

# Report 4

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## Task 1

We will construct the most powerful test using the Carlin-Rubin Theorem for the problem:

$$H_{0,i} : \mu_i = 3 \quad \left( \lambda_i = \frac{1}{3} \right) \quad vs \quad H_{1,i} : \mu_i > 3 \quad \left( \lambda_i < \frac{1}{3} \right)$$

First, we need to show that the likelihood ration is monotonic. Let's have  $\lambda_1 < \lambda_2 \in \Theta$ ,  $\lambda_i = \frac{1}{\mu_i}$ .

$$L(X) = \frac{\prod_{j=1}^m f(x_j, \lambda_2)}{\prod_{j=1}^m f(x_j, \lambda_1)} = \frac{\prod_{j=1}^m \lambda_2 e^{-x_j \lambda_2}}{\prod_{j=1}^m \lambda_1 e^{-x_j \lambda_1}} = \left( \frac{\lambda_2}{\lambda_1} \right)^m e^{-(\lambda_2 - \lambda_1) \sum_{j=1}^m x_j}$$

Let  $T = \sum_{i=1}^n x_i$ , than

$$L(X) = \left(\frac{\lambda_2}{\lambda_1}\right)^n e^{-(\lambda_2 - \lambda_1)T}$$

is a non-decreasing function of the statistic  $-T$ .

We reject  $H_{0,i}$  if  $-T < c$ , for  $T$  such that  $\mathbb{E}_{\mu=3}[-T < c] = \alpha$ .

We know that under  $H_{0,i}$   $T \sim \text{Gamma}(n, \frac{1}{3})$ . Thus,  $-c = F_{\text{Gamma}(n, \frac{1}{3})}^{-1}(1 - \alpha)$ .

Summarizing, we reject  $H_{0,i}$  if  $T > F_{\text{Gamma}(n, \frac{1}{3})}^{-1}(1 - \alpha)$ .

The p-value of the test:

$$p = \mathbb{P}_0(t > T) = 1 - F_{\text{Gamma}(n, \frac{1}{3})}(T)$$

## Task 2

Bonferroni:

Reject  $H_{0,i}$  if

$$p_i < \frac{\alpha}{n}$$

BFDR:

$$\frac{(1 - \epsilon)(1 - F_{m,3}(c_{BFDR}))}{1 - ((1 - \epsilon)F_{m,3}(c_{BFDR}) + \epsilon F_{m,5.5}(c_{BFDR}))} = q$$

Table 1: eps: 0.01, m: 20, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.414	0.324	0.456
fdr_vals	0.054	0.018	0.083
cost_vals_1	1.259	1.375	1.278
cost_vals_2	2.430	2.726	2.365
cost_vals_3	1.347	1.399	1.469

Table 2: eps: 0.01, m: 20, n: 200, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.505	0.308	0.600
fdr_vals	0.153	0.028	0.309
cost_vals_1	1.285	1.423	2.014
cost_vals_2	2.275	2.808	2.814
cost_vals_3	1.580	1.461	3.228

Table 3: eps: 0.01, m: 20, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.278	0.316	0.438
fdr_vals	0.024	0.035	0.098
cost_vals_1	10.207	9.744	8.700
cost_vals_2	20.313	19.313	16.575
cost_vals_3	10.308	9.919	9.525

Table 4: eps: 0.01, m: 20, n: 1000, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.369	0.316	0.617
fdr_vals	0.054	0.035	0.318
cost_vals_1	9.151	9.759	10.128
cost_vals_2	17.983	19.342	15.486
cost_vals_3	9.470	9.935	14.898

Table 5: eps: 0.01, m: 100, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.998	0.998	0.998
fdr_vals	0.047	0.048	0.099
cost_vals_1	0.098	0.102	0.237
cost_vals_2	0.100	0.104	0.239
cost_vals_3	0.194	0.202	0.472

Table 6: eps: 0.01, m: 100, n: 200, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.999	0.998	0.999
fdr_vals	0.072	0.055	0.144
cost_vals_1	0.152	0.117	0.370
cost_vals_2	0.153	0.119	0.371
cost_vals_3	0.303	0.232	0.739

Table 7: eps: 0.01, m: 100, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.993	0.997	0.999
fdr_vals	0.007	0.033	0.098
cost_vals_1	0.217	0.579	1.765
cost_vals_2	0.325	0.618	1.780
cost_vals_3	0.326	1.119	3.515

Table 8: eps: 0.01, m: 100, n: 1000, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.993	0.998	0.999
fdr_vals	0.010	0.033	0.137
cost_vals_1	0.264	0.575	2.568
cost_vals_2	0.366	0.612	2.581
cost_vals_3	0.426	1.113	5.123

Table 9: eps: 0.05, m: 20, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.403	0.499	0.580
fdr_vals	0.021	0.050	0.094
cost_vals_1	5.467	4.768	4.470
cost_vals_2	10.840	9.275	8.254
cost_vals_3	5.561	5.029	5.156

Table 10: eps: 0.05, m: 20, n: 200, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.511	0.496	0.755
fdr_vals	0.058	0.054	0.305
cost_vals_1	4.720	4.825	5.872
cost_vals_2	9.122	9.365	8.074
cost_vals_3	5.038	5.110	9.542

Table 11: eps: 0.05, m: 20, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.281	0.504	0.595
fdr_vals	0.007	0.048	0.095
cost_vals_1	36.789	26.599	24.004
cost_vals_2	73.479	51.884	44.667
cost_vals_3	36.888	27.913	27.345

Table 12: eps: 0.05, m: 20, n: 1000, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.367	0.500	0.767
fdr_vals	0.015	0.049	0.303
cost_vals_1	32.607	26.867	29.591
cost_vals_2	64.913	52.392	41.453
cost_vals_3	32.908	28.209	47.320

Table 13: eps: 0.05, m: 100, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.998	0.999	1.000
fdr_vals	0.010	0.048	0.097
cost_vals_1	0.133	0.558	1.188
cost_vals_2	0.155	0.567	1.192
cost_vals_3	0.244	1.107	2.372

Table 14: eps: 0.05, m: 100, n: 200, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.998	0.999	1.000
fdr_vals	0.012	0.046	0.136
cost_vals_1	0.155	0.534	1.744
cost_vals_2	0.180	0.543	1.746
cost_vals_3	0.285	1.059	3.486

Table 15: eps: 0.05, m: 100, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.993	0.999	1.000
fdr_vals	0.001	0.037	0.094
cost_vals_1	0.592	2.690	7.150
cost_vals_2	1.084	2.738	7.170
cost_vals_3	0.692	5.332	14.280

Table 16: eps: 0.05, m: 100, n: 1000, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.994	0.999	1.000
fdr_vals	0.002	0.036	0.133
cost_vals_1	0.531	2.626	10.566
cost_vals_2	0.927	2.671	10.573
cost_vals_3	0.666	5.207	21.125

Table 17: eps: 0.1, m: 20, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.397	0.588	0.667
fdr_vals	0.009	0.049	0.088
cost_vals_1	11.529	8.428	7.694
cost_vals_2	22.984	16.252	14.028
cost_vals_3	11.603	9.032	9.054

Table 18: eps: 0.1, m: 20, n: 200, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.516	0.599	0.837
fdr_vals	0.026	0.049	0.283
cost_vals_1	9.478	8.230	9.966
cost_vals_2	18.678	15.848	13.067
cost_vals_3	9.756	8.842	16.831

Table 19: eps: 0.1, m: 20, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.278	0.594	0.693
fdr_vals	0.003	0.042	0.087
cost_vals_1	83.822	50.133	43.451
cost_vals_2	167.562	97.234	79.066
cost_vals_3	83.904	53.165	51.287

Table 20: eps: 0.1, m: 20, n: 1000, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.366	0.596	0.852
fdr_vals	0.006	0.041	0.280
cost_vals_1	73.811	49.852	56.138
cost_vals_2	147.364	96.722	73.286
cost_vals_3	74.069	52.834	95.128

Table 21: eps: 0.1, m: 100, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.997	1.000	1.000
fdr_vals	0.004	0.057	0.092
cost_vals_1	0.126	1.093	1.828
cost_vals_2	0.171	1.099	1.832
cost_vals_3	0.207	2.180	3.652

Table 22: eps: 0.1, m: 100, n: 200, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.998	1.000	1.000
fdr_vals	0.007	0.056	0.131
cost_vals_1	0.155	1.070	2.753
cost_vals_2	0.189	1.072	2.755
cost_vals_3	0.276	2.138	5.504

Table 23: eps: 0.1, m: 100, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.993	1.000	1.000
fdr_vals	0.001	0.050	0.092
cost_vals_1	0.827	5.329	10.097
cost_vals_2	1.554	5.359	10.113
cost_vals_3	0.927	10.628	20.178

Table 24: eps: 0.1, m: 100, n: 1000, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.994	1.000	1.000
fdr_vals	0.001	0.051	0.129
cost_vals_1	0.703	5.361	14.854
cost_vals_2	1.263	5.388	14.862
cost_vals_3	0.846	10.695	29.700

Table 25: eps: 0.2, m: 20, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.403	0.695	0.769
fdr_vals	0.003	0.040	0.074
cost_vals_1	26.914	15.028	13.264
cost_vals_2	53.768	28.740	23.655
cost_vals_3	26.974	16.344	16.137

Table 26: eps: 0.2, m: 20, n: 200, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.514	0.699	0.908
fdr_vals	0.011	0.043	0.247
cost_vals_1	22.118	14.980	17.941
cost_vals_2	43.984	28.524	22.072
cost_vals_3	22.370	16.416	31.751

Table 27: eps: 0.2, m: 20, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.278	0.696	0.773
fdr_vals	0.001	0.043	0.076
cost_vals_1	166.103	77.013	67.047
cost_vals_2	332.126	146.873	119.340
cost_vals_3	166.183	84.166	81.801

Table 28: eps: 0.2, m: 20, n: 1000, q: 0.316

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.365	0.696	0.908
fdr_vals	0.003	0.042	0.244
cost_vals_1	146.232	77.022	88.942
cost_vals_2	292.231	147.024	110.208
cost_vals_3	146.465	84.042	156.618

Table 29: eps: 0.2, m: 100, n: 200, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.997	1.000	1.000
fdr_vals	0.003	0.052	0.081
cost_vals_1	0.210	2.149	3.425
cost_vals_2	0.318	2.156	3.428
cost_vals_3	0.312	4.291	6.847

Table 30: eps: 0.2, m: 100, n: 200, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.998	1.000	1.000
fdr_vals	0.003	0.052	0.115
cost_vals_1	0.166	2.121	5.078
cost_vals_2	0.234	2.125	5.079
cost_vals_3	0.264	4.238	10.155

Table 31: eps: 0.2, m: 100, n: 1000, q: 0.1

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.993	1.000	1.000
fdr_vals	0.000	0.047	0.080
cost_vals_1	1.643	10.395	18.348
cost_vals_2	3.199	10.424	18.363
cost_vals_3	1.730	20.761	36.681

Table 32: eps: 0.2, m: 100, n: 1000, q: 0.141

	Bonferroni	control BFDR	Benjamini-Hochberg
power_vals	0.994	1.000	1.000
fdr_vals	0.001	0.047	0.111
cost_vals_1	1.344	10.398	26.437
cost_vals_2	2.580	10.425	26.448
cost_vals_3	1.452	20.769	52.863



### Task 3

In this task, we are going to derive the optimal Bayesian classifier for each set of parameters  $m$ ,  $\epsilon$ ,  $c_0$ ,  $c_A$ .

Rejection region (classify as rejected  $H_{0,i}$ ):

$$\Gamma_A = \left\{ T : \frac{f(T|H_A)}{f(T|H_0)} \geq \frac{c_0 \mathbb{P}(H_0)}{c_A \mathbb{P}(H_A)} \right\}$$

$$\frac{f(T|H_A)}{f(T|H_0)} = \frac{\frac{(\frac{1}{5.5})^m}{\Gamma(m)} T^{m-1} e^{-\frac{1}{5.5}T}}{\frac{(\frac{1}{3})^m}{\Gamma(m)} T^{m-1} e^{-\frac{1}{3}T}} = \left( \frac{3}{5.5} \right)^m e^{(\frac{1}{3} - \frac{1}{5.5})T}$$

Thus:

$$\frac{f(T|H_A)}{f(T|H_0)} = \left( \frac{3}{5.5} \right)^m e^{T \frac{5}{33}} \geq \frac{c_0 \mathbb{P}(H_0)}{c_A \mathbb{P}(H_A)} = \frac{c_0(1-\epsilon)}{c_A \epsilon}$$

$$T \geq \frac{33}{5} \ln \left( \left( \frac{5.5}{3} \right)^m \cdot \frac{c_0(1-\epsilon)}{c_A \epsilon} \right) = \tau$$

$$\mathbb{P}(\text{rejected}|H_0) = \mathbb{P}_0(T > \tau) = 1 - F_{\text{Gamma}(m, \frac{1}{3})}(\tau)$$

$$\mathbb{P}(\text{rejected}|H_1) = \mathbb{P}_1(T > \tau) = 1 - F_{\text{Gamma}(m, \frac{1}{5.5})}(\tau)$$

$$BFDR = \mathbb{P}(H_0|\text{rejected}) = \frac{\mathbb{P}(H_0 \cap \text{rejected})}{\mathbb{P}(\text{rejected})} = \frac{\mathbb{P}(\text{rejected}|H_0)\mathbb{P}(H_0)}{\mathbb{P}(\text{rejected})} = \frac{\mathbb{P}(\text{rejected}|H_0)\mathbb{P}(H_0)}{\mathbb{P}(\text{rejected}|H_0)\mathbb{P}(H_0) + \mathbb{P}(\text{rejected}|H_1)\mathbb{P}(H_1)}$$

$$BFDR = \frac{(1 - F_{\text{Gamma}(m, \frac{1}{3})}(\tau)) \cdot (1 - \epsilon)}{(1 - F_{\text{Gamma}(m, \frac{1}{3})}(\tau)) \cdot (1 - \epsilon) + (1 - F_{\text{Gamma}(m, \frac{1}{5.5})}(\tau)) \cdot \epsilon}$$

$$\text{power} = \mathbb{P}(\text{rejected}|H_1) = 1 - F_{\text{Gamma}(m, \frac{1}{5.5})}(\tau)$$

$$\mathbb{E}C = c_0 \cdot \mathbb{P}(\text{rejected}|H_0)\mathbb{P}(H_0) + c_A \cdot \mathbb{P}(\text{accepted}|H_1)\mathbb{P}(H_1)$$

$$\mathbb{E}C = c_0(1-\epsilon)(1 - F_{\text{Gamma}(m, \frac{1}{3})}(\tau)) + c_A \epsilon (1 - F_{\text{Gamma}(m, \frac{1}{5.5})}(\tau))$$

eps	m	c0	cA	tau	BFDR	power	cost
0.01	20	1	1	110.338	0.061	0.465	0.006
0.01	20	2	1	114.912	0.030	0.393	0.005
0.01	20	1	2	105.763	0.117	0.540	0.013
0.01	100	1	1	430.377	0.003	0.990	0.010
0.01	100	2	1	434.952	0.002	0.987	0.010
0.01	100	1	2	425.803	0.004	0.992	0.020
0.05	20	1	1	99.443	0.061	0.644	0.037
0.05	20	2	1	104.018	0.032	0.569	0.034

eps	m	c0	cA	tau	BFDR	power	cost
0.05	20	1	2	94.868	0.109	0.716	0.082
0.05	100	1	1	419.483	0.002	0.995	0.050
0.05	100	2	1	424.058	0.001	0.993	0.050
0.05	100	1	2	414.908	0.003	0.996	0.100
0.10	20	1	1	94.512	0.057	0.721	0.083
0.10	20	2	1	99.086	0.031	0.650	0.076
0.10	20	1	2	89.937	0.100	0.787	0.177
0.10	100	1	1	414.551	0.001	0.996	0.100
0.10	100	2	1	419.126	0.001	0.995	0.100
0.10	100	1	2	409.977	0.002	0.997	0.200
0.20	20	1	1	89.159	0.052	0.797	0.179
0.20	20	2	1	93.734	0.029	0.733	0.167
0.20	20	1	2	84.585	0.088	0.853	0.377
0.20	100	1	1	409.199	0.001	0.997	0.200
0.20	100	2	1	413.774	0.001	0.996	0.200
0.20	100	1	2	404.624	0.001	0.998	0.400

