

MLP Report (Week 5)

The following is examinations on data of 2020Q1.

Here state(class) 7 means delinquency state of higher than 6 months.

Data volumn is added to **500000** for alignment from now.

Parametre Setting

```
# reclassify delinquency status
# clustered to the rest class(n+) if frequency accumulated to threshold
threshold = 0.995

# relabel credit score
df["Credit Score"] = df["Credit Score"].apply(lambda x: 0 if x <= 700 else 1)
```

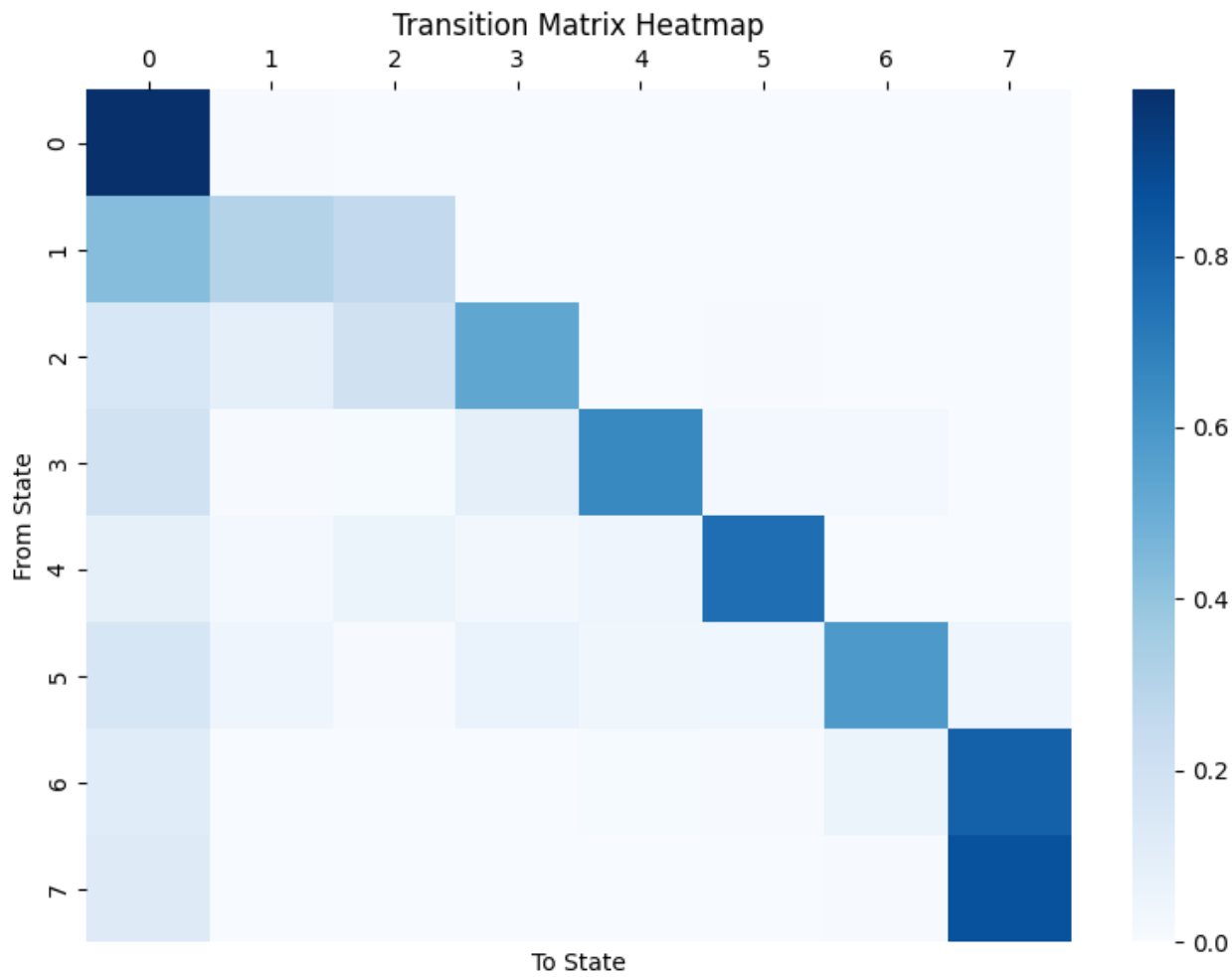
```
mlp = MLPClassifier(hidden_layer_sizes = (10, 10, 10), activation = 'relu',
max_iter = 5000, random_state = 1, learning_rate_init = 0.0001, learning_rate =
'adaptive')
```

