Definitions

```
In[1]:= IsDistr[p_] := Total[p] == 1 && And @@ NonNegative[p]

In[2]:= IsDistrAppr[p_] := Total[p] == 1 && And @@ Table[p[[i]] ≥ -0.00001, {i, 1, Length[p]}]

In[3]:= BrierScore[p_, q_] := Sum[2 * q[[i]] * p[[i]], {i, 1, Length[q]}] - Sum[p[[i]] ^ 2, {i, 1, Length[q]}]

In[4]:= logscoreh[0, 0] := 0; logscoreh[0, 0.0] = 0; logscoreh[0, x_] := -∞;
        logscoreh[0.0, 0.0] := 0 ; logscoreh[0.0, 0]; logscoreh[0.0, x_] := -∞;
        logscoreh[pi_, qi_] := qi * Log[pi];

In[7]:= LogScore[p_, q_] := Sum[logscoreh[p[[i]], q[[i]]], {i, 1, Length[q]}]

In[8]:= uniform[dim_] := Table[1 / dim, dim]

In[19]:= RandomDistr[dim_] :=
          Block[{$RecursionLimit = 1000, res = Table[RandomInteger[{0, 1000}] / 1000, dim - 1]},
           If[Total[res] ≤ 1, Append[res, 1 - Total[res]], RandomDistr[dim]]]

In[20]:= RandomA[dim_] := Transpose[Table[RandomDistr[dim], dim]];

In[21]:= FixedPointDistr[A_] := Last /@
           Last@Solve[A.Array[x, Length[A]] == Array[x, Length[A]] && IsDistr[Array[x, Length[A]]],
             Array[x, Length[A]]]

In[22]:= Clear[pmax];
         Clear[S];
         Clear[A];
         OptReportN[S_, A_] := Last /@ Last@NMaximize[
             {S[Array[pmax, Length[A]], A.Array[pmax, Length[A]]], IsDistr[Array[pmax, Length[A]]]},
             Array[pmax, Length[A]], Method → {"RandomSearch", "SearchPoints" → 100}]
```

For the Brier scoring rule, we can actually solve for the optimal report exactly using Maximize:

```
In[23]:= OptReportBrier[A_] :=
          Last /@ Last@Maximize[{BrierScore[Array[pmax, Length[A]], A.Array[pmax, Length[A]]],
              IsDistr[Array[pmax, Length[A]]]}, Array[pmax, Length[A]]]
```

The following definition of the operator norm is from https://mathworld.wolfram.com/OperatorNorm.html.

```
In[24]:= OperatorNorm[a_List ? MatrixQ] := Sqrt[Max[Eigenvalues[Transpose[a].a]]]

In[25]:= TangentSpaceOpNorm[A_] := First@N@Maximize[{Norm[A.Array[v, Length[A]]],
              Total[Array[v, Length[A]]] == 0 && Norm[Array[v, Length[A]]] ≤ 1}, Array[v, Length[A]]]

In[16]:= TangentSpaceOpNormN[A_] := First@NMaximize[{Norm[A.Array[v, Length[A]]],
             Total[Array[v, Length[A]]] == 0 && Norm[Array[v, Length[A]]] ≤ 1}, Array[v, Length[A]]]
```

For our tests we also use the following function to generate constant functions.

```
In[26]:= ConstantA[q_] := Table[Table[q[[i]], Length[q]], {i, 1, Length[q]}]

In[27]:= AccuracyBoundBrier[A_] := TangentSpaceOpNorm[A]
```

Tests

```
In[28]:= testdim = 5;

In[29]:= trueFraction[table_] := Count[table, True] / Length[table]
```

Operator norm

Example from https://math.stackexchange.com/questions/2670350/operator-norm-calculation-for-simple-matrix.

```
In[30]:= OperatorNorm[{{1, 4}, {5, 6}}] == Sqrt[39 + 5 * Sqrt[53]]
Out[30]= True
```

Example from https://mathworld.wolfram.com/OperatorNorm.html.

```
In[31]:= OperatorNorm[{{2, 0, 0}, {3, 0, 2}}] == 4
Out[31]= True

In[32]:= FullSimplify[OperatorNorm[{{a}}] == Abs[a], Element[a, Reals]]
Out[32]= True

In[33]:= TangentSpaceOpNorm[IdentityMatrix[3]] == 1
Out[33]= True

In[40]:= AbsoluteTiming[And @@ Table[A = RandomA[2];
            Abs[TangentSpaceOpNorm[A] - TangentSpaceOpNormN[A]] < 0.00001, {i, 1, 60}]]
Out[40]= {7.65016, True}

In[41]:= AbsoluteTiming[And @@ Table[A = RandomA[3];
            Abs[TangentSpaceOpNorm[A] - TangentSpaceOpNormN[A]] < 0.00001, {i, 1, 35}]]
Out[41]= {10.7363, True}

In[42]:= AbsoluteTiming[And @@ Table[A = RandomA[4];
            Abs[TangentSpaceOpNorm[A] - TangentSpaceOpNormN[A]] < 0.00001, {i, 1, 25}]]
Out[42]= {26.2169, True}
```

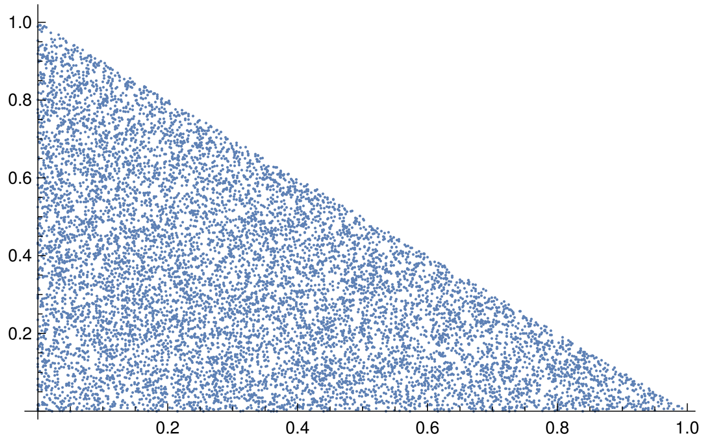
Probability distributions

```
In[44]:= IsDistr[uniform[testdim]]
Out[44]= True
```

The following should look roughly uniform.

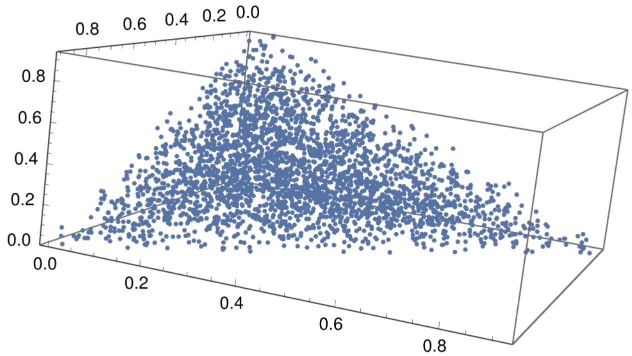
In[45]:=
```
ListPlot@Table[RandomDistr[3][[1 ;; 2]], 10 000]
```

Out[45]=



In[46]:=
```
ListPointPlot3D@Table[RandomDistr[4][[1 ;; 3]], 3000]
```

Out[46]=



In[47]:=
```
And @@ Table[IsDistr[RandomDistr[testdim]], 100]
```

Out[47]= True

In[48]:=
```
And @@ Table[IsDistr[RandomA[testdim].RandomDistr[testdim]], 1000]
```

Out[48]= True

The following lets Mathematica show symbolically that constantA works as intended, i.e., that constantA[q].p=q for any distributions q and p.

