Chemical Process Viscosity Readings by time series

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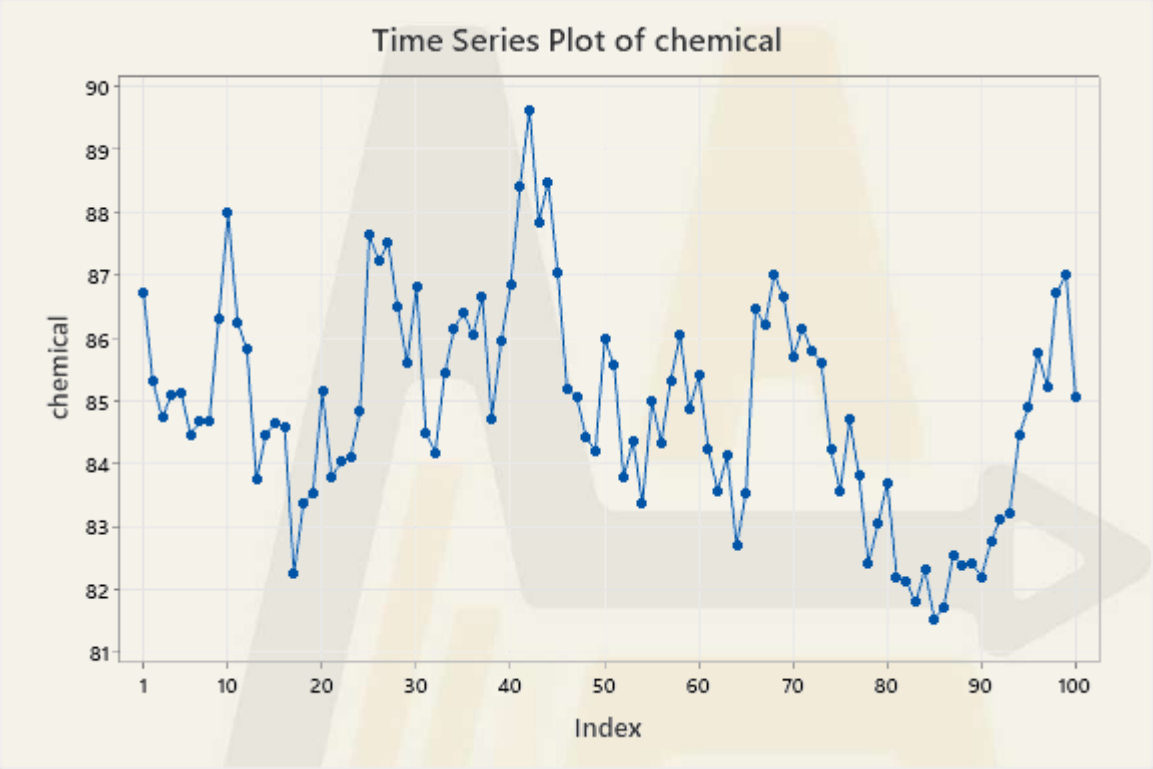
This project presents a statistical time series analysis for viscosity readings of a chemical process. The objective was to examine the stability of the process over time and forecast future behavior using ARIMA modeling.

Key Analysis Steps:

