Monte Carlo Simulation Results

qonlab

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1 Mean$_R$ecurring(20260213Breaks)

This section contains results for mean$_r$ecurring(20260213breaks).

1.1 Mean$_R$ecurring(20260213Breaks) − MarkovSwitching

Table 1: Mean Recurring Results - MarkovSwitching

Method	RMSE	MAE	Bias	Variance	Successes
ARIMA Global	0.9478	0.6793	0.0583	0.8949	10
MS AR(1)	1.0261	0.6544	-0.1479	1.0310	10

2 Mean$_S$ingle(20260212Breaks)

This section contains results for mean$_s$ingle(20260212breaks).

2.1 Mean$_S$ingle(20260212Breaks) − Gaussian

Table 2: Mean Single Results - Gaussian

Method	RMSE	MAE	Bias
SARIMA + Break Dummy (oracle Tb)	1.1398	1.0641	-0.0498
Simple Exp. Smoothing (SES)	1.1600	1.0012	-0.3293
SARIMA Global	—	—	—
SARIMA Rolling	—	—	—

2.2 Mean$_S$ingle(20260212Breaks) − Gaussian

Table 3: Mean Single Results - Gaussian

Method	RMSE	MAE	Bias
SARIMA + Break Dummy (oracle Tb)	1.1276	0.9194	0.1522
Simple Exp. Smoothing (SES)	1.2572	1.0213	0.0017
SARIMA Global	—	—	—
SARIMA Rolling	—	—	—

2.3 Mean$_S$ingle(20260212Breaks) − Student − tdf3

2.4 Mean$_S$ingle(20260212Breaks) − Student − tdf3

2.5 Mean$_S$ingle(20260212Breaks) − Student − tdf5

2.6 Mean$_S$ingle(20260212Breaks) − Student − tdf5

3 Mean$_S$ingle(20260213Breaks)

This section contains results for mean$_s$ingle(20260213breaks).

Table 4: Mean Single Results - Student-tdf3

Method	RMSE	MAE	Bias
Simple Exp. Smoothing (SES)	0.9825	0.8055	0.1534
SARIMA + Break Dummy (oracle Tb)	1.1240	0.8670	0.1357
SARIMA Global	—	—	—
SARIMA Rolling	—	—	—

Table 5: Mean Single Results - Student-tdf3

Method	RMSE	MAE	Bias
SARIMA + Break Dummy (oracle Tb)	1.2176	0.8826	0.1855
Simple Exp. Smoothing (SES)	1.2633	0.9438	0.0473
SARIMA Global	—	—	—
SARIMA Rolling	—	—	—

Table 6: Mean Single Results - Student-tdf5

Method	RMSE	MAE	Bias
SARIMA + Break Dummy (oracle Tb)	1.1699	0.9351	0.2816
Simple Exp. Smoothing (SES)	1.2290	1.0607	0.3414
SARIMA Global	—	—	—
SARIMA Rolling	—	—	—

Table 7: Mean Single Results - Student-tdf5

Method	RMSE	MAE	Bias
SARIMA + Break Dummy (oracle Tb)	1.1782	0.8878	0.3303
Simple Exp. Smoothing (SES)	1.2694	0.9644	0.1962
SARIMA Global	—	—	—
SARIMA Rolling	—	—	—

3.1 $\mathbf{Mean}_{S}ingle(20260213Breaks) - Gaussian$

Table 8: Mean Single Results - Gaussian

Method	RMSE	MAE	Bias
SARIMA Global	0.9850	0.9119	0.0984
SARIMA Rolling	0.9879	0.9070	0.0377
SARIMA + Break Dummy (oracle Tb)	1.1398	1.0641	-0.0498
Simple Exp. Smoothing (SES)	1.1600	1.0012	-0.3293

3.2 $\mathbf{Mean}_{S}ingle(20260213Breaks) - Student - tdf3$

3.3 $\mathbf{Mean}_{S}ingle(20260213Breaks) - Student - tdf5$

4 $\mathbf{Parameter}_{R}ecurring(20260213Breaks)$

This section contains results for parameter$_{r}ecurring(20260213breaks)$.

Table 9: Mean Single Results - Student-tdf3

Method	RMSE	MAE	Bias
SARIMA + Break Dummy (oracle Tb)	0.9359	0.6666	0.5477
Simple Exp. Smoothing (SES)	1.0029	0.8446	0.2053
SARIMA Global	1.1386	0.7599	0.7591
SARIMA Rolling	1.1950	0.8281	0.6137

Table 10: Mean Single Results - Student-tdf5

Method	RMSE	MAE	Bias
SARIMA Global	0.9903	0.8471	0.0077
SARIMA + Break Dummy (oracle Tb)	0.9956	0.8117	-0.1953
SARIMA Rolling	1.0360	0.9092	-0.0458
Simple Exp. Smoothing (SES)	1.1983	1.0891	-0.4101

