1)Standalone DL Data

1-1) Bubble Only Fed with Bubble Data

Target File	BiLSTM	Transformer
Nifty Fifty	99.1%	0.9026
Black Monday	99.7%	0.9919
Dot Com	95.52%	0.9567
Subprime	87.16%	0.9627

1-2) Bubble Only Fed with Non-Bubble Data

Target File	BiLSTM	Transformer
1962-1965	95.0%	0.9959
1975-1980	96.23%	0.9453
1987-1995	95.94%	0.9948
2001-2004	89.62%	0.9978

2-1) Non-Bubble Data Fed with Bubble Data

Target File	BiLSTM	Transformer
Nifty Fifty	0.72%	0.0383
Black Monday	1.5%	0.0052
Dot Com	0.76%	0.0222
Subprime	2.4%	0.0256

2-2) Non-Bubble Data Fed with Non-Bubble Data

Target File	BiLSTM	Transformer
1962-1965	0.1086	0.0032
1975-1980	0.0141	0.0958

1987-1995	0.0280	0.0388
2001-2004	0.0025	0.0090

3-1) Bubble & Non-Bubble Fed with Bubble

Target File	BiLSTM	Transformer
Nifty Fifty	69.77%	0.7061
Black Monday	92.36%	0.9936
Dot Com	18.24%	0.0601
Subprime	77.63%	0.0060

3-2) Bubble & Non-Bubble Fed with Non-Bubble

Target File	BiLSTM	Transformer
1962-1965	0.17%	0.9899
1975-1980	21.87%	0.9423
1987-1995	75.09%	0.9152
2001-2004	6.85%	0.9800

2) Standalone LLMs Data

How to read the following tables
LLM tag legend: 1 = Gemini 2.5 Pro, **2 = GPT-5**, **3 = Grok-4**.
Structure: The columns list the **bubble or non-bubble episodes** that the Standalone LLM or DL-LLM architecture was evaluated upon. Under each episode are three subcolumns labeled **1, 2, 3** (the LLM tags above). **Rows 1–5** are the five independent evaluation runs per LLM.
Values: Each cell is the model's **P(bubble)∈[0,1]** for that episode in that run (no conversion needed). Higher values are better for bubble episodes.

1-1) Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3

1	0.85	0.69	0.60	0.35	0.67	0.65	0.685	0.57	0.65	0.05	0.18	0.3
2	0.65	0.67	0.80	0.875	0.73	0.65	0.7	0.63	0.55	0.20	0.20	0.35
3	0.15	0.67	0.65	0.725	0.75	0.7	0.45	0.39	0.65	0.15	0.18	0.25
4	0.75	0.67	0.60	0.850	0.74	0.7	0.685	0.6	0.62	0.15	0.19	0.40
5	0.65	0.28	0.65	0.35	0.82	0.8	0.70	0.65	0.65	0.15	0.30	0.35

1-2) Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.2	0.22	0.5	0.850	0.36	0.5	0.625	0.32	0.75	0.15	0.34	0.45
2	0.35	0.18	0.45	0.45	0.57	0.45	0.825	0.42	0.6	0.2	0.16	0.5
3	0.2	0.22	0.6	0.65	0.68	0.5	0.6	0.32	0.6	0.05	0.24	0.65
4	0.15	0.24	0.35	0.7	0.62	0.65	0.6	0.41	0.6	0.3	0.21	0.5
5	0.25	0.29	0.5	0.775	0.57	0.7	0.35	0.47	0.62	0.25	0.32	0.45

2-1) Non-Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.925	0.83	0.75	0.725	0.32	0.5	0.8	0.82	0.8	0.9	0.82	0.75
2	0.875	0.89	0.65	0.3	0.62	0.35	0.825	0.84	0.7	0.85	0.83	0.65
3	0.80	0.87	0.75	0.3	0.57	0.35	0.8	0.86	0.8	0.85	0.81	0.65
4	0.880	0.86	0.85	0.3	0.33	0.35	0.925	0.74	0.7	0.7	0.87	0.65
5	0.925	0.82	0.75	0.4	0.37	0.4	0.8	0/8	0.7	0.825	0.835	0.65