In[49]:=
```
Clear[q];
FullSimplify[ConstantA[Array[q, testdim]].Array[p, testdim],
  IsDistr[Array[p, testdim]]] == Array[q, testdim]
```

Out[49]= True

Scoring rules

In[50]:=
```
-0.23 ≤ LogScore[{0.8, 0.2}, {1, 0}] ≤ -0.21
```

Out[50]= True

Log scoring rule degenerate cases

In[51]:=
```
Simplify[logscoreh[0, x], x > 0] == -∞
```
Out[51]=
```
True
```
In[52]:=
```
logscoreh[1, 0] == 0
```
Out[52]=
```
True
```
In[53]:=
```
logscoreh[0, 0] == 0
```
Out[53]=
```
True
```
In[54]:=
```
LogScore[{1, 0, 0}, {1, 0, 0}] == 0
```
Out[54]=
```
True
```
In[55]:=
```
LogScore[{1/2, 1/2, 0}, uniform[3]] == -∞
```
Out[55]=
```
True
```

Propriety

We here test that scoring rules we defined are indeed proper. We do this specifically by making sure that if the environment probability is a fixed distribution q, then the optimal report is q.

LogScore:

In[56]:=
```
Clear[p];
N[Last /@ Last@Maximize[LogScore[Array[p, testdim], uniform[testdim]],
      IsDistr[Array[p, testdim]], Array[p, testdim]]] == uniform[testdim]
```
Out[56]=
```
True
```
In[58]:=
```
Clear[p];
AbsoluteTiming[trueFraction@Table[q = RandomDistr[testdim];
    N@Last /@ Last@Maximize[LogScore[Array[p, testdim], q],
        IsDistr[Array[p, testdim]], Array[p, testdim]] == N@q, 500]]
```
Out[58]= $\left\{50.7544, \frac{247}{250}\right\}$

In[59]:=
```
AbsoluteTiming[trueFraction@Table[q = RandomDistr[testdim];
    N /@ Last /@ Last@Maximize[LogScore[Array[p, testdim], q],
         IsDistr[Array[p, testdim]], Array[p, testdim]] == q, 1000]]
```
Out[59]= $\left\{98.6938, \frac{989}{1000}\right\}$

BrierScore:

In[60]:=
```
Clear[p];
N[Last /@ Last@Maximize[BrierScore[Array[p, testdim], uniform[testdim]],
      IsDistr[Array[p, testdim]], Array[p, testdim]]] == uniform[testdim]
```
Out[60]=
```
True
```

In[61]:=
```
AbsoluteTiming[trueFraction@Table[q = RandomDistr[testdim];
    N[Last /@ Last@Maximize[BrierScore[Array[p, testdim], q],
          IsDistr[Array[p, testdim]], Array[p, testdim]]] == q, 100]]
```
Out[61]=
```
{1.77375, 1}
```

Finding fixed points

In[62]:=
```
AbsoluteTiming[And @@ Table[q = RandomDistr[testdim];
    FixedPointDistr[ConstantA[q]] == q, 5000]]
```
Out[62]=
```
{26.6679, True}
```

In[63]:=
```
AbsoluteTiming[And @@ Table[IsDistr[FixedPointDistr[RandomA[testdim]]], 1000]]
```
Out[63]=
```
{6.34849, True}
```

In[64]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim]; p = FixedPointDistr[A]; A.p == p, 1000]]
```
Out[64]=
```
{6.51482, True}
```

Optimal report function

Optimal reports should be probability distributions.

LogScore:

In[65]:=
```
AbsoluteTiming[And @@ Table[IsDistr[OptReportN[LogScore, RandomA[testdim]]], 10]]
```
Out[65]=
```
{8.54731, True}
```

BrierScore:

In[66]:=
```
AbsoluteTiming[And @@ Table[IsDistrAppr[OptReportN[BrierScore, RandomA[testdim]]], 10]]
```
Out[66]=
```
{41.1975, True}
```

In[67]:=
```
AbsoluteTiming[And @@ Table[IsDistrAppr[OptReportBrier[RandomA[testdim]]], 5]]
```
Out[67]=
```
{19.3808, True}
```

On randomly generated A, I test whether the “optimal report” is at least as good as the fixed point.

LogScore:

In[68]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim];
    p = OptReportN[LogScore, A];
    fp = FixedPointDistr[A];
    LogScore[p, A.p] ≥ LogScore[fp, fp], 10]]
```
Out[68]=
```
{8.21456, True}
```

BrierScore:

In[69]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim];
    p = OptReportN[BrierScore, A];
    fp = FixedPointDistr[A];
    BrierScore[p, A.p] ≥ BrierScore[fp, fp], 5]]
```

Out[69]= {20.5907, True}

In[70]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim];
    p = OptReportBrier[A];
    fp = FixedPointDistr[A];
    BrierScore[p, A.p] ≥ BrierScore[fp, fp], 10]]
```

Out[70]= {37.0149, True}

On randomly generated A, I test whether the “optimal report” (as found by OptReport) is at least as good as a bunch of randomly generated reports.

LogScore:

In[71]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim];
    p = OptReportN[LogScore, A];
    And @@ Table[randp = RandomDistr[testdim];
      LogScore[p, A.p] ≥ LogScore[randp, A.randp], 5000], 10]]
```

Out[71]= {24.7238, True}

BrierScore:

In[72]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim];
    p = OptReportN[BrierScore, A];
    And @@ Table[randp = RandomDistr[testdim];
      BrierScore[p, A.p] ≥ BrierScore[randp, A.randp], 5000], 10]]
```

Out[72]= {71.5036, True}

In[73]:=
```
AbsoluteTiming[And @@ Table[A = RandomA[testdim]; p = OptReportBrier[A];
    And @@ Table[randp = RandomDistr[testdim];
      BrierScore[p, A.p] ≥ BrierScore[randp, A.randp], 10 000], 5]]
```

Out[73]= {48.5961, True}

If A is simply the matrix that maps each probability distribution onto q, then the optimal report should be approximately q.

LogScore:

In[74]:=
```
AbsoluteTiming[And @@ Table[q = RandomDistr[testdim];
    p = OptReportN[LogScore, ConstantA[q]];
    Norm[p - q] ≤ 0.00001, 10]]
```

Out[74]= {7.93832, True}

BrierScore:

In[75]:=
```
AbsoluteTiming[And @@ Table[q = RandomDistr[testdim];
    p = OptReportN[BrierScore, ConstantA[q]];
    Norm[p - q] ≤ 0.00001, 10]]
```

Out[75]= {10.5164, True}

In[76]:=
```
AbsoluteTiming[And @@ Table[q = RandomDistr[testdim];
    p = OptReportBrier[ConstantA[q]];
    p == q, 100]]
```

Out[76]= {30.9712, True}

We can now test the NMaximized-based approximate best report function against the Maximize-based exact best report function for the Brier scoring rule.

In[77]:=
```
AbsoluteTiming[trueFraction@Table[A = RandomA[3];
    p1 = OptReportBrier[A];
    p2 = OptReportN[BrierScore, A];
    Norm[p1 - p2] ≤ 0.001, 10]]
```

Out[77]= {11.1122, 1}

In[78]:=
```
AbsoluteTiming[trueFraction@Table[A = RandomA[4];
    p1 = OptReportBrier[A];
    p2 = OptReportN[BrierScore, A];
    Norm[p1 - p2] ≤ 0.001, 8]]
```

Out[78]= $\left\{28.3122, \frac{7}{8}\right\}$

In[79]:=
```
AbsoluteTiming[trueFraction@Table[A = RandomA[5];
    p1 = OptReportBrier[A];
    p2 = OptReportN[BrierScore, A];
    Norm[p1 - p2] ≤ 0.001, 3]]
```

Out[79]= {31.2598, 1}

Experiment

In[82]:=
```
S = BrierScore;
```

%Unfortunately, at dimensions higher than 4, calculating the tangent space operator norm _exactly_ seems to currently cause crashes. So we use dim=4.

In[83]:=
```
dim = 5;
```

We sample n matrices A. For each of them we record four numbers: 1) the operator norm of A; 2) how far the fixed point distribution of A is from the uniform distribution; 3) how far the optimal report is from the fixed point; 4) how far the optimal report is from the true distribution when the optimal report is made; 5) how far the actual report is from the uniform distribution.