4.1 $\textbf{Parameter}_{R}ecurring(20260213Breaks) - p09$

Table 11: Parameter Recurring Results - p09

Method	RMSE	MAE	Bias	Variance
Global SARIMA	1.2675	1.0715	0.1426	1.5863
Rolling SARIMA	1.3709	1.2187	0.1557	1.8550
MS AR	1.4163	1.2082	0.0722	2.0006

4.2 $\textbf{Parameter}_{R}ecurring(20260213Breaks) - p095$

Table 12: Parameter Recurring Results - p095

Method	RMSE	MAE	Bias	Variance
Rolling SARIMA	1.2691	1.1563	-0.1392	1.5913
Global SARIMA	1.3297	1.1595	-0.1544	1.7443
MS AR	1.6367	1.3973	0.0740	2.6732

4.3 $\textbf{Parameter}_{R}ecurring(20260213Breaks) - p099$

Table 13: Parameter Recurring Results - p099

Method	RMSE	MAE	Bias	Variance
MS AR	1.3499	1.1722	0.1302	1.8052
Rolling SARIMA	1.3657	1.1970	0.1081	1.8536
Global SARIMA	1.3941	1.2077	0.0651	1.9394

5 Parameter$_{S}ingle(20260212Breaks)$

This section contains results for parameter$_{s}ingle(20260212breaks)$.

5.1 Parameter$_{S}ingle(20260212Breaks) - Gaussian$

Table 14: Parameter Single Results - Gaussian

Method	RMSE	MAE	Bias	Variance
MS AR	1.1212	0.9162	-0.2833	1.1768
Global SARIMA	—	—	—	—
Rolling SARIMA	—	—	—	—

5.2 Parameter$_{S}ingle(20260212Breaks) - Gaussian$

Table 15: Parameter Single Results - Gaussian

Method	RMSE	MAE	Bias	Variance
MS AR	1.0735	0.8456	0.0353	1.1512
Global SARIMA	—	—	—	—
Rolling SARIMA	—	—	—	—

5.3 Parameter$_{S}ingle(20260212Breaks) - Student - tdf3$

Table 16: Parameter Single Results - Student-tdf3

Method	RMSE	MAE	Bias	Variance
MS AR	3.4101	1.6459	1.0060	10.6166
Global SARIMA	—	—	—	—
Rolling SARIMA	—	—	—	—

5.4 Parameter$_{S}ingle(20260212Breaks) - Student - tdf3$

Table 17: Parameter Single Results - Student-tdf3

Method	RMSE	MAE	Bias	Variance
MS AR	1.0502	0.7118	-0.0138	1.1027
Global SARIMA	—	—	—	—
Rolling SARIMA	—	—	—	—

Table 18: Parameter Single Results - Student-tdf5

Method	RMSE	MAE	Bias	Variance
MS AR	0.8861	0.8291	-0.3022	0.6939
Global SARIMA	—	—	—	—
Rolling SARIMA	—	—	—	—

Table 19: Parameter Single Results - Student-tdf5

Method	RMSE	MAE	Bias	Variance
MS AR	0.9653	0.7309	0.0408	0.9302
Global SARIMA	—	—	—	—
Rolling SARIMA	—	—	—	—

5.5 $\textbf{Parameter}_{S}ingle(20260212Breaks) - Student - tdf5$

5.6 $\textbf{Parameter}_{S}ingle(20260212Breaks) - Student - tdf5$

6 $\textbf{Parameter}_{S}ingle(20260213Breaks)$

This section contains results for parameter$_{s}ingle(20260213breaks)$.

6.1 $\textbf{Parameter}_{S}ingle(20260213Breaks) - Gaussian$

Table 20: Parameter Single Results - Gaussian

Method	RMSE	MAE	Bias	Variance
Rolling SARIMA	1.1190	0.8938	-0.2841	1.1715
MS AR	1.1212	0.9162	-0.2833	1.1768
Global SARIMA	1.2706	0.9965	-0.3358	1.5016

6.2 $\textbf{Parameter}_{S}ingle(20260213Breaks) - Student - tdf3$

Table 21: Parameter Single Results - Student-tdf3

Method	RMSE	MAE	Bias	Variance
Rolling SARIMA	1.2528	0.9521	-0.0633	1.5655
Global SARIMA	1.3277	1.1018	-0.1449	1.7418
MS AR	3.4101	1.6459	1.0060	10.6166

6.3 $\textbf{Parameter}_{S}ingle(20260213Breaks) - Student - tdf5$

7 $\textbf{Variance}_{R}ecurring(20260213Breaks)$

This section contains results for variance$_{r}ecurring(20260213breaks)$.

Table 22: Parameter Single Results - Student-tdf5

Method	RMSE	MAE	Bias	Variance
MS AR	0.8861	0.8291	-0.3022	0.6939
Rolling SARIMA	1.0738	0.9428	-0.0976	1.1436
Global SARIMA	1.1083	1.0098	-0.1715	1.1989

Table 23: Variance Recurring Results - MarkovSwitching

Method	RMSE	MAE	Bias	Variance	Successes
SARIMA Global	1.7994	1.4932	-0.1874	3.2028	10
SARIMA Rolling	1.8878	1.5463	-0.1852	3.5296	10
SARIMA Avg-Window	1.8878	1.5463	-0.1852	3.5296	10
MS AR(1)	1.9063	1.6385	-0.0966	3.6245	10

7.1 $\textbf{Variance}_{R}ecurring(20260213Breaks) - MarkovSwitching$

8 $\textbf{Variance}_{S}ingle(20260212Breaks)$

This section contains results for $\text{variance}_{s}ingle(20260212breaks)$.