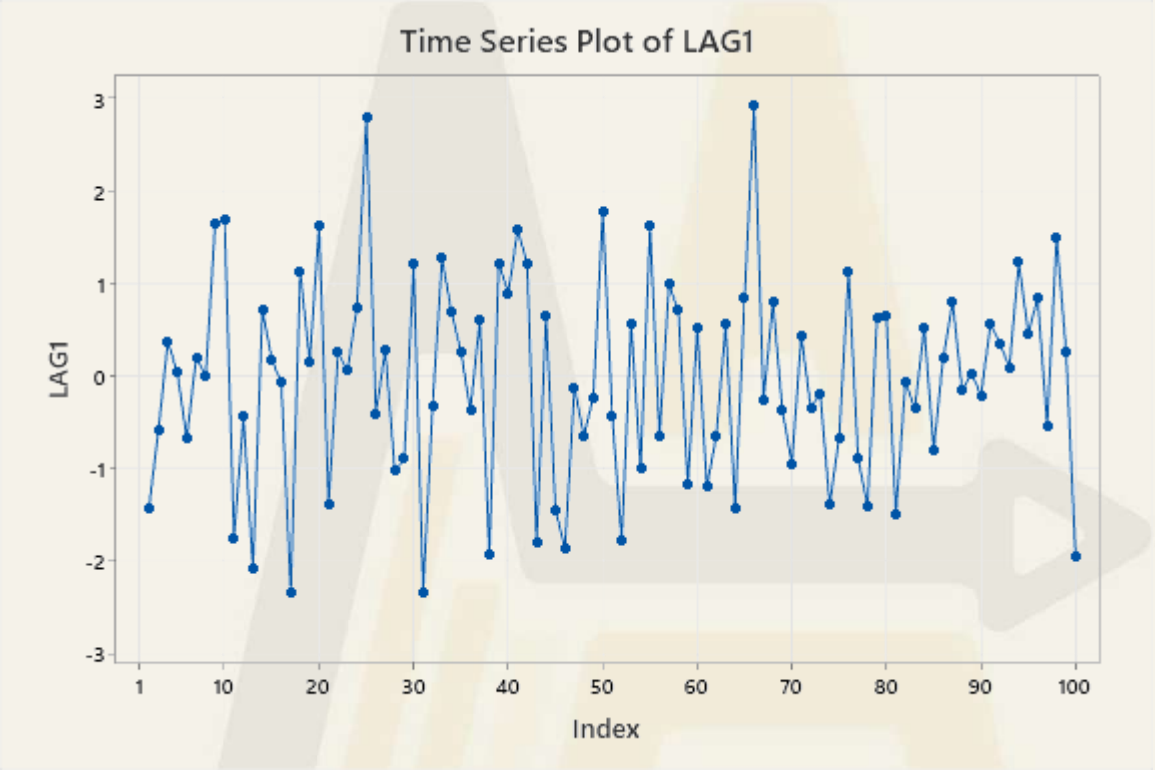
- Stationarity check using ACF, PACF, and differencing
- Identification of the best-fit model: ARIMA(1,1,1) based on minimum AICc
- Estimation of AR and MA parameters with statistical significance
- Diagnostic checks including:
- Ljung-Box test for independence of residuals
- Grubbs' test for outliers
- Normality check of residuals
- Final model validation confirmed residuals were normal and independent
- Forecasting up to 3 future time periods with 95% confidence intervals

Result:

The model captures the dynamics of the viscosity process and confirms the process follows a stable, stochastic pattern with no outliers or autocorrelation issues.



