

105.89	14.71934	14.71223	-0.0482674
105.98	14.68531	14.67824	-0.0481311
106.08	14.65135	14.64432	-0.0479927
106.17	14.61747	14.61047	-0.0478521
106.27	14.58365	14.57669	-0.0477094
106.36	14.54990	14.54298	-0.0475645
106.46	14.51623	14.50934	-0.0474175
106.55	14.48262	14.47577	-0.0472683
106.65	14.44908	14.44228	-0.0471169
106.74	14.41562	14.40885	-0.0469633
106.84	14.38222	14.37549	-0.0468075
106.93	14.34889	14.34220	-0.0466495
107.03	14.31564	14.30898	-0.0464893
107.12	14.28245	14.27583	-0.0463268
107.22	14.24933	14.24275	-0.0461622
107.31	14.21628	14.20974	-0.0459953
107.41	14.18330	14.17680	-0.0458261
107.51	14.15039	14.14393	-0.0456547
107.60	14.11755	14.11113	-0.0454811
107.70	14.08477	14.07839	-0.0453052
107.79	14.05207	14.04573	-0.0451270
107.89	14.01943	14.01313	-0.0449465
107.98	13.98687	13.98061	-0.0447637
108.08	13.95437	13.94815	-0.0445787
108.17	13.92194	13.91576	-0.0443913
108.27	13.88957	13.88343	-0.0442016
108.36	13.85728	13.85118	-0.0440096
108.46	13.82505	13.81900	-0.0438153
108.55	13.79289	13.78688	-0.0436187
108.65	13.76080	13.75483	-0.0434197
108.74	13.72878	13.72285	-0.0432183
108.84	13.69682	13.69093	-0.0430146
108.93	13.66494	13.65909	-0.0428086
109.03	13.63311	13.62731	-0.0426001
109.12	13.60136	13.59560	-0.0423893
109.22	13.56967	13.56395	-0.0421761
109.31	13.53805	13.53237	-0.0419605
109.41	13.50650	13.50086	-0.0417425
109.50	13.47502	13.46942	-0.0415221
109.60	13.44360	13.43804	-0.0412992
109.69	13.41224	13.40674	-0.0410740
109.79	13.38096	13.37549	-0.0408463
109.88	13.34974	13.34432	-0.0406161
109.98	13.31858	13.31321	-0.0403836
110.07	13.28750	13.28216	-0.0401485
110.17	13.25648	13.25119	-0.0399110
110.26	13.22552	13.22027	-0.0396711
110.36	13.19463	13.18943	-0.0394286
110.45	13.16381	13.15865	-0.0391837
110.55	13.13305	13.12794	-0.0389363
110.64	13.10236	13.09729	-0.0386864
110.74	13.07173	13.06671	-0.0384339
110.83	13.04117	13.03619	-0.0381790
110.93	13.01067	13.00574	-0.0379215