In[221]:=
```
data = {};
```

In[222]:=
```
AbsoluteTiming[data = Union[data, ParallelTable[TimeConstrained[A = RandomA[dim];
      fixedpoint = FixedPointDistr[A];
      optrep = OptReportBrier[A];
      {N@TangentSpaceOpNormN[A], N@Norm[fixedpoint - uniform[dim]],
       N@Norm[optrep - fixedpoint], N@Norm[optrep - A.optrep],
       N@Norm[optrep - uniform[dim]]}, 120, "NT"], 1000], SameTest → (False &)]]
```

Out[222]=
```
{1997.66, {NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT,
  NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT,
  NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT, NT,
  NT, NT, NT, {0.287294, 0.160406, 0.0338846, 0.0384459, 0.152913},
  {0.287471, 0.283364, 0.0823841, 0.0782734, 0.317986},
  {0.293199, 0.295648, 0.0819243, 0.0679183, 0.354878},
  {0.301354, 0.0493446, 0.0120521, 0.0118459, 0.0525828},
  {0.304183, 0.116113, 0.0192772, 0.0238657, 0.100321},
  {0.304797, 0.147636, 0.0272263, 0.0281215, 0.162009},
  {0.323485, 0.161487, 0.0532133, 0.0434441, 0.176862},
  {0.326796, 0.3019, 0.0278609, 0.0270734, 0.324136},
  {0.332082, 0.179317, 0.0709467, 0.055486, 0.223933},
  {0.333855, 0.17813, 0.110973, 0.0871581, 0.271009},
  {0.341602, 0.259914, 0.0918424, 0.0814227, 0.302529},
  {0.342809, 0.199897, 0.0495139, 0.0467803, 0.22592},
  {0.343491, 0.161795, 0.0960976, 0.0714028, 0.257569},
  {0.349923, 0.161703, 0.0646615, 0.0511907, 0.207481},
  {0.35102, 0.102608, 0.0310329, 0.0267597, 0.125686},
  {0.35189, 0.0663474, 0.0216735, 0.0215453, 0.0684303},
  {0.352117, 0.0716701, 0.0188626, 0.0217653, 0.0631874},
  {0.352816, 0.143114, 0.0450126, 0.0418587, 0.164742},
  {0.353163, 0.213068, 0.0683486, 0.0698769, 0.23139},
  {0.353851, 0.183841, 0.0824097, 0.0702735, 0.2125},
  {0.355177, 0.185552, 0.0702371, 0.0672386, 0.23212},
  {0.355702, 0.186114, 0.0749744, 0.0543016, 0.24798},
  {0.357694, 0.12214, 0.0418994, 0.0380312, 0.132818},
  {0.364581, 0.14884, 0.0795568, 0.057, 0.210935},
  {0.366247, 0.14934, 0.0248343, 0.0293813, 0.126736},
  {0.366489, 0.148404, 0.030304, 0.0350565, 0.161716},
  {0.37168, 0.291658, 0.163626, 0.118452, 0.455075},
  {0.372435, 0.149766, 0.0275515, 0.0275207, 0.145685},
  {0.37298, 0.209129, 0.116003, 0.0973877, 0.277163},
  {0.376156, 0.191139, 0.0917749, 0.0652746, 0.26836},
  {0.376182, 0.136439, 0.0235607, 0.0249276, 0.145403},
```

{0.376285, 0.241844, 0.0898071, 0.0587759, 0.27049},
{0.378244, 0.263214, 0.212484, 0.147207, 0.436519},
{0.378848, 0.121851, 0.0387877, 0.0390119, 0.139755},
{0.382044, 0.153162, 0.168983, 0.111624, 0.321552},
{0.383416, 0.13104, 0.0651358, 0.0552148, 0.187609},
{0.384155, 0.108995, 0.0149977, 0.0156447, 0.108154},
{0.388811, 0.152781, 0.0106195, 0.0106649, 0.15427},
{0.392007, 0.0813608, 0.0127008, 0.010786, 0.0909207},
{0.392675, 0.155478, 0.0605699, 0.0590638, 0.18101},
{0.394886, 0.148815, 0.0222872, 0.024676, 0.1547},
{0.399258, 0.198843, 0.0509532, 0.0546274, 0.208002},
{0.400255, 0.161848, 0.0546699, 0.0445779, 0.194844},
{0.403376, 0.120452, 0.0912272, 0.0602603, 0.186373},
{0.403857, 0.102396, 0.0439225, 0.0283175, 0.113727},
{0.405219, 0.192119, 0.123397, 0.0989516, 0.269377},
{0.40543, 0.0973698, 0.0316914, 0.0319662, 0.0992804},
{0.406527, 0.412703, 0.220416, 0.174792, 0.574919},
{0.407841, 0.126626, 0.0113765, 0.0145174, 0.12471},
{0.408525, 0.168858, 0.0185836, 0.0201198, 0.172142},
{0.410642, 0.12821, 0.0278903, 0.0343761, 0.136684},
{0.410728, 0.148257, 0.0307642, 0.0332781, 0.168484},
{0.411505, 0.13004, 0.0363305, 0.0403579, 0.141918},
{0.411787, 0.111411, 0.0920137, 0.0650172, 0.163855},
{0.411922, 0.0951907, 0.0167339, 0.0219223, 0.0791967},
{0.413576, 0.15416, 0.031313, 0.0371537, 0.144889},
{0.413836, 0.250972, 0.0690738, 0.0595386, 0.306659},
{0.413854, 0.113616, 0.057095, 0.046295, 0.126461},
{0.415704, 0.276992, 0.0644673, 0.0756675, 0.261355},
{0.416384, 0.266337, 0.0472088, 0.0529183, 0.296401},
{0.416435, 0.271571, 0.100971, 0.0769235, 0.338146},
{0.416878, 0.21532, 0.158078, 0.119171, 0.340518},
{0.417231, 0.212847, 0.0455232, 0.0419281, 0.258369},
{0.417259, 0.13411, 0.0421017, 0.0425352, 0.168095},
{0.417672, 0.215246, 0.0536134, 0.0495671, 0.252324},
{0.417968, 0.125146, 0.12438, 0.0768947, 0.229871},
{0.418057, 0.12414, 0.0340486, 0.0298115, 0.145463},
{0.418533, 0.261617, 0.141628, 0.106685, 0.387767},
{0.418661, 0.14156, 0.00858665, 0.00962669, 0.14029},
{0.419609, 0.189186, 0.0790852, 0.0742417, 0.241031},
{0.420096, 0.244906, 0.0865096, 0.0864838, 0.2762},
{0.420196, 0.126575, 0.0886152, 0.0692131, 0.190893},
{0.420733, 0.0894869, 0.0278346, 0.0307478, 0.082489},
{0.421095, 0.141356, 0.0411293, 0.0349009, 0.166662},

{0.42149, 0.201388, 0.0298708, 0.0254138, 0.224929},
{0.421735, 0.170123, 0.0625148, 0.0565976, 0.204009},
{0.422151, 0.0805334, 0.044148, 0.0345243, 0.11577},
{0.422732, 0.139468, 0.216665, 0.136294, 0.346894},
{0.422892, 0.0645359, 0.0122396, 0.0150381, 0.0540879},
{0.42389, 0.202581, 0.0301349, 0.0355098, 0.174691},
{0.425615, 0.146366, 0.0242285, 0.0213917, 0.156734},
{0.426497, 0.151654, 0.0154569, 0.0157574, 0.156445},
{0.426855, 0.151991, 0.0843609, 0.0678468, 0.204237},
{0.427171, 0.0856337, 0.0391546, 0.0399577, 0.105903},
{0.427749, 0.114059, 0.035113, 0.0412371, 0.115861},
{0.429011, 0.10533, 0.145235, 0.0854531, 0.216556},
{0.429221, 0.180573, 0.0775479, 0.0736629, 0.233981},
{0.429292, 0.238888, 0.190886, 0.11387, 0.380551},
{0.42934, 0.185806, 0.0467297, 0.0488951, 0.20541},
{0.43086, 0.0784148, 0.0332019, 0.0257931, 0.093697},
{0.431671, 0.131482, 0.0368346, 0.0365456, 0.143374},
{0.43209, 0.0788733, 0.101881, 0.0666789, 0.163282},
{0.432478, 0.140308, 0.0534414, 0.0529349, 0.158905},
{0.43271, 0.119414, 0.124127, 0.0782965, 0.217817},
{0.43321, 0.121472, 0.200182, 0.125949, 0.318829},
{0.433668, 0.164636, 0.127465, 0.0908921, 0.288772},
{0.433788, 0.131133, 0.0290414, 0.0379592, 0.104229},
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In[232]:=
```
Length@data
```
Out[232]=
```
948
```

Analyzing and visualizing the results

Averages, medians, maxes, mins, etc.