TODO: add above results to task 2 as column: theoretical

## Task 4

Likelihood for EM algorithm:

$Z_i$  - latent indicators form binomial distribution ( $\mathbb{P}(Z_i = 1) = \epsilon$ )

$$L(T, Z|\mu, \epsilon) = L(T|Z, \mu, \epsilon) \cdot L(Z|\epsilon) = \prod_{i=1}^n f_{Gamma(m, \frac{1}{\mu})}(T)^{Z_i} \cdot \epsilon^{Z_i} \cdot f_{Gamma(m, \frac{1}{3})}(T)^{1-Z_i} \cdot (1 - \epsilon)^{1-Z_i}$$

$$L(T|Z, \mu, \epsilon) = \prod_{i=1}^n f_{Gamma(m, \frac{1}{\mu})}(T)^{Z_i} \cdot f_{Gamma(m, \frac{1}{3})}(T)^{1-Z_i} = \prod_{i=1}^n \left[ \frac{(\frac{1}{\mu})^m}{\Gamma(m)} T_i^{m-1} e^{-\frac{1}{\mu} T_i} \right]^{Z_i} \left[ \frac{(\frac{1}{3})^m}{\Gamma(m)} T_i^{m-1} e^{-\frac{1}{3} T_i} \right]^{1-Z_i}$$

$$l(T|Z, \mu, \epsilon) = \sum_{i=1}^n Z_i \cdot \ln(f_{Gamma(m, \frac{1}{\mu})}(T_i)) + (1 - Z_i) \cdot \ln(f_{Gamma(m, \frac{1}{3})}(T_i))$$

$$l(T, Z|\mu, \epsilon) = \sum_{i=1}^n Z_i \cdot (\ln(f_{Gamma(m, \frac{1}{\mu})}(T_i)) + \ln(\epsilon)) + (1 - Z_i) \cdot (\ln(f_{Gamma(m, \frac{1}{3})}(T_i)) + \ln(1 - \epsilon))$$

Expectation step:

Replace  $\epsilon$  with estimator

$$\pi_i^k = \mathbb{E}(Z_i|T, \mu_k) = \mathbb{P}(Z_i = 1|T, \mu_k)$$

$$\pi_i^k = \frac{f_{Gamma(m, \frac{1}{\mu_k})}(T_i) \cdot \epsilon_k}{f_{Gamma(m, \frac{1}{\mu_k})}(T_i) \cdot \epsilon_k + f_{Gamma(m, \frac{1}{3})}(T_i) \cdot (1 - \epsilon_k)}$$

$$Q(\mu, \epsilon | \mu_k, \epsilon_k) = \mathbb{E}_{Z|T, \mu_k, \epsilon_k} \log(L(T, Z | \mu, \epsilon))$$

$$Q(\mu, \epsilon | \mu_k, \epsilon_k) = \sum_{i=1}^n \pi_i^k \cdot (\ln(f_{Gamma(m, \frac{1}{\mu})}(T_i)) + \ln(\epsilon)) + (1 - \pi_i^k) \cdot (\ln(f_{Gamma(m, \frac{1}{3})}(T_i)) + \ln(1 - \epsilon))$$

Maximization step

$$Q_{k+1} = \operatorname{argmax}_{\mu, \epsilon} Q(\mu, \epsilon | \mu_k, \epsilon_k)$$

```
##
##
## ## eps: 0.01 , m: 20 , n: 200
##
## Table: epsilon: 0.01, m: 20, n: 200
##
## |          |          mu |          eps |
## |:-----|-----:|-----:|
## |bias      | 0.3857| -0.0096|
## |mse       | 1.6589| 0.0001|
## |cov_mu_eps| -0.0029| -0.0029|
## |mse_mu_eps| 1.1142| 1.1142|
##
##
## ## eps: 0.01 , m: 20 , n: 1000
##
## Table: epsilon: 0.01, m: 20, n: 1000
##
## |          |          mu |          eps |
## |:-----|-----:|-----:|
## |bias      | 1.4885| -0.0092|
## |mse       | 2.8697| 0.0001|
## |cov_mu_eps| -0.0133| -0.0133|
## |mse_mu_eps| 1.6071| 1.6071|
##
##
## ## eps: 0.01 , m: 100 , n: 200
##
## Table: epsilon: 0.01, m: 100, n: 200
##
## |          |          mu |          eps |
## |:-----|-----:|-----:|
## |bias      | 0.6653| -0.0062|
## |mse       | 1.8164| 0.0001|
## |cov_mu_eps| -0.0045| -0.0045|
## |mse_mu_eps| 0.8770| 0.8770|
##
##
## ## eps: 0.01 , m: 100 , n: 1000
##
## Table: epsilon: 0.01, m: 100, n: 1000
##
## |          |          mu |          eps |
## |:-----|-----:|-----:|
## |bias      | 0.5220| -0.0066|
```

```

## |mse          | 0.3181| 0.0000|
## |cov_mu_eps   | -0.0033| -0.0033|
## |mse_mu_eps   | 0.5360| 0.5360|
##
##
## ## eps: 0.05 , m: 20 , n: 200
##
## Table: epsilon: 0.05, m: 20, n: 200
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | 1.5969| -0.0448|
## |mse       | 2.9681| 0.0021|
## |cov_mu_eps| -0.0704| -0.0704|
## |mse_mu_eps| 1.6473| 1.6473|
##
##
## ## eps: 0.05 , m: 20 , n: 1000
##
## Table: epsilon: 0.05, m: 20, n: 1000
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | 1.5888| -0.0397|
## |mse       | 2.6033| 0.0016|
## |cov_mu_eps| -0.0646| -0.0646|
## |mse_mu_eps| 1.5893| 1.5893|
##
##
## ## eps: 0.05 , m: 100 , n: 200
##
## Table: epsilon: 0.05, m: 100, n: 200
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | 0.5513| -0.0307|
## |mse       | 0.3432| 0.0010|
## |cov_mu_eps| -0.0164| -0.0164|
## |mse_mu_eps| 0.5662| 0.5662|
##
##
## ## eps: 0.05 , m: 100 , n: 1000
##
## Table: epsilon: 0.05, m: 100, n: 1000
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | 0.5635| -0.0322|
## |mse       | 0.3222| 0.0011|
## |cov_mu_eps| -0.0181| -0.0181|
## |mse_mu_eps| 0.5644| 0.5644|
##
##
## ## eps: 0.1 , m: 20 , n: 200

```

```

##
## Table: epsilon: 0.1, m: 20, n: 200
##
## |          |          mu|          eps|
## |:-----|-----:|-----:|
## |bias      |    1.6503| -0.0857|
## |mse       |    2.8064|  0.0077|
## |cov_mu_eps| -0.1443| -0.1443|
## |mse_mu_eps|    1.6528|  1.6528|
##
##
## ## eps: 0.1 , m: 20 , n: 1000
##
## Table: epsilon: 0.1, m: 20, n: 1000
##
## |          |          mu|          eps|
## |:-----|-----:|-----:|
## |bias      |    1.5376| -0.0760|
## |mse       |    2.5027|  0.0060|
## |cov_mu_eps| -0.1204| -0.1204|
## |mse_mu_eps|    1.5395|  1.5395|
##
##
## ## eps: 0.1 , m: 100 , n: 200
##
## Table: epsilon: 0.1, m: 100, n: 200
##
## |          |          mu|          eps|
## |:-----|-----:|-----:|
## |bias      |    0.5055| -0.0528|
## |mse       |    0.3114|  0.0042|
## |cov_mu_eps| -0.0338| -0.0338|
## |mse_mu_eps|    0.5132|  0.5132|
##
##
## ## eps: 0.1 , m: 100 , n: 1000
##
## Table: epsilon: 0.1, m: 100, n: 1000
##
## |          |          mu|          eps|
## |:-----|-----:|-----:|
## |bias      |    0.5798| -0.0650|
## |mse       |    0.3385|  0.0043|
## |cov_mu_eps| -0.0377| -0.0377|
## |mse_mu_eps|    0.5835|  0.5835|
##
##
## ## eps: 0.2 , m: 20 , n: 200
##
## Table: epsilon: 0.2, m: 20, n: 200
##
## |          |          mu|          eps|
## |:-----|-----:|-----:|
## |bias      |    1.2228| -0.1178|

```

```

## |mse          | 1.9877| 0.0197|
## |cov_mu_eps   | -0.1917| -0.1917|
## |mse_mu_eps   | 1.2310| 1.2310|
##
##
## ## eps: 0.2 , m: 20 , n: 1000
##
## Table: epsilon: 0.2, m: 20, n: 1000
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | 0.9549| -0.0908|
## |mse       | 1.5355| 0.0122|
## |cov_mu_eps| -0.1351| -0.1351|
## |mse_mu_eps| 0.9595| 0.9595|
##
##
## ## eps: 0.2 , m: 100 , n: 200
##
## Table: epsilon: 0.2, m: 100, n: 200
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | 0.0209| -0.0046|
## |mse       | 0.0150| 0.0018|
## |cov_mu_eps| -0.0031| -0.0031|
## |mse_mu_eps| 0.0856| 0.0856|
##
##
## ## eps: 0.2 , m: 100 , n: 1000
##
## Table: epsilon: 0.2, m: 100, n: 1000
##
## |          |      mu|      eps|
## |:-----|-----:|-----:|
## |bias      | -0.0060| 0.0010|
## |mse       | 0.0016| 0.0002|
## |cov_mu_eps| 0.0000| 0.0000|
## |mse_mu_eps| 0.0356| 0.0356|

```

MSE is an estimator of the variance (for one dimensional parameter).

## Task 5

**eps: 0.01 , m: 20 , n: 200**

Table 34: eps: 0.000415571787757385, m: 20, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.000	0.000	0.000	0	0.000
fdr_vals	0.003	0.001	0.013	0	0.083
cost_vals_1	0.003	0.001	0.013	0	0.100
cost_vals_2	0.003	0.001	0.013	0	0.100

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
cost_vals_3	0.006	0.002	0.026	0	0.200

Table 35: eps: 0.000415571787757385, m: 20, n: 200, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.000	0.000	0.000	0	0.000
fdr_vals	0.005	0.001	0.011	0	0.323
cost_vals_1	0.005	0.001	0.011	0	0.675
cost_vals_2	0.005	0.001	0.011	0	0.675
cost_vals_3	0.010	0.002	0.022	0	1.350

**eps: 0.01 , m: 20 , n: 1000**

Table 36: eps: 0.000803674231640075, m: 20, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.638	0.581	0.690	0.492	0.688
fdr_vals	0.026	0.009	0.064	0.002	0.094
cost_vals_1	0.400	0.432	0.416	0.511	0.516
cost_vals_2	0.762	0.851	0.726	1.019	0.828
cost_vals_3	0.438	0.445	0.522	0.514	0.720

Table 37: eps: 0.000803674231640075, m: 20, n: 1000, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.629	0.563	0.685	0.488	0.775
fdr_vals	0.029	0.018	0.065	0.003	0.302
cost_vals_1	0.412	0.461	0.414	0.516	1.212
cost_vals_2	0.783	0.898	0.729	1.028	1.437
cost_vals_3	0.453	0.485	0.513	0.520	2.199

**eps: 0.01 , m: 100 , n: 200**

Table 38: eps: 0.00380053972729494, m: 100, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	1.000	1.000	1.000	1.000
fdr_vals	0.001	0.001	0.002	0.010	0.095
cost_vals_1	0.004	0.003	0.008	0.032	0.327
cost_vals_2	0.005	0.004	0.009	0.032	0.327
cost_vals_3	0.007	0.005	0.015	0.064	0.654

Table 39: eps: 0.00380053972729494, m: 100, n: 200, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	1.000	1.000	1.000	1.000
fdr_vals	0.002	0.001	0.004	0.012	0.134
cost_vals_1	0.007	0.005	0.013	0.035	0.485
cost_vals_2	0.007	0.006	0.013	0.035	0.485
cost_vals_3	0.014	0.009	0.026	0.070	0.970

**eps: 0.01 , m: 100 , n: 1000**

Table 40: eps: 0.00344050240796706, m: 100, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.999	0.999	0.999	0.999	0.999
fdr_vals	0.006	0.003	0.012	0.058	0.099
cost_vals_1	0.021	0.012	0.037	0.183	0.345
cost_vals_2	0.023	0.014	0.039	0.185	0.347
cost_vals_3	0.040	0.022	0.072	0.364	0.688

Table 41: eps: 0.00344050240796706, m: 100, n: 1000, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	1.000	1.000	1.000	1.000
fdr_vals	0.011	0.007	0.016	0.062	0.144
cost_vals_1	0.034	0.024	0.050	0.199	0.544
cost_vals_2	0.034	0.025	0.050	0.199	0.544
cost_vals_3	0.068	0.047	0.100	0.398	1.088

**eps: 0.05 , m: 20 , n: 200**

Table 42: eps: 0.00519386105594498, m: 20, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.796	0.752	0.837	0.679	0.807
fdr_vals	0.043	0.026	0.095	0.010	0.096
cost_vals_1	0.281	0.292	0.343	0.336	0.405
cost_vals_2	0.485	0.540	0.506	0.657	0.598
cost_vals_3	0.358	0.336	0.523	0.351	0.617



Table 43: eps: 0.00519386105594498, m: 20, n: 200, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.796	0.737	0.830	0.661	0.876
fdr_vals	0.048	0.024	0.102	0.007	0.317
cost_vals_1	0.287	0.302	0.359	0.350	1.177
cost_vals_2	0.491	0.565	0.529	0.689	1.301
cost_vals_3	0.370	0.341	0.548	0.361	2.230

**eps: 0.05 , m: 20 , n: 1000**

Table 44: eps: 0.0103188175922397, m: 20, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.847	0.804	0.884	0.746	0.850
fdr_vals	0.092	0.047	0.172	0.019	0.105
cost_vals_1	2.699	2.625	3.444	2.966	2.892
cost_vals_2	4.381	4.779	4.717	5.756	4.542
cost_vals_3	3.716	3.096	5.615	3.142	4.134

Table 45: eps: 0.0103188175922397, m: 20, n: 1000, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.847	0.805	0.882	0.744	0.917
fdr_vals	0.089	0.044	0.168	0.018	0.313
cost_vals_1	2.670	2.595	3.408	2.976	6.232
cost_vals_2	4.355	4.743	4.702	5.787	7.142
cost_vals_3	3.655	3.042	5.522	3.141	11.554

**eps: 0.05 , m: 100 , n: 200**

Table 46: eps: 0.0192897562151207, m: 100, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	0.999	1.000	1.000	1.000
fdr_vals	0.003	0.002	0.004	0.031	0.098
cost_vals_1	0.017	0.015	0.026	0.188	0.664
cost_vals_2	0.018	0.018	0.027	0.188	0.664
cost_vals_3	0.033	0.027	0.051	0.376	1.328

Table 47: eps: 0.0192897562151207, m: 100, n: 200, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	1.000	1.000	1.000	1.000
fdr_vals	0.002	0.001	0.004	0.030	0.135
cost_vals_1	0.015	0.011	0.026	0.184	0.986
cost_vals_2	0.016	0.013	0.027	0.184	0.986
cost_vals_3	0.029	0.020	0.051	0.368	1.972

**eps: 0.05 , m: 100 , n: 1000**

Table 48: eps: 0.0177927010137045, m: 100, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.999	0.999	0.999	1.000	1.000
fdr_vals	0.006	0.004	0.009	0.060	0.101
cost_vals_1	0.098	0.072	0.144	0.956	1.695
cost_vals_2	0.106	0.086	0.152	0.959	1.697
cost_vals_3	0.188	0.130	0.280	1.909	3.388

Table 49: eps: 0.0177927010137045, m: 100, n: 1000, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.999	0.999	1.000	1.000	1.000
fdr_vals	0.005	0.002	0.008	0.058	0.138
cost_vals_1	0.080	0.048	0.127	0.916	2.416
cost_vals_2	0.090	0.061	0.134	0.917	2.416
cost_vals_3	0.150	0.083	0.247	1.831	4.832