2-2) Non-Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.9	0.83	0.8	0.85	0.86	0.75	0.85	0.74	0.65	0.15	0.64	0.5
2	0.3	0.81	0.35	0.7	0.82	0.75	0.9	0.82	0.8	0.95	0.77	0.65
3	0.25	0.82	0.6	0.65	0.77	0.75	0.4	0.82	0.7	0.15	0.61	0.55

| 4 | 0.925 | 0.84 | 0.4 | 0.3 | 0.75 | 0.65 | 0.82 | 0.78 | 0.7 | 0.1 | 0.78 | 0.65 |
| 5 | 0.85 | 0.8 | 0.7 | 0.35 | 0.76 | 0.65 | 0.35 | 0.848 | 0.75 | 0.1 | 0.68 | 0.7 |

3-1) Bubble and Non-Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.785	0.29	0.6	0.15	0.78	0.6	0.4	0.34	0.65	0.15	0.19	0.3
2	0.6	0.6	0.6	0.65	0.6	0.65	0.35	0.23	0.6	0.25	0.17	0.35
3	0.65	0.602	0.6	0.2	0.62	0.2	0.35	0.24	0.45	0.15	0.14	0.3
4	0.675	0.61	0.65	0.785	0.64	0.3	0.6	0.32	0.65	0.15	0.18	0.25
5	0.15	0.22	0.3333	0.15	0.67	0.6	0.425	0.27	0.8	0.21	0.18	0.3

3-2) Bubble and Non-Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.25	0.18	0.65	0.15	0.37	0.65	0.25	0.27	0.35	0.75	0.21	0.3

2	0.35	0.23	0.65	0.25	0.56	0.65	0.3	0.22	0.4	0.15	0.2	0.6
3	0.35	0.2	0.6	0.225	0.27	0.6	0.2	0.6	0.4	0.225	0.24	0.65
4	0.35	0.24	0.6	0.9	0.28	0.5	0.3	0.34	0.6	0.2	0.32	0.45
5	0.2	0.23	0.7	0.35	0.38	0.65	0.25	0.24	0.65	0.25	0.29	0.5

3) DL-LLM Outputs Based on BiLSTM DL Model

1-1) Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.99	0.988	0.96	0.995	0.985	0.99	0.94	0.954	0.9552	0.8761	0.61	0.85
2	0.985	0.99	0.991	0.997	0.996	0.99	0.95	0.942	0.92	0.8	0.8	0.75
3	0.991	0.991	0.95	0.997	0.985	0.997	0.9552	0.9552	0.94	0.785	0.68	0.75
4	0.985	0.989	0.991	0.997	0.992	0.997	0.955	0.946	0.9	0.625	0.78	0.7
5	0.991	0.982	0.95	0.995	0.97	0.95	0.955	0.9552	0.92	0.8050	0.65	0.7

1-2) Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.95	0.91	0.95	0.95	0.942	0.9	0.9594	0.9594	0.93	0.875	0.87	0.82
2	0.95	0.92	0.9	0.95	0.96	0.95	0.9594	0.9594	0.92	0.9	0.88	0.75
3	0.95	0.92	0.8	0.9623	0.958	0.95	0.9594	0.9594	0.8	0.85	0.86	0.85
4	0.825	0.8	0.9	0.96	0.9623	0.9623	0.9594	0.955	0.9594	0.85	0.89	0.8
5	0.95	0.88	0.95	0.95	0.952	0.92	0.95	0.956	0.85	0.89	0.8	0.8

2-1) Non-Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.0072	0.18	0.25	0.015	0.018	0.2	0.0076	0.18	0.76	0.05	0.15	0.15
2	0.05	0.12	0.72	0.015	0.018	0.05	0.0076	0.18	0.35	0.024	0.11	0.024
3	0.0072	0.2	0.72	0.015	0.025	0.25	0.0076	0.58	0.25	0.024	0.07	0.1
4	0.0072	0.12	0.25	0.015	0.02	0.25	0.0076	0.32	0.1	0.035	0.07	0.024