111.02	12.98024	12.97535	-0.0376615
111.12	12.94987	12.94503	-0.0373990
111.21	12.91957	12.91477	-0.0371339
111.31	12.88933	12.88458	-0.0368663
111.40	12.85916	12.85446	-0.0365961
111.50	12.82905	12.82439	-0.0363233
111.59	12.79901	12.79440	-0.0360480
111.69	12.76903	12.76446	-0.0357701
111.78	12.73912	12.73460	-0.0354896
111.88	12.70927	12.70479	-0.0352065
111.97	12.67948	12.67505	-0.0349208
112.07	12.64976	12.64538	-0.0346325
112.16	12.62010	12.61577	-0.0343416
112.26	12.59050	12.58622	-0.0340480
112.35	12.56097	12.55673	-0.0337518
112.45	12.53151	12.52731	-0.0334530
112.55	12.50210	12.49796	-0.0331515
112.64	12.47276	12.46866	-0.0328473
112.74	12.44348	12.43943	-0.0325405
112.83	12.41427	12.41027	-0.0322311
112.93	12.38512	12.38116	-0.0319189
113.02	12.35603	12.35212	-0.0316041
113.12	12.32700	12.32314	-0.0312865
113.21	12.29804	12.29423	-0.0309663
113.31	12.26914	12.26538	-0.0306434
113.40	12.24030	12.23659	-0.0303177
113.50	12.21152	12.20786	-0.0299893
113.59	12.18281	12.17919	-0.0296582
113.69	12.15415	12.15059	-0.0293244
113.78	12.12556	12.12205	-0.0289878
113.88	12.09704	12.09357	-0.0286485
113.97	12.06857	12.06515	-0.0283064
114.07	12.04017	12.03680	-0.0279615
114.16	12.01182	12.00851	-0.0276139
114.26	11.98354	11.98027	-0.0272634
114.35	11.95532	11.95210	-0.0269102
114.45	11.92716	11.92399	-0.0265542
114.54	11.89906	11.89595	-0.0261954
114.64	11.87103	11.86796	-0.0258338
114.73	11.84305	11.84004	-0.0254694
114.83	11.81514	11.81217	-0.0251021
114.92	11.78728	11.78437	-0.0247320
115.02	11.75949	11.75663	-0.0243591
115.11	11.73176	11.72894	-0.0239833
115.21	11.70408	11.70132	-0.0236047
115.30	11.67647	11.67376	-0.0232232
115.40	11.64892	11.64626	-0.0228388
115.49	11.62143	11.61882	-0.0224516
115.59	11.59400	11.59144	-0.0220615
115.68	11.56663	11.56412	-0.0216685
115.78	11.53931	11.53686	-0.0212725
115.87	11.51206	11.50966	-0.0208737
115.97	11.48487	11.48252	-0.0204720
116.06	11.45774	11.45544	-0.0200674

116.16	11.43066	11.42841	-0.0196598
116.25	11.40365	11.40145	-0.0192493
116.35	11.37669	11.37455	-0.0188359
116.44	11.34980	11.34770	-0.0184195
116.54	11.32296	11.32092	-0.0180001
116.63	11.29618	11.29419	-0.0175778
116.73	11.26946	11.26753	-0.0171525
116.82	11.24280	11.24092	-0.0167243
116.92	11.21620	11.21437	-0.0162930
117.01	11.18965	11.18788	-0.0158588
117.11	11.16317	11.16144	-0.0154216
117.20	11.13674	11.13507	-0.0149813
117.30	11.11037	11.10875	-0.0145381
117.39	11.08406	11.08250	-0.0140918
117.49	11.05780	11.05630	-0.0136425
117.59	11.03161	11.03015	-0.0131902
117.68	11.00547	11.00407	-0.0127348
117.78	10.97939	10.97804	-0.0122764
117.87	10.95337	10.95207	-0.0118150
117.97	10.92740	10.92616	-0.0113504
118.06	10.90149	10.90031	-0.0108828
118.16	10.87564	10.87451	-0.0104121
118.25	10.84985	10.84877	-0.0099384
118.35	10.82411	10.82309	-0.0094615
118.44	10.79843	10.79746	-0.0089816
118.54	10.77281	10.77189	-0.0084985
118.63	10.74724	10.74638	-0.0080123
118.73	10.72173	10.72093	-0.0075230
118.82	10.69628	10.69553	-0.0070306
118.92	10.67088	10.67019	-0.0065351
119.01	10.64554	10.64490	-0.0060364
119.11	10.62026	10.61967	-0.0055346
119.20	10.59503	10.59450	-0.0050296
119.30	10.56986	10.56938	-0.0045214
119.39	10.54474	10.54432	-0.0040101
119.49	10.51968	10.51931	-0.0034956
119.58	10.49467	10.49436	-0.0029779
119.68	10.46972	10.46947	-0.0024570
119.77	10.44483	10.44463	-0.0019330
119.87	10.41999	10.41984	-0.0014057
119.96	10.39521	10.39512	-0.0008752
120.06	10.37048	10.37044	-0.0003415
120.15	10.34580	10.34582	0.0001954
120.25	10.32119	10.32126	0.0007355
120.34	10.29662	10.29675	0.0012789
120.44	10.27211	10.27230	0.0018256
120.53	10.24766	10.24790	0.0023755
120.63	10.22326	10.22356	0.0029286
120.72	10.19891	10.19927	0.0034850
120.82	10.17462	10.17503	0.0040447
120.91	10.15038	10.15085	0.0046077
121.01	10.12620	10.12673	0.0051740
121.10	10.10207	10.10265	0.0057435
121.20	10.07800	10.07863	0.0063164

