Parametric Market Proxy Model Report

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1. User defined inputs and rationale

In both models S_0 is defined to be 100, a neutral amount.

I used a numpy seed to make sure the reproducing the results.

For the market proxy model:

p_{HH}: probability of being at head-biased state (up-trend) at current time and staying at the same state the next period, is 0.7

p_{TT}: probability of being at tail-biased state (dn-trend) at current time and staying at the same state the next period, is 0.3

p_{FF}: probability of being at fair state (random walk) at current time and staying at the same state the next period is, 0.2

p: probability of up-move in the up-trend state is 0.7

q: probability of up-move in the dn-trend state is 0.1

Those set of parameters set up a very head prone trend, and overall makes a very volatile and upward-sticky market. Consider the cryptocurrency market: it's over all very volatile, and the long-term trend is very upward, but once you are in a downward state, it is very hard for you to have any gain.

For the Modified Proxy Model,

p_{HH}: probability of being at head-biased state (up-trend) at current time and staying at the same state the next period, is 0.5

p_{TT}: probability of being at tail-biased state (dn-trend) at current time and staying at the same state the next period, is 0.5

p_{FF}: probability of being at fair state (random walk) at current time and staying at the same state the next period is, 0.7

p: probability of up-move in the up-trend state is 0.7

q: probability of up-move in the dn-trend state is 0.3

λ1: parameter of Poisson distribution for head-biased state(up-trend) in the modified proxy model, is 15

λ2: parameter of Poisson distribution for tail-biased state(dn-trend)in the modified proxy model, is 7 λ3: parameter of Poisson distribution for fair state(random walk in the modified proxy model), is 12.

Overall this is a neutral-upward market. We have a relative high trend in staying in the random walk, and same probability of escape the upward and downward trend. But notice this setup we have a higher expected time of staying in the uptrend compared to down trend, making it more likely to stay upward.

2. Implementation

I used an Enum class to denote which coin we are currently in.

For experiment 1, two functions were implemented.

stateChange:

- Takes in parameter p_HH, p_TT, p_FF, curr (the current state)
- Generate the next state we are in

pathSim:

- Parameter: p_HH, p_TT, p_FF, p, q, S,
  - Sigma: movement size
  - L: time length
  - moveType: 'uni' or 'norm' denotes which random variable type to use.
- Return a series of asset price of length L

For experiment 2, 3 functions were implemented.

stepGenerator

- Parameter: p_HH, p_TT, p_FF, lamb1, lamb2, lamb3, curr
- This function returns a tuple of next state that we are in, and times we stay at the current stage. Notice that we decide if we switch stage after we simulate a Poisson process

stateGenerator

- Parameter: p_HH, p_TT, p_FF, lamb1, lamb2, lamb3, L
- Generate array of length L+1 representing state at each time index

pathSim: Similar to experiment 1, but with 3 lambdas

Notice I use a different scheme compared to experiment 1, where given a fixed length, we generate the state we have during the time, and then simulate the result. This helps track the history of state, and improved path simulation speed, but with the risk of exploding when L is too large, 2^24, for example. It's a matter of tradeoff.

3. Statistics Analysis

For both experiment

I used a generated path, plotted its ACF and PACF.

As we can see for experiment 1, Autocorrelation was high from 1-50, but compared to PACF, only lag 1 is significant. This makes sense since we regenerate state at each step.

For experiment 2, for a 50-period data, ACF was decreasing, since we might move to a different stage during the time, making the ACF negative.

