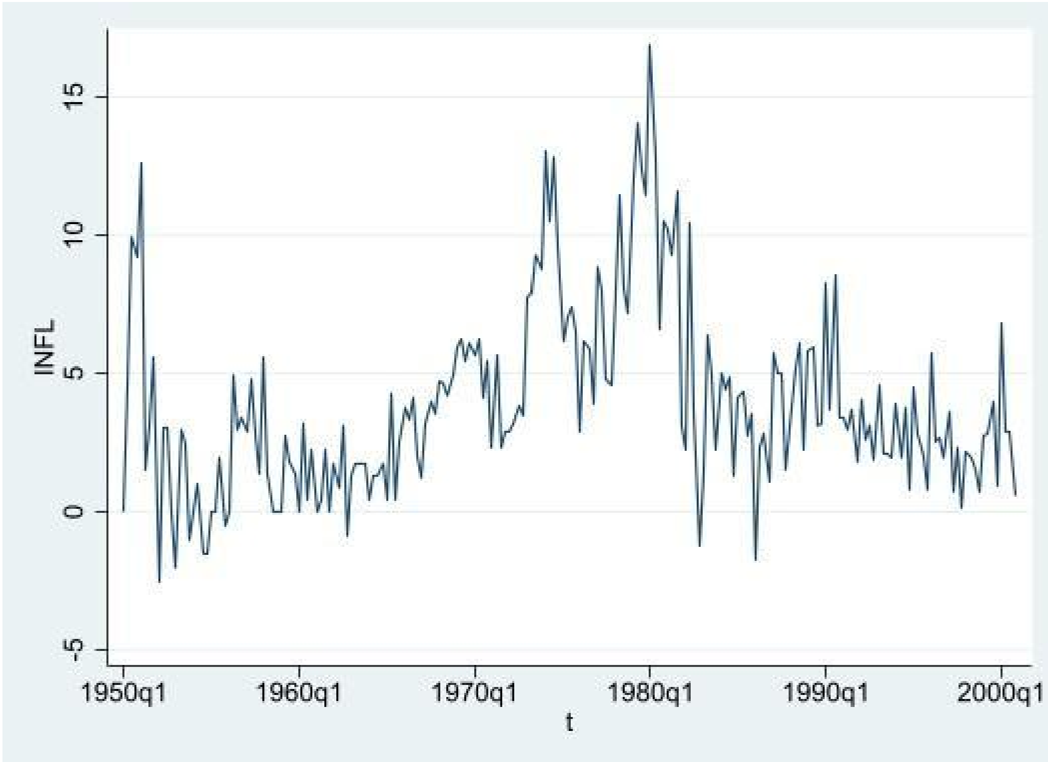
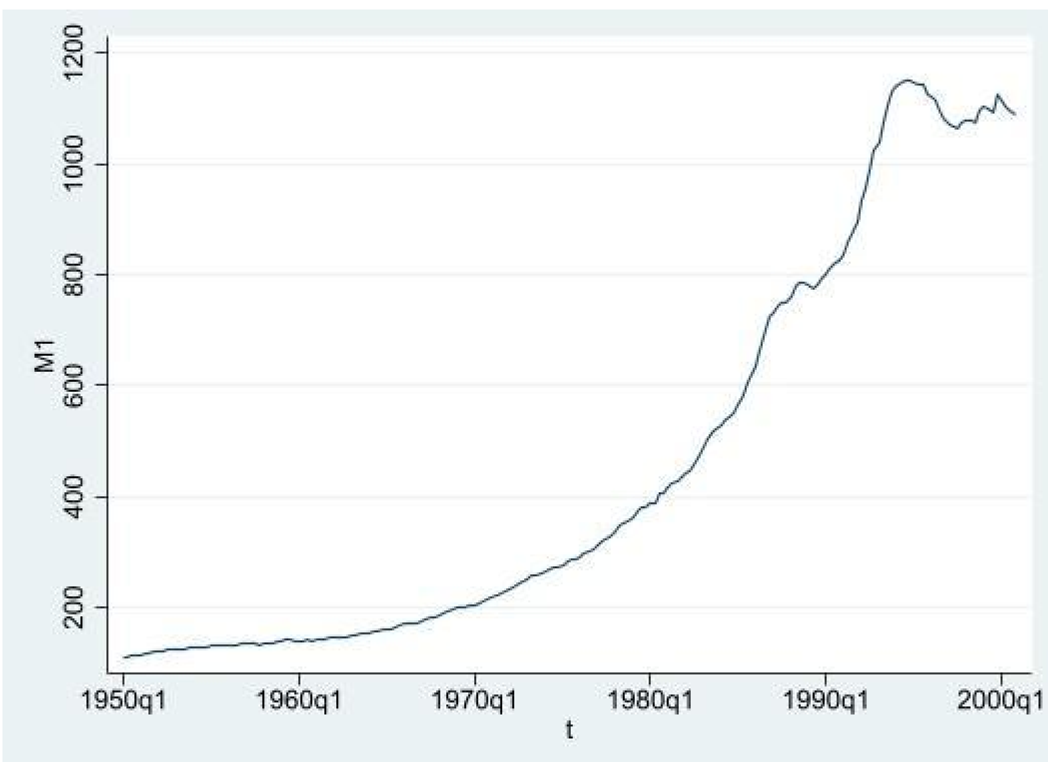
Demand for Money