121.29	10.05398	10.05467	0.0068925
121.39	10.03001	10.03076	0.0074720
121.48	10.00610	10.00690	0.0080548
121.58	9.98224	9.98310	0.0086409
121.67	9.95843	9.95935	0.0092304
121.77	9.93468	9.93565	0.0098232
121.86	9.91098	9.91201	0.0104194
121.96	9.88733	9.88842	0.0110189
122.05	9.86373	9.86488	0.0116217
122.15	9.84019	9.84140	0.0122280
122.24	9.81670	9.81796	0.0128376
122.34	9.79327	9.79459	0.0134506
122.43	9.76989	9.77126	0.0140670
122.53	9.74655	9.74799	0.0146868
122.63	9.72328	9.72477	0.0153100
122.72	9.70005	9.70160	0.0159366
122.82	9.67688	9.67848	0.0165667
122.91	9.65376	9.65542	0.0172001
123.01	9.63069	9.63240	0.0178370
123.10	9.60767	9.60944	0.0184773
123.20	9.58470	9.58654	0.0191211
123.29	9.56179	9.56368	0.0197683
123.39	9.53893	9.54087	0.0204190
123.48	9.51612	9.51812	0.0210732
123.58	9.49336	9.49542	0.0217308
123.67	9.47065	9.47277	0.0223919
123.77	9.44799	9.45017	0.0230565
123.86	9.42539	9.42762	0.0237246
123.96	9.40283	9.40512	0.0243961
124.05	9.38033	9.38268	0.0250712
124.15	9.35787	9.36028	0.0257498
124.24	9.33547	9.33794	0.0264319
124.34	9.31312	9.31565	0.0271176
124.43	9.29082	9.29340	0.0278068
124.53	9.26857	9.27121	0.0284995
124.62	9.24637	9.24907	0.0291958
124.72	9.22422	9.22698	0.0298956
124.81	9.20212	9.20493	0.0305990
124.91	9.18007	9.18294	0.0313059
125.00	9.15807	9.16100	0.0320164
125.10	9.13612	9.13911	0.0327305
125.19	9.11422	9.11727	0.0334482
125.29	9.09237	9.09548	0.0341695
125.38	9.07057	9.07373	0.0348944
125.48	9.04882	9.05204	0.0356229
125.57	9.02711	9.03040	0.0363550
125.67	9.00546	9.00880	0.0370907
125.76	8.98386	8.98726	0.0378301
125.86	8.96230	8.96576	0.0385731
125.95	8.94080	8.94431	0.0393197
126.05	8.91934	8.92291	0.0400700
126.14	8.89793	8.90156	0.0408239
126.24	8.87657	8.88026	0.0415815
126.33	8.85526	8.85901	0.0423427