**eps: 0.1 , m: 20 , n: 200**

Table 50: eps: 0.0142939589539676, m: 20, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.874	0.836	0.906	0.786	0.876
fdr_vals	0.081	0.039	0.147	0.016	0.101
cost_vals_1	0.669	0.626	0.875	0.696	0.779
cost_vals_2	1.047	1.119	1.158	1.339	1.150
cost_vals_3	0.960	0.759	1.467	0.749	1.187

Table 51: eps: 0.0142939589539676, m: 20, n: 200, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.863	0.823	0.901	0.772	0.932
fdr_vals	0.076	0.043	0.145	0.022	0.318
cost_vals_1	0.689	0.673	0.886	0.749	2.169
cost_vals_2	1.101	1.204	1.183	1.432	2.373
cost_vals_3	0.966	0.815	1.475	0.815	4.134

**eps: 0.1 , m: 20 , n: 1000**

Table 52: eps: 0.0240104139445368, m: 20, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.886	0.848	0.916	0.802	0.891
fdr_vals	0.089	0.046	0.162	0.021	0.101
cost_vals_1	5.714	5.429	7.448	6.049	5.988
cost_vals_2	8.918	9.686	9.789	11.600	9.043
cost_vals_3	8.224	6.601	12.555	6.547	8.921

Table 53: eps: 0.0240104139445368, m: 20, n: 1000, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.883	0.845	0.914	0.798	0.948
fdr_vals	0.086	0.045	0.159	0.022	0.312
cost_vals_1	5.688	5.486	7.360	6.154	14.136
cost_vals_2	8.977	9.830	9.766	11.798	15.588
cost_vals_3	8.087	6.628	12.314	6.664	26.820

**eps: 0.1 , m: 100 , n: 200**

Table 54: eps: 0.047189960703966, m: 100, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	0.999	1.000	1.000	1.000
fdr_vals	0.003	0.002	0.006	0.053	0.097
cost_vals_1	0.031	0.024	0.054	0.495	0.984
cost_vals_2	0.035	0.029	0.056	0.495	0.984
cost_vals_3	0.058	0.043	0.106	0.990	1.968

Table 55: eps: 0.047189960703966, m: 100, n: 200, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	0.999	1.000	1.000	1.000
fdr_vals	0.003	0.001	0.005	0.053	0.140
cost_vals_1	0.028	0.018	0.048	0.496	1.483
cost_vals_2	0.032	0.023	0.051	0.496	1.483
cost_vals_3	0.052	0.031	0.093	0.992	2.966

**eps: 0.1 , m: 100 , n: 1000**

Table 56: eps: 0.0350328529035779, m: 100, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	1.000	1.000	1.000	1.000
fdr_vals	0.004	0.002	0.006	0.050	0.100
cost_vals_1	0.136	0.093	0.207	1.830	3.890
cost_vals_2	0.144	0.108	0.215	1.834	3.893
cost_vals_3	0.264	0.171	0.406	3.656	7.777

Table 57: eps: 0.0350328529035779, m: 100, n: 1000, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	1.000	0.999	1.000	1.000	1.000
fdr_vals	0.004	0.003	0.006	0.050	0.143
cost_vals_1	0.146	0.112	0.222	1.840	5.883
cost_vals_2	0.160	0.134	0.231	1.841	5.883
cost_vals_3	0.278	0.202	0.435	3.679	11.766

**eps: 0.2 , m: 20 , n: 200**

Table 58: eps: 0.0822471347010928, m: 20, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.914	0.879	0.939	0.849	0.919
fdr_vals	0.088	0.045	0.154	0.027	0.099
cost_vals_1	3.386	3.123	4.528	3.340	3.576
cost_vals_2	5.027	5.418	5.679	6.217	5.111
cost_vals_3	5.131	3.951	7.905	3.803	5.617

Table 59: eps: 0.0822471347010928, m: 20, n: 200, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.911	0.877	0.938	0.845	0.969
fdr_vals	0.085	0.047	0.148	0.028	0.311
cost_vals_1	3.383	3.186	4.418	3.416	9.567
cost_vals_2	5.080	5.522	5.596	6.355	10.161
cost_vals_3	5.069	4.036	7.658	3.893	18.540

**eps: 0.2 , m: 20 , n: 1000**

Table 60: eps: 0.109190821913321, m: 20, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.899	0.860	0.930	0.827	0.893
fdr_vals	0.110	0.062	0.183	0.040	0.101
cost_vals_1	21.929	20.372	28.804	21.332	21.466
cost_vals_2	32.365	34.832	36.057	39.115	32.465
cost_vals_3	33.422	26.284	50.355	24.881	31.933

Table 61: eps: 0.109190821913321, m: 20, n: 1000, q: 0.316

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.899	0.861	0.929	0.829	0.959
fdr_vals	0.108	0.060	0.183	0.038	0.319
cost_vals_1	21.754	20.013	28.905	21.075	51.130
cost_vals_2	32.154	34.329	36.183	38.736	55.343
cost_vals_3	33.108	25.710	50.532	24.489	98.047

**eps: 0.2 , m: 100 , n: 200**

Table 62: eps: 0.195428607469712, m: 100, n: 200, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.997	0.997	0.998	1.000	1.000
fdr_vals	0.002	0.001	0.003	0.051	0.101
cost_vals_1	0.189	0.188	0.199	2.156	4.506
cost_vals_2	0.290	0.317	0.272	2.159	4.506
cost_vals_3	0.277	0.247	0.325	4.309	9.012

Table 63: eps: 0.195428607469712, m: 100, n: 200, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.997	0.996	0.998	1.000	1.000
fdr_vals	0.002	0.001	0.003	0.048	0.141
cost_vals_1	0.190	0.201	0.180	2.005	6.561
cost_vals_2	0.309	0.357	0.259	2.010	6.562
cost_vals_3	0.261	0.246	0.281	4.005	13.121

**eps: 0.2 , m: 100 , n: 1000**

Table 64: eps: 0.20102798220207, m: 100, n: 1000, q: 0.1

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.997	0.996	0.998	1.000	1.000
fdr_vals	0.002	0.001	0.003	0.048	0.099
cost_vals_1	0.966	1.060	1.011	10.586	23.240
cost_vals_2	1.553	1.875	1.435	10.608	23.245
cost_vals_3	1.345	1.305	1.598	21.150	46.475

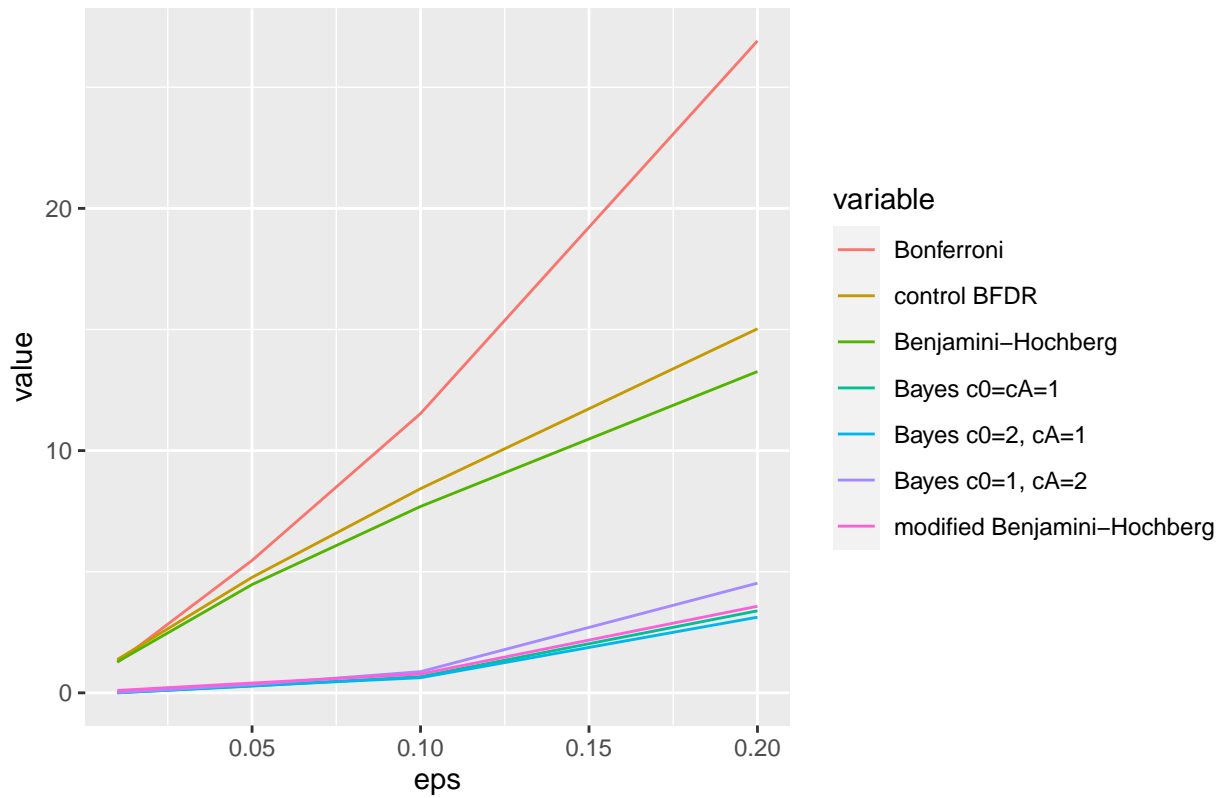
Table 65: eps: 0.20102798220207, m: 100, n: 1000, q: 0.141

	Bayes c0=cA=1	Bayes c0=2, cA=1	Bayes c0=1, cA=2	plug-in control BFDR	modified Benjamini-Hochberg
power_vals	0.997	0.996	0.998	1.000	1.000
fdr_vals	0.002	0.001	0.003	0.047	0.141
cost_vals_1	0.939	1.027	0.958	10.476	34.537
cost_vals_2	1.506	1.807	1.348	10.497	34.544
cost_vals_3	1.311	1.274	1.526	20.931	69.067