MLP with only 'Previous Delinquency Status'

transition matrix

```
[9.94022382e-01 5.91521145e-03 3.53646655e-05 1.65107880e-05 1.52347455e-06 3.90762043e-12
9.00726338e-06 6.42965974e-12]
[4.29968070e-01 3.04129887e-01 2.63430149e-01 1.16433425e-03 9.65682209e-05 1.13860951e-03
7.23276223e-05 5.46326123e-08]
[1.59101852e-01 9.61874368e-02 1.99423758e-01 5.35428959e-01 2.98161966e-03 4.18574525e-03
2.68991327e-03 7.16357348e-07]
[1.90799217e-01 4.12130835e-03 8.72337102e-03 9.26175642e-02 6.55340713e-01 2.62664009e-02
2.11928704e-02 9.38554720e-04]
[8.74477619e-02 2.12788311e-02 5.55825813e-02 3.02593629e-02 4.83112171e-02 7.55418136e-01
1.57560624e-03 1.26503425e-04]
[1.66481742e-01 4.93420972e-02 6.58605048e-03 6.58269185e-02 4.05227218e-02 3.65501338e-02
5.88432013e-01 4.62583229e-02]
[1.14996044e-01 3.52477123e-03 2.63427799e-04 1.88527814e-03 8.82535338e-03 4.63159975e-03
6.10542163e-02 8.04819309e-01]
[1.25505362e-01 1.68915453e-04 1.62949988e-06 2.20215520e-05 1.91204341e-04 1.53606912e-05
```

5.26767766e-03 8.68827829e-01]]



average probability = 0.5646595842821458

Probability of truly predicting class 0 is 0.9906949606952459
Probability of truly predicting class 1 is 0.09058384986135457
Probability of truly predicting class 2 is 0.24479073779037797
Probability of truly predicting class 3 is 0.4618508911199944
Probability of truly predicting class 4 is 0.5709482540755463
Probability of truly predicting class 5 is 0.7397531600611733
Probability of truly predicting class 6 is 0.5719197904238215
Probability of truly predicting class 7 is 0.8467350302296532