126.43	8.83400	8.83781	0.0431077
126.52	8.81279	8.81665	0.0438763
126.62	8.79162	8.79555	0.0446486
126.71	8.77050	8.77449	0.0454246
126.81	8.74944	8.75348	0.0462042
126.90	8.72841	8.73252	0.0469876
127.00	8.70744	8.71160	0.0477748
127.09	8.68652	8.69073	0.0485656
127.19	8.66564	8.66992	0.0493601
127.28	8.64481	8.64914	0.0501584
127.38	8.62403	8.62842	0.0509605
127.47	8.60329	8.60775	0.0517662
127.57	8.58260	8.58712	0.0525758
127.67	8.56196	8.56654	0.0533890
127.76	8.54137	8.54600	0.0542061
127.86	8.52083	8.52551	0.0550269
127.95	8.50033	8.50507	0.0558515
128.05	8.47987	8.48468	0.0566799
128.14	8.45947	8.46433	0.0575121
128.24	8.43911	8.44403	0.0583481
128.33	8.41880	8.42378	0.0591878
128.43	8.39853	8.40358	0.0600314
128.52	8.37831	8.38342	0.0608788
128.62	8.35814	8.36330	0.0617301
128.71	8.33802	8.34323	0.0625851
128.81	8.31794	8.32321	0.0634440
128.90	8.29790	8.30324	0.0643068
129.00	8.27791	8.28331	0.0651734
129.09	8.25797	8.26343	0.0660438
129.19	8.23808	8.24359	0.0669182
129.28	8.21822	8.22380	0.0677963
129.38	8.19842	8.20405	0.0686784
129.47	8.17866	8.18435	0.0695643
129.57	8.15895	8.16469	0.0704542
129.66	8.13928	8.14508	0.0713479
129.76	8.11965	8.12552	0.0722455
129.85	8.10007	8.10600	0.0731470
129.95	8.08054	8.08653	0.0740525
130.04	8.06105	8.06710	0.0749619
130.14	8.04161	8.04771	0.0758752
130.23	8.02221	8.02837	0.0767924
130.33	8.00286	8.00908	0.0777136
130.42	7.98355	7.98983	0.0786387
130.52	7.96428	7.97062	0.0795677
130.61	7.94506	7.95146	0.0805008
130.71	7.92589	7.93234	0.0814377
130.80	7.90675	7.91327	0.0823787
130.90	7.88767	7.89424	0.0833236
130.99	7.86862	7.87525	0.0842726
131.09	7.84962	7.85631	0.0852255
131.18	7.83067	7.83741	0.0861824
131.28	7.81175	7.81856	0.0871433
131.37	7.79288	7.79975	0.0881082
131.47	7.77406	7.78098	0.0890772

131.56	7.75528	7.76226	0.0900501
131.66	7.73654	7.74358	0.0910271
131.75	7.71785	7.72495	0.0920081
131.85	7.69919	7.70635	0.0929932
131.94	7.68059	7.68780	0.0939823
132.04	7.66202	7.66930	0.0949754
132.13	7.64350	7.65083	0.0959727
132.23	7.62502	7.63241	0.0969740
132.32	7.60658	7.61404	0.0979793
132.42	7.58819	7.59570	0.0989887
132.52	7.56984	7.57741	0.1000023
132.61	7.55153	7.55916	0.1010199
132.71	7.53326	7.54095	0.1020416
132.80	7.51504	7.52279	0.1030674
132.90	7.49686	7.50466	0.1040973
132.99	7.47872	7.48658	0.1051314
133.09	7.46062	7.46854	0.1061695
133.18	7.44257	7.45055	0.1072118
133.28	7.42455	7.43259	0.1082582
133.37	7.40658	7.41468	0.1093088
133.47	7.38865	7.39681	0.1103635
133.56	7.37076	7.37898	0.1114223
133.66	7.35292	7.36119	0.1124854
133.75	7.33511	7.34344	0.1135525
133.85	7.31735	7.32574	0.1146239
133.94	7.29963	7.30807	0.1156994
134.04	7.28195	7.29045	0.1167791
134.13	7.26431	7.27287	0.1178630
134.23	7.24671	7.25533	0.1189511
134.32	7.22915	7.23783	0.1200434
134.42	7.21163	7.22037	0.1211399
134.51	7.19416	7.20295	0.1222406
134.61	7.17672	7.18557	0.1233456
134.70	7.15933	7.16824	0.1244547
134.80	7.14197	7.15094	0.1255681
134.89	7.12466	7.13369	0.1266858
134.99	7.10739	7.11647	0.1278077
135.08	7.09015	7.09930	0.1289338
135.18	7.07296	7.08216	0.1300642
135.27	7.05581	7.06507	0.1311988
135.37	7.03870	7.04801	0.1323377
135.46	7.02162	7.03100	0.1334809
135.56	7.00459	7.01402	0.1346284
135.65	6.98760	6.99709	0.1357802
135.75	6.97064	6.98019	0.1369362
135.84	6.95373	6.96333	0.1380966
135.94	6.93686	6.94652	0.1392612
136.03	6.92002	6.92974	0.1404302
136.13	6.90323	6.91300	0.1416035
136.22	6.88647	6.89630	0.1427811
136.32	6.86975	6.87964	0.1439630
136.41	6.85308	6.86302	0.1451493
136.51	6.83644	6.84644	0.1463399
136.60	6.81984	6.82990	0.1475348