The average distance to the fixed point:

In[233]:=
```
Mean[Table[data[[i]][[3]], {i, 1, Length@data}]]
```
Out[233]=
```
0.151503
```

In[234]:=
```
Median[Table[data[[i]][[3]], {i, 1, Length@data}]]
```
Out[234]=
```
0.0915011
```

In[235]:=
```
Max[Table[data[[i]][[3]], {i, 1, Length@data}]]
```
Out[235]=
```
0.898855
```

In[236]:=
```
Min[Table[data[[i]][[3]], {i, 1, Length@data}]]
```
Out[236]=
```
0.00670928
```

In[344]:=
```
Quartiles[Table[data[[i]][[3]], {i, 1, Length@data}]]
```
Out[344]=
```
{0.0442067, 0.0915011, 0.210143}
```

In[238]:=
```
StandardDeviation[Table[data[[i]][[3]], {i, 1, Length@data}]]
```
Out[238]=
```
0.153577
```

The average distance of the optimal report to the true distribution (under reporting the optimal report):

In[335]:=
```
Mean[Table[data[[i]][[4]], {i, 1, Length@data}]]
```
Out[335]=
```
0.100481
```

In[240]:=
```
Median[Table[data[[i]][[4]], {i, 1, Length@data}]]
```
Out[240]=
```
0.0759112
```

In[241]:=
```
Max[Table[data[[i]][[4]], {i, 1, Length@data}]]
```
Out[241]=
```
0.430119
```

In[242]:=
```
Min[Table[data[[i]][[4]], {i, 1, Length@data}]]
```
Out[242]=
```
0.00514653
```

In[243]:=
```
Quartiles[Table[data[[i]][[4]], {i, 1, Length@data}]]
```
Out[243]=
```
{0.0419256, 0.0759112, 0.138358}
```

In[244]:=
```
StandardDeviation[Table[data[[i]][[4]], {i, 1, Length@data}]]
```
Out[244]=
```
0.0770124
```

Distances to bounds

In[384]:=
```
diststoloosebounds = Table[data[[i]][[1]] * 2 / Sqrt[5] - data[[i]][[4]], {i, 1, Length@data}]
```
Out[384]=
```
{0.218518, 0.178848, 0.194327, 0.257694, 0.248204, 0.244497, 0.24589, 0.265222,
 0.241538, 0.211451, 0.224115, 0.259838, 0.235825, 0.26179, 0.287202, 0.293194,
 0.293178, 0.27371, 0.246002, 0.24622, 0.250441, 0.263848, 0.2819, 0.269092,
 0.2982, 0.292741, 0.213989, 0.305595, 0.236216, 0.27117, 0.311539, 0.277784,
 0.191105, 0.29984, 0.230087, 0.287723, 0.327954, 0.337099, 0.339835, 0.292155,
 0.328521, 0.30248, 0.313421, 0.30053, 0.332904, 0.263487, 0.330662, 0.188816,
 0.350266, 0.345276, 0.332914, 0.334088, 0.327703, 0.303296, 0.346512, 0.332759,
 0.310607, 0.323868, 0.29615, 0.319507, 0.295547, 0.253695, 0.331254, 0.330673,
```

0.32401, 0.296947, 0.34411, 0.267662, 0.364835, 0.301068, 0.289261, 0.306622,
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0.335119, 0.35958, 0.349553, 0.319794, 0.333885, 0.308731, 0.261526, 0.296992,
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```

```
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0.329428, 0.593075, 0.66156, 0.558475, 0.608592, 0.700436, 0.706203, 0.620894}
```

In[395]:= **Mean[diststoloosebounds]**

Out[395]=

0.404227

In[396]:= **StandardDeviation[diststoloosebounds]**

Out[396]=

0.0998345

In[397]:= **Quartiles[diststoloosebounds]**

Out[397]=

{0.336856, 0.399868, 0.471375}

In[383]:= **diststotightbounds = Table[data⟦i⟧⟦1⟧ * data⟦i⟧⟦5⟧ - data⟦i⟧⟦4⟧, {i, 1, Length@data}]**

Out[383]=

```
{0.00548494, 0.0131382, 0.0361315, 0.00400018, 0.00665014, 0.0212583, 0.0137683,
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0.0173586, 0.00253461, 0.000484063, 0.0162648, 0.0118415, 0.00491981, 0.0152052,
0.0339055, 0.00947689, 0.019903, 0.0170353, 0.0242107, 0.05069, 0.0267375,
0.00598837, 0.0356707, 0.0297703, 0.0430053, 0.0179035, 0.0139339, 0.0112232,
```

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Out[398]=

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In[399]:= **StandardDeviation[diststotightbounds]**

Out[399]=

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In[400]:= **Quartiles[diststotightbounds]**

Out[400]=

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In[411]:=
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1.63933, 1.69361, 1.50146, 1.27697, 1.54431, 1.71496, 1.48091, 1.72437, 1.75961,
1.63454, 1.212, 1.66012, 1.72633, 1.7496, 1.77397, 1.53773, 1.77566, 1.759,
1.73907, 1.7717, 1.79712, 1.7255, 1.6246, 1.34342, 1.76657, 1.51175, 1.69039,
1.63898, 1.63076, 1.76097, 1.78962, 1.84002, 1.8567, 1.70445, 1.49426, 1.79388,
1.64038, 1.57838, 1.75111, 1.83535, 1.90038, 1.83103, 1.88385, 1.85854, 1.91599,
1.46878, 1.92514, 1.93675, 1.1307, 1.92916, 1.80882, 1.93009, 1.91931, 1.84484,
1.85553, 1.98981, 1.89171, 1.79218, 1.42886, 1.94731, 1.98525, 1.79112,
1.56213, 2.00043, 1.70786, 2.0155, 1.6003, 1.98152, 1.80408, 1.60928, 2.01812,
2.052, 2.01185, 2.02103, 1.63181, 1.66288, 1.89692, 2.07217, 1.96421, 1.29934,
1.97606, 1.79617, 2.04082, 1.92896, 1.55398, 1.92256, 2.12019, 1.83532, 1.84441,
1.97384, 1.953, 1.97309, 1.9908, 2.1987, 2.22533, 2.17964, 2.1909, 1.70431,
2.20838, 2.2501, 2.2418, 2.27362, 1.57331, 2.06643, 2.30319, 2.32118, 2.25773,
2.28413, 2.11924, 2.39155, 2.24016, 2.25531, 1.76849, 2.27958, 2.40989,
2.44242, 2.42078, 2.37138, 2.11633, 2.3234, 2.48726, 2.54692, 2.52761, 2.52507,
2.46831, 2.35113, 2.27067, 2.62282, 2.65506, 2.64, 2.563, 2.35877, 2.44706,
2.33842, 2.3813, 2.19082, 2.73936, 2.61169, 2.41225, 2.61545, 2.80983, 2.29516,
2.07577, 2.91369, 2.47702, 2.81936, 2.61323, 2.92011, 2.99773, 3.05717, 2.8189,
3.07435, 3.09764, 2.95152, 3.10299, 3.27741, 3.43236, 3.47668, 3.50459,
3.25312, 3.15851, 3.48545, 4.07837, 4.03767, 4.67236, 4.86426, 4.88093, 4.86869}
```

In[412]:= **Mean[diststoloose boundsfp]**

Out[412]=

