Question 1:

$$Y_t = \beta_0 + Y_{t-1} + \varepsilon_t$$

$$\Leftrightarrow \Delta Y_t = \beta_0 + (1-1)Y_{t-1} + \varepsilon_t$$

$$\Rightarrow The\ process\ is\ non-stationary$$

Question 2:

y1t (Mink) – ACF 4

y2t (Passengers) – ACF 1

y3t (Deaths) – ACF 2

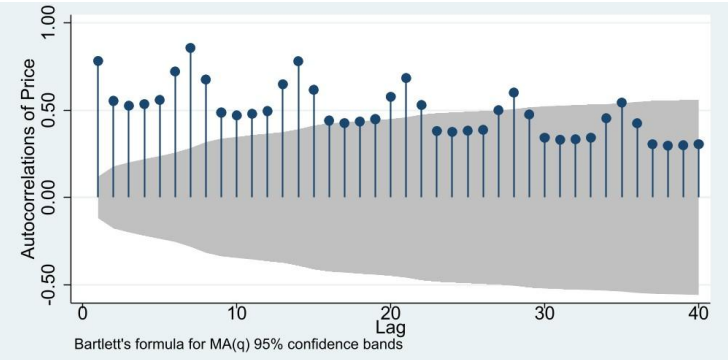
y4t (Cow's temp) – ACF 3

Question 3:

1. Stock prices of Vinamilk — sheet VNM

i. Data format
Price: %14.2fc
Td = Date: %td

ii.



iii. Unit roots test
To examine whether the Vinamilk stock price series is stationary, the Augmented Dickey–Fuller (ADF) test was conducted.

The optimal lag length was determined using the "varsoc" command in Stata, which evaluates several information criteria (AIC, BIC, HQIC). Based on these criteria, 1 lag was selected for the ADF test.

Lag-order selection criteria

Sample: **13sep2024** thru **03oct2025**, but with gaps

Number of obs = **51**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-493.69				1.6e+07	19.3996	19.4141	19.4375
1	-410.952	165.48*	1	0.000	631816*	16.1942*	16.2231*	16.2699*
2	-410.86	.18427	1	0.668	654779	16.2298	16.2732	16.3434
3	-410.854	.01093	1	0.917	680948	16.2688	16.3267	16.4203
4	-409.729	2.2505	1	0.134	677820	16.2639	16.3363	16.4533

* optimal lag
Endogenous: **Price**
Exogenous: **_cons**

Augmented Dickey–Fuller test for unit root							
Variable	**Model Specification**	**Test Statistic**	**1% Critical Value**	**5% Critical Value**	**10% Critical Value**	**p-value**	**Stationary Decision**
Price	No constant	-0.942	-2.580	-1.950	-1.620	-	Non-stationary
Price	Default	-2.496	-3.458	-2.879	-2.570	0.1165	Non-stationary
Price	Drift	-2.496	-2.340	-1.651	-1.285	0.0066	Stationary
Price	Trend	-2.112	-3.989	-3.429	-3.130	0.5391	Non-stationary
lnPrice	No constant	-0.714	-2.580	-1.950	-1.620	-	Non-stationary
lnPrice	Default	-2.421	-3.458	-2.879	-2.570	0.1358	Non-stationary
lnPrice	Drift	-2.421	-2.340	-1.651	-1.285	0.0081	Stationary
lnPrice	Trend	-2.098	-3.989	-3.429	-3.130	0.5470	Non-stationary
d1.Price	No constant	-13.647	-2.580	-1.950	-1.620	-	Stationary
d1.Price	Default	-13.677	-3.458	-2.879	-2.570	0.0000	Stationary
d1.Price	Drift	-13.677	-2.340	-1.651	-1.285	0.0000	Stationary
d1.Price	Trend	-13.831	-3.989	-3.429	-3.130	0.0000	Stationary
d1.lnPrice	No constant	-13.828	-2.580	-1.950	-1.620	-	Stationary
d1.lnPrice	Default	-13.847	-3.458	-2.879	-2.570	0.0000	Stationary
d1.lnPrice	Drift	-13.847	-2.340	-1.651	-1.285	0.0000	Stationary
d1.lnPrice	Trend	-13.976	-3.989	-3.429	-3.130	0.0000	Stationary

iv. Short interpretation

The Augmented Dickey–Fuller (ADF) test results show that both Price and ln(Price) are non-stationary at their levels, as their test statistics are higher than the critical values and p-values exceed 0.05. However, after taking the first differences, both series (d1.Price and d1.lnPrice) become highly stationary, with large negative test statistics and p-values of 0.0000. This indicates that each variable is integrated of order one, I(1). In other words, the original series contain a unit root but become stable after differencing once. Therefore, for further time-series modeling, the first-differenced or log-differenced data should be used to ensure stationarity.