136.70	6.80328	6.81340	0.1487341
136.79	6.78676	6.79693	0.1499378
136.89	6.77027	6.78051	0.1511458
136.98	6.75383	6.76412	0.1523582
137.08	6.73742	6.74777	0.1535750
137.17	6.72106	6.73146	0.1547961
137.27	6.70473	6.71519	0.1560217
137.36	6.68844	6.69895	0.1572516
137.46	6.67218	6.68276	0.1584860
137.56	6.65597	6.66660	0.1597247
137.65	6.63979	6.65048	0.1609679
137.75	6.62365	6.63440	0.1622154
137.84	6.60755	6.61835	0.1634674
137.94	6.59149	6.60235	0.1647239
138.03	6.57547	6.58638	0.1659847
138.13	6.55948	6.57045	0.1672500
138.22	6.54353	6.55456	0.1685198
138.32	6.52762	6.53870	0.1697940
138.41	6.51174	6.52288	0.1710727
138.51	6.49590	6.50710	0.1723558
138.60	6.48010	6.49136	0.1736434
138.70	6.46434	6.47565	0.1749355
138.79	6.44861	6.45998	0.1762320
138.89	6.43293	6.44435	0.1775331
138.98	6.41727	6.42875	0.1788386
139.08	6.40166	6.41319	0.1801486
139.17	6.38608	6.39767	0.1814632
139.27	6.37054	6.38218	0.1827822
139.36	6.35503	6.36673	0.1841058
139.46	6.33956	6.35132	0.1854339
139.55	6.32413	6.33594	0.1867665
139.65	6.30874	6.32060	0.1881037
139.74	6.29338	6.30530	0.1894454
139.84	6.27805	6.29003	0.1907916
139.93	6.26277	6.27480	0.1921424
140.03	6.24752	6.25961	0.1934978
140.12	6.23230	6.24445	0.1948577
140.22	6.21712	6.22932	0.1962222
140.31	6.20198	6.21423	0.1975912
140.41	6.18687	6.19918	0.1989649
140.50	6.17180	6.18417	0.2003431
140.60	6.15676	6.16918	0.2017259
140.69	6.14176	6.15424	0.2031133
140.79	6.12680	6.13933	0.2045054
140.88	6.11187	6.12445	0.2059020
140.98	6.09697	6.10961	0.2073032
141.07	6.08212	6.09481	0.2087091
141.17	6.06729	6.08004	0.2101196
141.26	6.05250	6.06531	0.2115347
141.36	6.03775	6.05061	0.2129545
141.45	6.02303	6.03594	0.2143789
141.55	6.00834	6.02131	0.2158079
141.64	5.99370	6.00672	0.2172416
141.74	5.97908	5.99216	0.2186800

141.83	5.96450	5.97763	0.2201230
141.93	5.94995	5.96314	0.2215707
142.02	5.93544	5.94868	0.2230231
142.12	5.92097	5.93426	0.2244802
142.21	5.90652	5.91987	0.2259419
142.31	5.89212	5.90551	0.2274084
142.40	5.87774	5.89119	0.2288795
142.50	5.86340	5.87691	0.2303554

Average Abs Error (%) : 0.095

Time decay: 4.166666666666667e-07

Moneyness decay: 4.166666666666667e-06

Number of option price/parameter sets generated: 24000

2024-09-06 11:05:16.080015

Selected Parameters:

Features:

spot_price

strike_price

years_to_maturity

Target: observed_price

Security: vanilla options

Data Processed with the StandardScaler

Scaler: StandardScaler

Activation function: relu

Maximum iterations: 10000

Hidden Layer Sizes: (10, 10, 10)

Solver: sgd

Learning Rate: adaptive

Alpha: 0.0001

(10, 10, 10) Deep Neural Network (relu) (StandardScaler) (sgd) (relu activation)

Deep Neural Network estimated in 1 seconds!

