CEC 2020 results

Contents

Benchmark & algorithms setup

- $N = 10,\ 20$
- $\lambda = 4$ * N
- $\sigma_0 = 1$
- `max_restarts` = 100
- budget:
  - $N = 10 \implies 200000$
  - $N = 20 \implies 1000000$
- $x_0 = \texttt{runif}(N, -100, 100)$

Stop conditions:

```
Maximal number of function evaluations reached.
```

Restart triggers:

```
- Standard deviation below tolerance in all coordinates.
- Condition number of covariance matrix exceeds 1e14.
- Covariance matrix is not numerically positive definite.
- Addition of 0.1 times sigma does not change mean value.
- Addition of 0.2 times sigma in any coordinate does not change mean value.
```

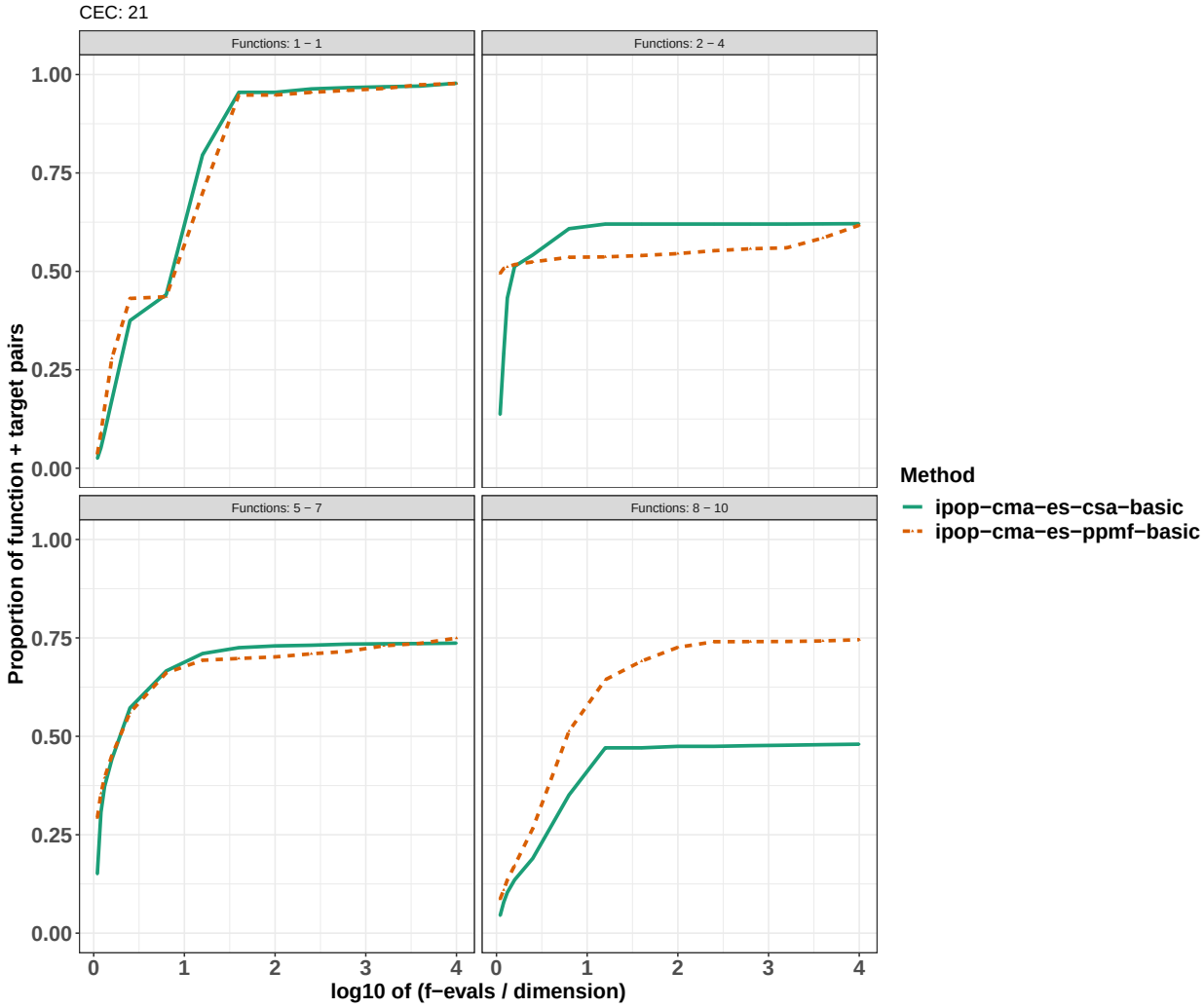
Results

```
library(cecb)
library(tidyverse)

knitr::opts_chunk$set(fig.width=12, fig.height=10)

"%+%" <- function(str1, str2) {
  paste0(str1, str2)
}
prefix = "../data/"

csa = list(
    basic = prefix %+% "csa/ipop-cma-es-csa-basic",
    rot = prefix %+% "csa/ipop-cma-es-csa-rot",
    shift = prefix %+% "csa/ipop-cma-es-csa-shift",
    bias = prefix %+% "csa/ipop-cma-es-csa-bias",
    bias_shift_rot = prefix %+% "csa/ipop-cma-es-csa-bias-shift-rot",
    shift_rot = prefix %+% "csa/ipop-cma-es-csa-shift-rot",
    bias_rot = prefix %+% "csa/ipop-cma-es-csa-bias-rot",
    bias_shift = prefix %+% "csa/ipop-cma-es-csa-bias-shift"
)
ppmf = list(
    basic = prefix %+% "ppmf/ipop-cma-es-ppmf-basic",
    rot = prefix %+% "ppmf/ipop-cma-es-ppmf-rot",
    shift = prefix %+% "ppmf/ipop-cma-es-ppmf-shift",
    bias = prefix %+% "ppmf/ipop-cma-es-ppmf-bias",
    bias_shift_rot = prefix %+% "ppmf/ipop-cma-es-ppmf-bias-shift-rot",
    shift_rot = prefix %+% "ppmf/ipop-cma-es-ppmf-shift-rot",
    bias_rot = prefix %+% "ppmf/ipop-cma-es-ppmf-bias-rot",
    bias_shift = prefix %+% "ppmf/ipop-cma-es-ppmf-bias-shift"
)
config = list(dim = 10, problems = 1:10, repetitions = 30)
```