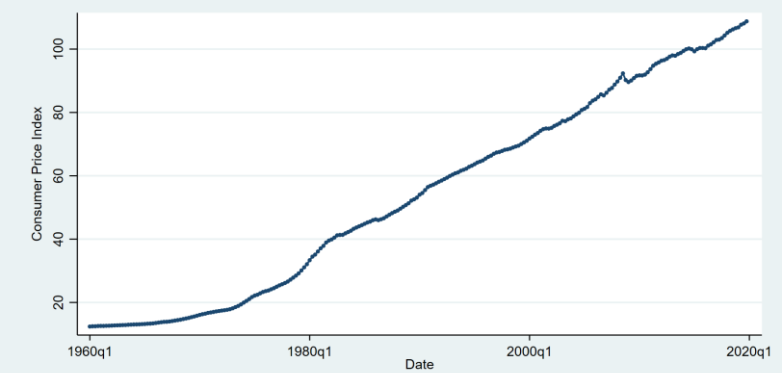
2. Seasonally adjusted US CPI — sheet PC

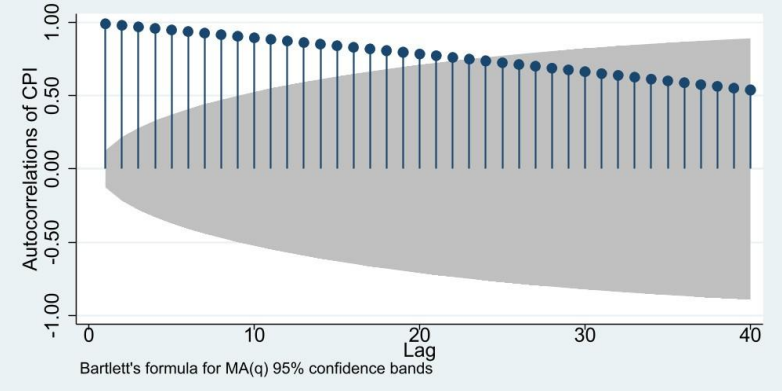
i. Data format

CPI: %10.0g

Tq = Date: %tq

ii.





iii. Unit roots test

To examine whether the CPI is stationary, the Augmented Dickey–Fuller (ADF) test was conducted.

The optimal lag length was determined using the "varsoc" command in Stata, which evaluates several information criteria (AIC, BIC, HQIC). Based on these criteria, 4 lags was selected for the ADF test.

Lag-order selection criteria

Sample: **1961q1** thru **2019q4** Number of obs = **236**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1145.53				971.113	9.71632	9.72224	9.731
1	-83.1724	2124.7	1	0.000	.120503	.7218	.733633	.751154
2	-63.0843	40.176	1	0.000	.102505	.560037	.577786*	.604069*
3	-63.0808	.00713	1	0.933	.103375	.568481	.592147	.62719
4	-59.6983	6.765*	1	0.009	.101309*	.548291*	.577873	.621677