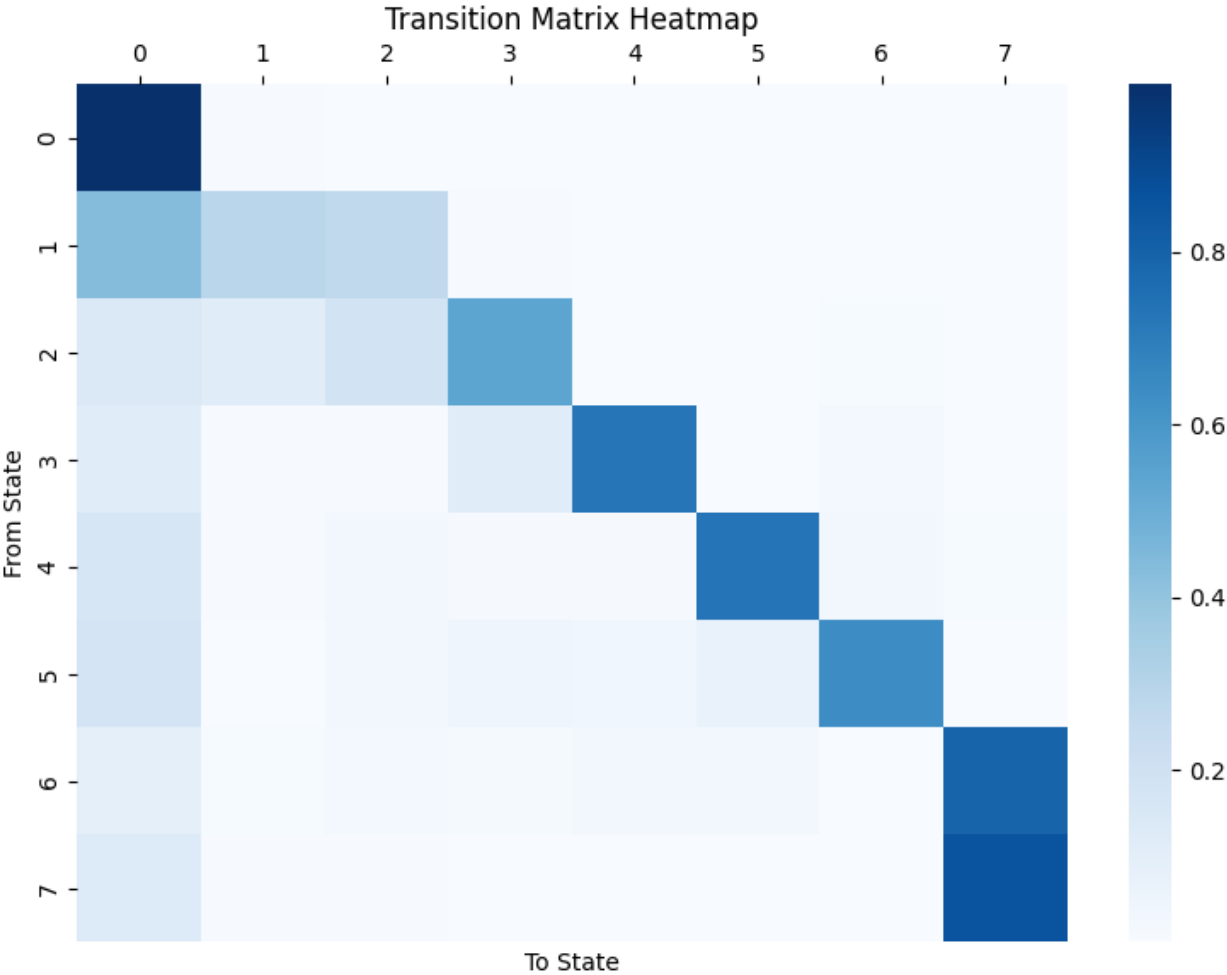
brier score = 0.0212103697713376

Brier score for state 0 is 0.008971940392926118
Brier score for state 1 is 0.007354259839925652
Brier score for state 2 is 0.0021244604544810664
Brier score for state 3 is 0.0009008098940400641
Brier score for state 4 is 0.0005279990404296202
Brier score for state 5 is 0.00031970478263967955
Brier score for state 6 is 0.00029700065555969443
Brier score for state 7 is 0.0007141947113357033

MLP with also **Credit Score**

transition matrix

[[9.95047585e-01 4.90737658e-03 4.27363606e-05 2.07489406e-06 1.90226112e-10 1.88482031e-07 1.72891125e-08 2.12676897e-08]
[4.34902407e-01 2.90623138e-01 2.65008899e-01 6.11232597e-03 9.38133146e-05 2.08662908e-03 4.20362049e-04 7.52425415e-04]
[1.41536016e-01 1.13674411e-01 1.89687558e-01 5.37729944e-01 3.17133891e-03 2.30013934e-03 1.14492829e-02 4.51308922e-04]
[1.16385673e-01 4.78865710e-03 7.27920090e-03 1.15844962e-01 7.28709208e-01 6.15194065e-04 2.43690225e-02 2.00808285e-03]
[1.65544127e-01 5.20959387e-03 2.93208197e-02 1.48324279e-02 1.40212416e-02 7.34519179e-01 2.72392609e-02 9.31334953e-03]
[1.78490945e-01 3.58105591e-03 2.79027961e-02 4.38076830e-02 3.55247240e-02 7.16355896e-02 6.39057001e-01 2.05309370e-07]
[9.28229774e-02 8.68367003e-03 2.51236951e-02 1.82251434e-02 2.77808973e-02 3.38230006e-02 2.51603100e-04 7.93289013e-01]
[1.29494457e-01 3.92415740e-03 4.29124942e-03 4.73980647e-04 9.76489391e-04 1.30023313e-04 4.86196214e-07 8.60709156e-01]]



average probability = 0.5792166247445898

Probability of truly predicting class 0 is 0.9914236849857416
Probability of truly predicting class 1 is 0.08949801394345165
Probability of truly predicting class 2 is 0.24800217831361326
Probability of truly predicting class 3 is 0.4744340618151356

Probability of truly predicting class 4 is 0.5753527166628497

Probability of truly predicting class 5 is 0.7528810368983833

Probability of truly predicting class 6 is 0.6467992795010082

Probability of truly predicting class 7 is 0.8553420258365351

brier score = 0.02115816506891893

Brier score for state 0 is 0.00896251921771285

Brier score for state 1 is 0.007324184955299592

Brier score for state 2 is 0.002119494691205232

Brier score for state 3 is 0.0008923010351237158

Brier score for state 4 is 0.0005377736024357184

Brier score for state 5 is 0.00032175626383579086

Brier score for state 6 is 0.0002893907592798636

Brier score for state 7 is 0.0007107445440261659

After relabelling Credit Score

transition matrix

[[9.93755645e-01 6.18381057e-03 5.09668653e-05 1.80389718e-07 7.70106365e-12 7.07812008e-08
9.32616781e-06 9.37033474e-11]