Variance is constant but mean not constant will differences lag 1

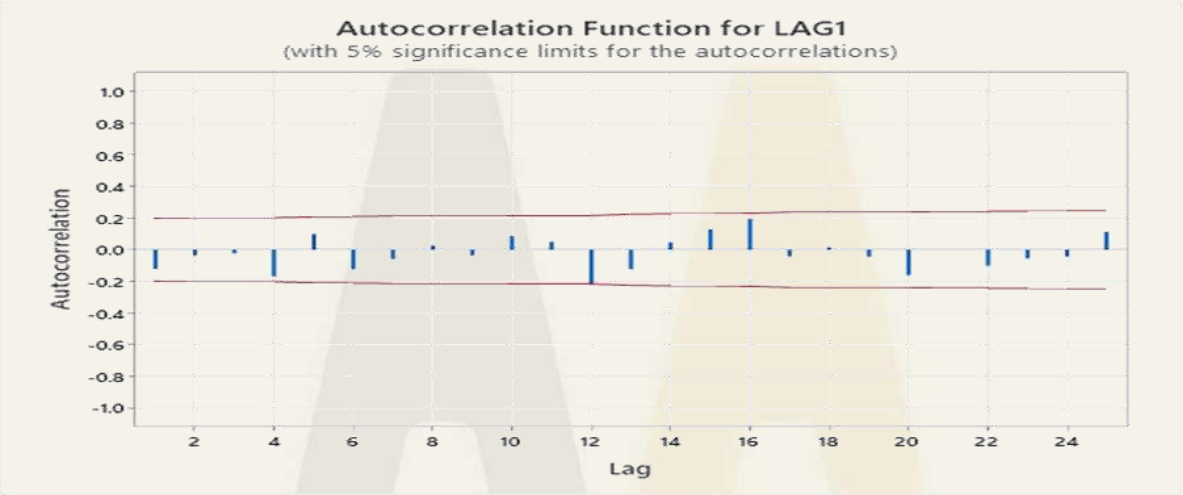


No trend **No cyclical**

No seasonality **no irregular**

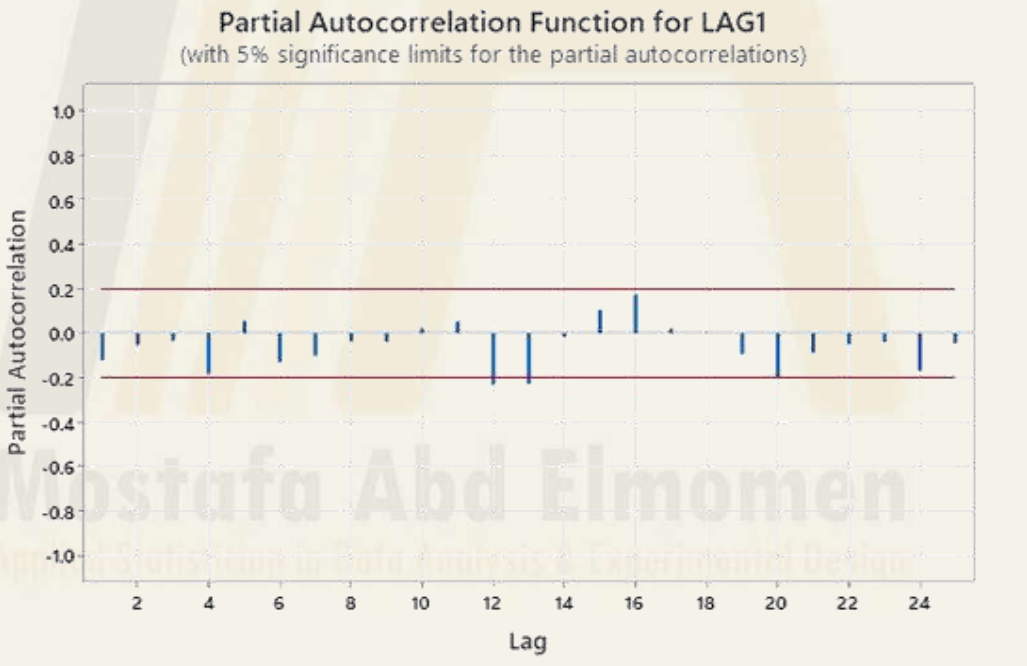
Mean and variance is constant

2- ACF AND PACF



Not cutoff but tial off

Not MA only because not cutoff but maybe ARMA OR AR



Maybe ARMA(1,1,1)

AR(1) , lag(1),MA(1)

Model Selection

Model (d = 1)	LogLikelihood	AICc	AIC	BIC
p = 1, q = 1*	-144.773	297.971	297.545	307.926
p = 1, q = 2	-144.469	299.583	298.938	311.914
p = 2, q = 1	-144.513	299.671	299.025	312.001
p = 2, q = 2	-144.227	301.367	300.454	316.025
p = 0, q = 0	-149.107	302.338	302.213	307.404
p = 0, q = 1	-148.245	302.742	302.489	310.275
p = 1, q = 0	-148.340	302.933	302.680	310.466
p = 0, q = 2	-148.036	304.498	304.073	314.453
p = 2, q = 0	-148.203	304.831	304.405	314.786