1. Basic

ECDF curves N = 10

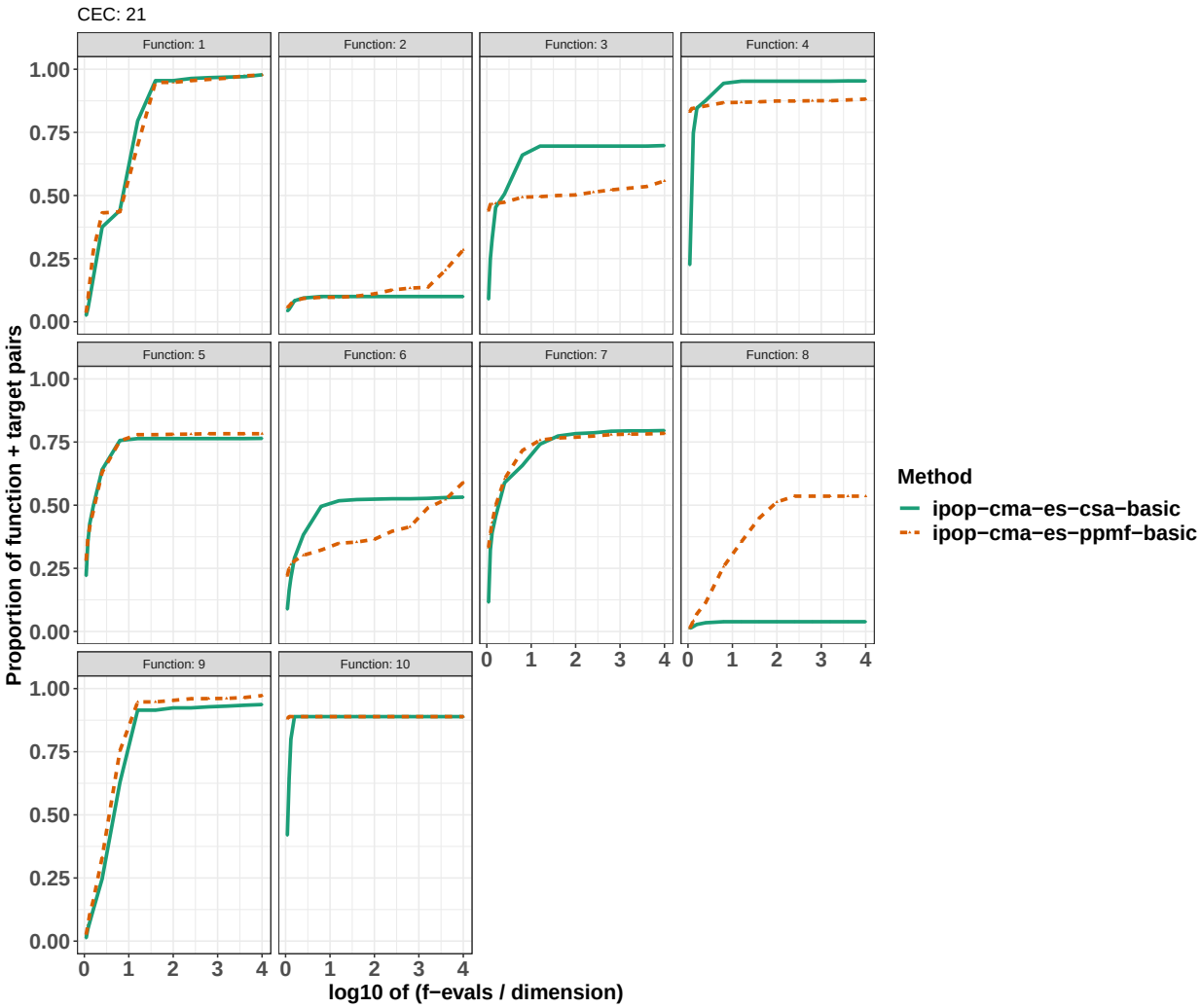
```
cecb::cec_class_grid(c(csa$basic, ppmf$basic), 10, 21, 30)
```




```
cecb::cec_problem_grid(c(csa$basic, ppmf$basic), 21, config)
```

Table 1: CSA (basic)

Function	Best	Worst	Median	Mean	Std
1	1.381970e-08	5.565171e+09	3.200969e-04	6.269933e+08	1.627710e+09
2	2.715832e+03	3.306615e+03	2.715832e+03	2.792275e+03	1.651358e+02
3	1.263507e+01	7.068753e+02	1.263507e+01	9.510139e+01	1.886028e+02
4	8.799318e-01	6.203364e+04	8.801303e-01	4.501460e+03	1.656085e+04
5	7.587359e+02	1.237040e+09	7.587360e+02	8.933720e+07	3.303472e+08
6	4.760753e+02	6.493528e+02	4.762086e+02	5.176548e+02	7.093617e+01
7	1.846050e+01	3.213260e+09	2.007417e+01	2.297765e+08	8.587060e+08
8	1.741605e+03	2.004195e+03	1.752222e+03	1.775990e+03	7.230962e+01
9	5.218806e-07	1.144095e+03	6.227551e-07	1.574901e+02	3.343981e+02
10	4.799559e+01	1.180260e+03	4.804775e+01	1.445138e+02	3.016664e+02



CEC's tables N = 10

```
cecb::get_resultTable(csa$basic, 1:10, 10, caption = "CSA (basic)")
```

Table 2: PPMF (basic)

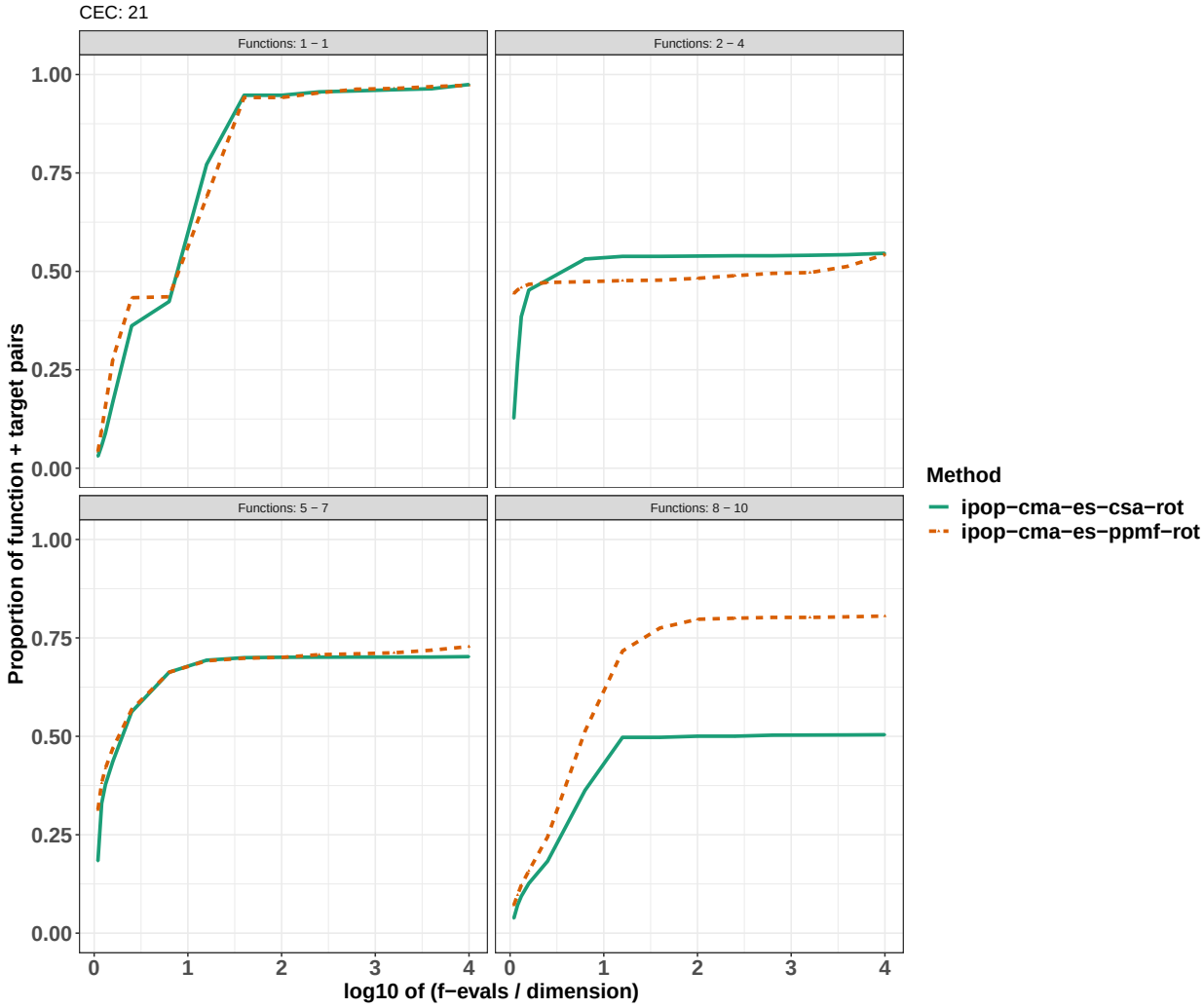
Function	Best	Worst	Median	Mean	Std
1	4.526549e-08	9.234456e+09	1.237334e-02	7.754739e+08	2.467175e+09
2	1.253918e+03	2.955554e+03	1.625398e+03	1.701811e+03	4.436810e+02
3	3.052620e+01	7.374674e+01	5.698455e+01	5.608301e+01	1.527645e+01
4	2.253222e+00	5.325964e+00	3.094592e+00	3.544897e+00	1.070668e+00
5	2.222612e+02	1.332106e+07	2.225184e+02	1.473110e+06	3.629690e+06
6	6.738882e-01	9.789427e+01	9.789427e+01	7.713761e+01	4.124658e+01
7	1.526430e+00	4.452000e+06	5.875382e+01	6.905335e+05	1.429682e+06
8	5.238032e-13	2.285284e+03	1.248677e+02	4.822427e+02	7.719461e+02
9	6.016171e-07	1.110196e+03	7.176749e-07	1.462584e+02	3.351837e+02
10	4.892959e+01	7.805625e+01	4.958008e+01	5.164326e+01	7.610996e+00

```
cecb::get_resultTable(ppmf$basic, 1:10, 10, caption = "PPMF (basic)")
```