5	0.7	0.12	0.15	0.015	0.02	0.3	0.0076	0.22	0.25	0.024	0.13	0.2

2-2) Non-Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.1086	0.38	0.1086	0.0141	0.02	0.2	0.028	0.028	0.25	0.0025	0.0025	0.05
2	0.125	0.24	0.1086	0.015	0.52	0.3	0.028	0.54	0.35	0.0025	0.01	0.1
3	0.1086	0.22	0.1086	0.0141	0.075	0.05	0.04	0.06	0.35	0.0025	0.01	0.25
4	0.115	0.36	0.2	0.0141	0.22	0.25	0.028	0.08	0.2	0.0025	0.005	0.15
5	0.1086	0.62	0.4	0.0141	0.18	0.05	0.028	0.15	0.2	0.0025	0.01	0.25

3-1) Bubble and Non-Bubble Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.725	0.6977	0.6977	0.9236	0.92	0.75	0.1824	0.18	0.1824	0.7753	0.43	0.65
2	0.6977	0.72	0.6977	0.9236	0.82	0.9236	0.1824	0.19	0.1824	0.685	0.46	0.5

3	0.65	0.6	0.65	0.9250	0.87	0.9236	0.1824	0.19	0.1824	0.77	0.4	0.6
4	0.6977	0.6977	0.6977	0.85	0.92	0.8	0.195	0.19	0.1824	0.625	0.42	0.6
5	0.65	0.7050	0.6977	0.9236	0.918	0.92	0.19	0.19	0.1824	0.755	0.46	0.6

3-2) Bubble and Non-Bubble Fed with Non-Bubble Data

Test Sessions	1962-1965			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.1	0.01	0.17	0.2187	0.22	0.3	0.7509	0.46	0.65	0.075	0.066	0.15
2	0.0017	0.0017	0.2	0.2187	0.2187	0.2187	0.75	0.62	0.65	0.0685	0.07	0.12
3	0.015	0.0017	0.25	0.2187	0.214	0.2187	0.7509	0.74	0.65	0.07	0.065	0.0685
4	0.0025	0.0035	0.001	0.2187	0.22	0.2187	0.7509	0.67	0.65	0.0685	0.075	0.15
5	0.0017	0.0025	0.1	0.2187	0.23	0.25	0.78	0.62	0.6	0.0685	0.085	0.0685

4) DL-LLM Outputs Based on Transformer DL Model

1-1) Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty	Black Monday	Dot Com	Subprime

	1	2	3	1	2	3	1	2	3	1	2	3
1	0.905	0.9	0.75	0.9919	0.985	0.9919	0.95	0.9567	0.9567	0.75	0.92	0.9
2	0.9026	0.9026	0.9026	0.9919	0.991	0.9919	0.9567	0.952	0.92	0.9627	0.936	0.95
3	0.9026	0.9026	0.75	0.992	0.9919	0.9919	0.94	0.953	0.9567	0.925	0.92	0.8
4	0.9026	0.9026	0.85	0.9919	0.9919	0.9919	0.925	0.9567	0.85	0.915	0.9627	0.85
5	0.9	0.905	0.9026	0.99	0.986	0.9919	0.955	0.9567	0.9567	0.785	0.78	0.7

1-2) Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.985	0.986	0.9959	0.915	0.935	0.92	0.995	0.9948	0.9948	0.6	0.982	0.95
2	0.995	0.995	0.9	0.925	0.9453	0.9453	0.995	0.992	0.9948	0.95	0.989	0.9
3	0.95	0.94	0.9959	0.9453	0.938	0.92	0.995	0.991	0.9948	0.997	0.983	0.95
4	0.9959	0.89	0.9959	0.9453	0.945	0.92	0.995	0.9948	0.9948	0.975	0.991	0.9978

| 5 | 0.995 | 0.972 | 0.95 | 0.9453 | 0.9453 | 0.9453 | 0.995 | 0.992 | 0.9948 | 0.95 | 0.973 | 0.95 |

2-1) Non-Bubble Only Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.0383	0.18	0.2	0.1	0.013	0.15	0.0222	0.26	0.1	0.0222	0.55	0.35
2	0.0383	0.23	0.5	0.0052	0.0052	0.1	0.0222	0.46	0.25	0.0222	0.18	0.25
3	0.0383	0.56	0.1	0.0052	0.0052	0.0052	0.0222	0.22	0.25	0.0222	0.6	0.2
4	0.0383	0.0383	0.25	0.0052	0.02	0.15	0.0222	0.35	0.25	0.0222	0.18	0.25
5	0.0383	0.57	0.0383	0.0052	0.01	0.1	0.0222	0.12	0.2	0.0222	0.46	0.4