8.1 $\textbf{Variance}_{S}ingle(20260212Breaks) - Gaussian$

Table 24: Variance Single Results - Gaussian

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	1.4769	1.3048	0.2618	2.1126	10
SARIMA Global	—	—	—	—	0
SARIMA Rolling	—	—	—	—	0
SARIMA Avg-Window	—	—	—	—	0

8.2 $\textbf{Variance}_{S}ingle(20260212Breaks) - Gaussian$

Table 25: Variance Single Results - Gaussian

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	2.0535	1.6338	0.2024	4.1759	300
SARIMA Global	—	—	—	—	0
SARIMA Rolling	—	—	—	—	0
SARIMA Avg-Window	—	—	—	—	0

Table 26: Variance Single Results - Student-tdf3

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	2.5254	2.0228	0.9078	5.5535	10
SARIMA Global	—	—	—	—	0
SARIMA Rolling	—	—	—	—	0
SARIMA Avg-Window	—	—	—	—	0

Table 27: Variance Single Results - Student-tdf3

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	2.0311	1.3335	0.2884	4.0423	300
SARIMA Global	—	—	—	—	0
SARIMA Rolling	—	—	—	—	0
SARIMA Avg-Window	—	—	—	—	0

Table 28: Variance Single Results - Student-tdf5

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	3.0309	2.2810	2.1353	4.6272	10
SARIMA Global	—	—	—	—	0
SARIMA Rolling	—	—	—	—	0
SARIMA Avg-Window	—	—	—	—	0

Table 29: Variance Single Results - Student-tdf5

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	2.2438	1.5575	0.1922	4.9975	300
SARIMA Global	—	—	—	—	0
SARIMA Rolling	—	—	—	—	0
SARIMA Avg-Window	—	—	—	—	0

8.3 $\mathbf{Variance}_Single(20260212Breaks) - Student - tdf3$

8.4 $\mathbf{Variance}_Single(20260212Breaks) - Student - tdf3$

8.5 $\mathbf{Variance}_Single(20260212Breaks) - Student - tdf5$

8.6 $\mathbf{Variance}_Single(20260212Breaks) - Student - tdf5$

9 $\mathbf{Variance}_Single(20260213Breaks)$

This section contains results for $variance_single(20260213breaks)$.

Table 30: Variance Single Results - Gaussian

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	1.4769	1.3048	0.2618	2.1126	10
SARIMA Global	1.5496	1.4153	0.3907	2.2485	10
SARIMA Rolling	1.6511	1.4857	0.4763	2.4994	10
SARIMA Avg-Window	1.6511	1.4857	0.4763	2.4994	10

Table 31: Variance Single Results - Student-tdf3

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	2.5254	2.0228	0.9078	5.5535	10
SARIMA Global	2.5853	2.0456	0.8160	6.0180	10
SARIMA Rolling	2.6679	2.1133	0.8064	6.4673	10
SARIMA Avg-Window	2.6679	2.1133	0.8064	6.4673	10

Table 32: Variance Single Results - Student-tdf5

Method	RMSE	MAE	Bias	Variance	Successes
GARCH	3.0309	2.2810	2.1353	4.6272	10
SARIMA Global	3.0660	2.3176	2.2219	4.4633	10
SARIMA Rolling	3.1092	2.3619	2.2584	4.5670	10
SARIMA Avg-Window	3.1092	2.3619	2.2584	4.5670	10

9.1 $\mathbf{Variance}_{single}(20260213Breaks) - Gaussian$

9.2 $\mathbf{Variance}_{single}(20260213Breaks) - Student - tdf3$

9.3 $\mathbf{Variance}_{single}(20260213Breaks) - Student - tdf5$

A Simulation Configuration

- Number of simulations: 300
- Time series length: 400
- Break point: 200 (single breaks)
- Rolling window size: 70
- Forecast horizon: 1-step ahead

B Innovation Types

- **Gaussian**: Standard normal distribution
- **Student-t(df=5)**: Heavy-tailed with 5 degrees of freedom
- **Student-t(df=3)**: Heavier-tailed with 3 degrees of freedom

C Methods

- **GARCH**: Generalized Autoregressive Conditional Heteroscedasticity

- **SARIMA Global**: Full-sample SARIMA fit
- **SARIMA Rolling**: Rolling-window SARIMA forecasts
- **SARIMA Avg-Window**: Average of rolling-window predictions
- **SARIMAX**: SARIMA with exogenous break dummy variable
- **SES**: Simple Exponential Smoothing
- **MS-AR**: Markov-switching autoregressive model