** Best model with minimum AICc. Output for the best model follows.*

Final Estimates of Parameters

Type	Coef	SE Coef	T-Value	P-Value
AR 1	0.7576	0.0787	9.63	0.000
MA 1	0.9702	0.0415	23.37	0.000
Constant	-0.00379	0.00644	-0.59	0.558

Differencing: 1 Regular
Number of observations after differencing: 99

$$\nabla Zt = \emptyset \nabla Z_{t-1} + a_t - \theta a_{t-1}$$

Where $\nabla Zt = Zt - Z_{t-1}$

AR(1)

Ø=0.7576 *P-Value =0.000 is reject ho is Ø =0*

Stationarity condition $|\emptyset| < 1$ $|0.7576|<1$

MA(1)

θ=0.9702 *P-Value =0.000 is reject ho is θ=0*

Invertibility $|\theta| < 1$ $|0.9702\ | < 1$

Costant term = -0.00379 *P-Value 0.558 > 0.05 is cannot reject ho is Costant term=0*

$$\nabla Zt=0.7576\nabla Z_{t-1} + a_t - 0.00379a_{t-1}$$

Modified Box-Pierce (Ljung-Box) Chi-Square Statistic

Lag	12	24	36	48
Chi-Square	10.68	25.69	39.32	51.73
DF	9	21	33	45
P-Value	0.298	0.219	0.208	0.228

Residuals is independent by modified box -pierce

Test

Null hypothesis H_0: The order of the data is random

Alternative hypothesis H_1: The order of the data is not random

Number of Runs

Observed	Expected	P-Value
53	50.37	0.595

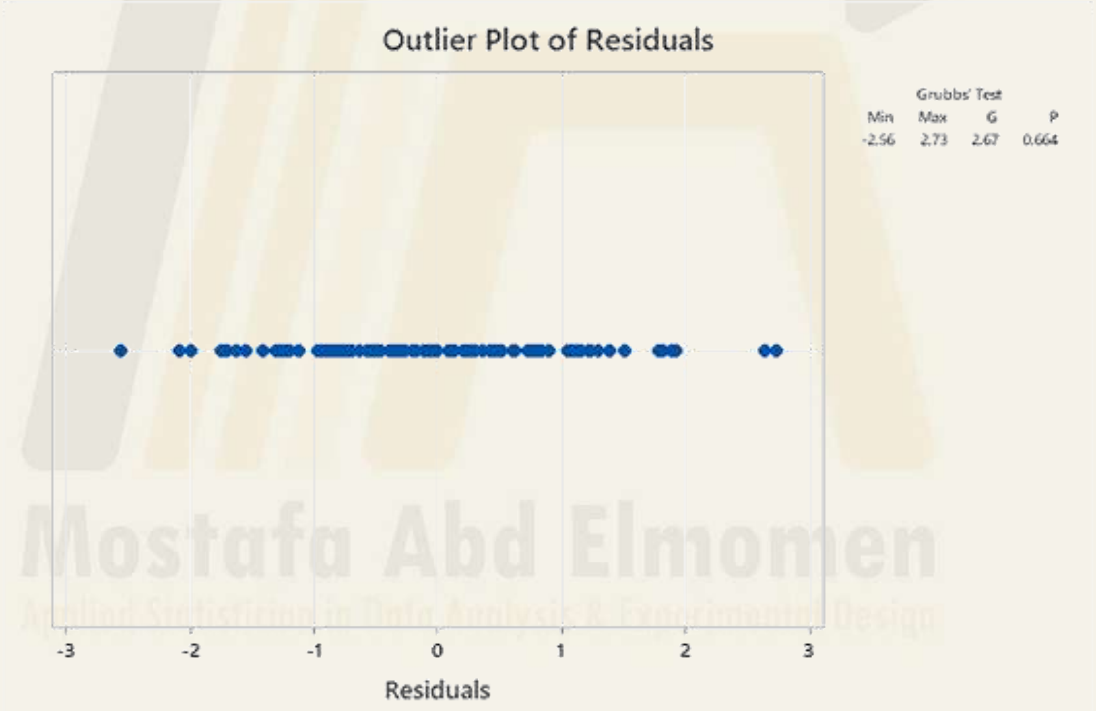
p-v >0.05 is cannot reject ho data is random