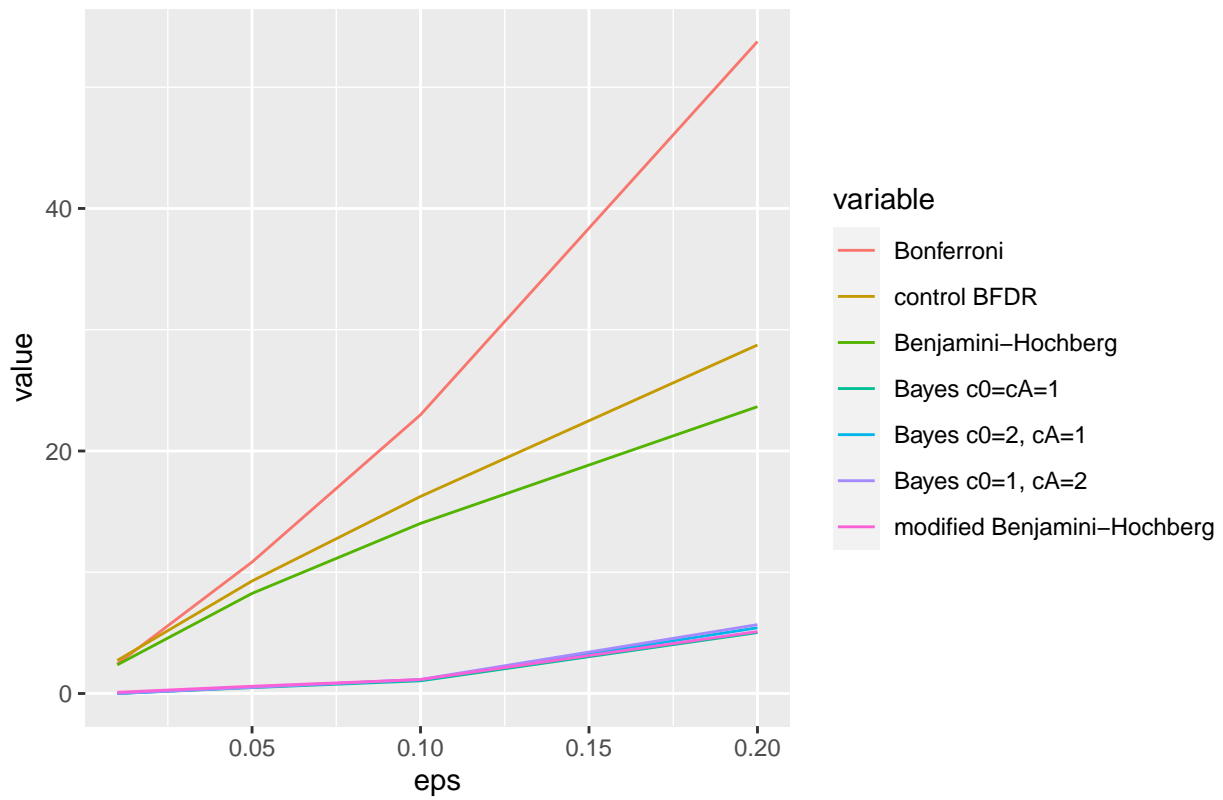


## Task 6

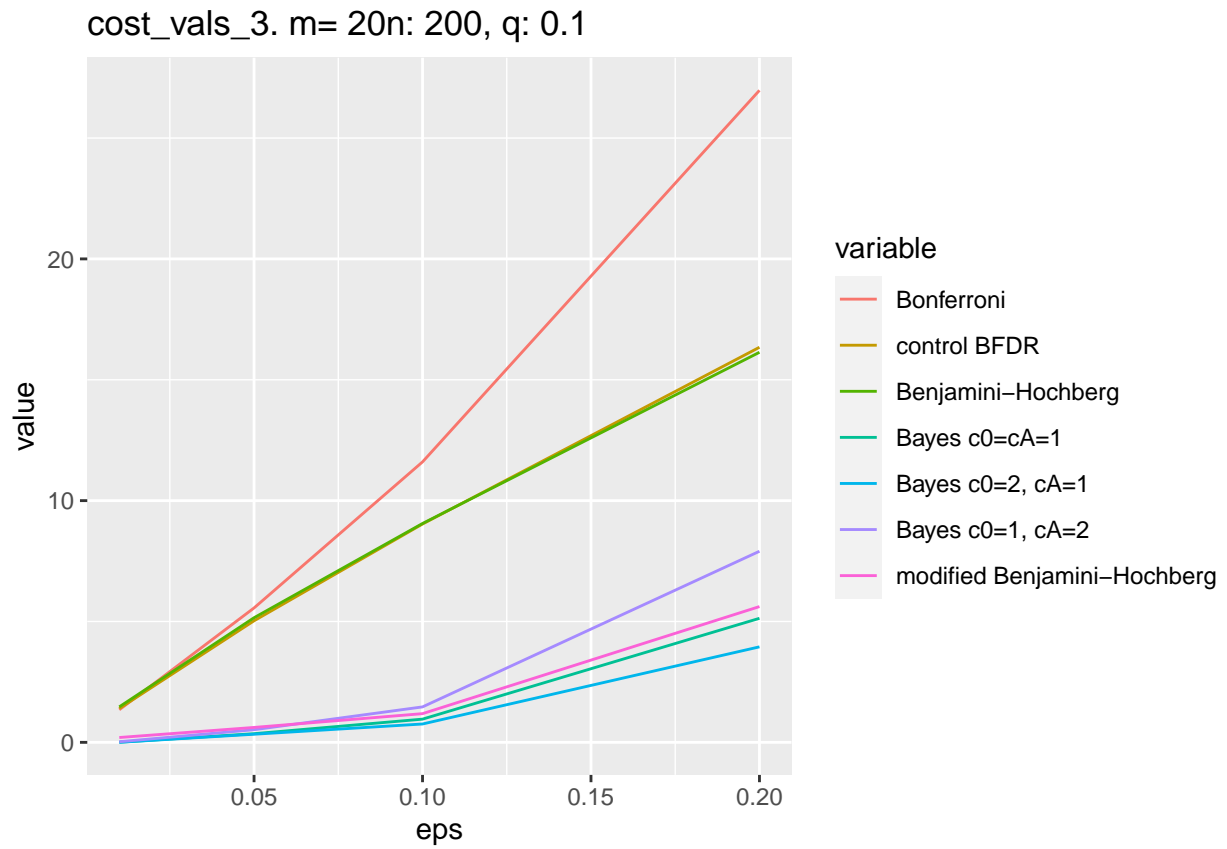
cost\_vals\_1. m= 20n: 200, q: 0.1

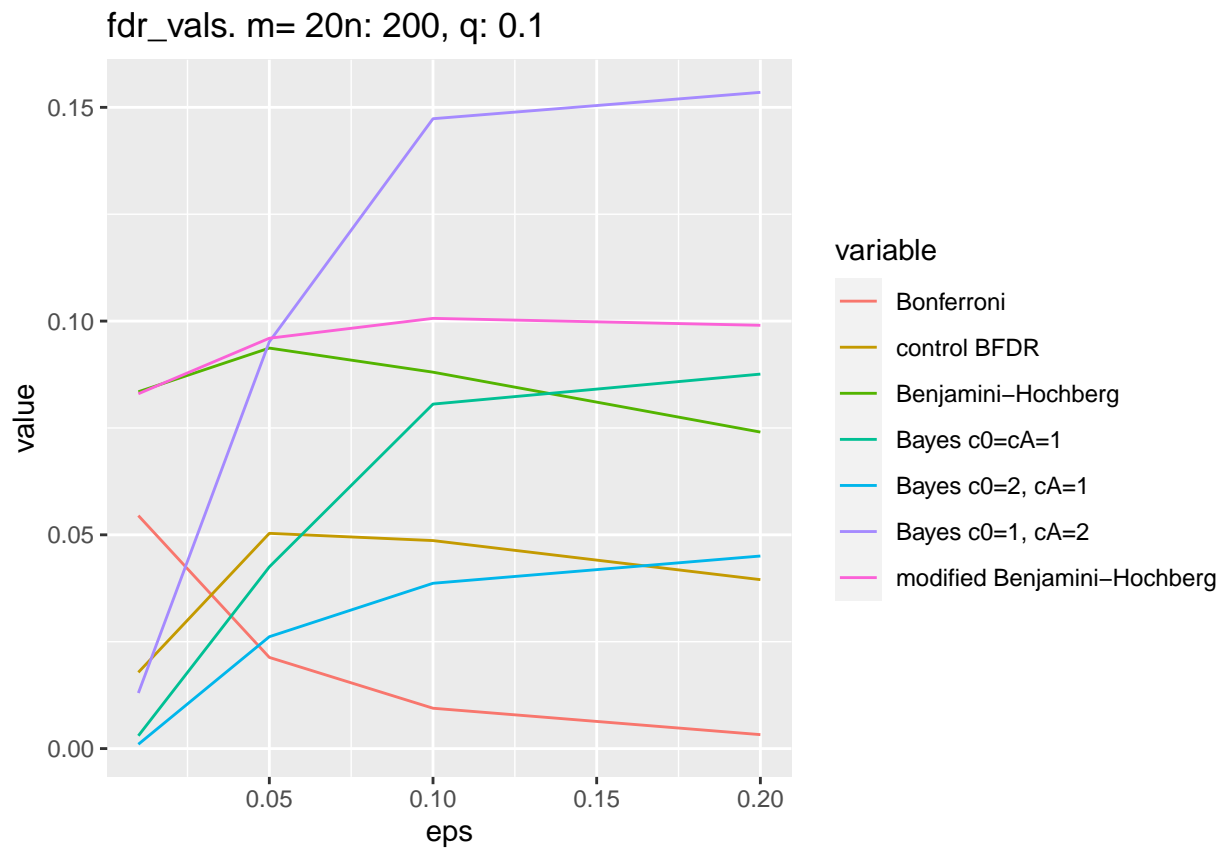


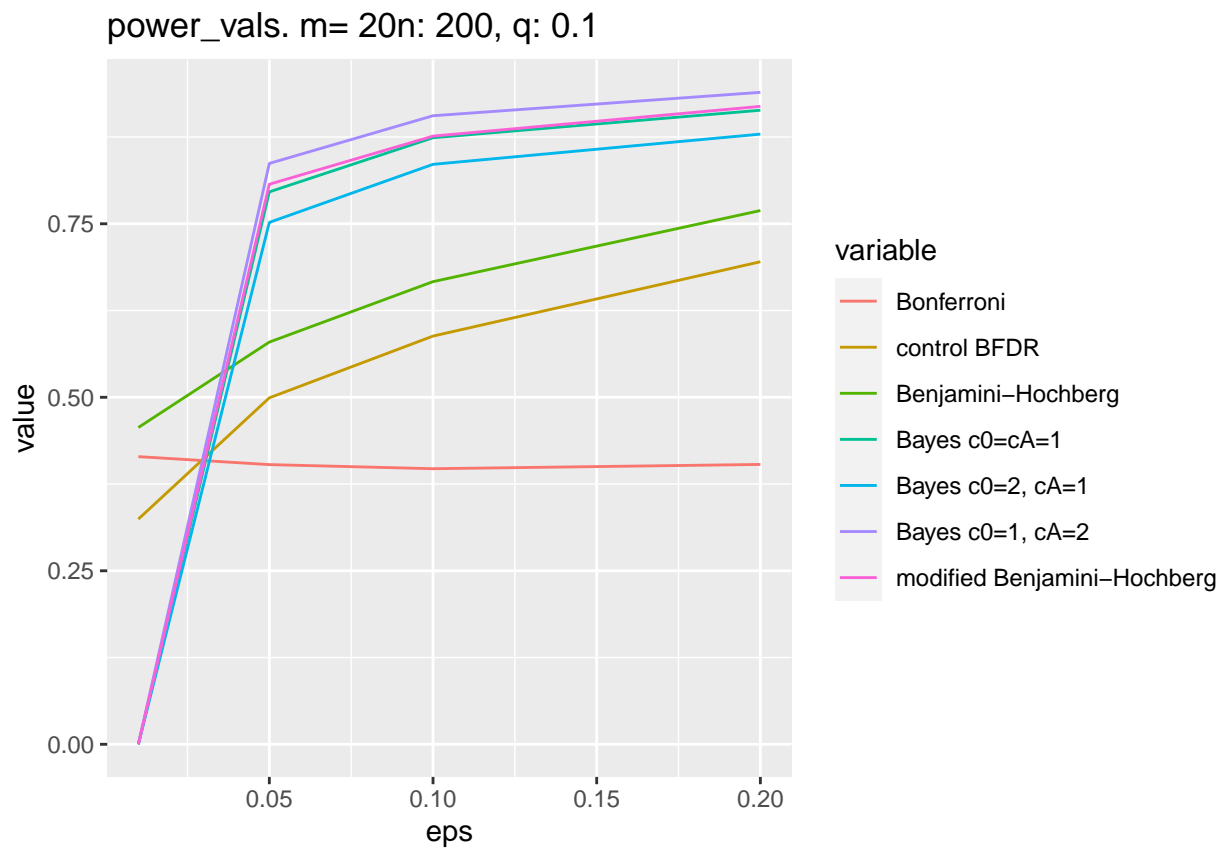
cost\_vals\_2. m= 20n: 200, q: 0.1