* optimal lag
Endogenous: **CPI**
Exogenous: **_cons**

Augmented Dickey–Fuller test for unit root							
Variable	**Model Specification**	**Test Statistic**	**1% Critical Value**	**5% Critical Value**	**10% Critical Value**	**p-value**	**Stationary Decision**
CPI	No constant	3.890	-2.582	-1.950	-1.619	-	Stationary
CPI	Default	1.597	-3.465	-2.881	-2.571	0.9978	Non-stationary
CPI	Drift	1.597	-2.343	-2.343	-1.285	0.9441	Non-stationary
CPI	Trend	-3.680	-3.995	-3.432	-3.132	0.0237	Stationary at 5% significant level
lnCPI	No constant	2.003	-2.582	-1.950	-1.619	-	Non-stationary
lnCPI	Default	-1.844	-3.465	-2.881	-2.571	0.3587	Non-stationary
lnCPI	Drift	-1.844	-2.343	-2.343	-1.285	0.0332	Stationary at 5% significant level
lnCPI	Trend	-0.766	-3.995	-3.432	-3.132	0.9685	Non-stationary
d1.CPI	No constant	-17.723	-2.582	-1.950	-1.619	-	Stationary
d1.CPI	Default	-17.683	-3.465	-2.881	-2.571	0.0000	Stationary
d1.CPI	Drift	-17.683	-2.343	-2.343	-1.285	0.0000	Stationary
d1.CPI	Trend	-17.645	-3.995	-3.432	-3.132	0.0000	Stationary
d1.lnCPI	No constant	-16.856	-2.582	-1.950	-1.619	-	Stationary
d1.lnCPI	Default	-16.819	-3.465	-2.881	-2.571	0.0000	Stationary
d1.lnCPI	Drift	-16.819	-2.343	-2.343	-1.285	0.0000	Stationary
d1.lnCPI	Trend	-16.782	-3.995	-3.432	-3.132	0.0000	Stationary

iv. Short interpretation

The Augmented Dickey–Fuller (ADF) test results indicate that the CPI and ln(CPI) series are mostly non-stationary at their levels, as their test statistics are higher than the critical values and have high p-values. However, the CPI (trend model) and ln(CPI) (drift model) show weak evidence of stationarity at the 5% significance level. After taking the first differences, both d1.CPI and d1.lnCPI become highly stationary, with very low p-values (0.0000) and large negative test statistics across all model specifications. This confirms that both series are integrated of order one, I(1). Therefore, for further analysis, the first-differenced or log-differenced versions of CPI should be used to ensure stationarity in the model.

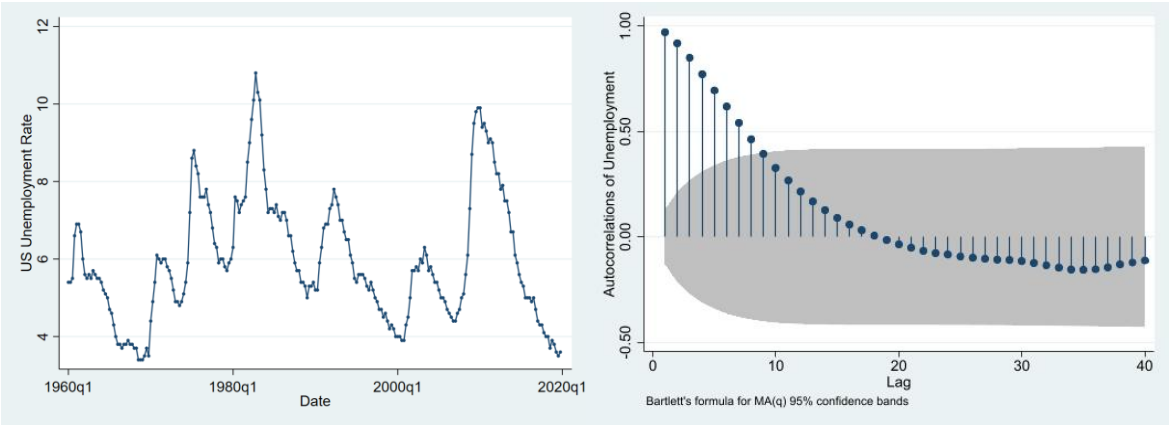
3. Seasonally adjusted US unemployment rate — sheet PC

i. Data format

Unemployment: %10.0g

Td = Date: %td

ii.



iii. Unit roots test

To examine whether the US Unemployment Rate is stationary, the Augmented Dickey–Fuller (ADF) test was conducted.

The optimal lag length was determined using the “varsoc” command in Stata, which evaluates several information criteria (AIC, BIC, HQIC). Based on these criteria, 3 lags was selected for the ADF test.