Method

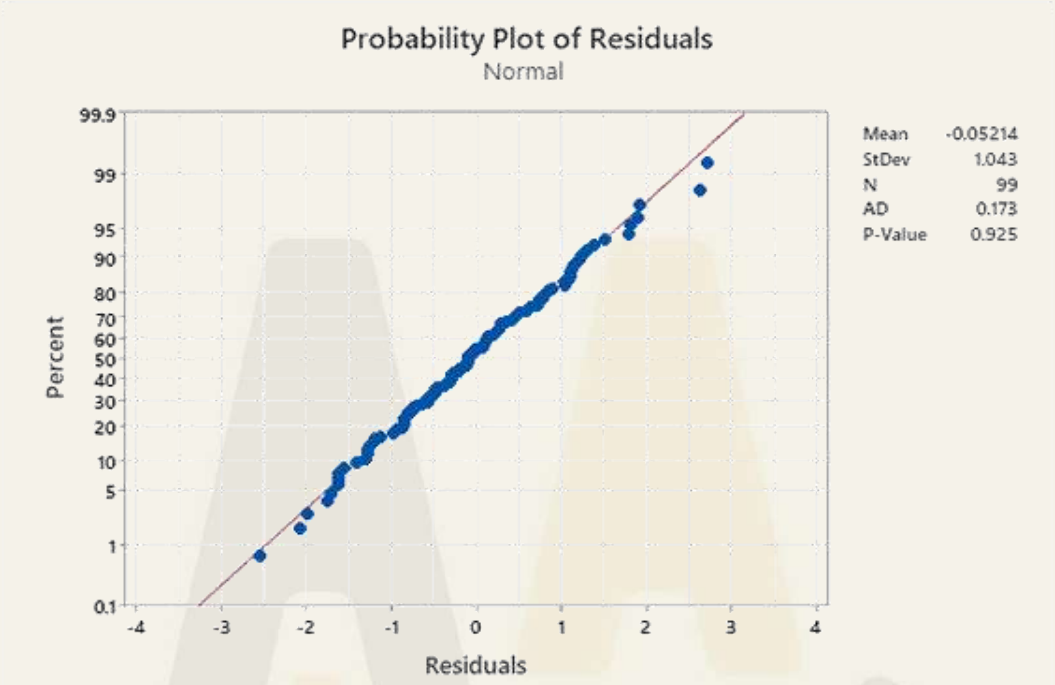
Null hypothesis	All data values come from the same normal population
Alternative hypothesis	Smallest or largest data value is an outlier
Significance level	α = 0.05

Grubbs' Test

Variable	N	Mean	StDev	Min	Max	G	P
Residuals	99	-0.052	1.043	-2.557	2.730	2.67	0.664



p-v > 0.05 cannot reject Ho is no outlier



p-v >0.05 cannot reject ho is residuals is normal

Model Summary

DF	SS	MS	MSD	AICc	AIC	BIC
96	106.914	1.11369	1.07994	297.971	297.545	307.926

MS = variance of the white noise series

Residuals is normal distribution a_t *is NIID(0, 1.11369)*

cannot reject model ARIMA(1,1,1)

$$\nabla Z_t = 0.7576 \nabla Z_{t-1} + a_t - 0.00379 a_{t-1}$$

Residuals is normal distribution a_t *is NIID(0, 1.11369)*

Forecasts from Time Period 100

			95% Limits		
Time Period	Forecast	SE Forecast	Lower	Upper	Actual
101	84.8178	1.05531	82.7489	86.8866	
102	84.6326	1.34316	81.9995	87.2657	
103	84.4885	1.49695	81.5539	87.4231	