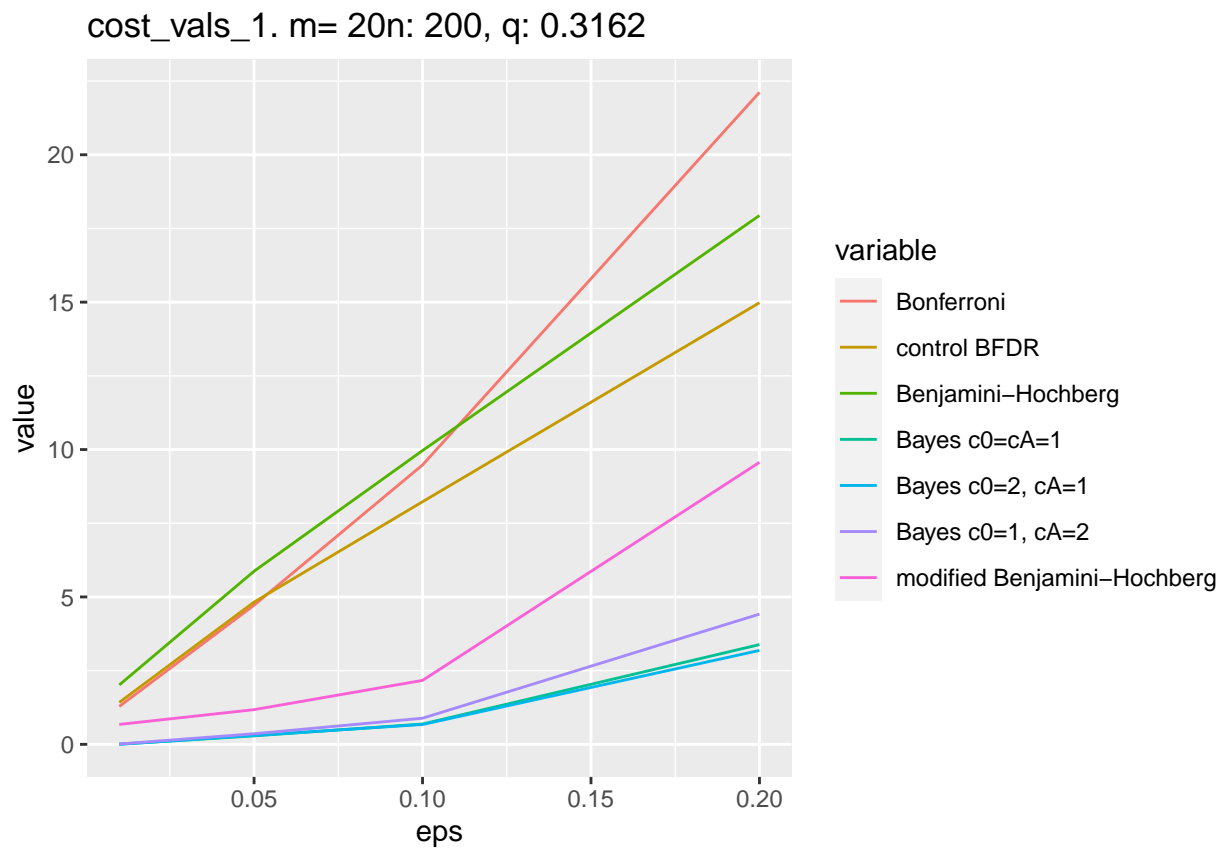


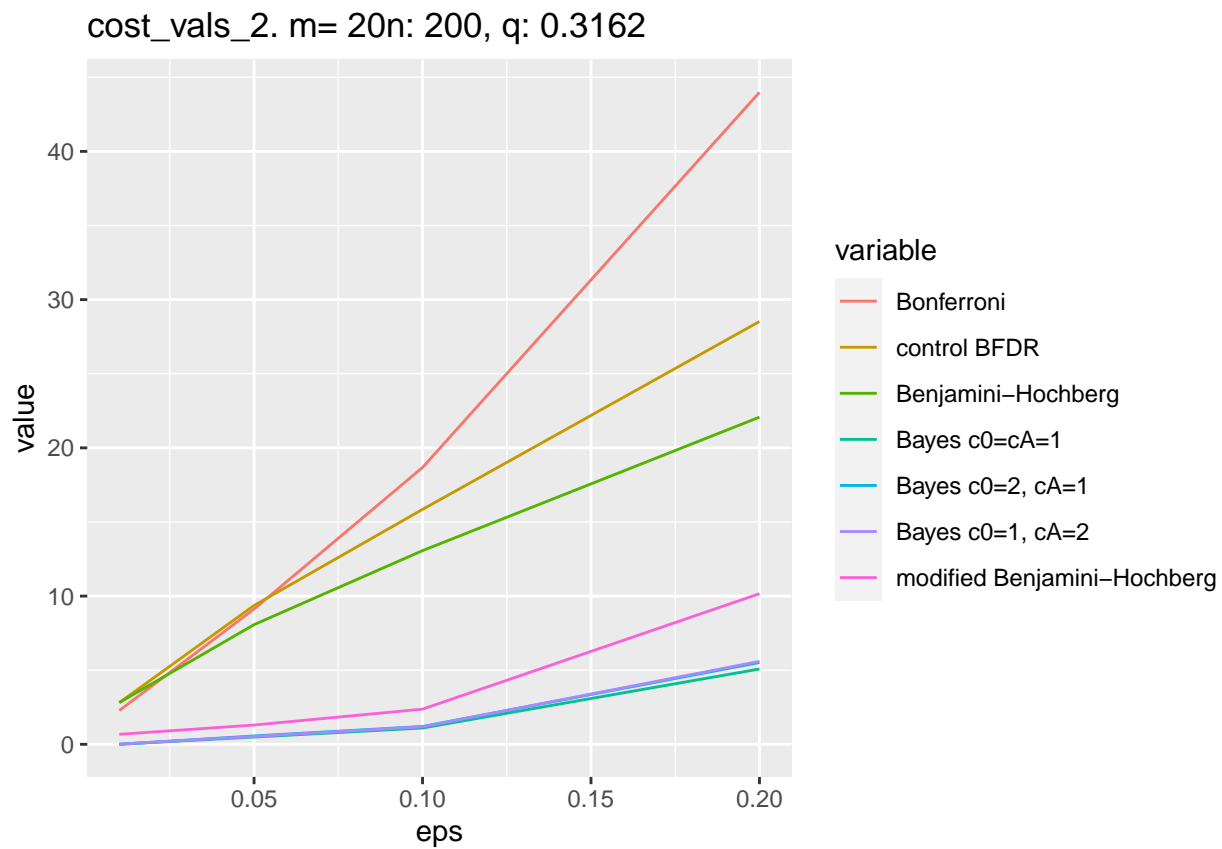


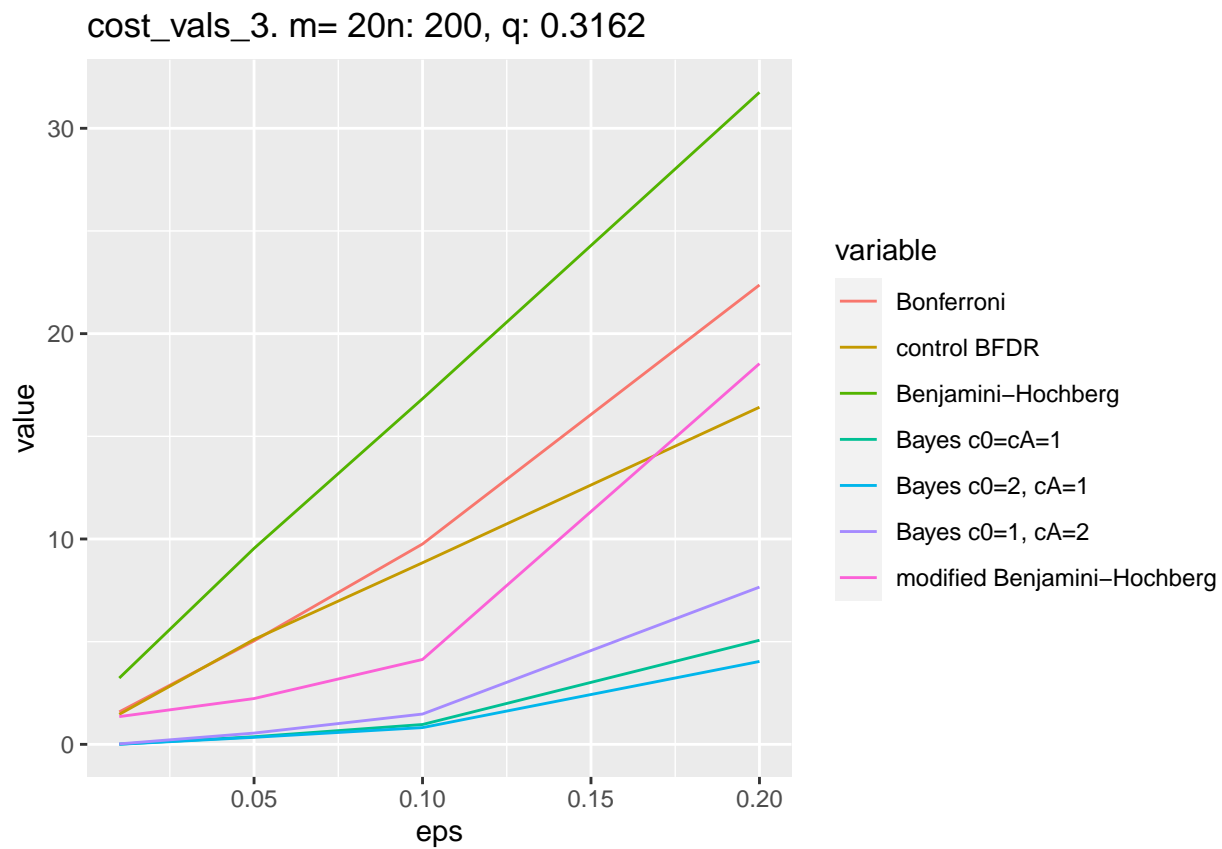


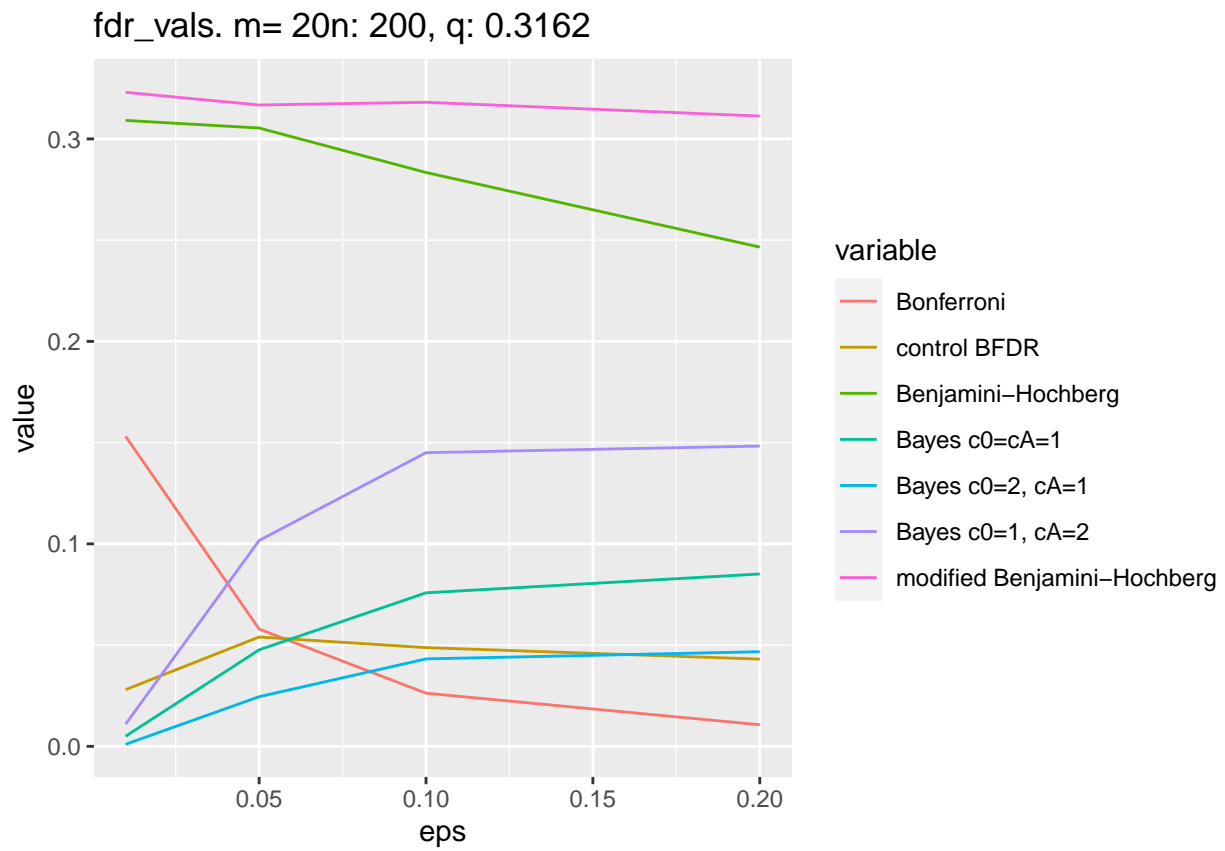


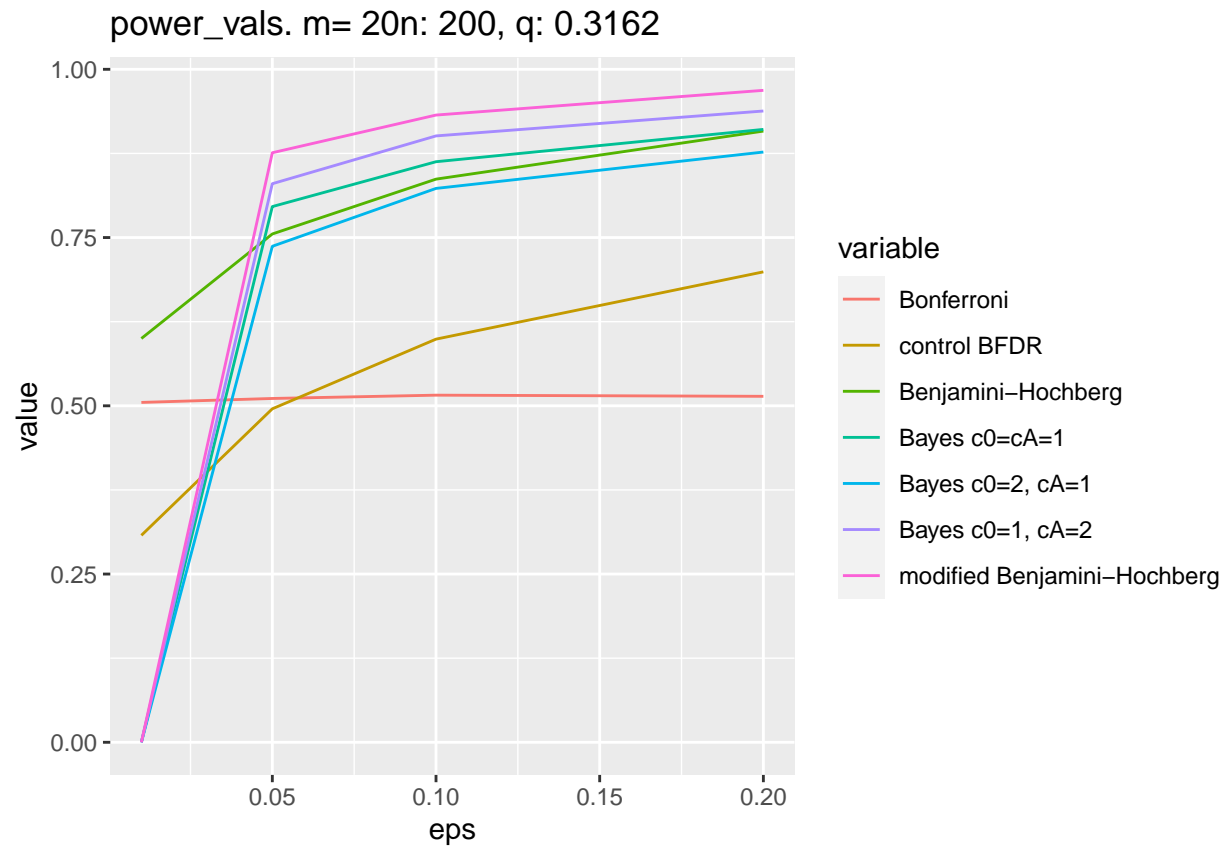




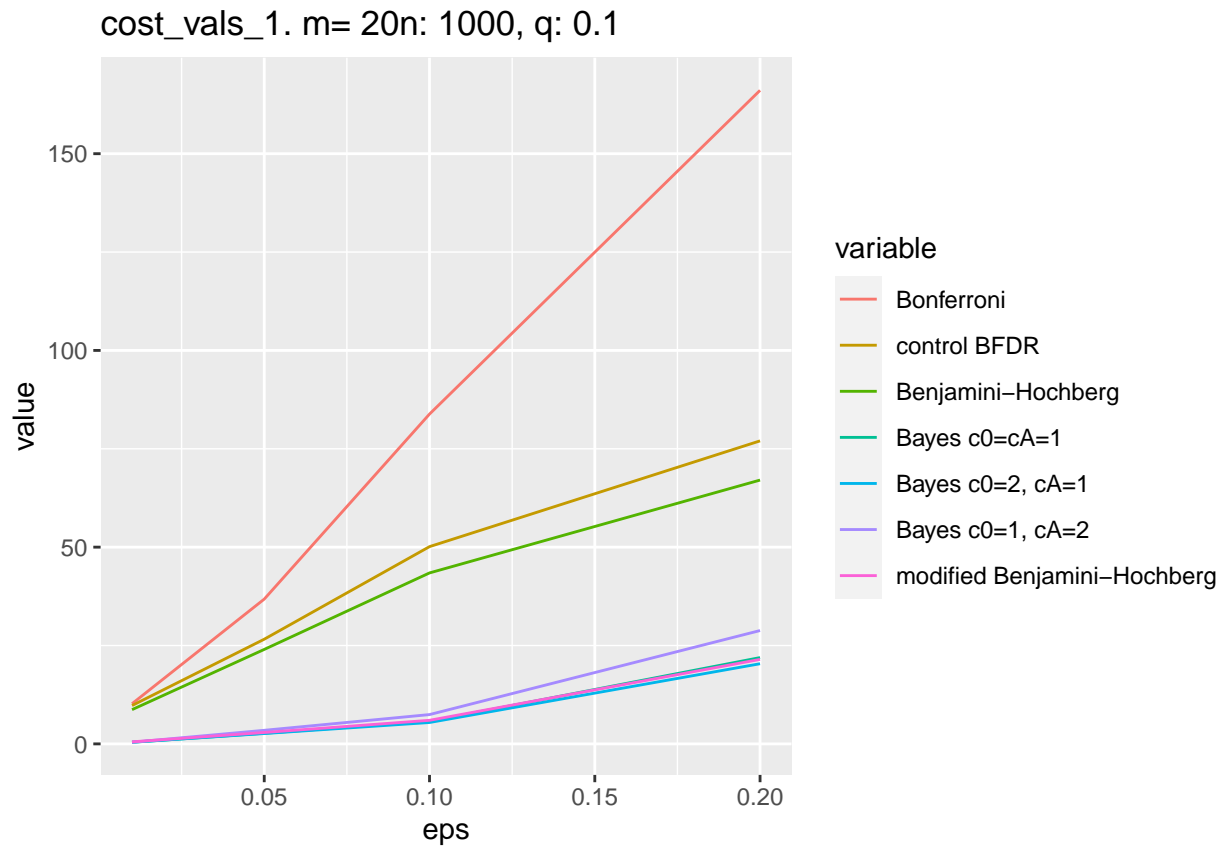