```
1.14807
```

In[413]:= **StandardDeviation[diststoloosebounds fp]**

Out[413]=

```
0.623784
```

In[414]:= **Quartiles[diststoloosebounds fp]**

Out[414]=

```
{0.736218, 0.987955, 1.39283}
```

In[415]:= **diststotightboundsfp =
Table[data[[i]][[1]] / (1 - data[[i]][[1]]) * data[[i]][[5]] - data[[i]][[3]], {i, 1, Length@data}]**

Out[415]=

```
{0.0277549, 0.0459076, 0.0652881, 0.010629, 0.0245789, 0.043803, 0.031356, 0.129486,
 0.0403907, 0.02485, 0.0651209, 0.0683322, 0.0386645, 0.0470213, 0.0369483,
 0.0154805, 0.015479, 0.0447974, 0.0579869, 0.0339617, 0.0576177, 0.0619299,
 0.0320655, 0.0414706, 0.0484066, 0.0632497, 0.105572, 0.0589066, 0.0488659,
 0.0700367, 0.0641218, 0.0733785, 0.0530722, 0.0464504, 0.0298125, 0.0515265,
 0.0524672, 0.0875205, 0.0459208, 0.0564649, 0.0786671, 0.0872872, 0.0753641,
 0.034779, 0.0331221, 0.0601268, 0.0360067, 0.173401, 0.0745155, 0.100313,
 0.0673461, 0.0866705, 0.0629053, 0.0226952, 0.0387399, 0.0708696, 0.147429,
 0.0321939, 0.121477, 0.16426, 0.140332, 0.0853609, 0.139455, 0.0782595, 0.127365,
 0.0406948, 0.0704488, 0.137482, 0.0924454, 0.095175, 0.113576, 0.0497291,
 0.0320788, 0.0801002, 0.134008, 0.0862709, 0.0404285, 0.0373648, 0.0273948,
 0.098399, 0.0919102, 0.100887, 0.0677462, 0.0398196, 0.051491, 0.0174739,
 0.0984033, 0.0953676, 0.107812, 0.0377303, 0.0720643, 0.0223506, 0.0676518,
 0.0420164, 0.0435059, 0.0936615, 0.0508107, 0.0762936, 0.0407006, 0.0516736,
 0.045243, 0.0817301, 0.124865, 0.117866, 0.0970955, 0.0882095, 0.0779098,
 0.0472269, 0.0887741, 0.0476842, 0.163644, 0.128401, 0.0660455, 0.143023,
 0.0415531, 0.0730114, 0.163182, 0.105133, 0.0482694, 0.0798945, 0.042124, 0.092188,
 0.0891952, 0.100478, 0.114533, 0.024468, 0.0577252, 0.0442915, 0.0329843,
 0.0887997, 0.0711033, 0.0993641, 0.0815446, 0.0741868, 0.0367264, 0.087816,
 0.0824392, 0.143169, 0.199546, 0.131612, 0.0492205, 0.0246613, 0.0763088,
 0.131789, 0.039184, 0.201358, 0.090512, 0.0528217, 0.13996, 0.194674, 0.14312,
 0.21776, 0.0995155, 0.191932, 0.180484, 0.0528399, 0.0192728, 0.0345666, 0.145408,
 0.0552859, 0.0968727, 0.0811219, 0.0806225, 0.206824, 0.0210318, 0.137378,
 0.0753995, 0.0629567, 0.104223, 0.113368, 0.0463603, 0.0674692, 0.166953,
 0.131476, 0.0806942, 0.186767, 0.0992091, 0.0639913, 0.178087, 0.0566642,
 0.218389, 0.153645, 0.103551, 0.0555001, 0.137927, 0.0518111, 0.0633174, 0.15103,
 0.121881, 0.139857, 0.0934592, 0.133012, 0.0680825, 0.143141, 0.0793429,
 0.11296, 0.205238, 0.140103, 0.0961383, 0.0823213, 0.16818, 0.028188, 0.159742,
 0.132994, 0.0964814, 0.0567552, 0.162172, 0.160514, 0.0855538, 0.237017,
 0.127825, 0.161293, 0.0992, 0.04282, 0.0781431, 0.0767164, 0.0990543, 0.0629318,
 0.156785, 0.0432473, 0.167779, 0.135909, 0.307258, 0.101072, 0.292269, 0.0571062,
```

0.0622578, 0.0801998, 0.207525, 0.232154, 0.125882, 0.123468, 0.0902931,
0.0911335, 0.0460933, 0.0724179, 0.14027, 0.139955, 0.109051, 0.107587, 0.296343,
0.140821, 0.113731, 0.15354, 0.0545925, 0.257356, 0.0953126, 0.125766, 0.0872137,
0.0992568, 0.162387, 0.363004, 0.234187, 0.25745, 0.160521, 0.0493893, 0.13722,
0.249458, 0.0955868, 0.181758, 0.0975885, 0.0811588, 0.0915973, 0.10118,
0.13566, 0.166992, 0.203711, 0.10955, 0.0468556, 0.145437, 0.126715, 0.0857377,
0.148184, 0.1226, 0.0899527, 0.0580018, 0.303707, 0.378495, 0.127175, 0.263495,
0.36117, 0.0327234, 0.0658868, 0.0206229, 0.138914, 0.196406, 0.159015, 0.166491,
0.0417276, 0.195748, 0.0751837, 0.149126, 0.134347, 0.106297, 0.109747, 0.125464,
0.0267275, 0.177271, 0.145817, 0.0547189, 0.134024, 0.0893915, 0.279383,
0.268379, 0.11212, 0.21374, 0.10189, 0.181655, 0.189264, 0.331114, 0.196231,
0.249292, 0.109603, 0.135704, 0.0236199, 0.170404, 0.407222, 0.221075, 0.200257,
0.0474858, 0.341508, 0.089701, 0.0649187, 0.0550031, 0.0843643, 0.0456625,
0.206973, 0.158485, 0.179494, 0.0813226, 0.139387, 0.0399131, 0.26291, 0.143177,
0.10722, 0.126347, 0.142785, 0.163333, 0.15663, 0.161781, 0.0938781, 0.272205,
0.184803, 0.115772, 0.0770259, 0.0805662, 0.0853641, 0.14824, 0.126294, 0.173483,
0.158947, 0.11728, 0.151354, 0.133057, 0.28716, 0.291806, 0.105701, 0.150883,
0.190758, 0.0645841, 0.253523, 0.191566, 0.134652, 0.0884598, 0.0494425,
0.193355, 0.142293, 0.376115, 0.0726959, 0.247715, 0.181978, 0.0771025, 0.22482,
0.176906, 0.131496, 0.229159, 0.124631, 0.0753922, 0.123463, 0.224374, 0.488972,
0.141925, 0.198097, 0.080625, 0.143628, 0.0745986, 0.177196, 0.0566905,
0.13539, 0.211641, 0.342956, 0.138216, 0.232406, 0.124915, 0.33082, 0.136549,
0.156803, 0.178044, 0.251191, 0.0398669, 0.182544, 0.140425, 0.255673, 0.186259,
0.154206, 0.187919, 0.225367, 0.18254, 0.107762, 0.386657, 0.10421, 0.117288,
0.167273, 0.151386, 0.114766, 0.263207, 0.100474, 0.15268, 0.267722, 0.16222,
0.24638, 0.0597036, 0.155583, 0.125116, 0.212093, 0.234776, 0.135975, 0.0947536,
0.084551, 0.305636, 0.332779, 0.32645, 0.27073, 0.08866, 0.261573, 0.14696,
0.132391, 0.129595, 0.0844908, 0.0598408, 0.113374, 0.203121, 0.181391, 0.178389,
0.111065, 0.119346, 0.111037, 0.122848, 0.190884, 0.1934, 0.280373, 0.111935,
0.269372, 0.427186, 0.419326, 0.166814, 0.120343, 0.084464, 0.284193, 0.128396,
0.122072, 0.192484, 0.320626, 0.154734, 0.136714, 0.18937, 0.239059, 0.0433677,
0.12332, 0.222328, 0.192603, 0.263568, 0.109568, 0.114044, 0.172693, 0.272246,
0.124181, 0.149183, 0.137799, 0.2144, 0.136111, 0.0958553, 0.314111, 0.366151,
0.278655, 0.143633, 0.264313, 0.203102, 0.0407616, 0.298411, 0.225286, 0.13683,
0.49496, 0.224794, 0.287393, 0.220657, 0.422701, 0.302051, 0.337122, 0.329204,
0.128393, 0.213195, 0.0969577, 0.126785, 0.0788627, 0.135543, 0.106345, 0.125461,
0.238808, 0.380233, 0.191439, 0.0759238, 0.283958, 0.331341, 0.13034, 0.207603,
0.231015, 0.185642, 0.432217, 0.0632775, 0.187714, 0.261464, 0.15068, 0.30661,
0.204958, 0.236461, 0.437783, 0.142754, 0.304604, 0.144202, 0.172144, 0.216235,
0.316181, 0.197085, 0.143979, 0.250051, 0.258977, 0.206348, 0.42155, 0.122893,
0.41049, 0.382553, 0.200841, 0.112907, 0.236259, 0.565525, 0.140311, 0.611101,
0.186663, 0.176064, 0.410807, 0.118027, 0.618001, 0.224571, 0.247364, 0.324434,
0.25808, 0.269699, 0.379011, 0.435604, 0.365991, 0.0691748, 0.241263, 0.297577,

0.179589, 0.091546, 0.241759, 0.344115, 0.23199, 0.290489, 0.13884, 0.268575,
0.10629, 0.136772, 0.113101, 0.133822, 0.169652, 0.244099, 0.172622, 0.459232,
0.120464, 0.358674, 0.680293, 0.0897219, 0.305751, 0.286189, 0.308434, 0.136964,
0.396289, 0.487094, 0.340813, 0.278203, 0.456673, 0.28942, 0.170806, 0.163774,
0.260374, 0.188548, 0.310739, 0.389828, 0.203559, 0.235939, 0.143176, 0.34126,
0.264759, 0.250299, 0.627503, 0.244223, 0.221635, 0.1291, 0.240022, 0.440696,
0.148953, 0.0814951, 0.186491, 0.239118, 0.293765, 0.228166, 0.168499, 0.212038,
0.176586, 0.607607, 0.41401, 0.265474, 0.195501, 0.249465, 0.19816, 0.123122,
0.0541518, 0.353828, 0.424882, 0.17911, 0.592407, 0.648395, 0.252955, 0.156746,
0.147548, 0.174703, 0.296391, 0.55085, 0.313493, 0.38556, 0.271603, 0.426981,
0.260464, 0.505459, 0.0610332, 0.327642, 0.112754, 0.276914, 0.233836, 0.302082,
0.131089, 0.102054, 0.442668, 0.386027, 0.46196, 0.167532, 0.159889, 0.413494,
0.131432, 0.253014, 0.268379, 0.192262, 0.180328, 0.571259, 0.278627, 0.204476,
0.396246, 0.169644, 0.239566, 0.119809, 0.22281, 0.34973, 0.686659, 0.525699,
0.317227, 0.360905, 0.29577, 0.131578, 0.223736, 0.150976, 0.24644, 0.466069,
0.152879, 0.170172, 0.250718, 0.335383, 0.454867, 0.116299, 0.3324, 0.292053,
0.199225, 0.430303, 0.134441, 0.59786, 0.495847, 0.562329, 0.496331, 0.260327,
0.214007, 0.30452, 0.0674207, 0.101327, 0.495222, 0.319527, 0.318856, 0.109238,
0.67879, 0.183297, 0.264275, 0.208207, 0.382334, 0.198572, 0.25091, 0.373605,
0.146663, 0.589608, 0.636248, 0.567233, 0.178106, 0.634934, 0.252845, 0.948059,
0.601569, 0.728277, 0.474308, 0.8673, 0.362523, 0.742039, 0.68375, 0.770154,
0.117636, 0.154248, 0.119996, 0.286796, 0.549608, 0.145582, 0.222435, 0.461651,
0.296305, 0.254963, 0.42125, 0.235908, 0.726374, 0.17377, 0.474957, 0.145432,
0.196181, 0.525681, 0.371928, 0.280627, 0.489816, 0.702767, 0.808159, 0.807841,
0.669863, 0.737594, 0.565988, 0.301986, 0.394161, 0.499221, 0.248782, 0.313298,
0.301241, 0.310078, 0.449515, 0.286663, 0.457096, 0.465502, 0.312038, 0.427074,
0.35092, 0.276721, 0.427822, 0.228423, 0.387262, 0.403608, 0.679905, 0.773104,
0.251713, 0.218991, 0.360051, 0.862313, 0.355195, 0.53849, 0.576246, 0.125438,
0.101941, 0.355706, 0.787713, 0.491466, 0.275826, 0.310039, 0.295326, 0.54692,
0.138876, 0.168031, 0.437757, 0.410595, 0.17623, 0.338821, 0.538463, 0.603446,
0.462745, 0.808456, 0.383588, 0.483558, 0.371557, 0.413485, 0.408556, 0.332133,
0.301302, 0.779447, 0.925696, 0.402998, 0.767061, 1.00946, 0.72909, 0.352672,
0.394115, 0.428991, 0.40782, 0.249715, 0.381655, 0.866639, 0.278245, 0.257424,
1.1307, 0.398599, 0.510036, 0.246738, 0.37147, 0.366489, 0.399771, 0.204526,
0.615343, 0.413966, 1.11099, 0.450248, 0.265392, 0.699633, 0.771636, 0.329796,
1.10175, 0.512223, 1.10398, 0.209286, 0.804584, 1.14996, 0.267157, 0.342244,
0.326607, 0.328471, 0.893028, 0.883884, 0.616716, 0.318167, 0.51742, 1.29934,
0.604692, 0.899572, 0.34645, 0.952405, 1.16757, 0.568455, 0.289874, 1.83532,
0.736736, 0.605626, 1.01816, 0.914176, 0.755656, 0.429056, 0.297483, 0.926697,
0.331815, 1.12517, 0.521775, 0.555035, 0.27078, 0.354449, 1.57331, 0.765768,
0.379319, 0.305406, 1.00678, 0.404207, 1.66337, 0.364654, 0.586645, 0.564854,
1.76849, 0.956271, 0.761958, 0.38993, 0.308723, 0.743421, 1.05849, 0.929696,
0.549202, 0.278867, 0.359207, 0.440779, 0.54813, 0.648665, 1.58213, 0.251457,

