (0.3)	-0.4 (0.3)	0.1 (0.8)	2.3 (0.4)	1.3 (0.3)	-0.1 (0.4)	0.5 (2.1)
Design2	-6.1 (3.8)	-4.0 (0.5)	0.6 (0.5)	-1.6 (0.6)	-0.7 (0.6)	0.6 (0.5)	1.0 (0.4)	0.6 (0.4)	1.2 (1.0)	0.9 (0.5)	1.4 (0.4)	1.1 (0.4)	-4.1 (2.6)
Design3	-1.6 (3.8)	-5.5 (0.5)	-1.9 (0.5)	-2.7 (0.6)	-4.6 (0.6)	-2.1 (0.5)	-1.5 (0.4)	-1.4 (0.4)	-4.7 (1.0)	-3.4 (0.5)	-2.5 (0.4)	-2.9 (0.4)	9.0 (2.6)
Nnr2	20.8 (3.8)	12.0 (0.5)	10.6 (0.5)	10.9 (0.6)	4.6 (0.6)	2.0 (0.5)	1.1 (0.4)	1.7 (0.4)	9.8 (1.0)	5.4 (0.5)	5.9 (0.4)	7.6 (0.4)	-19.4 (2.6)
Nnr3	5.8 (3.8)	18.5 (0.5)	13.0 (0.5)	14.3 (0.6)	5.1 (0.6)	0.4 (0.5)	-1.1 (0.4)	0.8 (0.4)	10.3 (1.0)	3.3 (0.5)	4.1 (0.4)	6.9 (0.4)	-22.9 (2.6)
R ²	0.44	0.97	0.95	0.94	0.76	0.77	0.75	0.39	0.74	0.81	0.84	0.90	0.65

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.

Table A.57: Regression of the average percentage improvement in MSE for $N = 72$ settings on a set of dummy variables describing the setting, data-driven λ

	Conventional PS			Shrinkage+ Trim 1 vs.others			Conventional PS+ Trim1			Conventional PS+ Trim2			Conventional PS+ HLW			
	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR	IPW1	IPW2	IPW3	DR
Cons	51.3 (3.1)	15.7 (1.3)	0.6 (0.7)	4.9 (0.8)	2.9 (0.2)	2.9 (0.1)	2.0 (0.1)	0.6 (0.0)	-6.0 (1.1)	-4.4 (0.7)	-8.8 (0.6)	-10.6 (0.6)	-1.5 (6.7)	27.3 (3.9)	12.8 (5.8)	27.7 (2.9)
Set2	0.4 (2.9)	-0.9 (1.2)	-1.5 (0.6)	-1.0 (0.7)	0.1 (0.2)	0.1 (0.1)	0.1 (0.1)	-0.1 (0.0)	-1.0 (1.0)	0.9 (0.7)	0.8 (0.6)	0.7 (0.5)	10.9 (6.3)	15.1 (3.7)	14.1 (5.5)	-0.2 (2.8)
Set3	-13.2 (2.9)	-12.6 (1.2)	-8.9 (0.6)	-10.2 (0.7)	-1.1 (0.2)	-1.8 (0.1)	-1.2 (0.1)	-0.2 (0.0)	1.5 (1.0)	-0.1 (0.7)	1.5 (0.6)	2.4 (0.5)	-3.7 (6.3)	-12.5 (3.7)	-9.1 (5.5)	-5.7 (2.8)
Set4	-11.5 (2.9)	-13.0 (1.2)	-9.8 (0.6)	-10.7 (0.7)	-1.0 (0.2)	-1.7 (0.1)	-1.1 (0.1)	-0.3 (0.0)	0.9 (1.0)	0.4 (0.7)	1.9 (0.6)	2.8 (0.5)	6.9 (6.3)	2.6 (3.7)	4.1 (5.5)	-6.0 (2.8)
Curve2	2.1 (2.1)	-0.6 (0.9)	0.5 (0.5)	0.6 (0.5)	0.4 (0.2)	0.2 (0.1)	0.2 (0.1)	0.0 (0.0)	2.5 (0.7)	0.6 (0.5)	0.6 (0.4)	0.4 (0.4)	25.8 (4.5)	22.4 (2.6)	24.3 (3.9)	0.9 (2.0)
Design2	-29.9 (2.5)	-6.4 (1.1)	-0.9 (0.6)	-2.5 (0.6)	-0.1 (0.2)	0.1 (0.1)	0.2 (0.1)	-0.1 (0.0)	1.3 (0.9)	1.2 (0.6)	1.8 (0.5)	1.9 (0.5)	-22.4 (5.5)	-26.2 (3.2)	-21.7 (4.8)	-4.2 (2.4)
Design3	-17.3 (2.5)	-5.1 (1.1)	0.7 (0.6)	0.1 (0.6)	-0.3 (0.2)	-0.2 (0.1)	0.0 (0.1)	0.0 (0.0)	0.1 (0.9)	0.2 (0.6)	0.9 (0.5)	0.6 (0.5)	35.1 (5.5)	17.9 (3.2)	27.6 (4.8)	10.1 (2.4)
Nnr2	4.4 (2.5)	7.1 (1.1)	5.5 (0.6)	5.9 (0.6)	0.2 (0.2)	-0.4 (0.1)	-0.4 (0.1)	0.1 (0.0)	3.0 (0.9)	2.3 (0.6)	3.4 (0.5)	4.6 (0.5)	-12.1 (5.5)	-2.3 (3.2)	-8.0 (4.8)	-22.4 (2.4)
Nnr3	11.4 (2.5)	13.1 (1.1)	9.5 (0.6)	10.2 (0.6)	-0.4 (0.2)	-0.8 (0.1)	-0.8 (0.1)	0.1 (0.0)	4.6 (0.9)	1.9 (0.6)	4.6 (0.5)	6.1 (0.5)	-15.6 (5.5)	-3.3 (3.2)	-14.6 (4.8)	-23.7 (2.4)
R ²	0.76	0.86	0.91	0.91	0.53	0.88	0.84	0.81	0.45	0.29	0.65	0.80	0.72	0.84	0.74	0.73

Note: OLS standard errors in brackets. Set1 = homogeneous treatment and homoscedasticity, Set2 = heterogeneous treatment and homoscedasticity, Set3 = homogeneous treatment and heteroscedasticity, Set4 = heterogeneous treatment and heteroscedasticity, Curve1 = Outcome equation depends linearly on the propensity score, Curve2 = Outcome equation depends on the propensity score in a nonlinear way, Ratio1 = Treated-to-Control Ratio 1:1, Ratio2 = Treated-to-Control Ratio 3:2, Ratio3 = Treated-to-Control Ratio 2:3, N1 = sample size 100, N2 = sample size 200, N3 = sample size 500.