Then I generate 10 data series to test the kurtosis and skewness

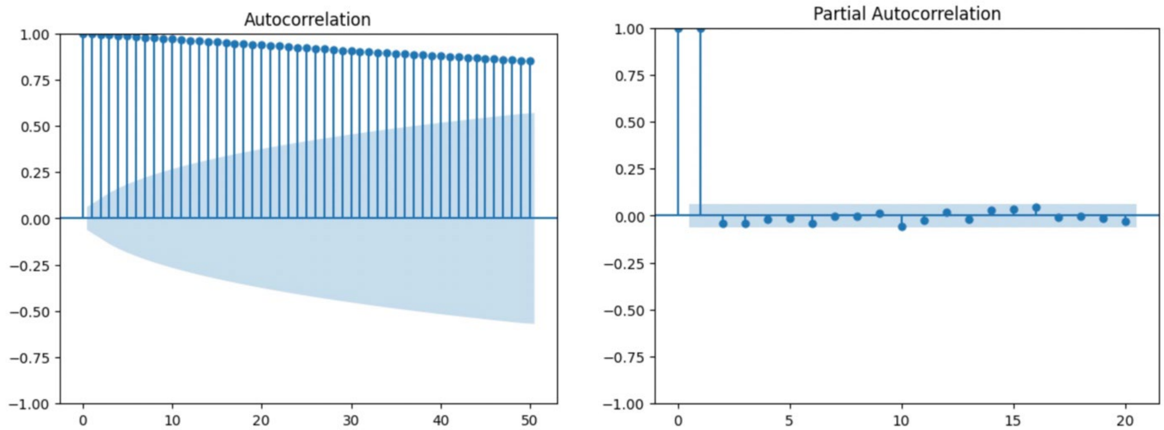
Experiment 1:

The kurtosis was negative, meaning the data's tail was slim, this makes sense since given our parameter, we expected our data is connected and close towards center.

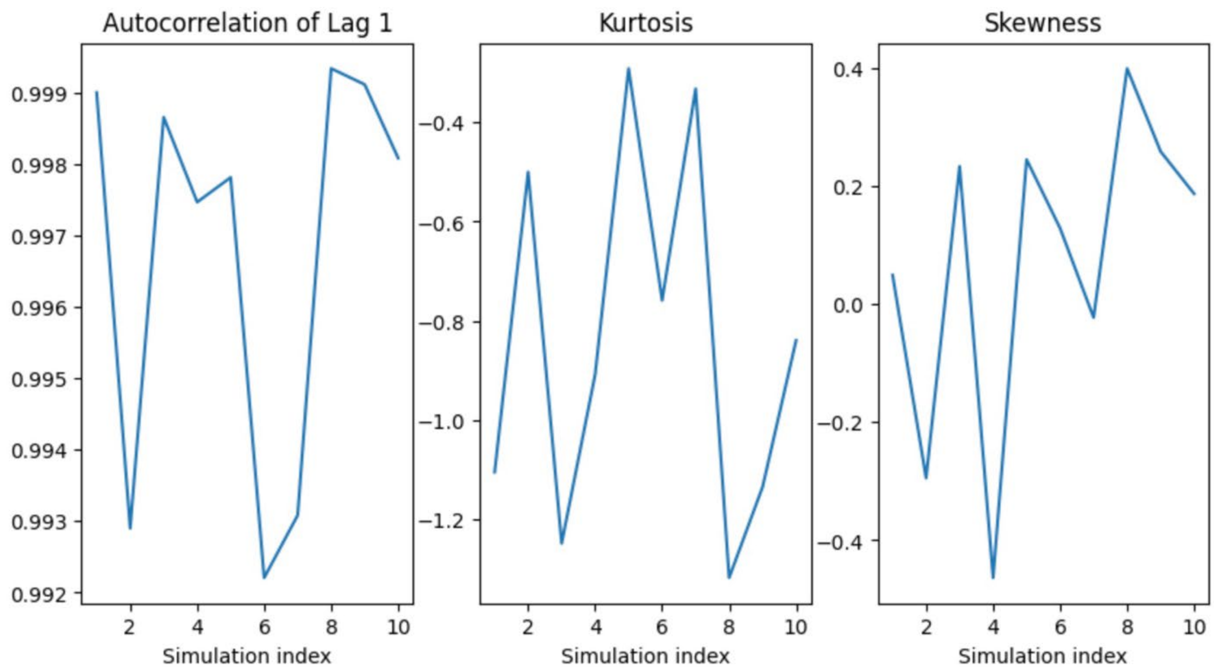
Skewness was negative, meaning it is negatively skewed, corresponding to our upward trend in both studies.