Lag-order selection criteria

Sample: **1961q1** thru **2019q4** Number of obs = **236**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-449.246				2.65852	3.81565	3.82156	3.83032
1	-82.8745	732.74	1	0.000	.1202	.719276	.731109	.74863
2	-43.8702	78.009	1	0.000	.087102	.397205	.414955	.441237
3	-39.4497	8.8411*	1	0.003	.084614*	.368217*	.391884*	.426926*
4	-39.277	.3454	1	0.557	.08521	.375228	.404811	.448615

* optimal lag
Endogenous: **Unemployment**
Exogenous: **_cons**

Augmented Dickey–Fuller test for unit root

Variable	Model Specification	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value	Stationary Decision
Unemployment	No constant	-1.236	-2.582	-1.950	-1.619	-	Non-stationary
Unemployment	Default	-3.435	-3.465	-2.881	-2.571	0.0098	Stationary
Unemployment	Drift	-3.435	-2.343	-2.343	-1.285	0.0004	Stationary
Unemployment	Trend	-3.435	-3.995	-3.432	-3.132	0.0469	Stationary at 5% significant level
lnUnemployment	No constant	-0.958	-2.582	-1.950	-1.619	-	Non-stationary
lnUnemployment	Default	-3.396	-3.465	-2.881	-2.571	0.0111	Stationary at 5% significant level
lnUnemployment	Drift	-3.396	-2.343	-2.343	-1.285	0.0004	Stationary
lnUnemployment	Trend	-3.393	-3.995	-3.432	-3.132	0.0523	Stationary at 10% significant level
d1.Unemployment	No constant	-12.763	-2.582	-1.950	-1.619	-	Stationary
d1.Unemployment	Default	-12.736	-3.465	-2.881	-2.571	0.0000	Stationary
d1.Unemployment	Drift	-12.736	-2.343	-2.343	-1.285	0.0000	Stationary
d1.Unemployment	Trend	-12.709	-3.995	-3.432	-3.132	0.0000	Stationary
d1.lnUnemployment	No constant	-13.302	-2.582	-1.950	-1.619	-	Stationary
d1.lnUnemployment	Default	-13.273	-3.465	-2.881	-2.571	0.0000	Stationary
d1.lnUnemployment	Drift	-13.273	-2.343	-2.343	-1.285	0.0000	Stationary
d1.lnUnemployment	Trend	-13.245	-3.995	-3.432	-3.132	0.0000	Stationary

iv. Short interpretation

The Augmented Dickey–Fuller (ADF) test results show that the Unemployment and ln(Unemployment) series are mostly stationary at their levels, as their test statistics are more negative than the critical values and the p-values are below 0.05 in several model specifications. Specifically, both variables are stationary under the default, drift, and trend models at the 5% significance level. After first differencing, the series (d1.Unemployment and d1.lnUnemployment) remain strongly stationary, with extremely low p-values (0.0000). This confirms that the unemployment series are at least integrated of order zero, I(0), or possibly weakly I(1) depending on model selection. Overall, the results indicate that the unemployment data are generally stationary, and differencing is not strictly necessary for further analysis.

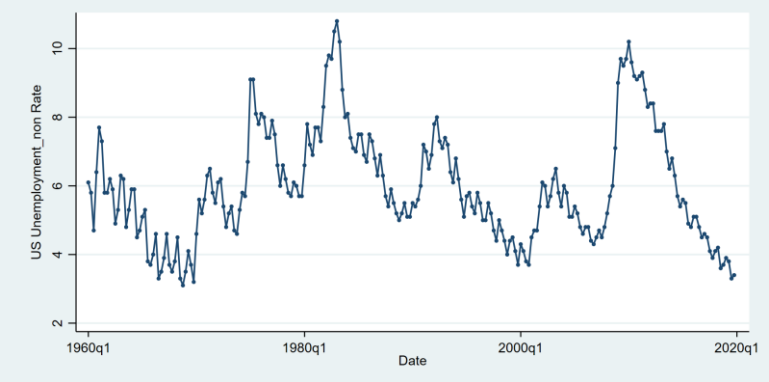
4. Non-seasonally adjusted US unemployment rate — sheet PC