Answers

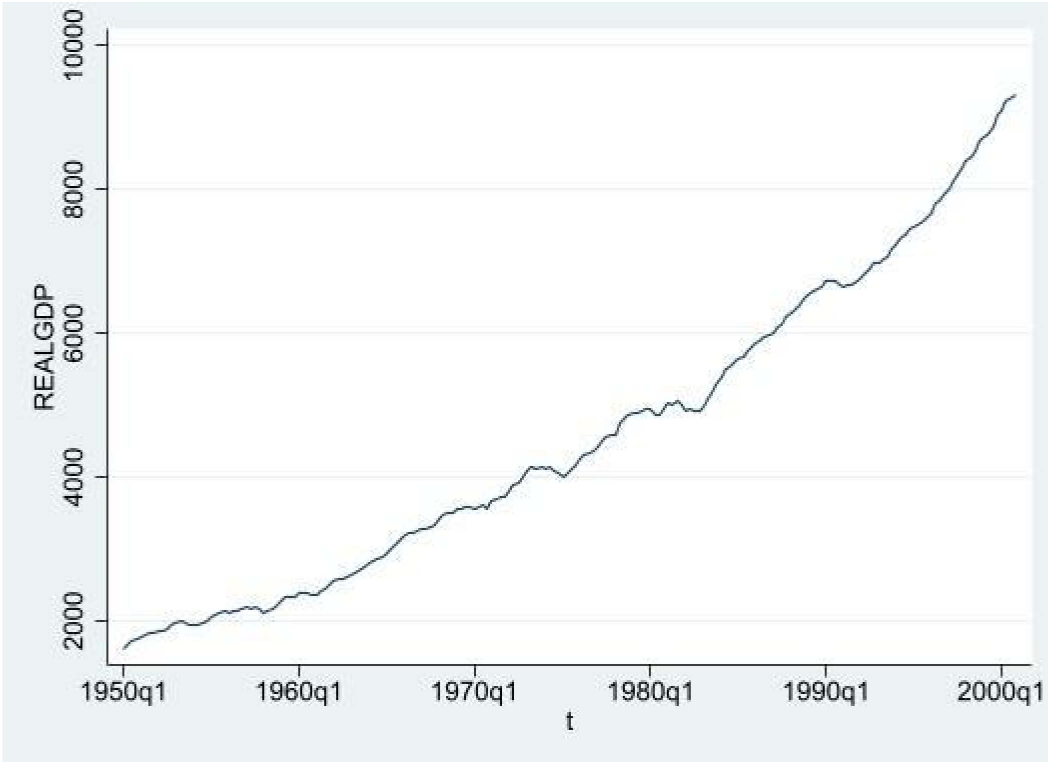
1. Plot

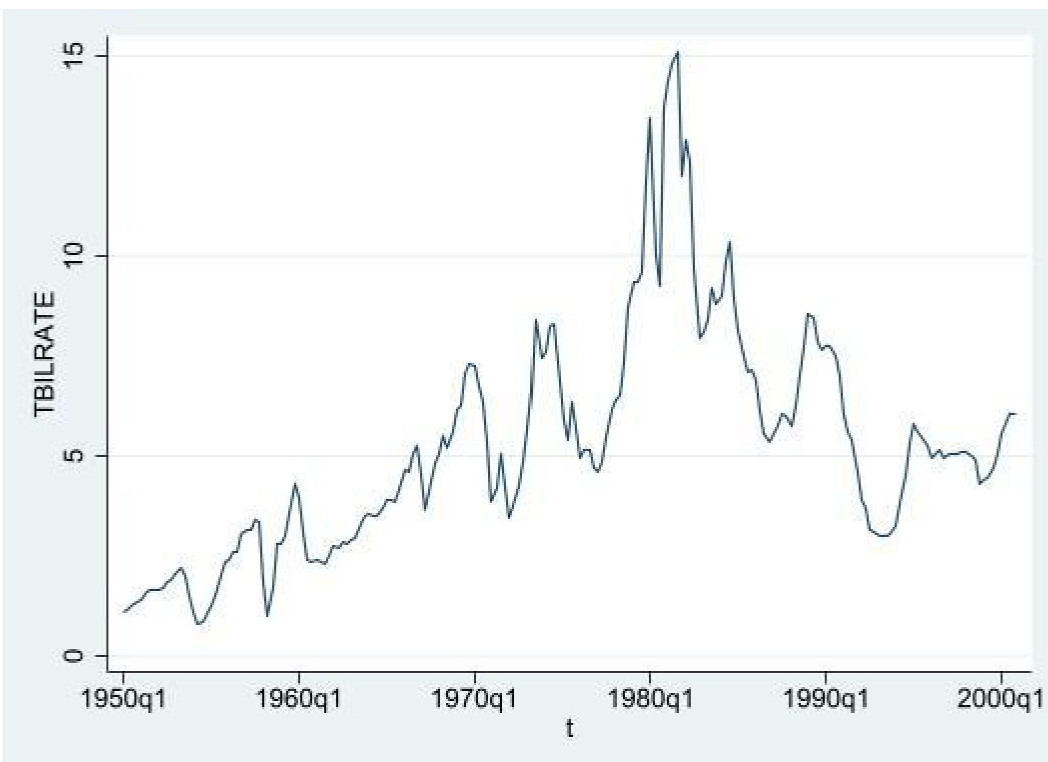


INFL
15
10
5
0
-5
1950q1
1960q1
1970q1
1980q1
1990q1
2000q1
t



M1
1200
1000
800
600
400
200
1950q1
1960q1
1970q1
1980q1
1990q1
2000q1
t


REALGDP
10000
8000
6000
4000
2000
1950q1
1960q1
1970q1
1980q1
1990q1
2000q1
t


TBILRATE
15
10
5
0
1950q1
1960q1
1970q1
1980q1
1990q1
2000q1
t

2. Model

Assuming money supply equals money demand, estimate the static demand for money equation below:

$$lm_t = \beta_0 + \beta_1 inf_t + \beta_2 ly_t + \beta_3 tbilrate_t + u_t$$

a) Model estimation

Estimate the model above using Ordinary Least Squares. Report the estimation output

VARIABLES	(1) OLSmodel lmt
INFL	-0.00840*
	(0.00442)
lyt	1.696***
	(0.0296)
TBILRATE	-0.0251***
	(0.00616)
Constant	-8.132***
	(0.233)
Observations	204
R-squared	0.956

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

b) Coefficients interpretation

Carefully interpret the estimated coefficients (including the intercept). Are the signs of the coefficients consistent with economic theory? Explain your reasoning.

c) Statistics significance

Test the statistical significance of the coefficients of the independent variables: inflation, real GDP and interest rates using the critical values corresponding to the t-distribution and the test p-values. Carefully state the null and alternative hypotheses. Interpret your results.