2. Rot

ECDF curves N = 10

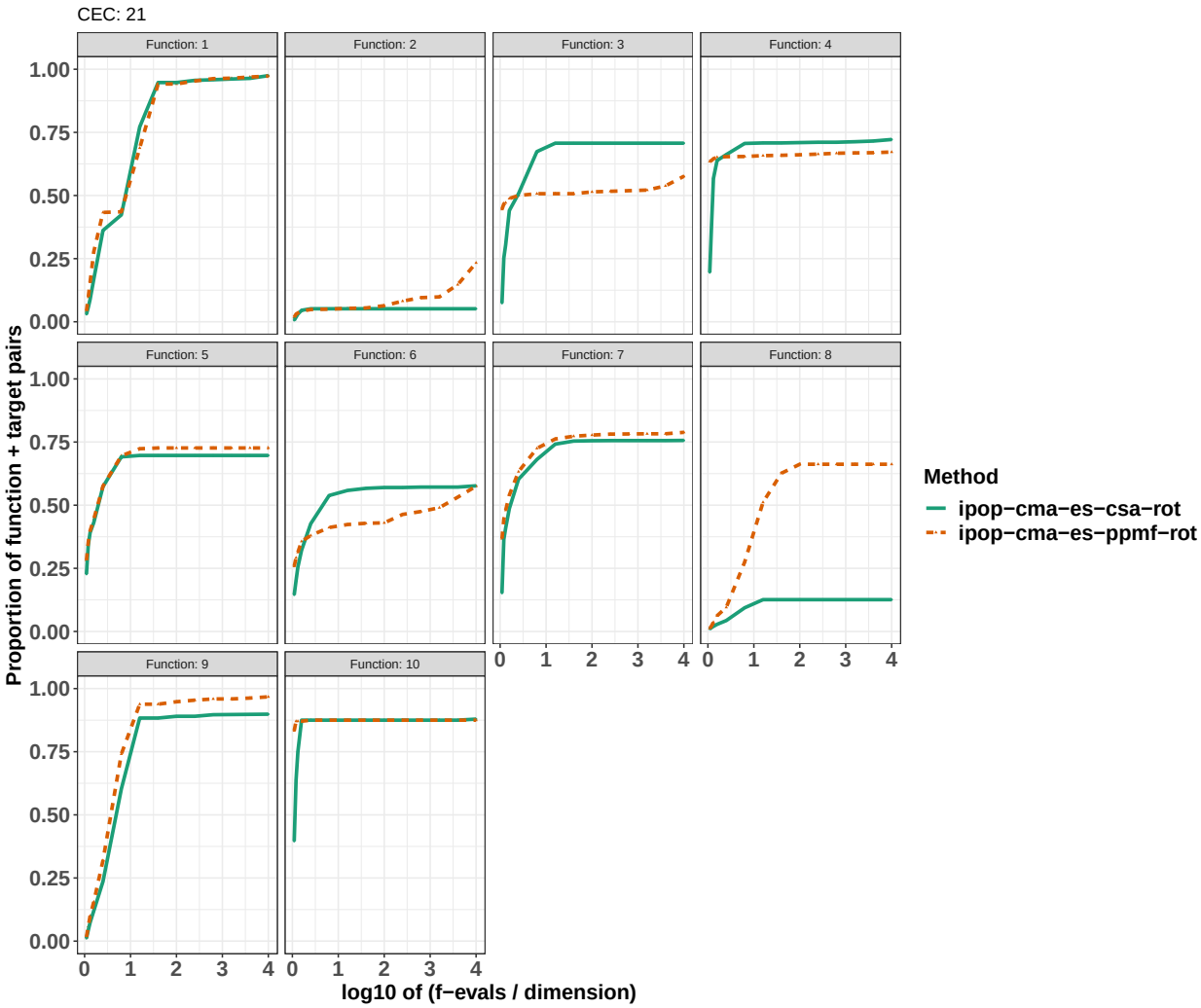
```
cecb::cec_class_grid(c(csa$rot, ppmf$rot), 10, 21, 30)
```




```
cecb::cec_problem_grid(c(csa$rot, ppmf$rot), 21, config)
```

Table 3: CSA (rot)

Function	Best	Worst	Median	Mean	Std
1	3.291628e-08	4.270728e+09	2.250660e-03	5.441650e+08	1.271176e+09
2	1.492080e+03	2.334146e+03	1.492080e+03	1.610302e+03	2.465251e+02
3	1.441855e+01	6.751787e+02	1.441855e+01	9.205052e+01	1.793975e+02
4	6.057982e-01	1.435883e+04	6.057988e-01	1.273526e+03	3.876453e+03
5	2.712272e+02	1.028810e+07	2.713273e+02	8.672508e+05	2.723878e+06
6	1.173368e+00	8.303983e+02	1.705386e+00	1.084915e+02	2.316881e+02
7	3.755383e+01	5.015480e+09	5.303967e+01	3.582962e+08	1.340430e+09
8	1.327306e+03	1.952857e+03	1.327306e+03	1.399494e+03	1.834003e+02
9	5.570145e-07	5.856929e+02	6.900576e-07	7.414447e+01	1.658055e+02
10	7.192467e+01	2.852177e+02	7.202770e+01	1.056930e+02	7.673065e+01



CEC's tables N = 10

```
cecb::get_resultTable(csa$rot, 1:10, 10, caption = "CSA (rot)")
```

Table 4: PPMF (rot)

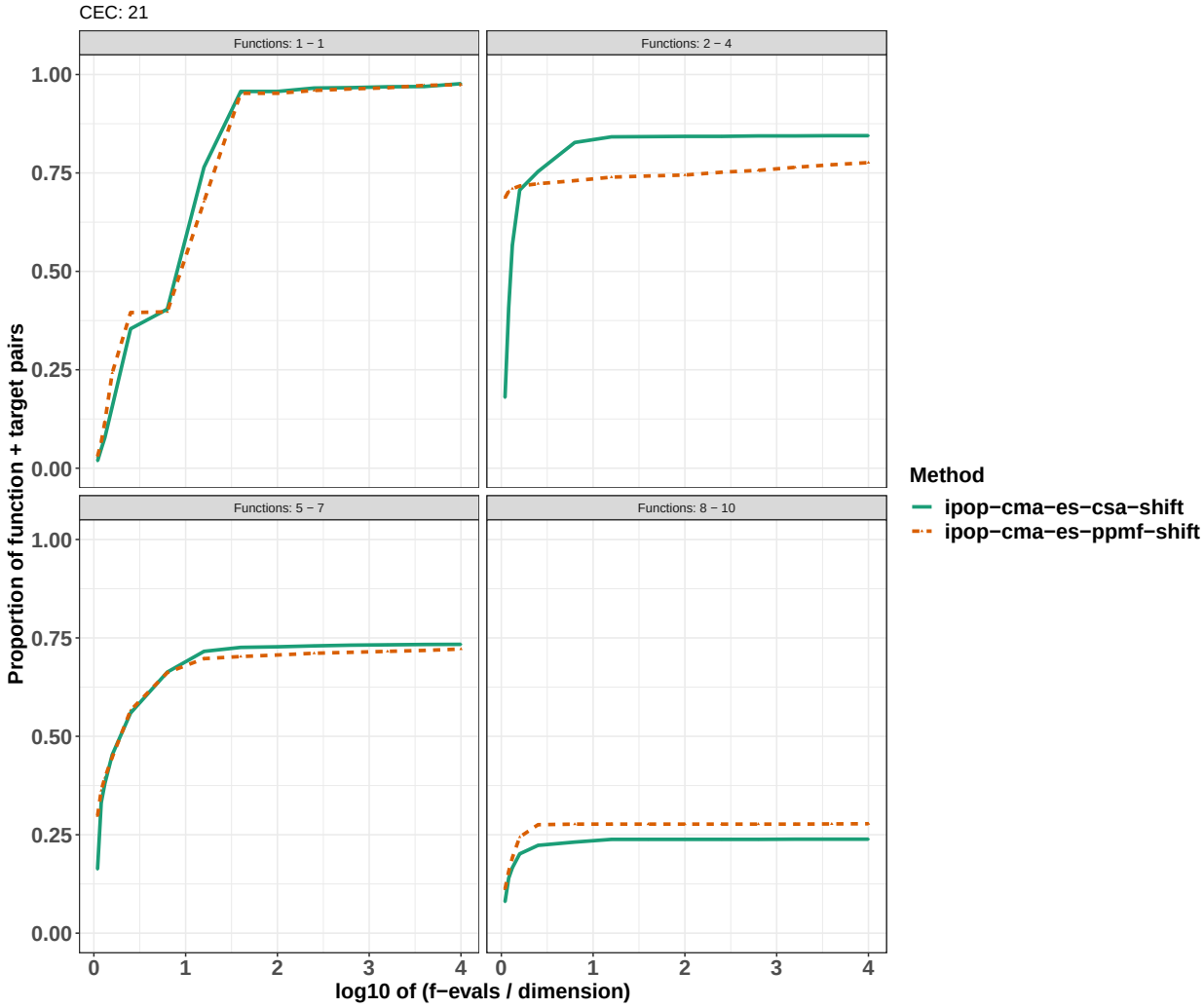
Function	Best	Worst	Median	Mean	Std
1	3.538610e-08	6.951559e+09	2.194341e-01	5.460441e+08	1.851596e+09
2	4.306353e+02	1.959936e+03	1.437636e+03	1.217029e+03	5.996686e+02
3	3.942626e+01	6.995433e+01	4.729791e+01	5.110510e+01	7.710821e+00
4	2.591483e+00	5.765637e+00	2.591483e+00	3.341175e+00	1.090444e+00
5	6.910066e+02	1.711381e+07	7.111487e+02	1.537553e+06	4.548023e+06
6	5.941119e+00	3.004036e+02	1.092354e+02	1.172899e+02	9.439337e+01
7	1.186603e+02	3.094054e+06	1.186647e+02	2.952324e+05	8.232478e+05
8	9.293307e-13	1.770004e+03	2.420919e-05	4.416629e+02	7.222227e+02
9	3.749865e-07	9.210357e+02	1.006669e-06	9.980013e+01	2.522753e+02
10	7.214410e+01	7.732678e+01	7.220499e+01	7.308074e+01	1.510819e+00

```
cecb::get_resultTable(ppmf$rot, 1:10, 10, caption = "PPMF (rot)")
```