[4.11599440e-01 3.04866550e-01 2.74205118e-01 6.91833161e-03 1.28460230e-03 7.03148665e-05
1.63368666e-04 8.92275219e-04]

[1.52066472e-01 1.08630015e-01 1.84316365e-01 5.24072288e-01 1.83254445e-02 1.18304950e-04
1.24659393e-02 5.17077320e-06]

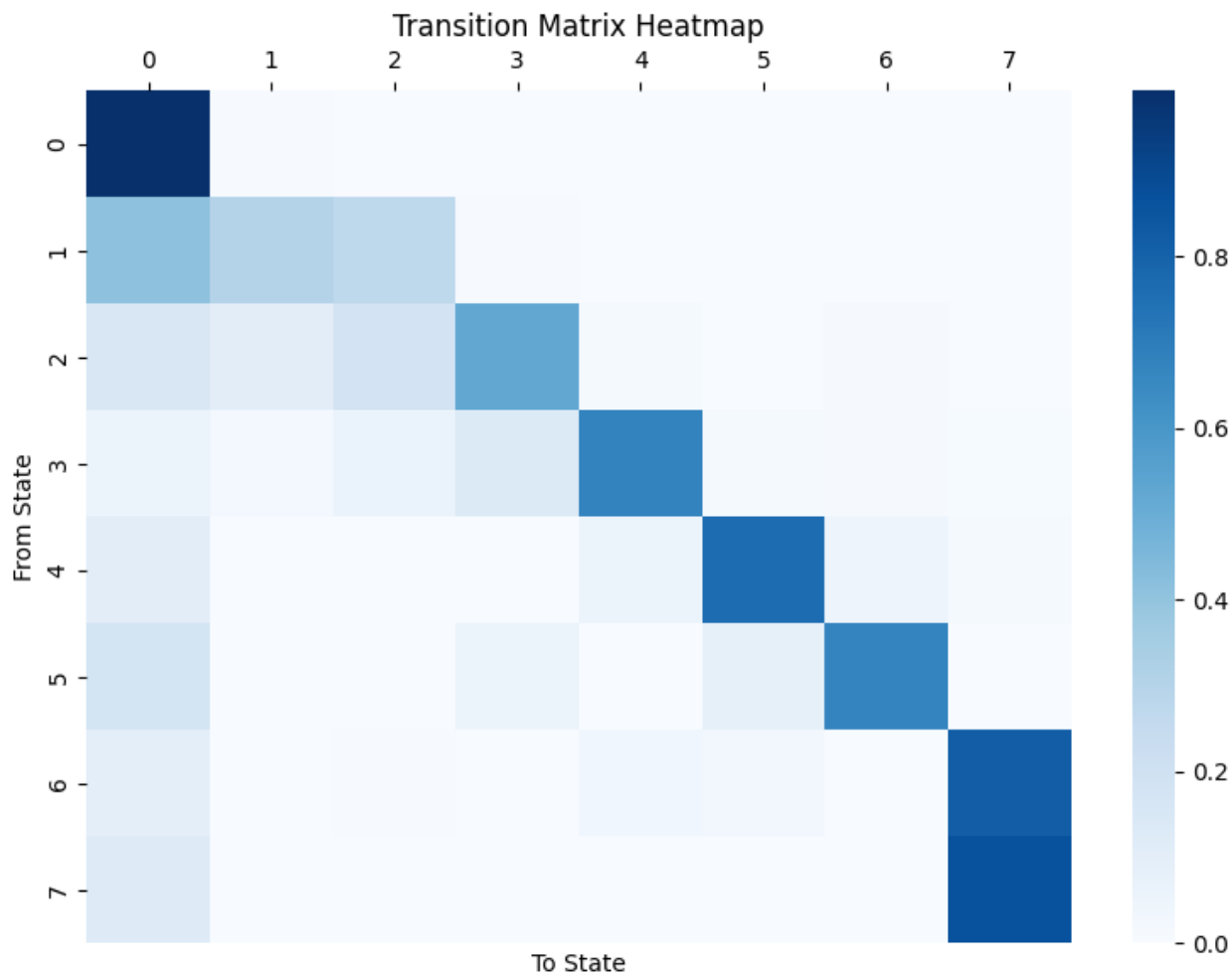
[5.85115976e-02 2.33033413e-02 6.56961380e-02 1.35151029e-01 6.77053257e-01 1.92322681e-02
1.20213908e-02 9.03097723e-03]