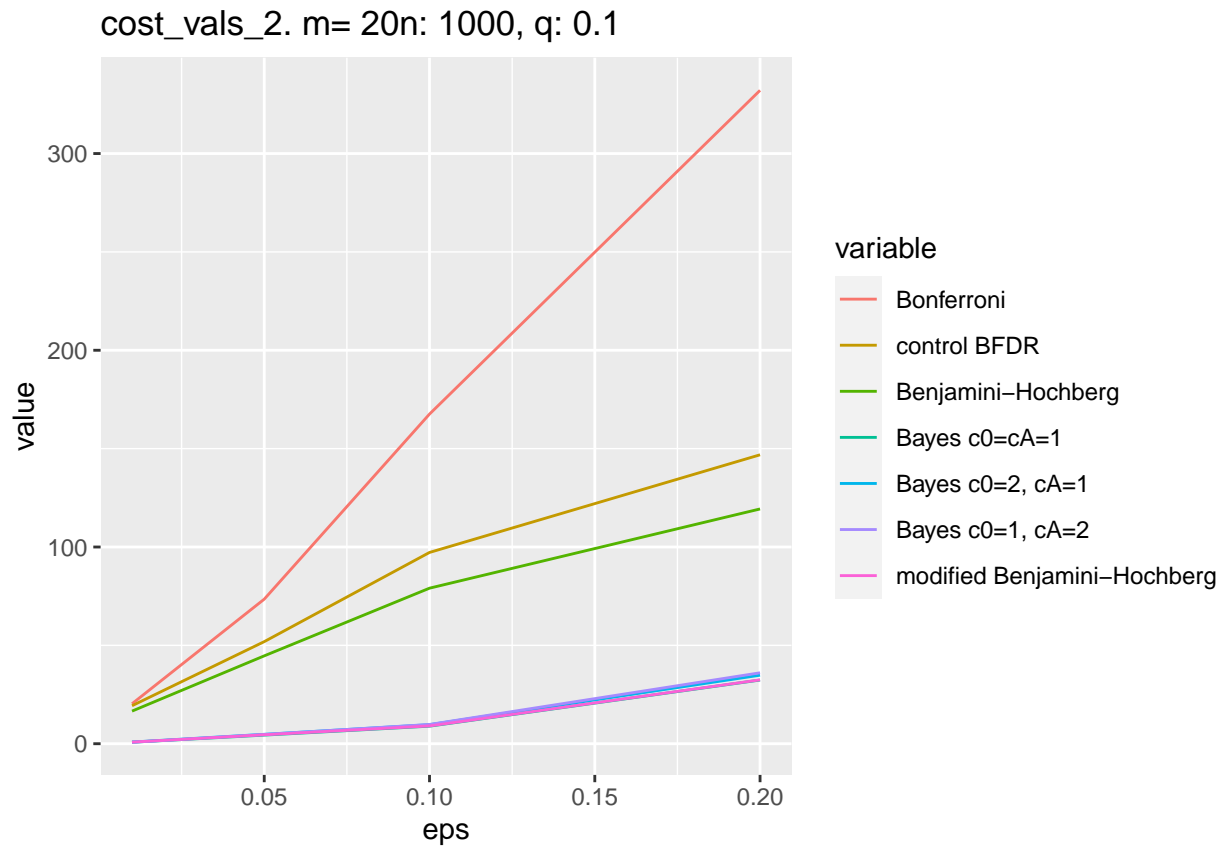


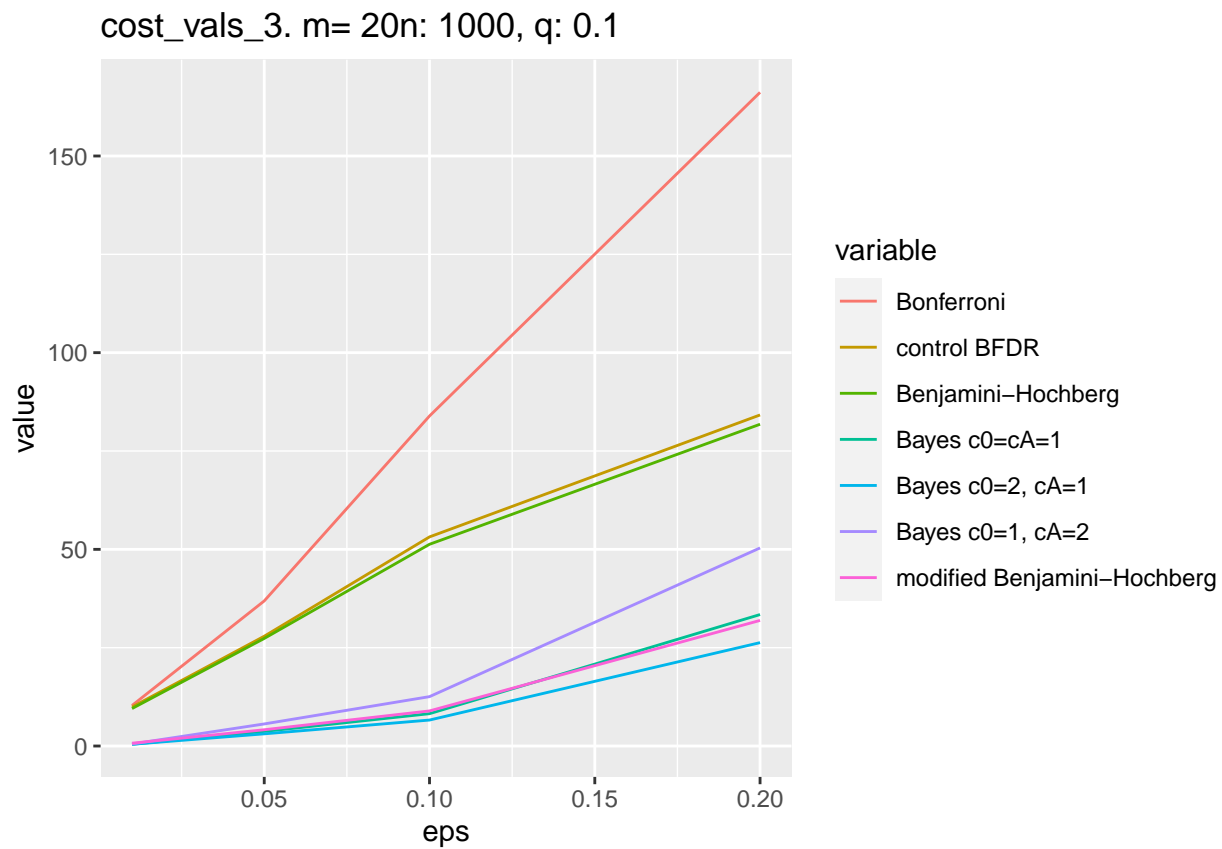


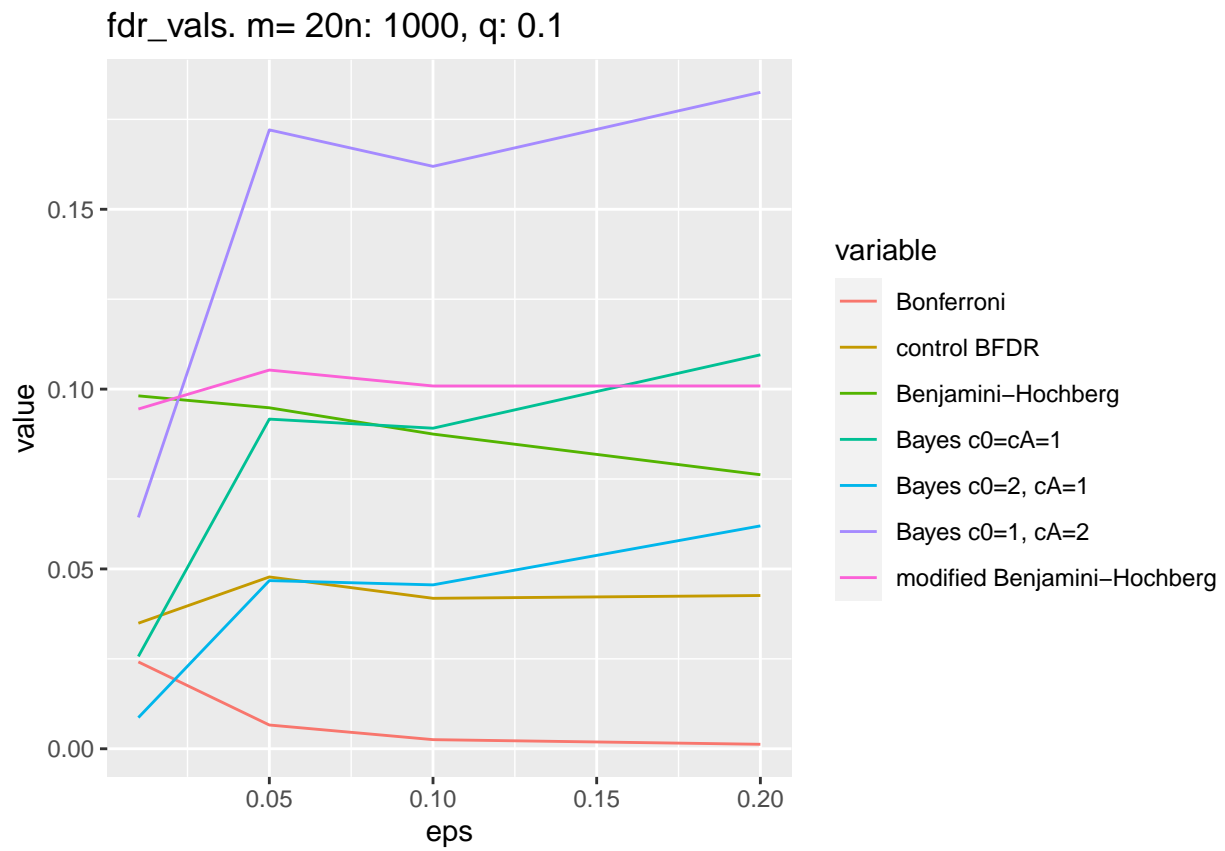


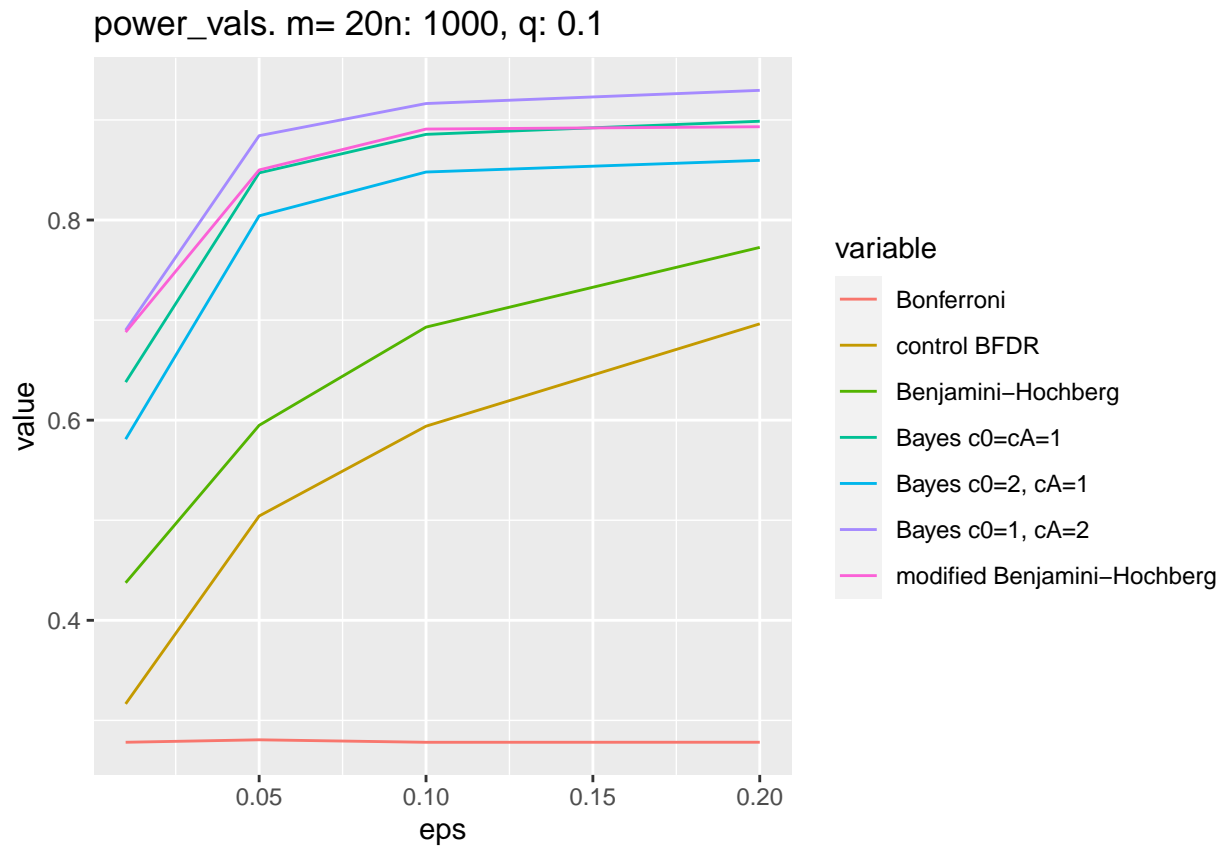


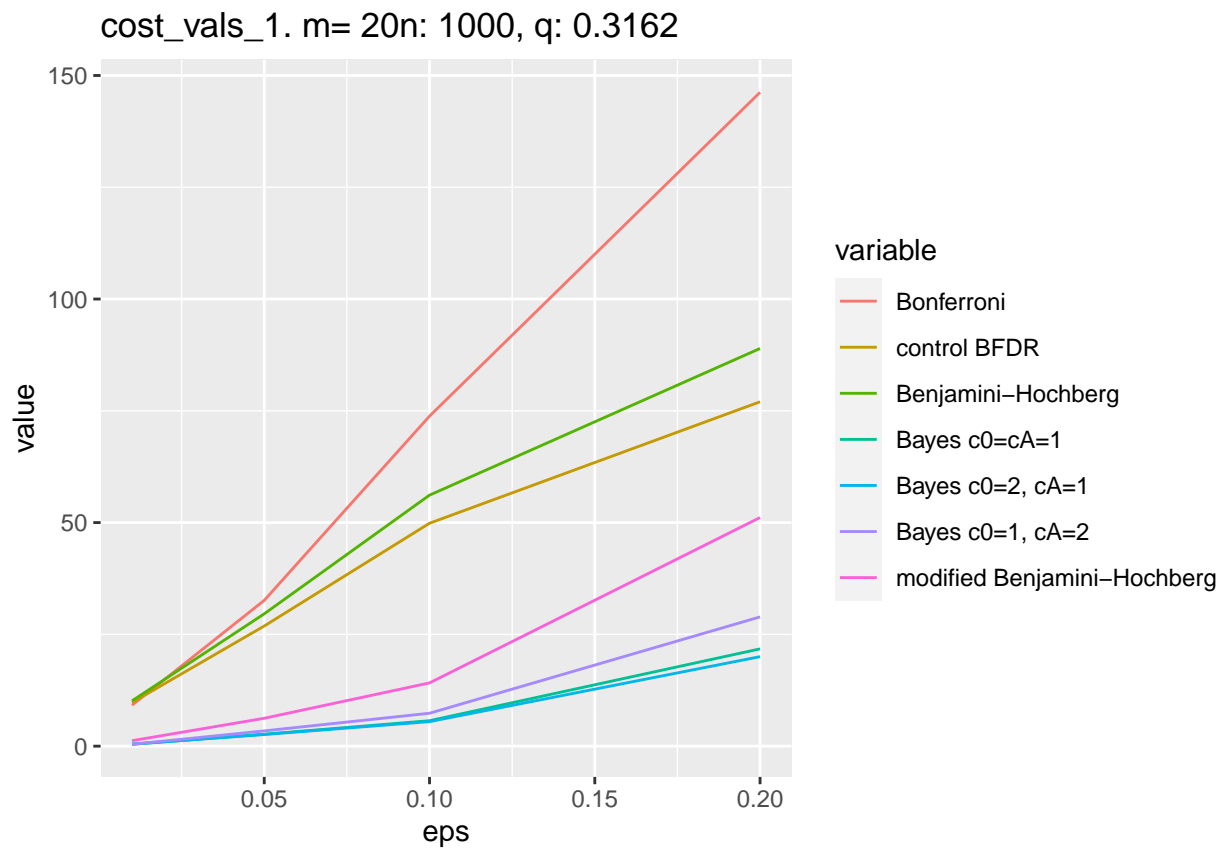


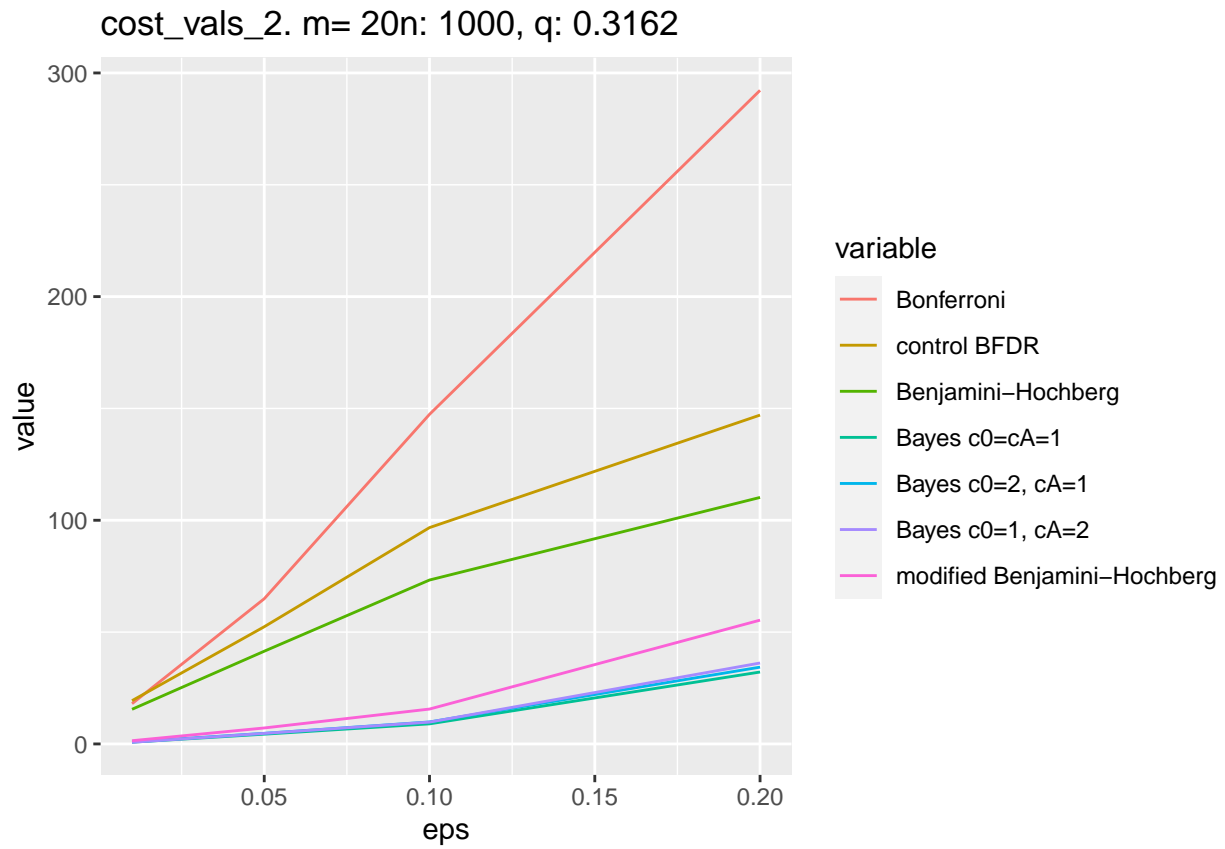