3. Shift

ECDF curves N = 10

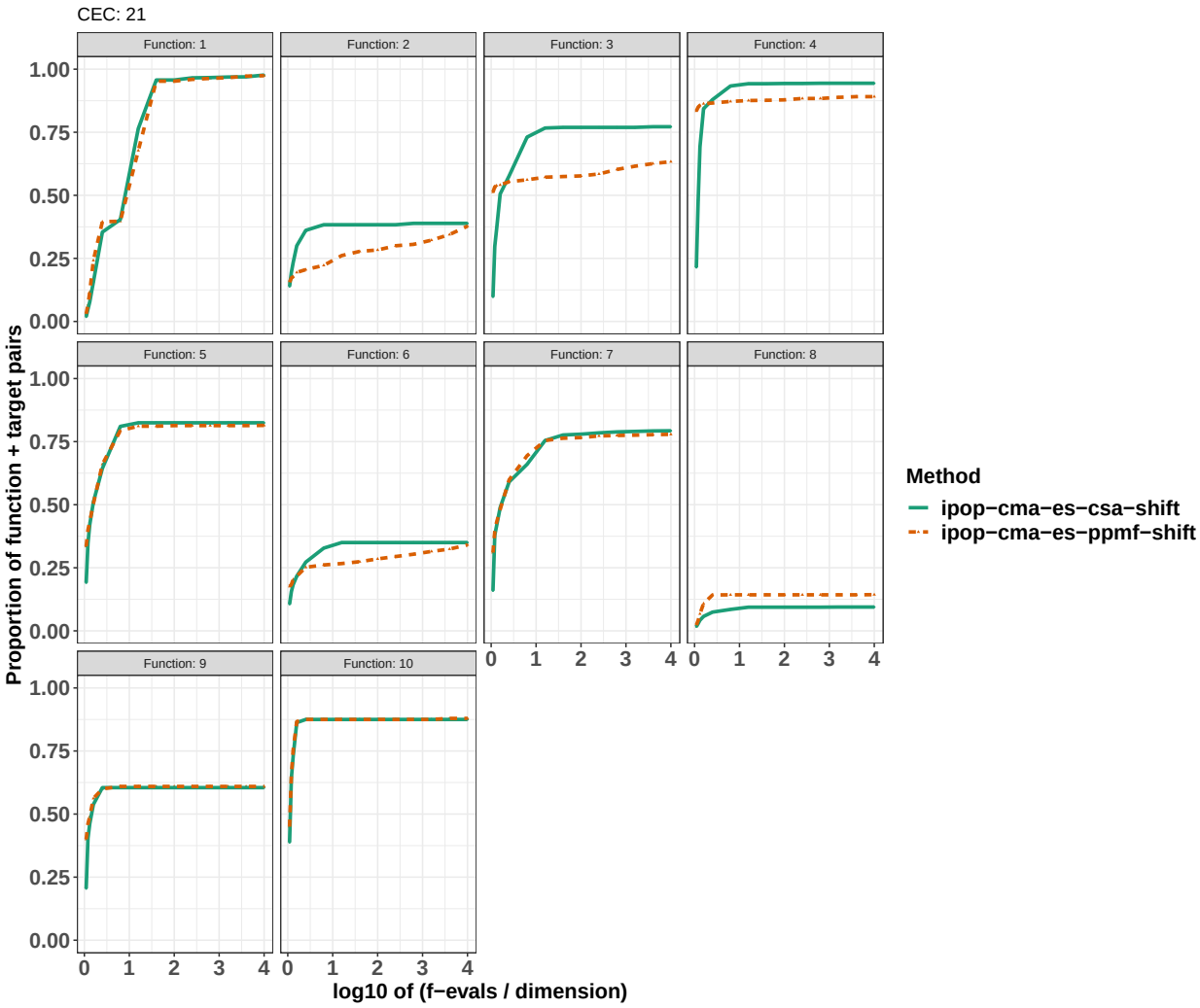
```
cecb::cec_class_grid(c(csa$shift, ppmf$shift), 10, 21, 30)
```




```
cecb::cec_problem_grid(c(csa$shift, ppmf$shift), 21, config)
```

Table 5: CSA (shift)

Function	Best	Worst	Median	Mean	Std
1	2.526855e-08	3.854679e+09	1.081869e-04	5.315445e+08	1.290996e+09
2	9.499729e+02	2.280037e+03	9.499729e+02	1.085011e+03	3.624137e+02
3	1.296279e+01	1.485941e+03	1.296279e+01	1.578600e+02	3.927642e+02
4	8.946582e-01	2.537162e+05	1.080651e+00	1.847241e+04	6.772012e+04
5	7.220152e+02	1.957572e+09	7.220154e+02	1.407798e+08	5.229169e+08
6	5.176949e+02	6.467574e+02	5.186769e+02	5.429984e+02	4.266582e+01
7	2.228318e+02	1.276313e+07	2.434813e+02	1.949950e+06	3.971860e+06
8	1.000000e+02	3.280595e+03	1.000000e+02	4.244082e+02	8.688850e+02
9	3.280391e+02	1.717819e+03	3.280391e+02	4.492744e+02	3.694334e+02
10	4.000000e+02	4.229524e+03	4.000000e+02	8.546243e+02	1.067593e+03



CEC's tables N = 10

```
cecb::get_resultTable(csa$shift, 1:10, 10, caption = "CSA (shift)")
```

Table 6: PPMF (shift)