```
0.420391, 0.420836, 0.610167, 1.49003, 0.958494, 1.04481, 1.65312, 1.43628,
0.202762, 0.997876, 1.10267, 1.13283, 0.668081, 2.29516, 2.07577, 0.711244,
1.81701, 0.805032, 1.82815, 0.672561, 0.400098, 0.600943, 1.37777, 0.779217,
0.951528, 0.944678, 1.25081, 1.0417, 0.820915, 0.530406, 0.708396, 1.72006,
2.02239, 3.48545, 1.33846, 1.97719, 1.41181, 0.784605, 0.749476, 1.31283}
```

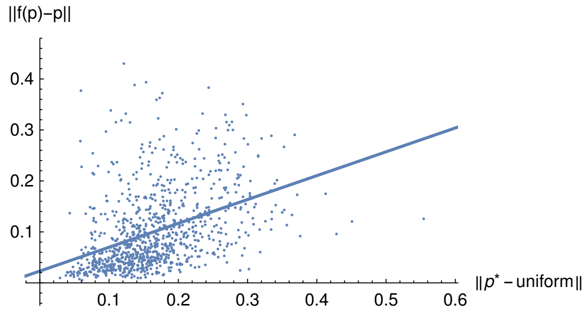
```
In[416]:= Mean[diststotightboundsfp]
Out[416]=
0.289826