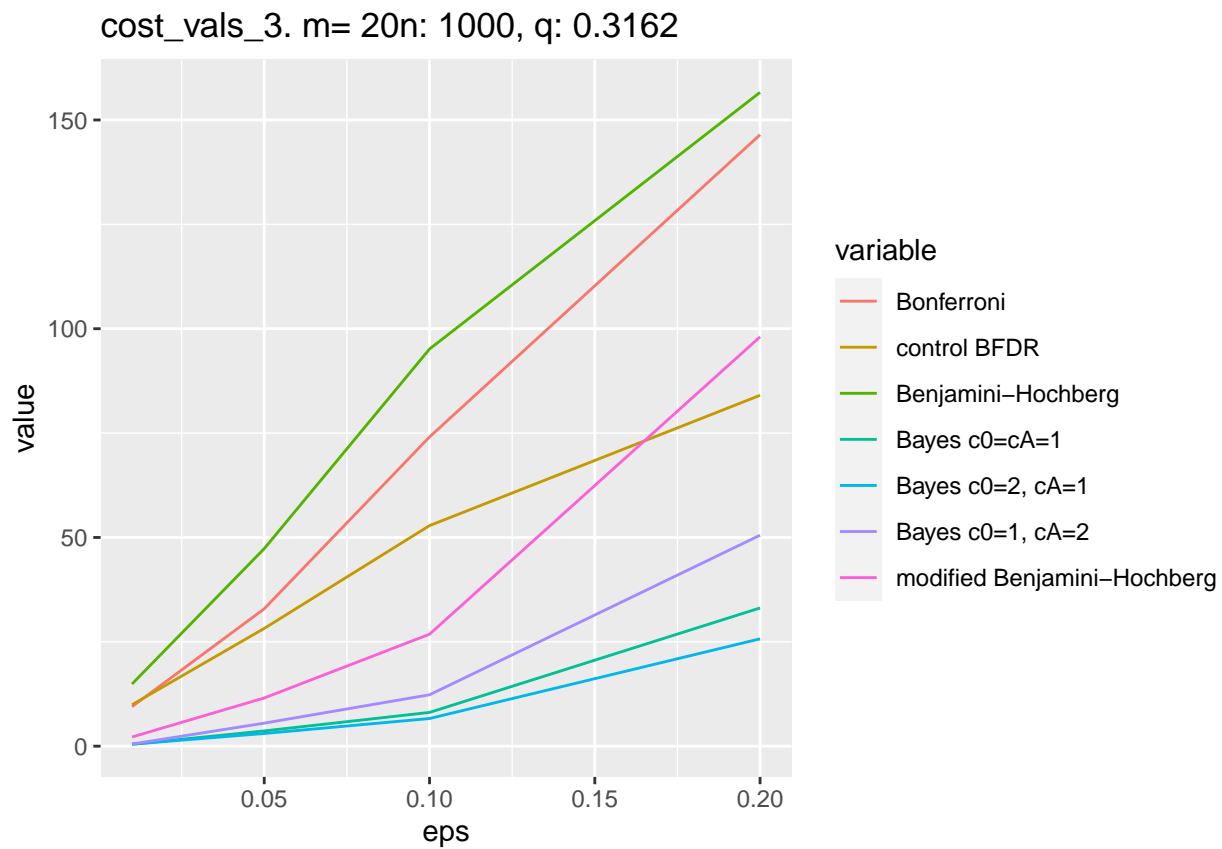




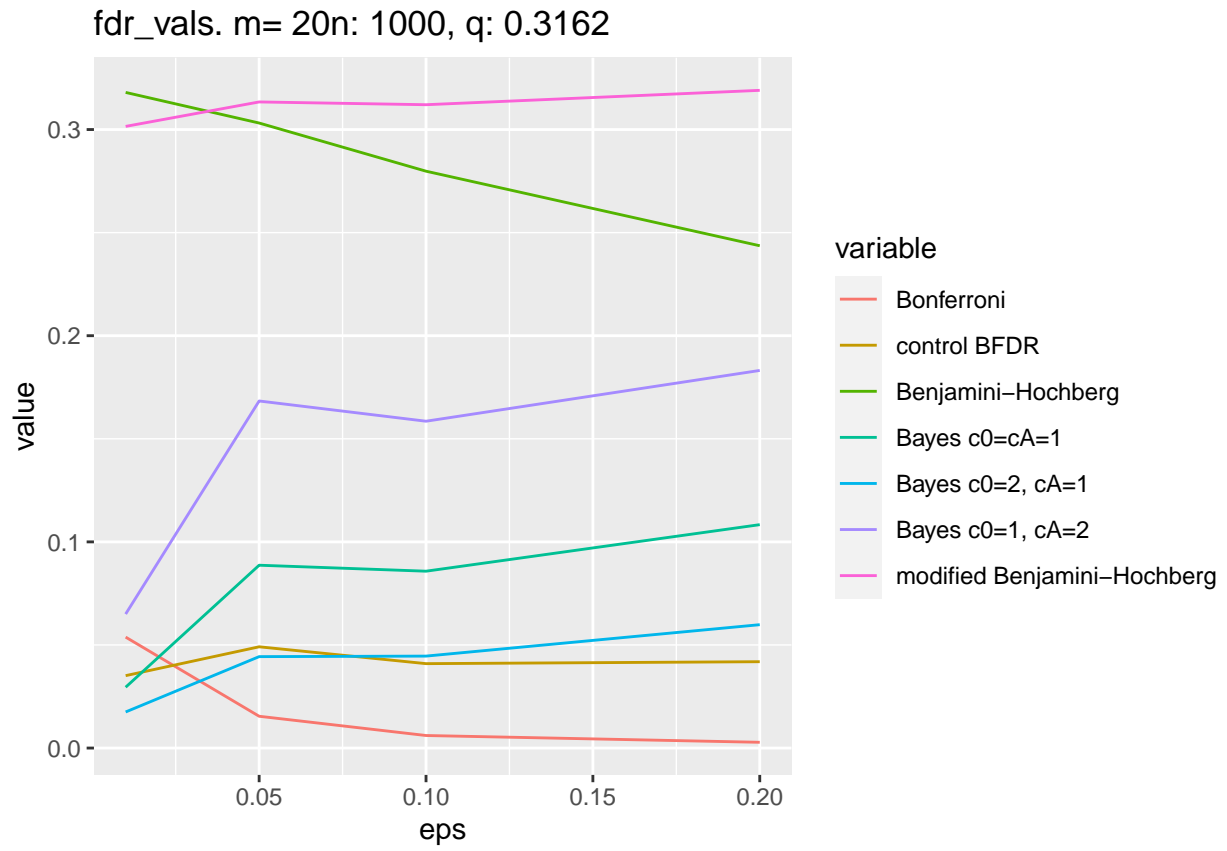




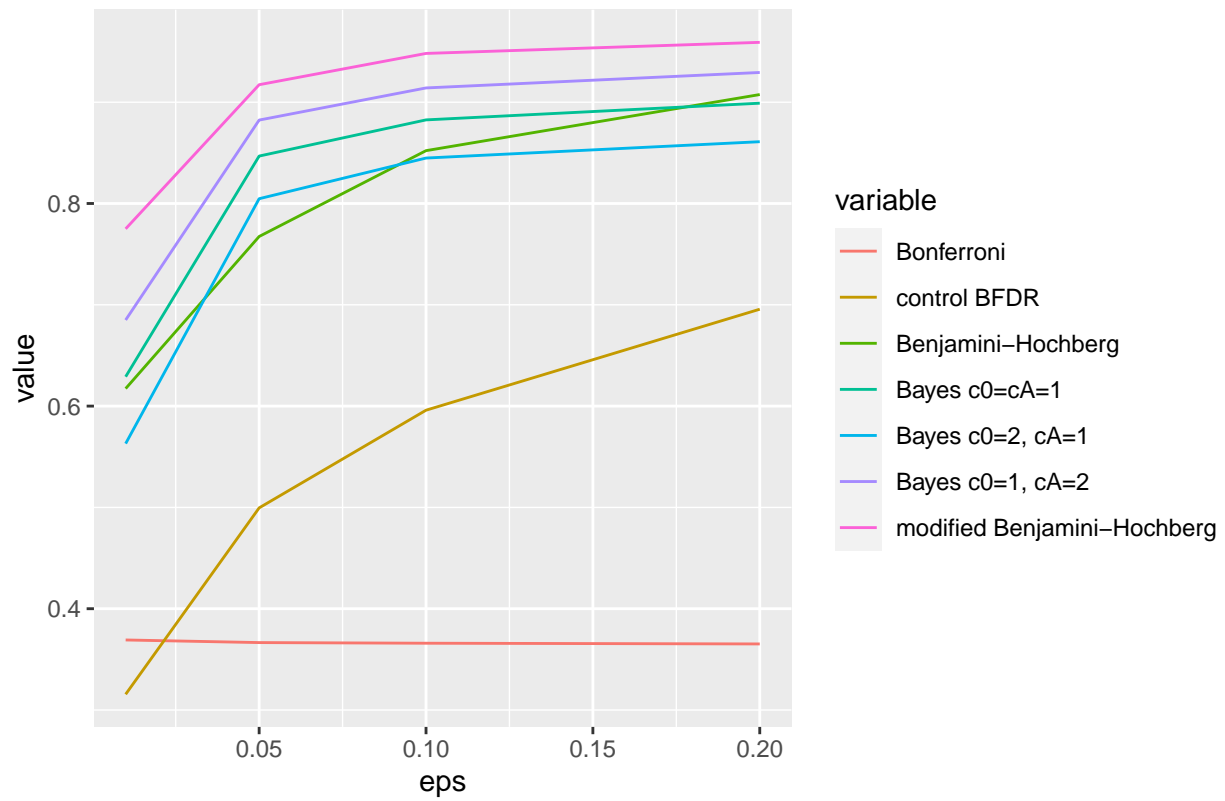


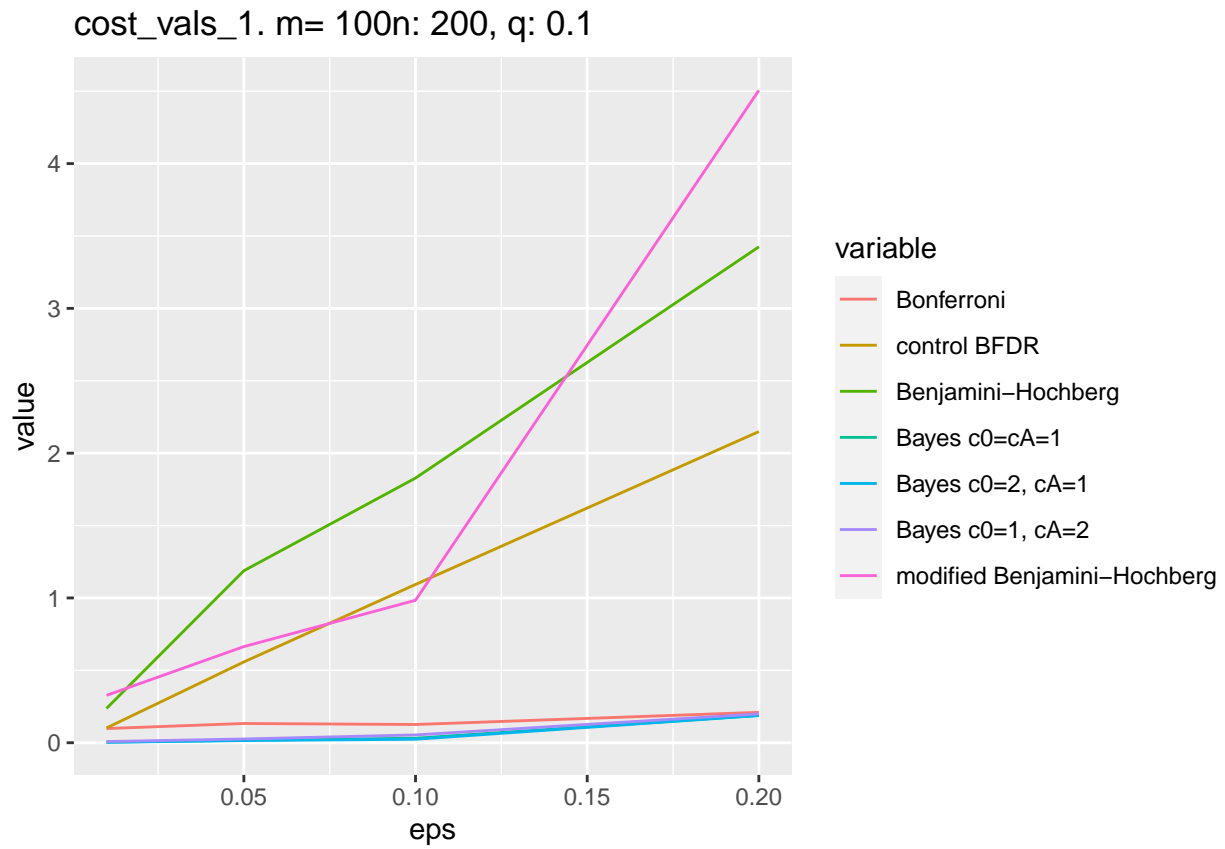


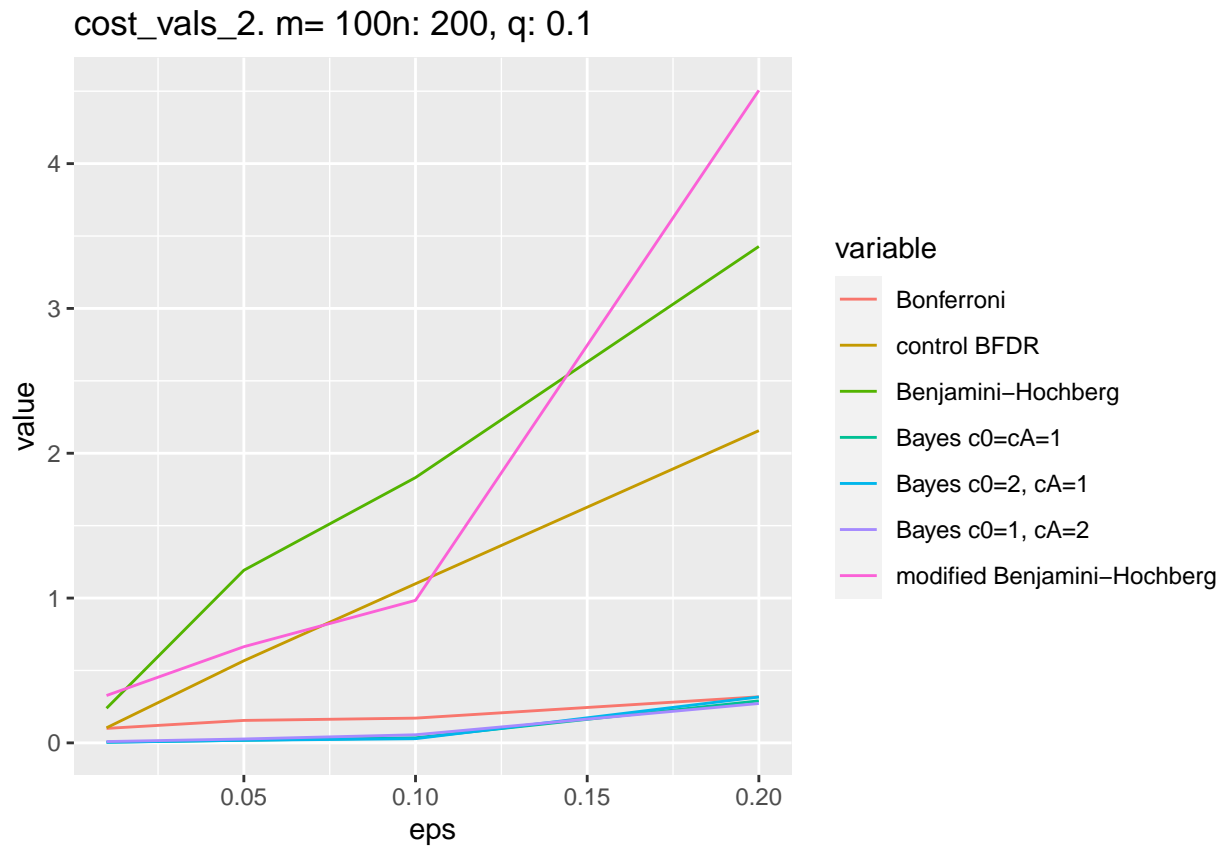


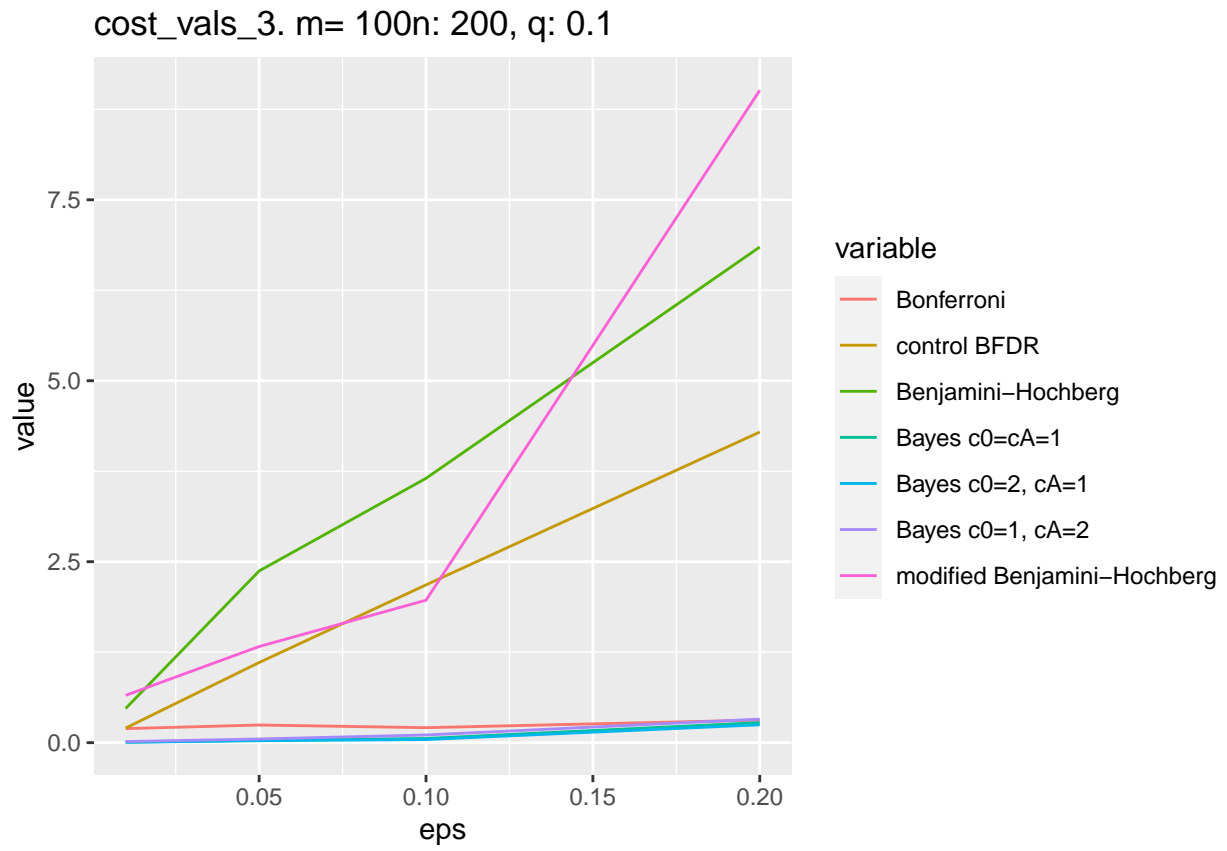