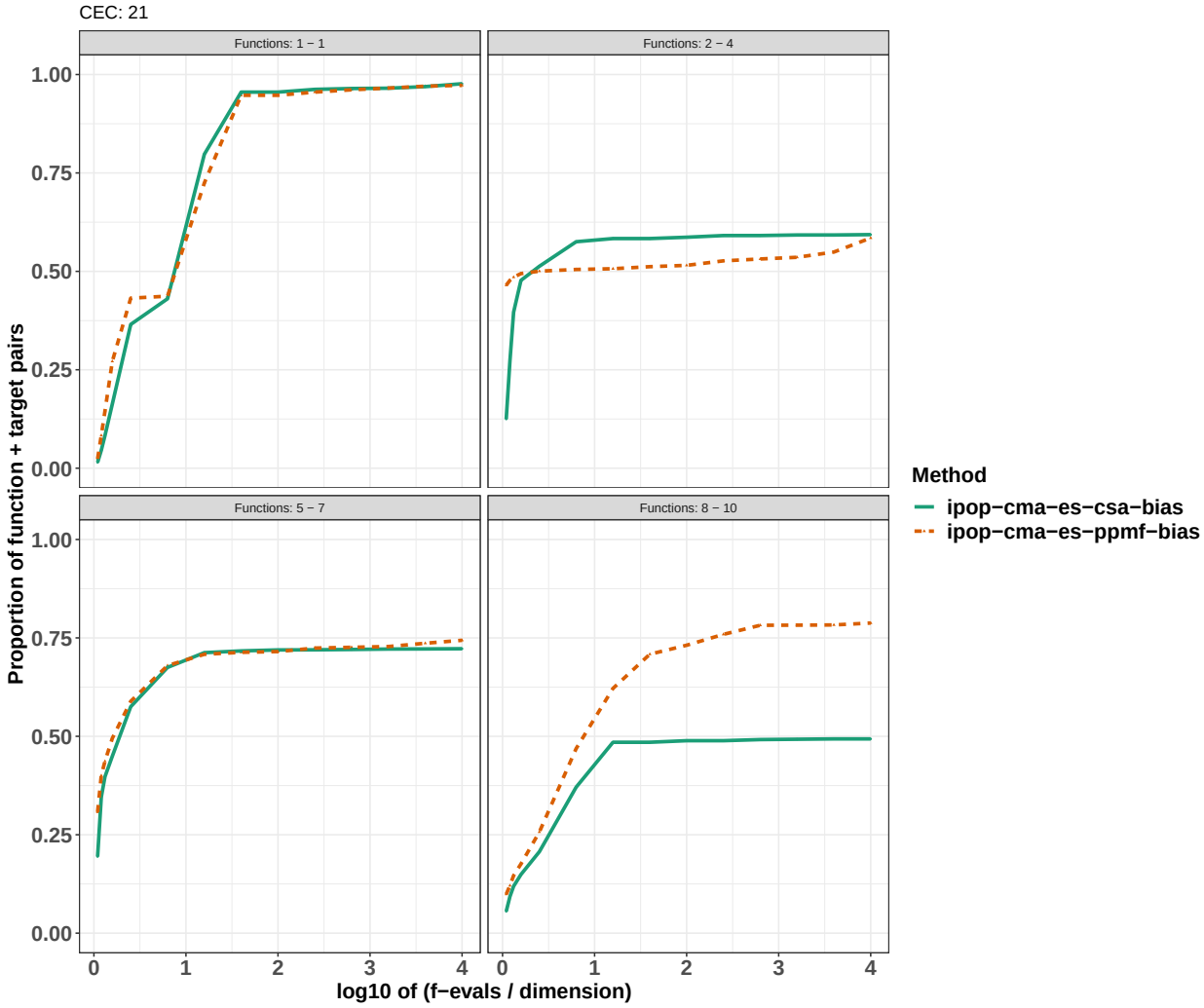
Function	Best	Worst	Median	Mean	Std
1	2.534186e-08	2.453955e+10	6.553811e-03	2.144216e+09	6.572666e+09
2	1.254582e+03	2.417254e+03	1.254582e+03	1.546888e+03	4.817112e+02
3	3.284677e+01	6.834951e+01	5.493681e+01	5.597986e+01	1.150531e+01
4	2.450217e+00	4.931657e+00	2.999026e+00	3.239135e+00	8.973915e-01
5	6.461693e+02	4.478067e+07	6.462548e+02	3.845844e+06	1.188652e+07
6	1.185706e+02	4.498320e+02	2.527457e+02	2.592226e+02	1.348198e+02
7	1.220629e+02	3.052262e+09	1.521296e+02	2.182513e+08	8.156846e+08
8	1.000000e+02	2.810087e+03	1.000000e+02	5.076926e+02	8.384198e+02
9	3.280391e+02	5.111418e+02	3.670626e+02	3.873709e+02	5.308716e+01
10	4.000000e+02	2.318159e+03	4.000000e+02	6.792952e+02	5.714756e+02

```
cecb::get_resultTable(ppmf$shift, 1:10, 10, caption = "PPMF (shift)")
```

4. Bias

ECDF curves N = 10

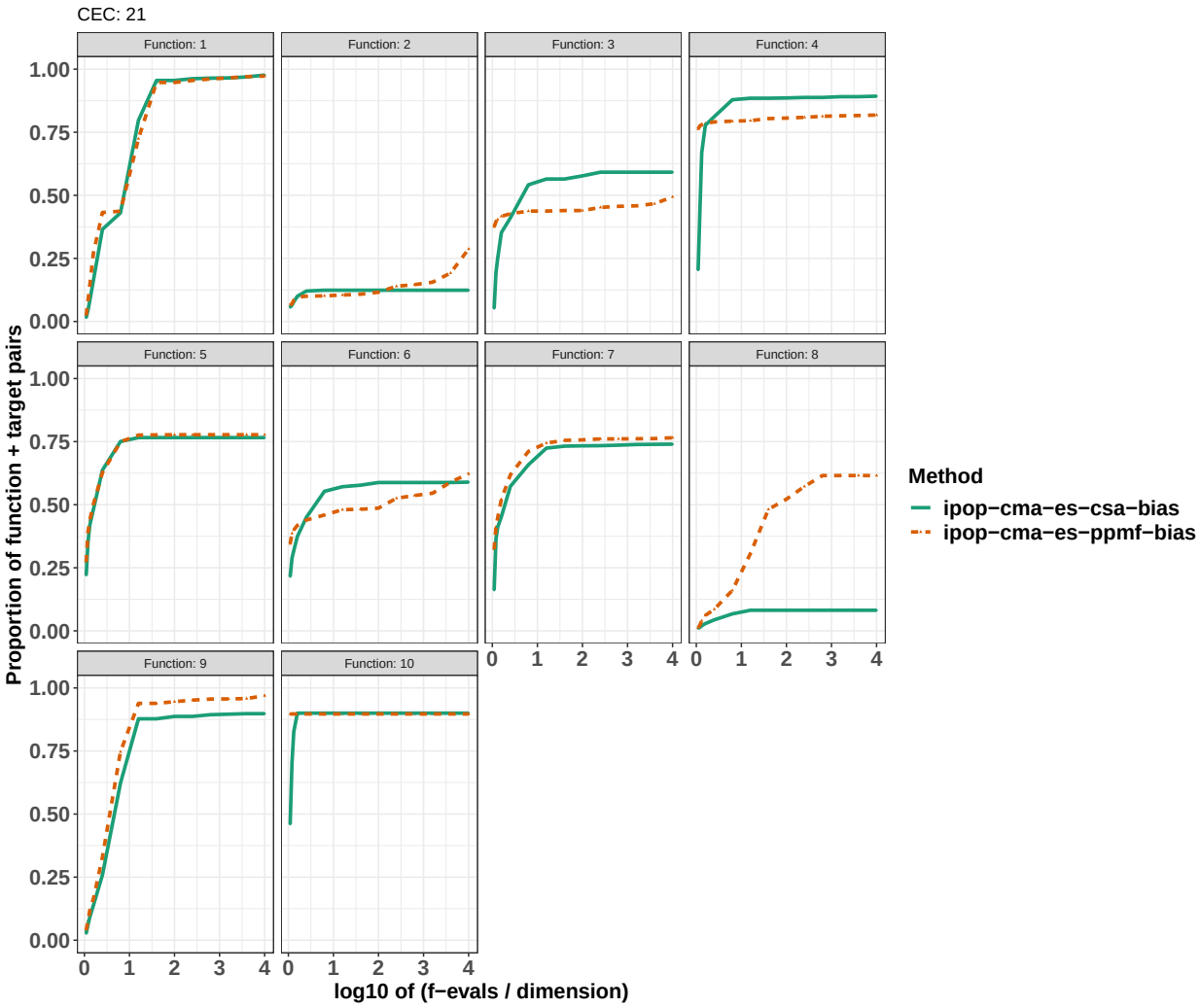
```
cecb::cec_class_grid(c(csa$bias, ppmf$bias), 10, 21, 30)
```




```
cecb::cec_problem_grid(c(csa$bias, ppmf$bias), 21, config)
```