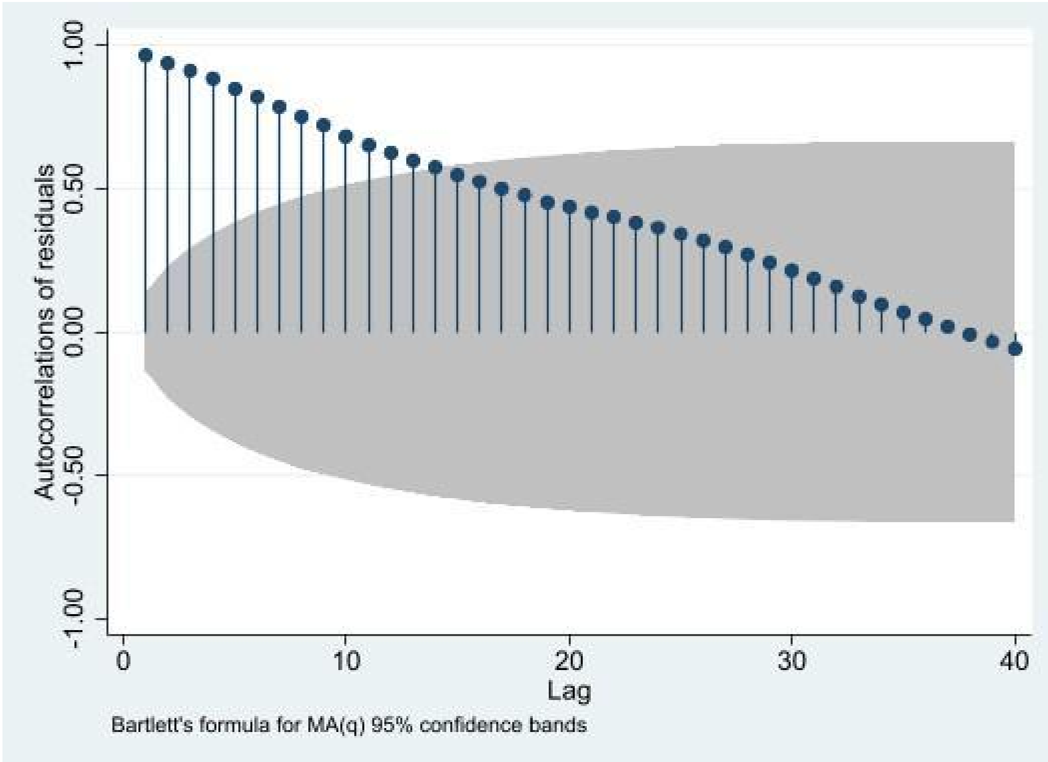
3. Joint significance test and goodness of fit