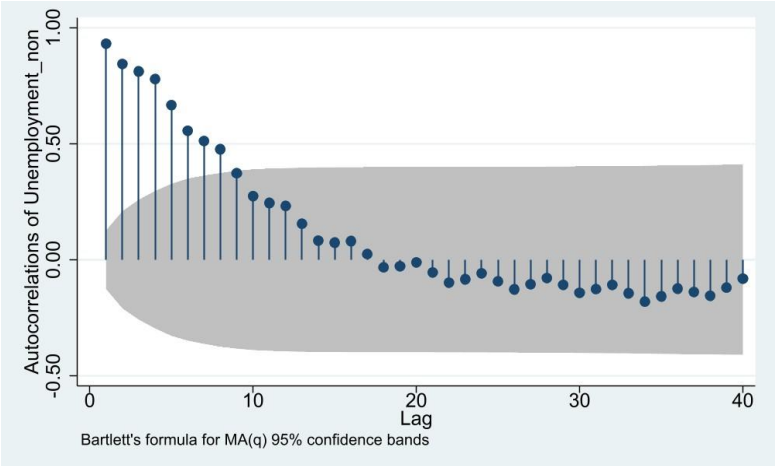
i. Data format

Unemployment_non: %10.0g

Td = Date: %td

ii.





iii. Unit roots test

To examine whether the Non-seasonally adjusted US unemployment rate is stationary, the Augmented Dickey–Fuller (ADF) test was conducted.

The optimal lag length was determined using the "varsoc" command in Stata, which evaluates several information criteria (AIC, BIC, HQIC). Based on these criteria, 4 lags was selected for the ADF test.

Lag-order selection criteria

Sample: **1961q1** thru **2019q4** Number of obs = **236**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-452.532				2.73358	3.84349	3.84941	3.85817
1	-201.05	502.96	1	0.000	.327222	1.72076	1.73259	1.75012
2	-196.163	9.7734	1	0.002	.31662	1.68782	1.70557	1.73185
3	-172.008	48.31	1	0.000	.260207	1.49159	1.51526	1.5503
4	-165.219	13.578*	1	0.000	.24775*	1.44254*	1.47212*	1.51592*

* optimal lag
Endogenous: **Unemployment_non**
Exogenous: **_cons**

Augmented Dickey–Fuller test for unit root							
Variable	Model Specification	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value	Stationary Decision
Unemployment_non	No constant	-1.485	-2.583	-1.950	-1.619	-	Non-stationary
Unemployment_non	Default	-4.628	-3.466	-2.881	-2.571	0.0001	Stationary
Unemployment_non	Drift	-4.628	-2.343	-1.652	-1.285	0.0000	Stationary
Unemployment_non	Trend	-4.628	-3.996	-3.433	-3.133	0.0009	Stationary
lnUnemployment_non	No constant	-1.056	-2.583	-1.950	-1.619	-	Non-stationary
lnUnemployment_non	Default	-4.386	-3.466	-2.881	-2.571	0.0003	Stationary
lnUnemployment_non	Drift	-4.386	-2.343	-1.652	-1.285	0.0000	Stationary
lnUnemployment_non	Trend	-4.377	-3.996	-3.433	-3.133	0.0024	Stationary
d1.Unemployment_non	No constant	-21.790	-2.583	-1.950	-1.619	-	Stationary
d1.Unemployment_non	Default	-21.742	-3.466	-2.881	-2.571	0.0000	Stationary
d1.Unemployment_non	Drift	-21.742	-2.343	-1.652	-1.285	0.0000	Stationary
d1.Unemployment_non	Trend	-21.691	-3.996	-3.433	-3.133	0.0000	Stationary
d1.lnUnemployment_non	No constant	-24.806	-2.583	-1.950	-1.619	-	Stationary
d1.lnUnemployment_non	Default	-24.752	-3.466	-2.881	-2.571	0.0000	Stationary
d1.lnUnemployment_non	Drift	-24.752	-2.343	-1.652	-1.285	0.0000	Stationary
d1.lnUnemployment_non	Trend	-24.694	-3.996	-3.433	-3.133	0.0000	Stationary

iv. Short interpretation

The Augmented Dickey–Fuller (ADF) test results indicate that both Unemployment_non and ln(Unemployment_non) are stationary at their levels across most model specifications. Their test statistics are well below the critical values, and p-values are highly significant (below 0.01), confirming rejection of the null hypothesis of a unit root. This means that these variables do not exhibit trends or stochastic drift over time. After first differencing, the variables remain strongly stationary, with extremely large negative test statistics and p-values of 0.0000. Overall, the results suggest that Unemployment_non and its logarithmic form are stationary (I(0)), so differencing is not necessary for subsequent time-series analysis.