Table 7: CSA (bias)

Function	Best	Worst	Median	Mean	Std
1	3.988036e-08	2.157485e+10	9.489354e-06	1.940291e+09	5.799666e+09
2	6.591886e+02	2.390713e+03	6.591886e+02	1.042529e+03	6.454640e+02
3	1.263507e+01	7.417596e+02	1.263507e+01	9.729713e+01	1.974213e+02
4	4.868443e-01	3.066726e+03	4.868443e-01	2.377414e+02	8.167479e+02
5	9.290403e+02	2.077320e+07	9.290404e+02	1.587631e+06	5.526559e+06
6	3.576970e+02	7.217731e+02	3.577493e+02	4.167949e+02	1.172628e+02
7	3.414936e+01	1.360581e+08	4.211715e+01	9.723208e+06	3.636170e+07
8	1.159368e+03	1.593345e+03	1.159368e+03	1.234316e+03	1.589917e+02
9	5.738707e-07	3.079668e+02	1.013336e-06	4.104929e+01	8.868482e+01
10	4.799559e+01	4.548818e+02	4.801011e+01	8.348626e+01	1.082281e+02



CEC's tables N = 10

```
cecb::get_resultTable(csa$bias, 1:10, 10, caption = "CSA (bias)")
```

Table 8: PPMF (bias)

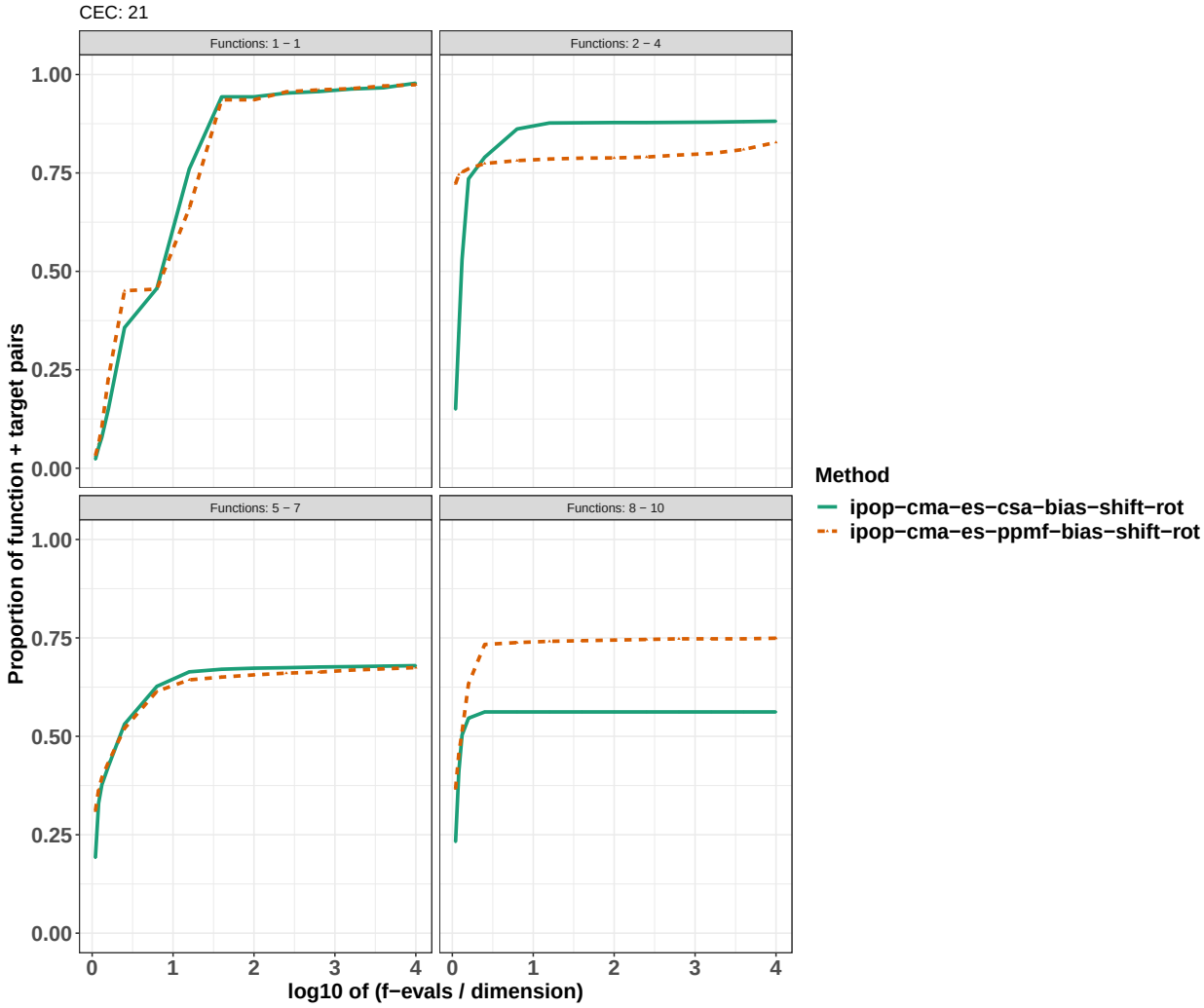
Function	Best	Worst	Median	Mean	Std
1	2.600997e-08	8.763281e+09	5.332626e-05	6.470525e+08	2.337070e+09
2	5.548191e+02	2.264993e+03	1.506039e+03	1.370307e+03	5.028775e+02
3	3.639134e+01	5.467233e+01	5.137314e+01	4.897954e+01	7.021258e+00
4	2.277531e+00	5.373099e+00	3.056537e+00	3.189242e+00	9.343251e-01
5	2.223226e+02	1.691341e+07	2.237840e+02	1.350856e+06	4.497769e+06
6	2.333065e+01	4.448363e+02	8.458234e+01	1.273700e+02	1.079669e+02
7	4.994350e+02	7.435401e+04	5.992492e+02	1.140780e+04	2.268470e+04
8	9.094947e-13	2.451228e+03	1.119581e+02	4.863120e+02	8.183874e+02
9	4.395292e-07	8.647112e+02	7.801864e-07	9.973639e+01	2.395103e+02
10	7.723921e+01	8.797692e+01	7.862770e+01	7.997452e+01	3.108196e+00

```
cecb::get_resultTable(ppmf$bias, 1:10, 10, caption = "PPMF (bias)")
```