[1.05087437e-01 1.17867451e-04 1.05425397e-04 1.45235755e-03 6.14056303e-02 7.62756914e-01
5.27338604e-02 1.63405084e-02]

[1.82051545e-01 1.12702228e-04 4.45921373e-05 5.44617097e-02 2.31361462e-03 8.76756342e-02
6.73340084e-01 1.18033211e-07]

[1.04758599e-01 3.27725600e-03 6.55221188e-03 1.53571536e-04 3.71009327e-02 2.89566266e-02
8.25851321e-05 8.19118217e-01]

[1.25029544e-01 1.23328193e-03 2.20919735e-03 1.73319912e-06 5.52517502e-04 1.80252530e-03
8.52945149e-07 8.69170348e-01]]



Compared to previous 2 heatmaps, TM is more clustered in the diagnose.

average probability = 0.5721887739016299

- Probability of truly predicting class 0 is 0.9901889640780351
- Probability of truly predicting class 1 is 0.09392540634762463
- Probability of truly predicting class 2 is 0.25587888583117097
- Probability of truly predicting class 3 is 0.49133749635299223
- Probability of truly predicting class 4 is 0.5567374810615824
- Probability of truly predicting class 5 is 0.7070187235333298
- Probability of truly predicting class 6 is 0.6306709445017364
- Probability of truly predicting class 7 is 0.8517522895065679

brier score = 0.021207271891365342

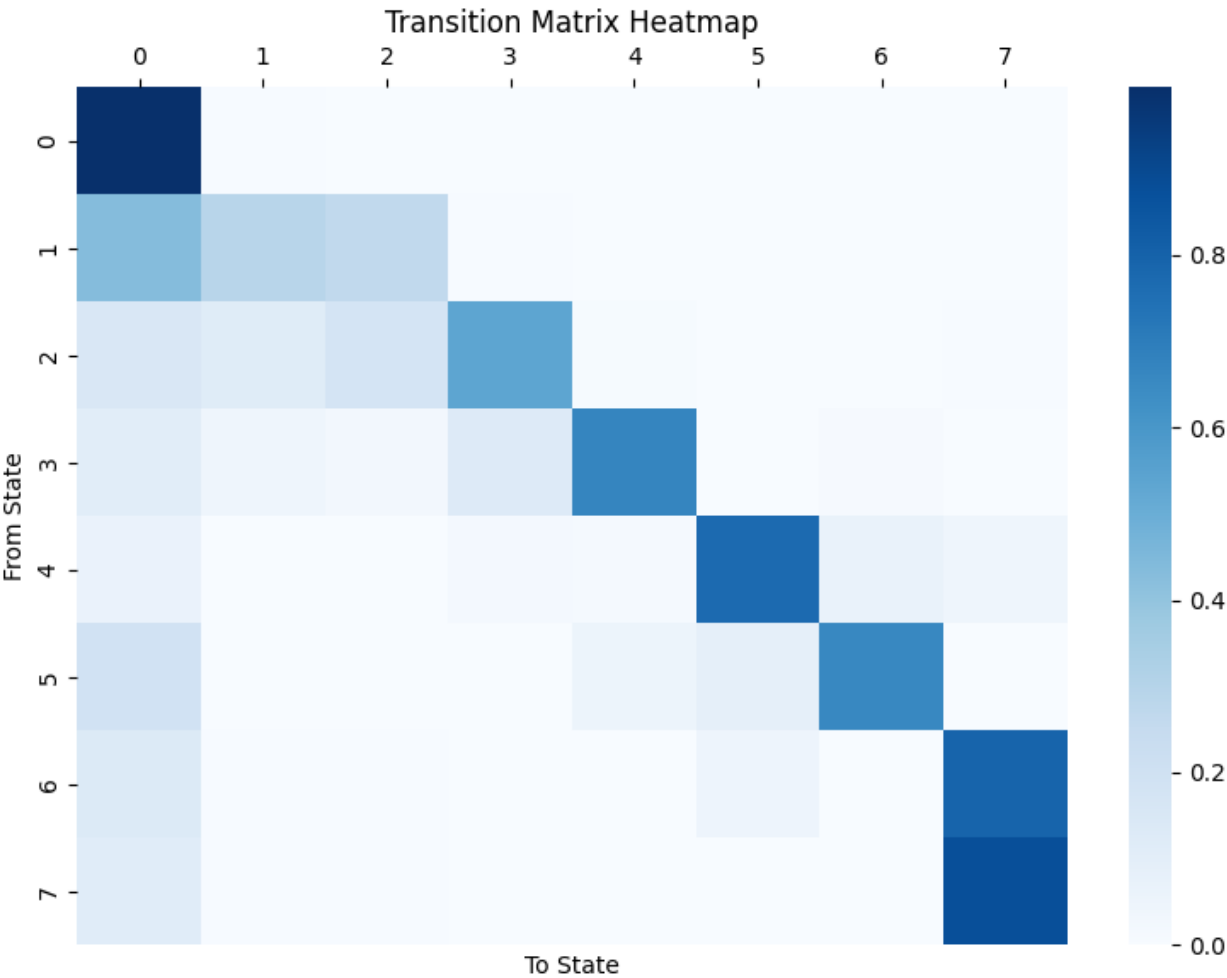
- Brier score for state 0 is 0.00898266041276095
- Brier score for state 1 is 0.007347500511825636
- Brier score for state 2 is 0.0021272615686340752
- Brier score for state 3 is 0.000893883816809593
- Brier score for state 4 is 0.0005316786331618528
- Brier score for state 5 is 0.0003200049037122438
- Brier score for state 6 is 0.0002928417604225396
- Brier score for state 7 is 0.000711440284038449