In[417]:= StandardDeviation[diststotightboundsfp]
Out[417]=
0.322655

In[418]:= Quartiles[diststotightboundsfp]
Out[418]=
{0.102802, 0.185223, 0.345282}
```

Scatter Plots

Accuracy of optimal report against distance of fixed point to uniform

```
In[364]:= subdata24 = Table[{data[[i]][[2]], data[[i]][[4]]}, {i, 1, Length@data}];

In[365]:= minx = Min[Table[subdata24[[i]][[1]], {i, 1, Length@data}]]
Out[365]=
0.0290707

In[366]:= maxx = Max[Table[subdata24[[i]][[1]], {i, 1, Length@data}]]
Out[366]=
0.554312

In[367]:= miny = Min[Table[subdata24[[i]][[2]], {i, 1, Length@data}]]
Out[367]=
0.00514653

In[368]:= maxy = Max[Table[subdata24[[i]][[2]], {i, 1, Length@data}]]
Out[368]=
0.430119

In[369]:= trend = Fit[subdata24, {1, x}, x]
Out[369]=
0.0231283 + 0.467939 x

In[378]:= Correlation[subdata24]
Out[378]=
{{1., 0.41132}, {0.41132, 1.}}
```

In[363]:=
```
Show[{Plot[Evaluate@trend, {x, minx - 0.05, maxx + 0.05},
    PlotRange → {{minx - 0.05, maxx + 0.05}, {miny - 0.05, maxy + 0.05}},
    AxesLabel → {TraditionalForm[Norm[ToExpression["p^*-uniform", TeXForm, HoldForm]]],
      "||f(p)-p||"}], ListPlot[subdata24]}, ImageSize → 300]
```



Distance of optimal report to fixed point against distance of fixed point to uniform

In[370]:=
```
subdata23 = Table[{data[[i]][[2]], data[[i]][[3]]}, {i, 1, Length@data}];
```

In[371]:=
```
minx = Min[Table[subdata23[[i]][[1]], {i, 1, Length@data}]]
```

Out[371]=
```
0.0290707
```

In[372]:=
```
maxx = Max[Table[subdata23[[i]][[1]], {i, 1, Length@data}]]
```

Out[372]=
```
0.554312
```

In[373]:=
```
miny = Min[Table[subdata23[[i]][[2]], {i, 1, Length@data}]]
```

Out[373]=
```
0.00670928
```

In[374]:=
```
maxy = Max[Table[subdata23[[i]][[2]], {i, 1, Length@data}]]
```

Out[374]=
```
0.898855
```

In[375]:=
```
trend = Fit[subdata23, {1, x}, x]
```

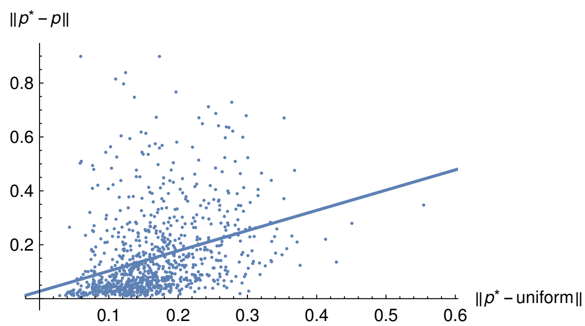
Out[375]=
```
0.0273991 + 0.750752 x
```

In[377]:=
```
Correlation[subdata23]
```

Out[377]=
```
{{1., 0.33092}, {0.33092, 1.}}
```

In[376]:=
```
Show[{Plot[Evaluate@trend, {x, minx - 0.05, maxx + 0.05},
    PlotRange → {{minx - 0.05, maxx + 0.05}, {miny - 0.05, maxy + 0.05}},
    AxesLabel → {TraditionalForm[Norm[ToExpression["p^*-uniform", TeXForm, HoldForm]]],
      TraditionalForm[Norm[ToExpression["p^*-p", TeXForm, HoldForm]]]}],
  ListPlot[subdata23]}, ImageSize → 300]
```

Out[376]=



Accuracy of the optimal report against operator norm of A

In[319]:=
```
subdata14 = Table[{data[[i]][[1]], data[[i]][[4]]}, {i, 1, Length@data}];
```

In[320]:=
```
minx = Min[Table[subdata14[[i]][[1]], {i, 1, Length@data}]]
```

Out[320]=
```
0.287294
```

In[321]:=
```
maxx = Max[Table[subdata14[[i]][[1]], {i, 1, Length@data}]]
```

Out[321]=
```
0.848944
```

In[322]:=
```
miny = Min[Table[subdata14[[i]][[2]], {i, 1, Length@data}]]
```

Out[322]=
```
0.00514653
```

In[323]:=
```
maxy = Max[Table[subdata14[[i]][[2]], {i, 1, Length@data}]]
```

Out[323]=
```
0.430119
```

In[324]:=
```
trend = Fit[subdata14, {1, x}, x]
```

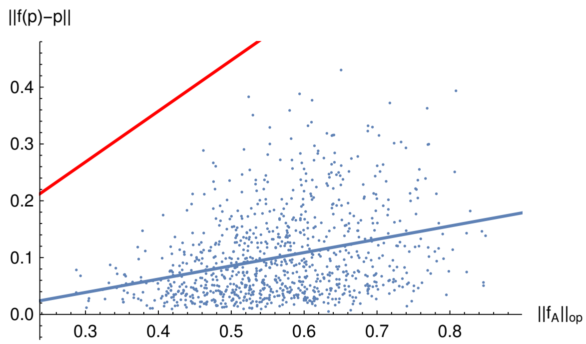
Out[324]=
```
-0.0313941 + 0.233705 x
```

In[379]:=
```
Correlation[subdata14]
```

Out[379]=
```
{{1., 0.311954}, {0.311954, 1.}}
```

In[325]:=
```
accbound[x_] := If[S == BrierScore, Sqrt[(dim - 1) / dim] * x, {}]
```

```
In[326]:= Show[{Plot[Evaluate@trend, {x, minx - 0.05, maxx + 0.05},
    PlotRange → {{minx - 0.05, maxx + 0.05}, {miny - 0.05, maxy + 0.05}}, AxesLabel →
     {Subscript["||" <> ToString[Subscript["f", "A"], StandardForm] <> "||", "op"],
      "||f(p)−p||"}], Plot[accbound[x], {x, minx - 0.05, maxx + 0.05},
    PlotStyle → Red], ListPlot[subdata14]}, ImageSize → 300]
```

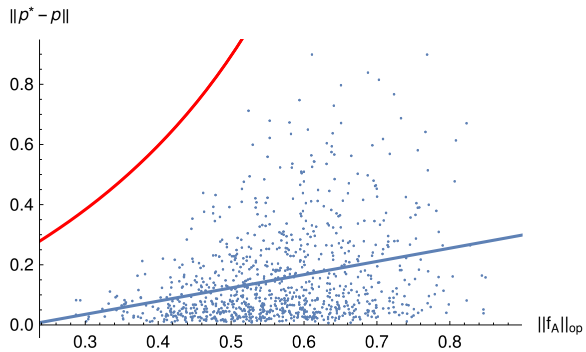


Distance of optimal report to fixed point against operator norm of A

```
In[336]:= subdata13 = Table[{data[[i]][[1]], data[[i]][[3]]}, {i, 1, Length@data}];

In[337]:= minx = Min[Table[subdata13[[i]][[1]], {i, 1, Length@data}]]
Out[337]=
          0.287294

In[338]:= maxx = Max[Table[subdata13[[i]][[1]], {i, 1, Length@data}]]
Out[338]=
          0.848944