5. Bias-shift-rot

ECDF curves N = 10

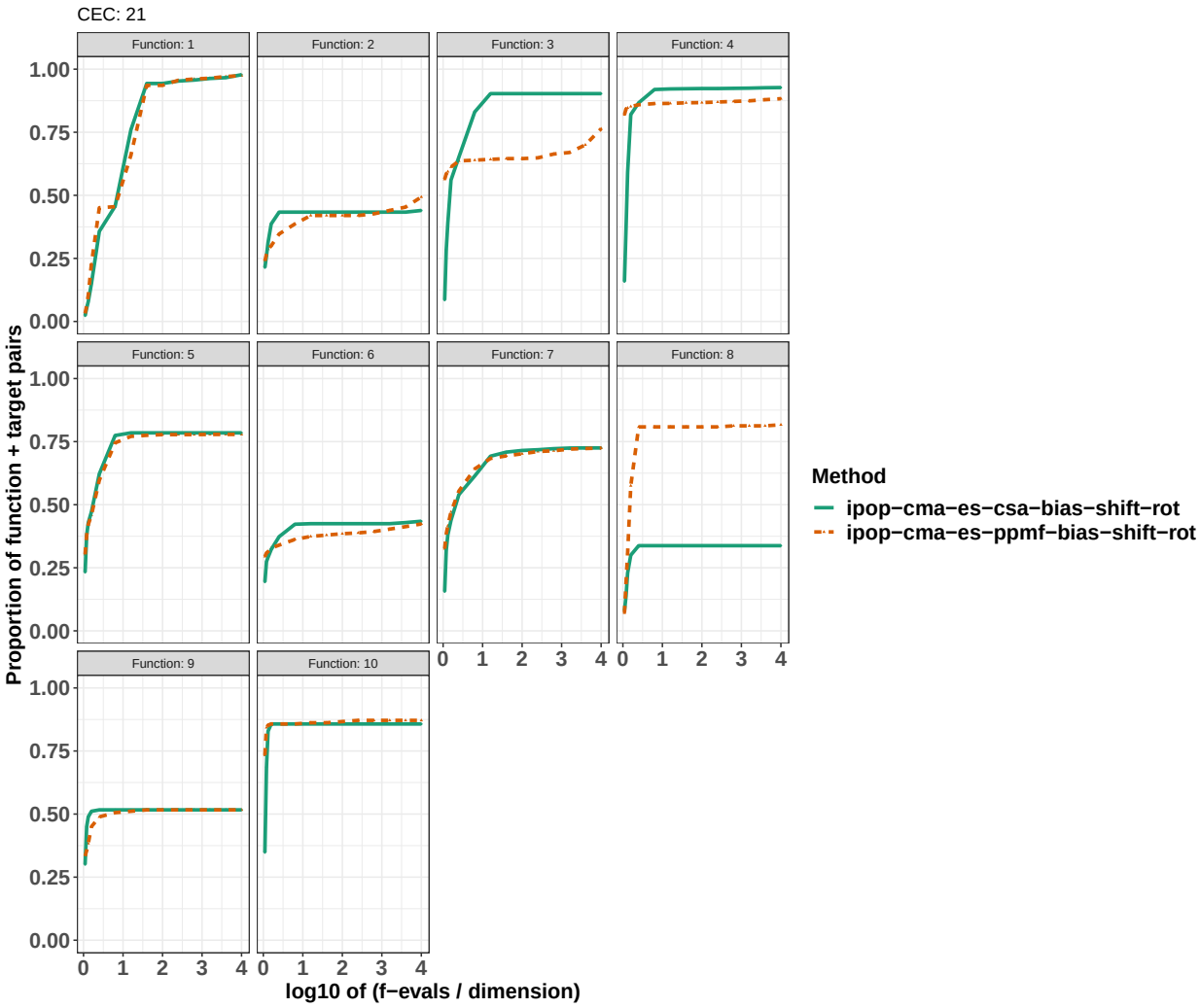
```
cecb::cec_class_grid(c(csa$bias_shift_rot, ppmf$bias_shift_rot), 10, 21, 30)
```




```
cecb::cec_problem_grid(c(csa$bias_shift_rot, ppmf$bias_shift_rot), 21, config)
```

Table 9: CSA (bias x shift x rot)

Function	Best	Worst	Median	Mean	Std
1	1.878216e-08	3.267344e+10	1.936252e-04	3.017906e+09	8.774831e+09
2	2.503784e+03	2.703859e+03	2.503784e+03	2.533087e+03	6.297542e+01
3	1.442334e+01	8.444371e+02	1.442334e+01	1.039160e+02	2.210380e+02
4	2.628805e-01	3.601702e+06	1.005825e+00	3.018885e+05	9.642014e+05
5	1.714270e+01	4.299388e+07	1.714277e+01	3.545077e+06	1.141353e+07
6	1.209039e+02	2.685284e+03	1.209603e+02	4.045387e+02	6.846469e+02
7	3.108539e+02	2.029269e+06	3.129592e+02	2.983111e+05	6.298108e+05
8	1.000000e+02	1.875163e+03	1.000000e+02	2.623945e+02	4.744942e+02
9	2.000000e+02	9.202337e+02	2.000000e+02	2.819787e+02	2.025073e+02
10	4.433300e+02	2.309982e+03	4.433339e+02	6.199665e+02	4.978345e+02



CEC's tables N = 10

```
cecb::get_resultTable(csa$bias_shift_rot, 1:10, 10, caption = "CSA (bias x shift x rot)")
```

Table 10: PPMF (bias x shift x rot)

Function	Best	Worst	Median	Mean	Std
1	5.089846e-08	1.320216e+10	1.816404	1.163346e+09	3.541659e+09
2	1.329538e+03	1.686187e+03	1606.467488	1.587868e+03	1.303366e+02
3	4.114522e+01	5.983890e+01	59.838897	5.385413e+01	7.601810e+00
4	2.140687e+00	8.532456e+00	2.757814	3.333276e+00	1.590034e+00
5	5.742098e+02	3.146300e+07	725.485593	2.371815e+06	8.376970e+06
6	5.061811e+01	4.439373e+02	219.581850	2.383743e+02	1.254092e+02
7	1.192477e+02	9.006818e+06	1292.335354	7.142417e+05	2.391226e+06
8	1.000000e+02	2.795206e+03	100.000000	4.731118e+02	8.217573e+02
9	2.311340e+02	4.810149e+02	302.005500	3.160133e+02	9.210612e+01
10	3.995850e+02	6.872566e+02	399.584968	4.237000e+02	7.687708e+01

```
cecb::get_resultTable(ppmf$bias_shift_rot, 1:10, 10, caption = "PPMF (bias x shift x rot)")
```

6. Shift-rot

ECDF curves N = 10

```
#cecb::cec_class_grid(c(csa$shift_rot, ppmf$shift_rot), 10, 21, 30)
#cecb::cec_problem_grid(c(csa$shift_rot, ppmf$shift_rot), 21, config)
```

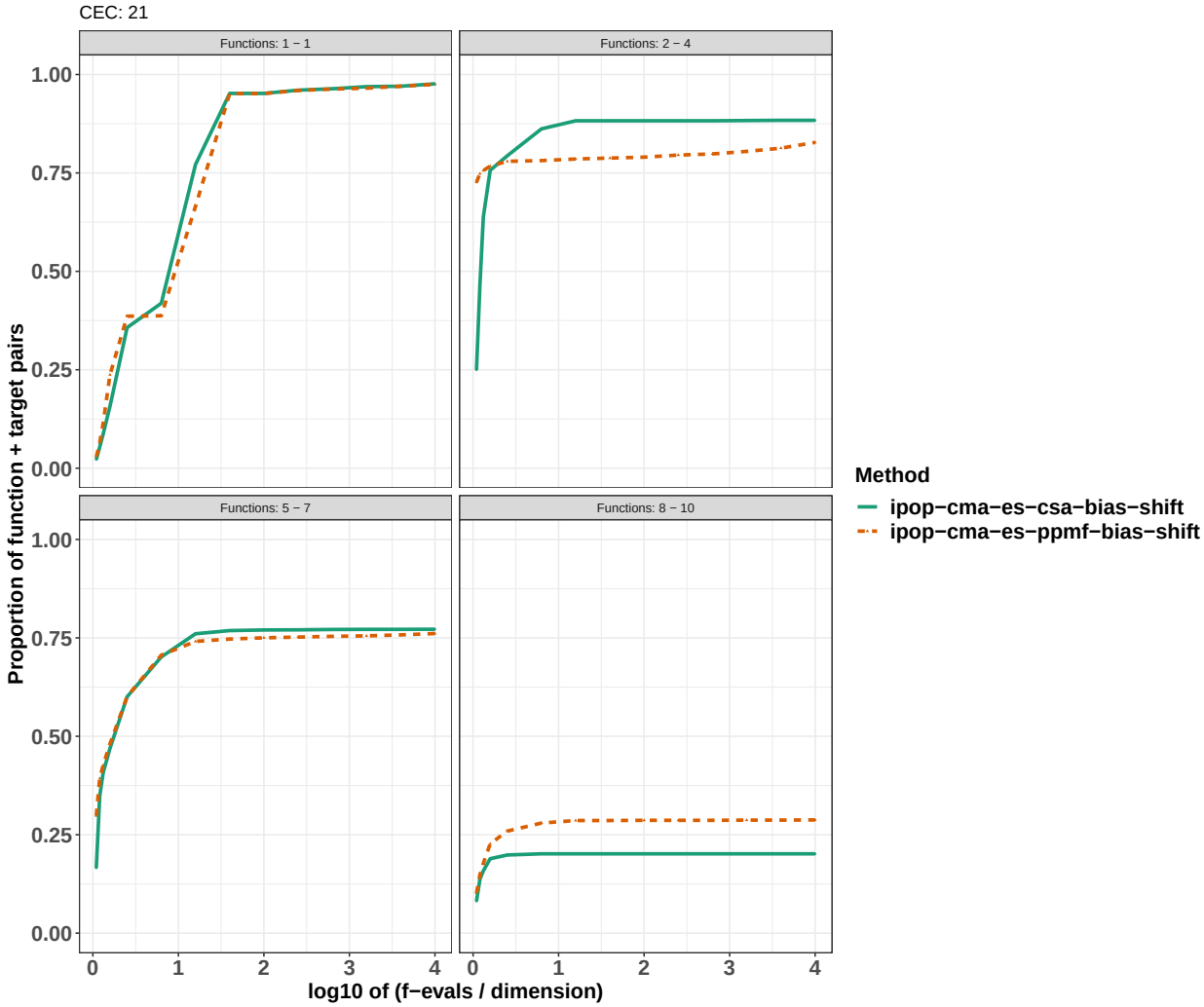
CEC's tables N = 10

```
#cecb::get_resultTable(csa$shift_rot, 1:10, 10, caption = "CSA (shift x rot)")
#cecb::get_resultTable(ppmf$shift_rot, 1:10, 10, caption = "PPMF (shift x rot)")
```