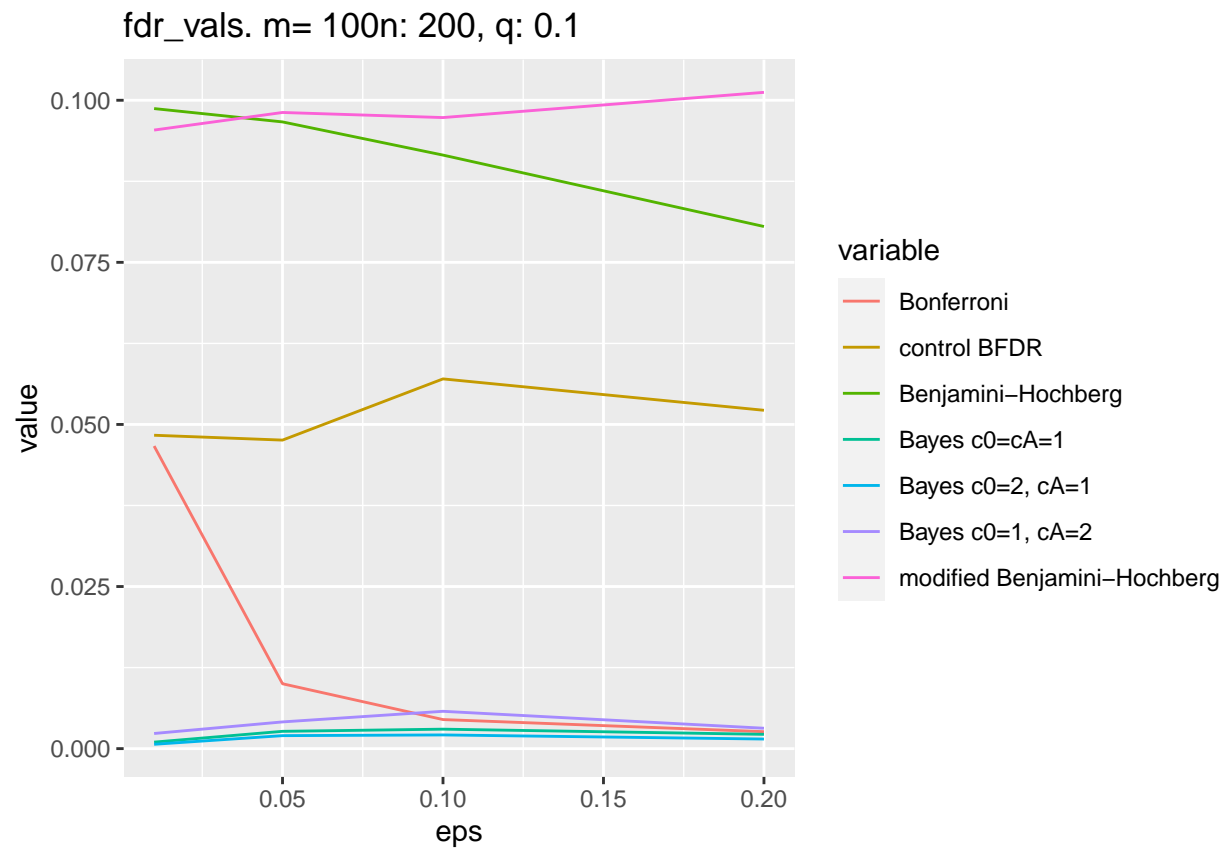
power\_vals. m= 20n: 1000, q: 0.3162

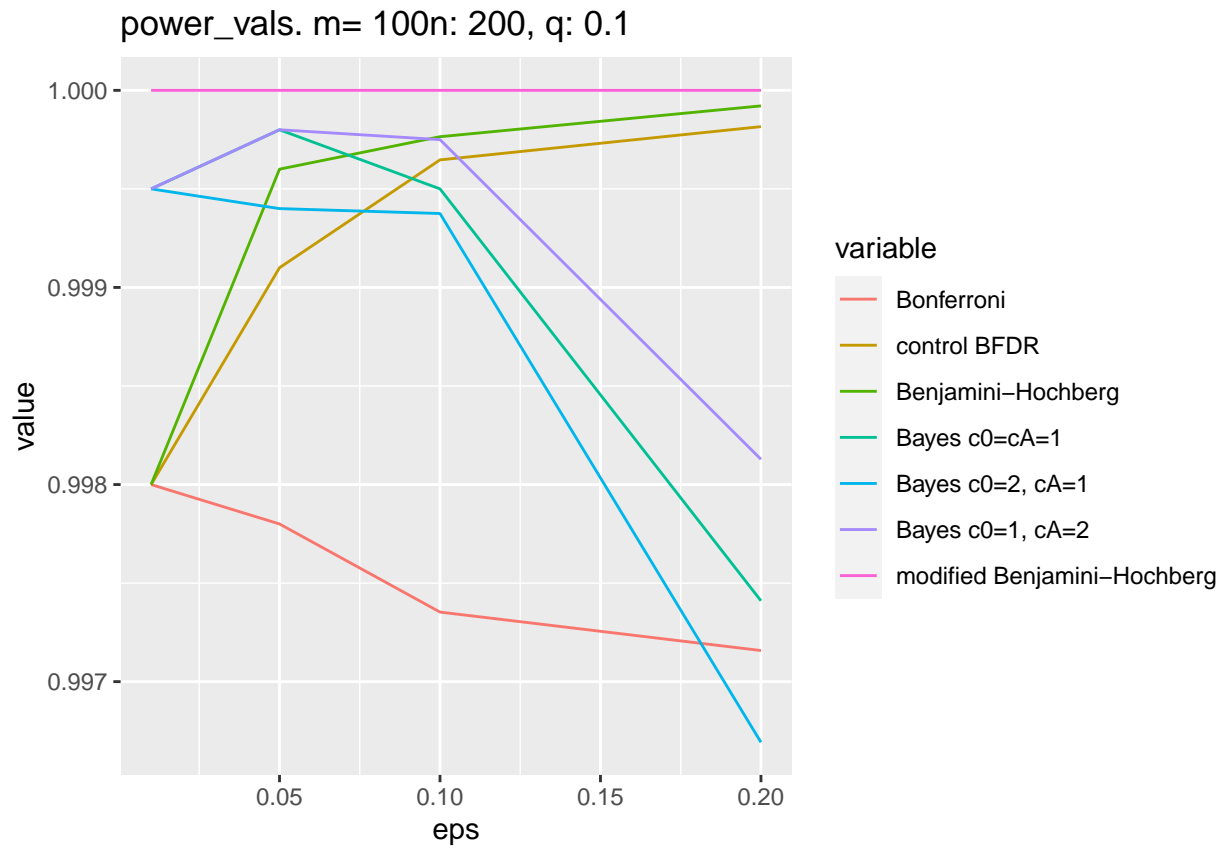


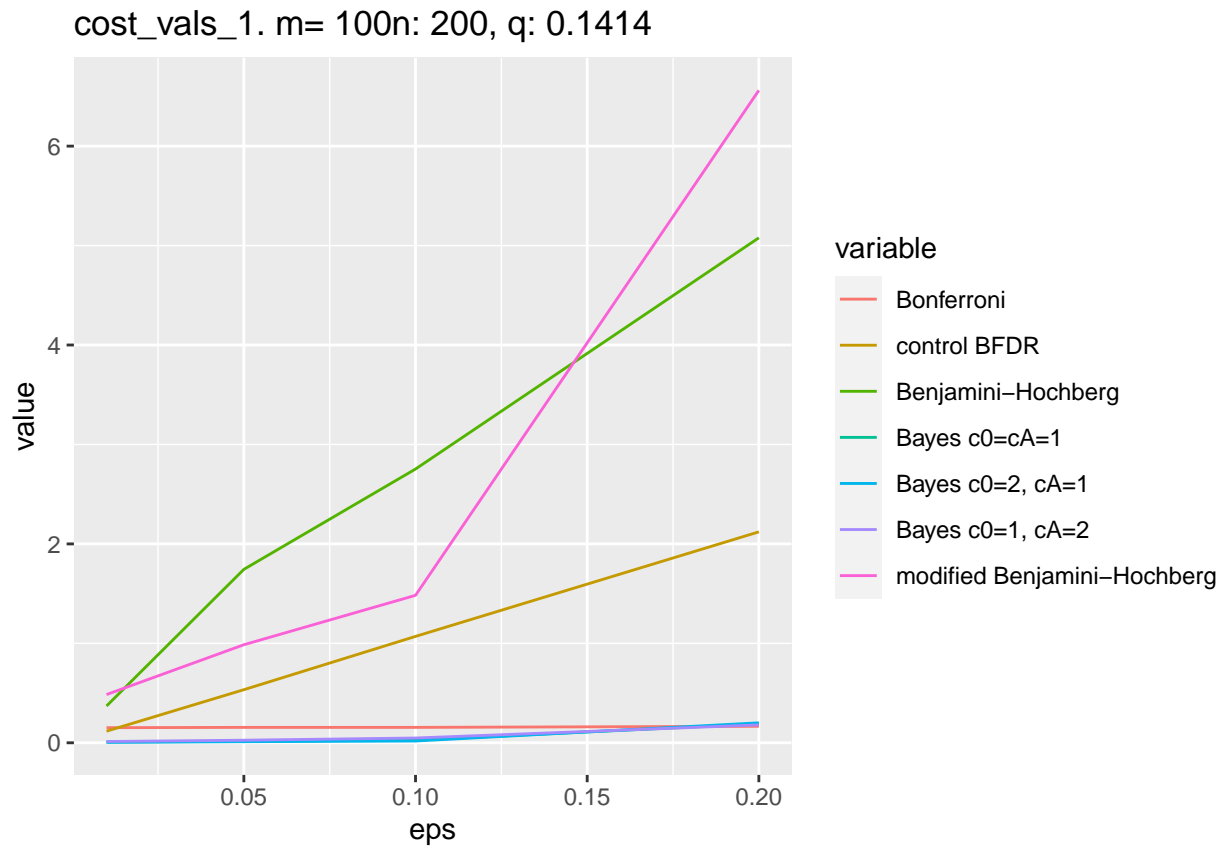




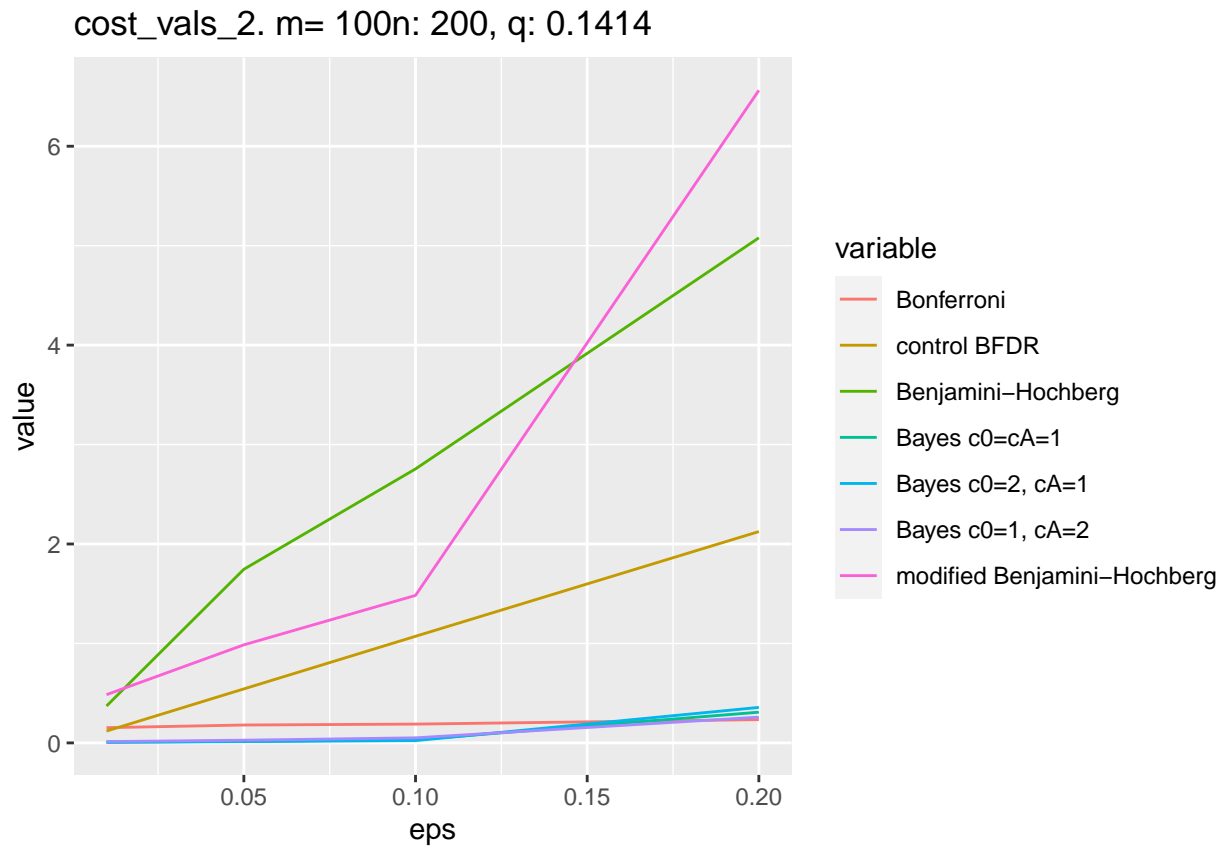












cost\_vals\_3. m= 100n: 200, q: 0.1414