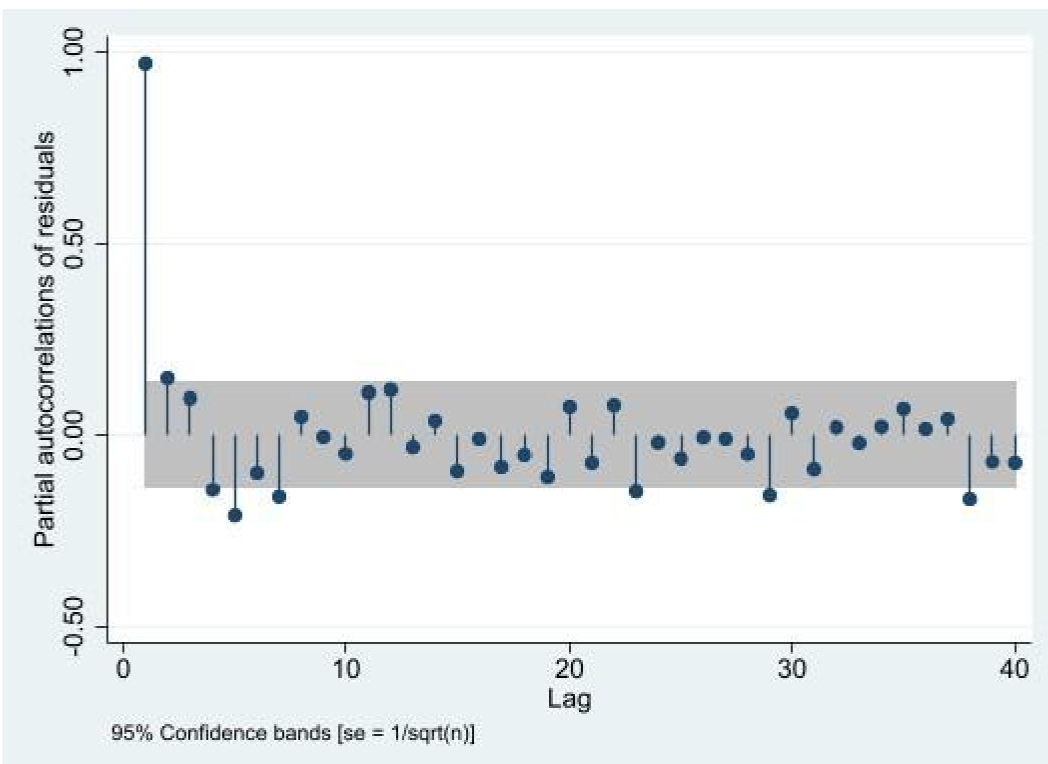
a) Joint test

Carry out a joint significance test for the independent variables of the model using the critical values corresponding to the F-distribution and the test p-values. Carefully state the null alternative hypotheses. Interpret your results.

b) Goodness of fit

4. Autocorrelation





5. Unobserved dependent variable

Money supply is not directly observed and suppose we observe instead the long run demand for money. Assume the desired level is defined as follows

a) $lnM_t - lnM_{t-1} = \delta\left(lnM_t^* - lnM_{t-1}\right)$el equation change

The dependent variable is not directly observed

$$lm_t^* = \beta_0 + \beta_1 inf_t + \beta_2 ly_t + \beta_3 tbilrate_t + u_t$$

And the assumption is

$$lm_t - lm_{t-1} = \delta\left(lm_t^* - lm_{t-1}\right)$$

Hence;

$$lm_t - lm_{t-1} = \delta lm_t^* - \delta lm_{t-1}$$

$$lm_t^* = \frac{lm_t - lm_{t-1} + \delta lm_{t-1}}{\delta}$$

$$lm_t^* = \frac{lm_t - (1-\delta) lm_{t-1}}{\delta}$$

Equalizing the two equations for lm_t^*:

$$\frac{lm_t - (1-\delta) lm_{t-1}}{\delta} = \beta_0 + \beta_1 inf_t + \beta_2 ly_t + \beta_3 tbilrate_t + u_t$$

$$lm_t = \delta\beta_0 + \delta\beta_1 inf_t + \delta\beta_2 ly_t + \delta\beta_3 tbilrate_t + (1 - \delta) lm_{t-1} + \delta u_t$$

b) State and estimate the new specification

VARIABLES	(1) OLSmodel lmt	(2) model5b lmt
INFL	-0.00840*	7.07e-05
	(0.00442)	(0.000299)
lyt	1.696***	0.0112
	(0.0296)	(0.00835)
TBILRATE	-0.0251***	0.000423
	(0.00616)	(0.000430)
L.lmt		0.994***
		(0.00477)
Constant	-8.132***	-0.0470
	(0.233)	(0.0421)
Observations	204	203
R-squared	0.956	1.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

c) Based your answer in part (b) above, what is the speed of adjustment to the long run level

The speed of adjustment is contained in the coefficient of the dependent variable:

$$coefficient\ of\ lm_{t-1} = (1 - \delta) = 0.994$$

$$\delta = 0.006$$

This means that the entire adjustment is completed in 20 months

d) Using the long run specification, derive the long run static model. How does this compare to the estimated specification based on equation (1)?