	strike_price	years_to_maturity	...	moneyness	pricing_error
0	105.698198	1.500000	...	-10.698198	0.598886
1	118.916416	0.250000	...	-23.916416	0.128982
2	60.147648	1.333333	...	34.852352	0.151355
3	81.448949	1.083333	...	13.551051	0.250882
4	58.626126	1.000000	...	36.373874	0.255730
...
1195	118.060561	0.333333	...	-23.060561	0.043579
1196	47.500000	0.666667	...	47.500000	0.152073
1197	98.566066	0.916667	...	-3.566066	0.360918
1198	122.530030	0.166667	...	-27.530030	0.081079
1199	115.397898	1.666667	...	-20.397898	0.070859


```

[1200 rows x 16 columns]
/Users/doomd/miniforge3/lib/python3.10/site-packages/plotnine/
ggplot.py:606: PlotnineWarning: Saving 6.4 x 4.8 in image.
/Users/doomd/miniforge3/lib/python3.10/site-packages/plotnine/
ggplot.py:607: PlotnineWarning: Filename: E:\OneDrive -
rsbrc\Files\Dissertation\06092024-110517.png
Traceback (most recent call last):

  File ~/miniforge3/lib/python3.10/site-packages/spyder_kernels/
py3compat.py:356 in compat_exec
    exec(code, globals, locals)

  File ~/git/brp/model_routine.py:169
    model_plot.save(filename = f'{end_tag}.png',

  File ~/miniforge3/lib/python3.10/site-packages/plotnine/ggplot.py:
677 in save
    sv.figure.savefig(**sv.kwargs)

  File ~/miniforge3/lib/python3.10/site-packages/matplotlib/figure.py:
3395 in savefig
    self.canvas.print_figure(fname, **kwargs)

  File ~/miniforge3/lib/python3.10/site-packages/matplotlib/
backend_bases.py:2204 in print_figure
    result = print_method(

  File ~/miniforge3/lib/python3.10/site-packages/matplotlib/
backend_bases.py:2054 in <lambda>
    print_method = functools.wraps(meth)(lambda *args, **kwargs: meth(

  File ~/miniforge3/lib/python3.10/site-packages/matplotlib/backends/
backend_agg.py:496 in print_png
    self._print_pil(filename_or_obj, "png", pil_kwargs, metadata)

  File ~/miniforge3/lib/python3.10/site-packages/matplotlib/backends/
backend_agg.py:445 in _print_pil
    mpl.image.imsave(