Experiment 2:

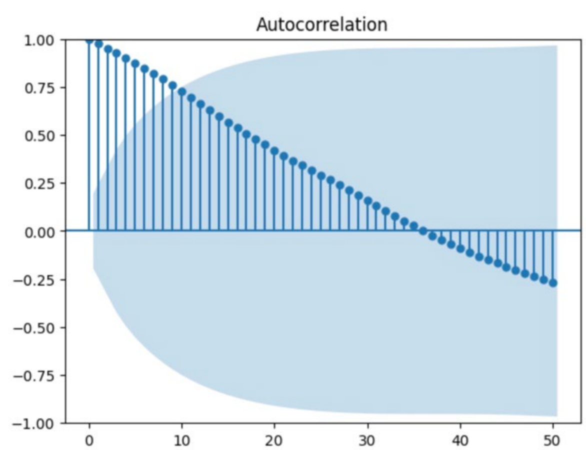
Across different experiments, kurtosis is still low, meaning centered towards middle, but the skewness varies significantly, this corresponding to the relatively neutral trend that we in.



(ACF and PACF of Market Proxy Model 1)



(Data Visualization of MPM1)



(ACF of MPM2)

	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6	Sim7	Sim8	Sim9	Sim10
Sim1	1.000000	0.540219	0.852996	-0.838109	-0.806391	-0.628877	0.103820	0.902398	0.924798	0.054136
Sim2	0.540219	1.000000	0.392002	-0.459263	-0.386969	-0.329329	-0.199796	0.621358	0.568166	0.293049
Sim3	0.852996	0.392002	1.000000	-0.821627	-0.820347	-0.591673	0.241286	0.869163	0.870831	-0.188045
Sim4	-0.838109	-0.459263	-0.821627	1.000000	0.759413	0.520004	-0.126865	-0.839715	-0.827239	-0.023861
Sim5	-0.806391	-0.386969	-0.820347	0.759413	1.000000	0.787697	0.056754	-0.855232	-0.861184	-0.056463
Sim6	-0.628877	-0.329329	-0.591673	0.520004	0.787697	1.000000	0.145041	-0.679440	-0.712744	-0.015721
Sim7	0.103820	-0.199796	0.241286	-0.126865	0.056754	0.145041	1.000000	-0.066516	0.071694	-0.399606
Sim8	0.902398	0.621358	0.869163	-0.839715	-0.855232	-0.679440	-0.066516	1.000000	0.949937	-0.038985
Sim9	0.924798	0.568166	0.870831	-0.827239	-0.861184	-0.712744	0.071694	0.949937	1.000000	0.041553
Sim10	0.054136	0.293049	-0.188045	-0.023861	-0.056463	-0.015721	-0.399606	-0.038985	0.041553	1.000000

(Cross Correlation of MPM1)

	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6	Sim7	Sim8	Sim9	Sim10
Sim1	1.000000	0.507334	0.894060	0.904417	0.652222	-0.599959	0.799385	0.903920	-0.105169	-0.741052
Sim2	0.507334	1.000000	0.412758	0.450083	0.433475	0.001635	0.399975	0.605970	0.198771	-0.517791
Sim3	0.894060	0.412758	1.000000	0.890630	0.690210	-0.552652	0.760723	0.830969	-0.135945	-0.746724
Sim4	0.904417	0.450083	0.890630	1.000000	0.520665	-0.593401	0.712017	0.798577	-0.294643	-0.667261
Sim5	0.652222	0.433475	0.690210	0.520665	1.000000	-0.073339	0.583645	0.628453	0.309199	-0.513433
Sim6	-0.599959	0.001635	-0.552652	-0.593401	-0.073339	1.000000	-0.659084	-0.468139	0.568790	0.481531
Sim7	0.799385	0.399975	0.760723	0.712017	0.583645	-0.659084	1.000000	0.861551	-0.204223	-0.845217
Sim8	0.903920	0.605970	0.830969	0.798577	0.628453	-0.468139	0.861551	1.000000	-0.030726	-0.855126
Sim9	-0.105169	0.198771	-0.135945	-0.294643	0.309199	0.568790	-0.204223	-0.030726	1.000000	-0.066465
Sim10	-0.741052	-0.517791	-0.746724	-0.667261	-0.513433	0.481531	-0.845217	-0.855126	-0.066465	1.000000

(Cross Correlation of MPM2)