In the long run, money demand equals money supply. Then, the long run specification is given by

$$lm_t^* = lm_t$$

$$lm_t^* = \beta_0 + \beta_1 inf_t + \beta_2 ly_t + \beta_3 tbilrate_t + u_t$$

$$lm_t = \beta_0 + \beta_1 inf_t + \beta_2 ly_t + \beta_3 tbilrate_t + u_t$$

The long run static model is

$$\beta_1 = \frac{\delta\beta_1}{\delta} = -\frac{7.07e-05}{0.006} = -1.1783$$

$$\beta_2 = \frac{\delta\beta_2}{\delta} = \frac{0.0112}{0.006} = 1.867$$

$$\beta_3 = \frac{\delta\beta_3}{\delta} = -\frac{0.000423}{0.006} = -0.0705$$

$$lm_t = -8.132 - 1.1783 inf_t + 1.867 ly_t - 0.0705 tbilrate_t + u_t$$

While the short run model short run model is:

$$lm_t = -8.132 - 0,00707 inf_t + 0.0112 ly_t - 0.000423 tbilrate_t + 0.994 lm_{t-1} + \varepsilon_t$$

Which means that almost 0.6 % of the discrepancy between money supply and money demand is corrected within a quarter

Comparison

The model estimation in question 2 is

$$lm^*_t = -8.132 - 0.0084 inf_t + 1.696 ly_t - 0.0251 tbilrate_t + u_t$$

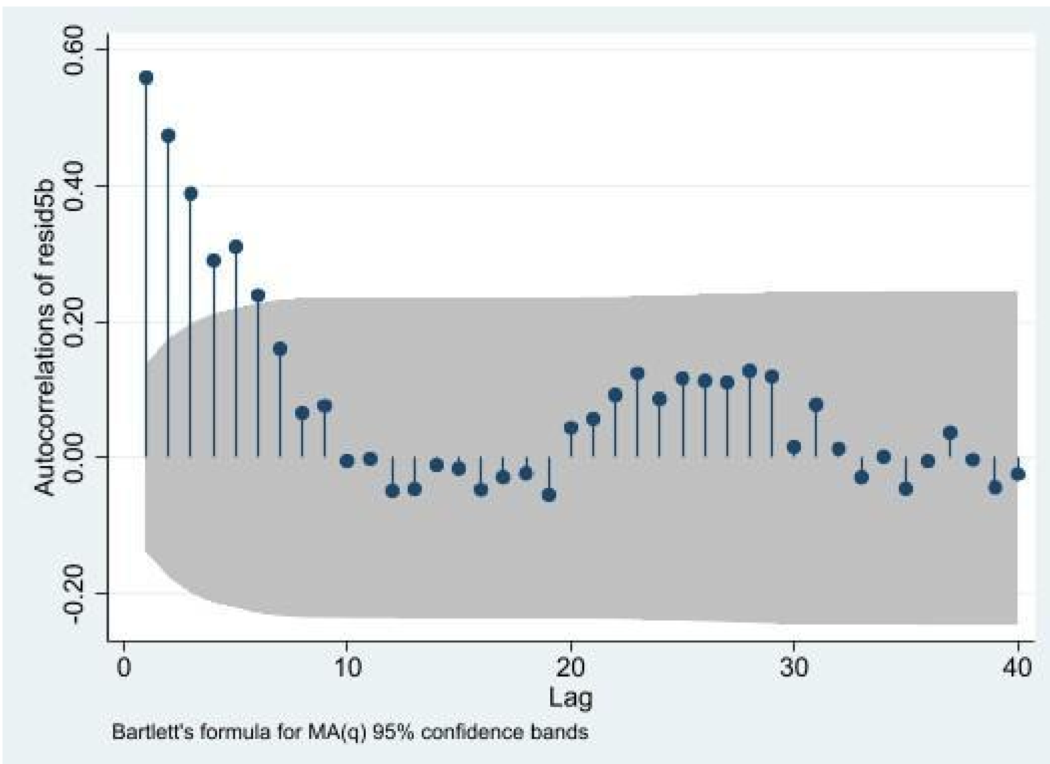
While the estimated model in this question is:

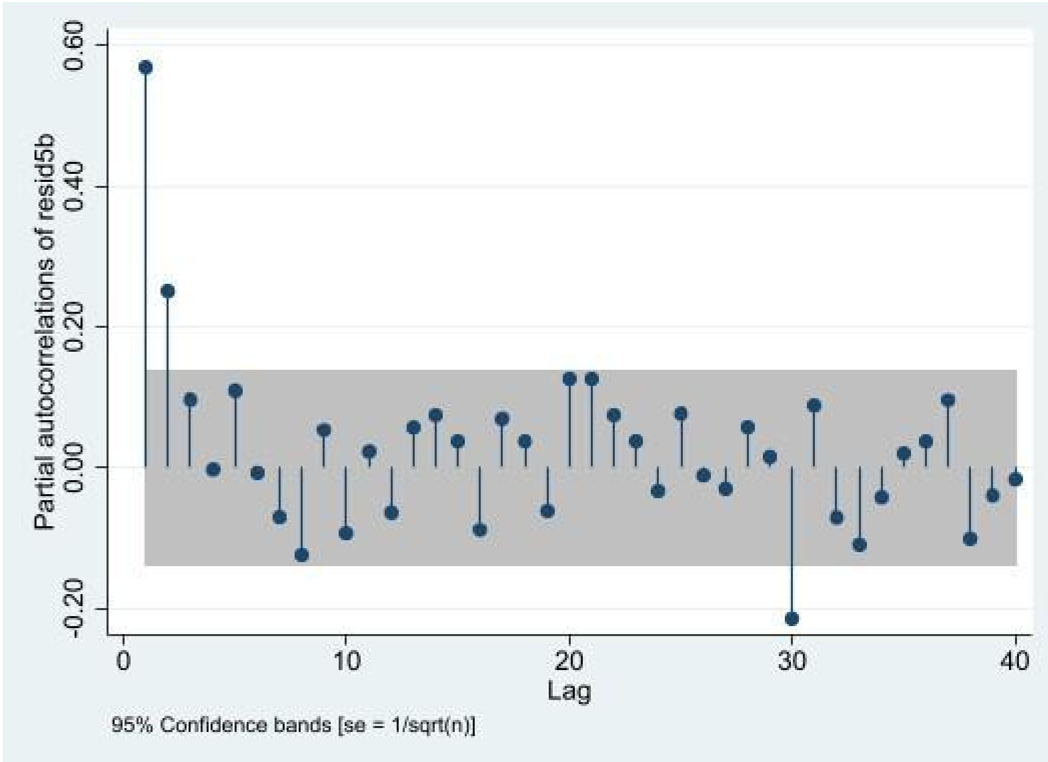
$$lm^*_t = -8.132 - 1.1783inf_t + 1.867ly_t - 0.0705tbilrate_t + u_t$$

The difference is in the coefficient estimate, with the exception of the intercept. All coefficients that partner an explanatory variable are bigger in the second model specification because the first one measure the desired quantity of money as equal to the actual money quantity causing a sub estimation of coefficients.