7. Bias-shift

ECDF curves N = 10

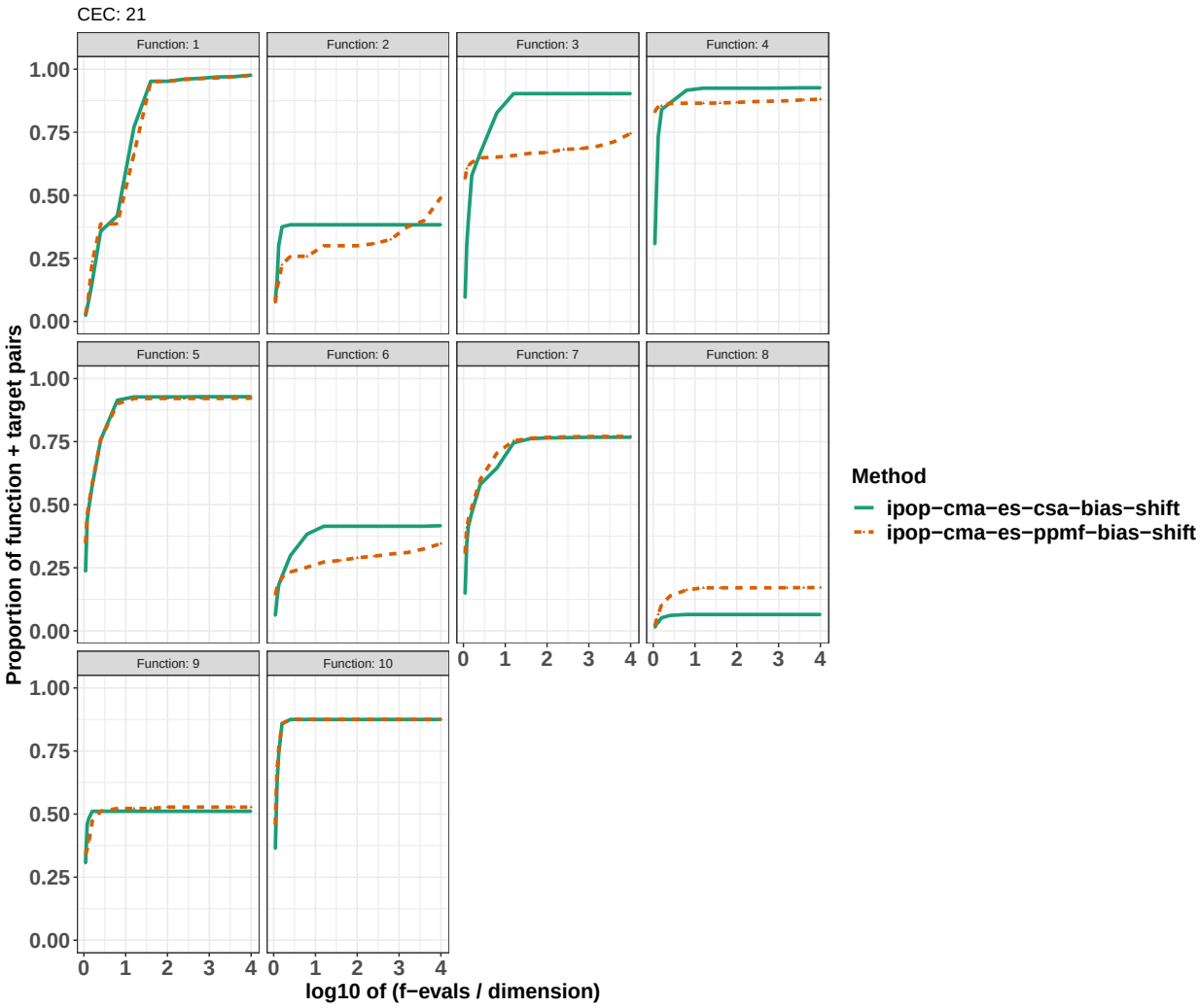
```
cecb::cec_class_grid(c(csa$bias_shift, ppmf$bias_shift), 10, 21, 30)
```




```
cecb::cec_problem_grid(c(csa$bias_shift, ppmf$bias_shift), 21, config)
```

Table 11: CSA (bias x shift)

Function	Best	Worst	Median	Mean	Std
1	4.131093e-08	1.664492e+10	3.369410e-04	1.829450e+09	4.701525e+09
2	1.101039e+03	1.983378e+03	1.101039e+03	1.233498e+03	2.977865e+02
3	1.202070e+01	1.186805e+03	1.202145e+01	1.369468e+02	3.138284e+02
4	1.138354e+00	1.238040e+05	1.138354e+00	8.941890e+03	3.306153e+04
5	3.876389e+02	6.865880e+07	3.876395e+02	6.099723e+06	1.833671e+07
6	3.487432e+02	1.003378e+03	3.488138e+02	4.408434e+02	1.867279e+02
7	2.531842e+02	8.991159e+05	2.590549e+02	1.770676e+05	3.122170e+05
8	1.305727e+03	2.375342e+03	1.305728e+03	1.552043e+03	4.280307e+02
9	3.326047e+02	1.437185e+03	3.326047e+02	4.432995e+02	2.960228e+02
10	4.000000e+02	1.232669e+03	4.000000e+02	5.193613e+02	2.416465e+02



CEC's tables N = 10

```
cecb::get_resultTable(csa$bias_shift, 1:10, 10, caption = "CSA (bias x shift)")
```

Table 12: PPMF (bias x shift)

Function	Best	Worst	Median	Mean	Std
1	5.417454e-08	1.890003e+10	7.906463e-05	2.239569e+09	5.457321e+09
2	1.146692e+03	2.140574e+03	1.572035e+03	1.698711e+03	3.117118e+02
3	3.884024e+01	6.827778e+01	5.267662e+01	5.449079e+01	1.014933e+01
4	2.187336e+00	7.310192e+00	3.302185e+00	3.779319e+00	1.327094e+00
5	1.651980e+02	6.684228e+06	1.652079e+02	5.884073e+05	1.771812e+06
6	2.036382e+02	5.932203e+02	2.036382e+02	2.922550e+02	1.335005e+02
7	1.944857e+01	7.642726e+06	4.134173e+01	1.087390e+06	2.230793e+06
8	1.000000e+02	7.809233e+02	1.000000e+02	1.734911e+02	1.882576e+02
9	3.277693e+02	4.785712e+02	3.684807e+02	3.859714e+02	3.776618e+01
10	4.000000e+02	1.179379e+03	4.000000e+02	5.010731e+02	2.189946e+02

```
cecb::get_resultTable(ppmf$bias_shift, 1:10, 10, caption = "PPMF (bias x shift)")
```

8. Bias-rot

ECDF curves N = 10

```
#cecb::cec_class_grid(c(csa$bias_rot, ppmf$bias_shift), 10, 21, 30)
#cecb::cec_problem_grid(c(csa$bias_rot, ppmf$bias_shift), 21, config)
```

CEC's tables N = 10

```
#cecb::get_resultTable(csa$bias_rot, 1:10, 10, caption = "CSA (bias x rot)")
#cecb::get_resultTable(ppmf$bias_rot, 1:10, 10, caption = "PPMF (bias x rot)")
```