2-2) Non-Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1980			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.0032	0.12	0.15	0.0958	0.0958	0.12	0.0388	0.32	0.25	0.009	0.03	0.25
2	0.0032	0.06	0.0032	0.0958	0.14	0.2	0.0388	0.15	0.25	0.009	0.009	0.9

3	0.0032	0.08	0.25	0.0958	0.11	0.2	0.0388	0.37	0.2	0.015	0.02	0.3
4	0.0032	0.16	0.0032	0.0958	0.18	0.0958	0.0388	0.36	0.15	0.009	0.05	0.2
5	0.0032	0.42	0.25	0.1	0.104	0.25	0.0388	0.3	0.2	0.009	0.011	0.3

3-1) Bubble and Non-Bubble Fed with Bubble Data

Test Sessions	Nifty Fifty			Black Monday			Dot Com			Subprime		
	1	2	3	1	2	3	1	2	3	1	2	3
1	0.7061	0.44	0.7061	0.9936	0.989	0.95	0.601	0.07	0.0601	0.006	0.03	0.006
2	0.7061	0.7061	0.7061	0.9936	0.9936	0.9936	0.650	0.07	0.0601	0.006	0.035	0.15
3	0.6850	0.610	0.65	0.9936	0.982	0.95	0.650	0.08	0.0601	0.006	0.03	0.25
4	0.7061	0.290	0.7061	0.9936	0.9936	0.8	0.601	0.650	0.25	0.006	0.018	0.4
5	0.7061	0.7061	0.7061	0.9936	0.9936	0.85	0.650	0.8	0.0601	0.006	0.02	0.006

3-2) Bubble and Bubble Only Fed with Non-Bubble Data

Test Sessions	1962-1965			1975-1980			1987-1995			2001-2004		
	1	2	3	1	2	3	1	2	3	1	2	3

1	0.985	0.955	0.95	0.9423	0.9423	0.9	0.9152	0.78	0.9152	0.975	0.965	0.98
2	0.9899	0.93	0.9899	0.9423	0.938	0.9423	0.92	0.84	0.9152	0.975	0.94	0.98
3	0.989	0.93	0.97	0.9423	0.935	0.91	0.915	0.65	0.6	0.98	0.97	0.98
4	0.985	0.989	0.989	0.9423	0.9423	0.9	0.9152	0.72	0.9152	0.98	0.94	0.95
5	0.9899	0.73	0.95	0.935	0.9423	0.9	0.915	0.72	0.85	0.98	0.92	0.98

4) Brier Score Under Each Approach

Architecture	Brier
Standalone DL (BiLSTM)	**0.446341**
Standalone DL (Transformer)	**0.485432**
Standalone LLM (mean of 3)	**0.230274**
DL-LLM (BiLSTM backbone, mean of 3)	**0.421102**
DL-LLM (Transformer backbone, mean of 3)	**0.436932**

Architecture	Brier (A2)
Standalone DL (BiLSTM)	**0.488262**
Standalone DL (Transformer)	**0.478852**
Standalone LLM (mean of 3)	**0.277544**

DL-LLM (BiLSTM backbone, mean of 3)	**0.372311**
DL-LLM (Transformer backbone, mean of 3)	**0.364864**

Architecture	Brier (A3)
Standalone DL (BiLSTM)	**0.179014**
Standalone DL (Transformer)	**0.702961**
Standalone LLM (mean of 3)	**0.248869**
DL-LLM (BiLSTM backbone, mean of 3)	**0.183022**
DL-LLM (Transformer backbone, mean of 3)	**0.602470**

Architecture	Approach 1 (Bubble-only)	Approach 2 (Non-bubble-only)	Approach 3 (Both)
Standalone DL (BiLSTM)	0.446341	0.488262	0.179014
Standalone DL (Transformer)	0.485432	0.478852	0.702961
Standalone LLM (mean of 3)	0.230274	0.277544	0.248869
DL-LLM (BiLSTM backbone, mean of 3)	0.421102	0.372311	0.183022
DL-LLM (Transformer backbone, mean of 3)	0.436932	0.364864	0.602470