  File ~/miniforge3/lib/python3.10/site-packages/matplotlib/image.py:
1676 in imsave
    image.save(fname, **pil_kwargs)

  File ~/miniforge3/lib/python3.10/site-packages/PIL/Image.py:2563 in
save
    fp = builtins.open(filename, "w+b")

FileNotFoundError: [Errno 2] No such file or directory: '/Users/doomd/
git/brp/E:\\OneDrive - rsbrc\\Files\\Dissertation\\06092024-110517.png'

In [2]: . = f'{ . }.png'
...: # path = r"E:\OneDrive -
rsbrc\Files\Dissertation",

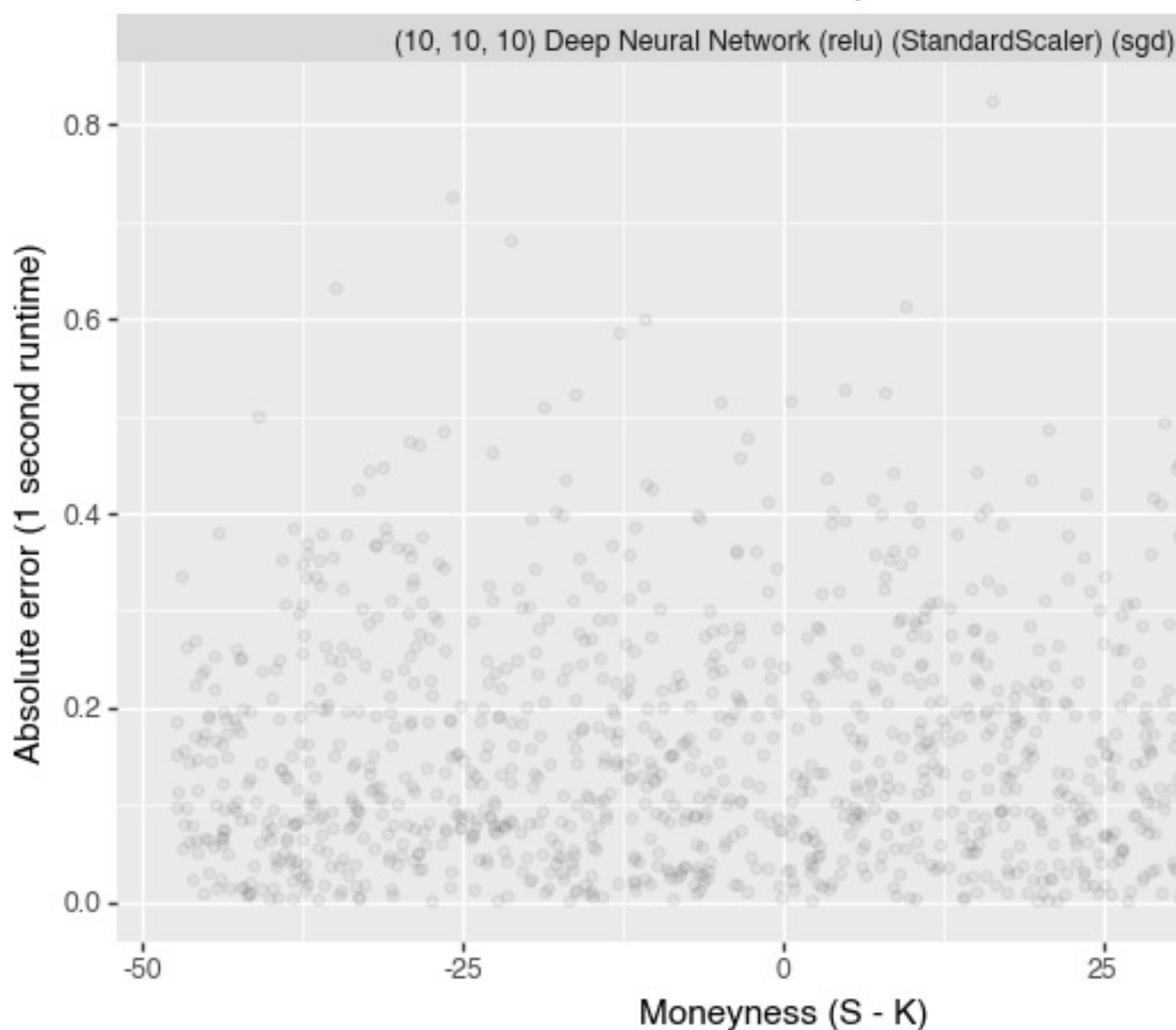
```

```

....:                                     = 600
....:                                     .
....:
....: print f"\n{                                     }"
....: print "\n "
....: = f""""Model estimated using {len                                     } options
....: with {                                     } spot prices between {                                     } to {                                     },
....: {                                     } strikes between {int                                     *100 }% and
....: {int                                     *100 }% moneyness, and {                                     }
maturities between
....: {round                                     2 } and {round                                     2 }
years (act/365)""""
....: =                                     =70
....: print
....: print "\nDATA NOT ROUNDED!"
/Users/doomd/miniforge3/lib/python3.10/site-packages/plotnine/
ggplot.py:606: PlotnineWarning: Saving 6.4 x 4.8 in image.
/Users/doomd/miniforge3/lib/python3.10/site-packages/plotnine/
ggplot.py:607: PlotnineWarning: Filename: 06092024-110517.png

```

Prediction error for vanilla options under Hest



2024-09-06 11:05:17.910244

Model estimated using 24000 options with 1 spot prices between 95 to 105, 1000 strikes between 50% and 150% moneyness, and 24 maturities between 0.08 and 2.01 years (act/365)

DATA NOT ROUNDED!

```
In [3]: 0  '/Users/doomd/git/brp/model_routine.py'
```