MLP with other five main features

[`"Credit Score"`, `"Original UPB"`, `"Original Debt-to-Income (DTI) Ratio"`, `"Original Loan-to-Value (LTV)"`, `"Original Interest Rate"`]

transition matrix

```
[[9.94226255e-01 5.73558792e-03 1.93409729e-05 8.85140557e-07 1.98225871e-06 4.33553909e-11
 1.59475232e-05 1.07971890e-09]
[4.31707925e-01 2.94934572e-01 2.67449416e-01 4.47796133e-03 8.63124902e-04 1.50496686e-08
 4.75152784e-06 5.62234301e-04]
[1.51682648e-01 1.18842370e-01 1.74857437e-01 5.38382725e-01 1.06384392e-02 7.09393535e-06
 5.85249198e-06 5.58343426e-03]
[1.11480468e-01 4.35569300e-02 2.94512319e-02 1.31987502e-01 6.69576225e-01 4.85788069e-04
 1.32217568e-02 2.40098319e-04]
[6.82927896e-02 6.11561336e-04 3.38238202e-04 2.00373300e-02 1.56376732e-02 7.71159639e-01
 7.34509748e-02 5.04717939e-02]
[1.90814627e-01 5.29761017e-04 1.45667221e-04 8.55397599e-04 5.57249442e-02 9.22639128e-02
 6.59427307e-01 2.38382797e-04]
[1.35912960e-01 7.37084088e-03 6.35722186e-03 3.20304919e-03 3.36536214e-04 5.12819454e-02
 1.93959102e-03 7.93597856e-01]
[1.14809821e-01 4.44898369e-03 4.04593358e-03 9.81438641e-04 1.91270833e-06 9.63995479e-04
 7.73640413e-06 8.74740178e-01]]
```



average probability = 0.5767204344078332

Probability of truly predicting class 0 is 0.9905541201083669
Probability of truly predicting class 1 is 0.0900952316483907
Probability of truly predicting class 2 is 0.25461444221525376
Probability of truly predicting class 3 is 0.48286748116691597
Probability of truly predicting class 4 is 0.5720632742502564
Probability of truly predicting class 5 is 0.7242598747138388
Probability of truly predicting class 6 is 0.6338587216182541
Probability of truly predicting class 7 is 0.8654503295413887

brier score = 0.021230246543668608

Brier score for state 0 is 0.008946590504328767
Brier score for state 1 is 0.007368248910457557
Brier score for state 2 is 0.0020834933577912004
Brier score for state 3 is 0.0008926066098393566
Brier score for state 4 is 0.0005461769749695848
Brier score for state 5 is 0.00034997860223982114
Brier score for state 6 is 0.0003135047161063727
Brier score for state 7 is 0.0007296468679359476

Authored by Peini SHE on Apr.10, 2025