In[339]:= miny = Min[Table[subdata13[[i]][[2]], {i, 1, Length@data}]]
Out[339]=
          0.00670928

In[340]:= maxy = Max[Table[subdata13[[i]][[2]], {i, 1, Length@data}]]
Out[340]=
          0.898855

In[341]:= trend = Fit[subdata13, {1, x}, x]
Out[341]=
          -0.0966647 + 0.439794 x

In[380]:= Correlation[subdata13]
Out[380]=
          {{1., 0.294379}, {0.294379, 1.}}

In[342]:= fpdistbound[x_] := If[S == BrierScore, Sqrt[(dim - 1) / dim] * (x / (1 - x)), {}]
```

In[343]:=
```
Show[{Plot[Evaluate@trend, {x, minx - 0.05, maxx + 0.05},
   PlotRange → {{minx - 0.05, maxx + 0.05}, {miny - 0.05, maxy + 0.05}}, AxesLabel →
    {Subscript["||" <> ToString[Subscript["f", "A"], StandardForm] <> "||", "op"],
     TraditionalForm[Norm[ToExpression["p^*-p", TeXForm, HoldForm]]]}],
  ListPlot[subdata13], Plot[fpdistbound[x], {x, minx - 0.05, maxx + 0.05},
   PlotStyle → Red]}, ImageSize → 300]
```

Out[343]=



Accuracy of the optimal report against distance of optimal report to fixed point, along with the plot

In[312]:=
```
subdata54 = Table[{data[[i]][[5]], data[[i]][[4]]}, {i, 1, Length@data}];
```

In[313]:=
```
minx = Min[Table[subdata54[[i]][[1]], {i, 1, Length@data}]]
```

Out[313]=

0.0328104

In[314]:=
```
maxx = Max[Table[subdata54[[i]][[1]], {i, 1, Length@data}]]
```

Out[314]=

0.894427

In[315]:=
```
miny = Min[Table[subdata54[[i]][[2]], {i, 1, Length@data}]]
```

Out[315]=

0.00514653

In[316]:=
```
maxy = Max[Table[subdata54[[i]][[2]], {i, 1, Length@data}]]
```

Out[316]=

0.430119

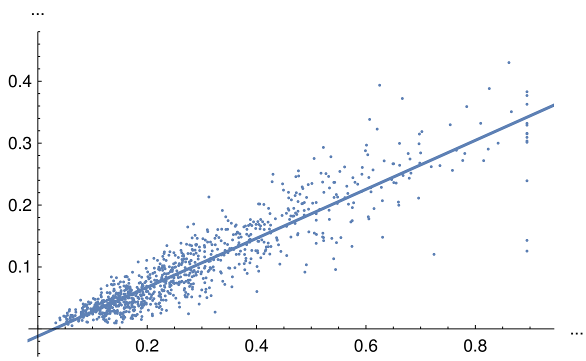
In[317]:=
```
trend = Fit[subdata54, {1, x}, x]
```

Out[317]=

$-0.0118858 + 0.395525\,x$

In[318]:=
```
Show[{Plot[Evaluate@trend, {x, minx - 0.05, maxx + 0.05},
   PlotRange → {{minx - 0.05, maxx + 0.05}, {miny - 0.05, maxy + 0.05}},
   AxesLabel → {"...", "..."}], ListPlot[subdata54]}, ImageSize → 300]
```

Out[318]=



How correlated are the two measures of interest?

In[288]:=
```
subdata34 = Table[{data[[i]][[3]], data[[i]][[4]]}, {i, 1, Length@data}];
```

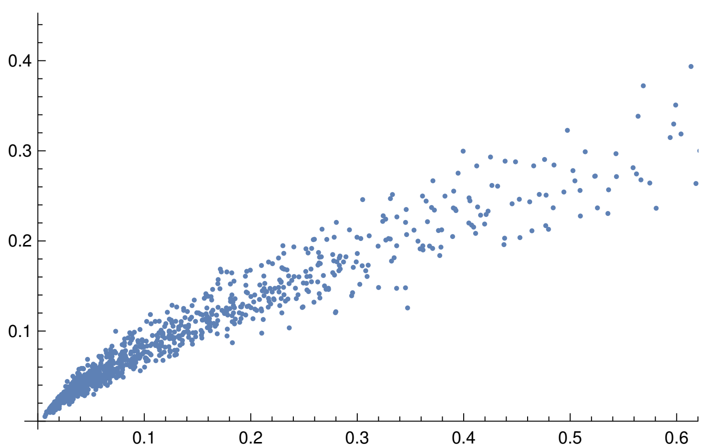
In[381]:=
```
Correlation[subdata34]
```

Out[381]=

```
{{1., 0.958551}, {0.958551, 1.}}
```

In[289]:=
```
ListPlot[subdata34]
```

Out[289]=



What kinds of f_A are we sampling?

In[290]:=
```
subdata12 = Table[{data[[i]][[1]], data[[i]][[2]]}, {i, 1, Length@data}];
```

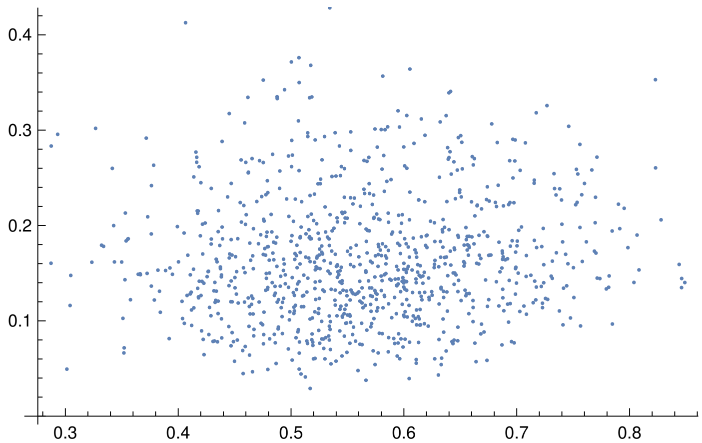
In[382]:=
```
Correlation[subdata12]
```

Out[382]=

```
{{1., 0.0875672}, {0.0875672, 1.}}
```

In[291]:=
```
ListPlot[subdata12]
```

Out[291]=



Appendix A: Finding optimal reports with Mathematica in the Log Scoring rule case seems difficult

In[∘]:=
```
Clear[x];
A = RandomA[3];
Timing[TimeConstrained[Solve[D[LogScore[Array[x, 3], A.Array[x, 3]], x[1]] == 0 &&
     D[LogScore[Array[x, 3], A.Array[x, 3]], x[2]] == 0 &&
     D[LogScore[Array[x, 3], A.Array[x, 3]], x[3]] == 0], 300]]
```

Out[∘]=
```
$Aborted
```

In[∘]:=
```
A = RandomA[3];
TimeConstrained[Maximize[{LogScore[Array[pmax, 3], A.Array[pmax, 3]],
    IsDistr[Array[pmax, 3]]}, Array[pmax, 3]], 500]
```

Out[∘]= Maximize[

$$\Big\{\text{Log}[\text{pmax}[3]]\left(\frac{37\,\text{pmax}[1]}{82}+\frac{9\,\text{pmax}[2]}{35}\right)+\text{Log}[\text{pmax}[2]]\left(\frac{35\,\text{pmax}[1]}{82}+\frac{54\,\text{pmax}[2]}{175}+\frac{11\,\text{pmax}[3]}{85}\right)+$$

$$\text{Log}[\text{pmax}[1]]\left(\frac{5\,\text{pmax}[1]}{41}+\frac{76\,\text{pmax}[2]}{175}+\frac{74\,\text{pmax}[3]}{85}\right),$$

pmax[1] + pmax[2] + pmax[3] == 1 && NonNegative[pmax[1]] && NonNegative[pmax[2]] &&
NonNegative[pmax[3]]}, {pmax[1], pmax[2], pmax[3]}]