6. Consider your output to Q5 b) using an appropriate procedure, test for autocorrelations in the residuals

First, checking for 5b model autocorrelations and partial autocorrelations. It is observed in total autocorrelations that at least 5 lags are out of interval confidence bands, and at the two first lags are out of interval confidence bands.





Now we test for the existence of autocorrelations. The Durbin Watson test results in:

$$Durbin\text{–}Watson\ d - statistic(\ 5,\ \ 203) = \ .8627994$$

Table A.5 Durbin–Watson d statistic: d_L and d_U, 5% significance level

n	$k=1$		$k=2$		$k=3$		$k=4$		$k=5$	
	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U
15	1.08	1.36	0.95	1.54	0.82	1.75	0.69	1.97	0.56	2.21
16	1.10	1.37	0.98	1.54	0.86	1.73	0.74	1.93	0.62	2.15
17	1.13	1.38	1.02	1.54	0.90	1.71	0.78	1.90	0.67	2.10
18	1.16	1.39	1.05	1.53	0.93	1.69	0.82	1.87	0.71	2.06
19	1.18	1.40	1.08	1.53	0.97	1.68	0.86	1.85	0.75	2.02
20	1.20	1.41	1.10	1.54	1.00	1.68	0.90	1.83	0.79	1.99
21	1.22	1.42	1.13	1.54	1.03	1.67	0.93	1.81	0.83	1.96
22	1.24	1.43	1.15	1.54	1.05	1.66	0.96	1.80	0.86	1.94
23	1.26	1.44	1.17	1.54	1.08	1.66	0.99	1.79	0.90	1.92
24	1.27	1.45	1.19	1.55	1.10	1.66	1.01	1.78	0.93	1.90
25	1.29	1.45	1.21	1.55	1.12	1.66	1.04	1.77	0.95	1.89
26	1.30	1.46	1.22	1.55	1.14	1.65	1.06	1.76	0.98	1.88
27	1.32	1.47	1.24	1.56	1.16	1.65	1.08	1.76	1.01	1.86
28	1.33	1.48	1.26	1.56	1.18	1.65	1.10	1.75	1.03	1.85
29	1.34	1.48	1.27	1.56	1.20	1.65	1.12	1.74	1.05	1.84
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83
31	1.36	1.50	1.30	1.57	1.23	1.65	1.16	1.74	1.09	1.83
32	1.37	1.50	1.31	1.57	1.24	1.65	1.18	1.73	1.11	1.82
33	1.38	1.51	1.32	1.58	1.26	1.65	1.19	1.73	1.13	1.81
34	1.39	1.51	1.33	1.58	1.27	1.65	1.21	1.73	1.15	1.81
35	1.40	1.52	1.34	1.58	1.28	1.65	1.22	1.73	1.16	1.80
36	1.41	1.52	1.35	1.59	1.29	1.65	1.24	1.73	1.18	1.80
37	1.42	1.53	1.36	1.59	1.31	1.66	1.25	1.72	1.19	1.80
38	1.43	1.54	1.37	1.59	1.32	1.66	1.26	1.72	1.21	1.79
39	1.43	1.54	1.38	1.60	1.33	1.66	1.27	1.72	1.22	1.79
40	1.44	1.54	1.39	1.60	1.34	1.66	1.29	1.72	1.23	1.79
45	1.48	1.57	1.43	1.62	1.38	1.67	1.34	1.72	1.29	1.78
50	1.50	1.59	1.46	1.63	1.42	1.67	1.38	1.72	1.34	1.77
55	1.53	1.60	1.49	1.64	1.45	1.68	1.41	1.72	1.38	1.77
60	1.55	1.62	1.51	1.65	1.48	1.69	1.44	1.73	1.41	1.77
65	1.57	1.63	1.54	1.66	1.50	1.70	1.47	1.73	1.44	1.77
70	1.58	1.64	1.55	1.67	1.52	1.70	1.49	1.74	1.46	1.77
75	1.60	1.65	1.57	1.68	1.54	1.71	1.51	1.74	1.49	1.77
80	1.61	1.66	1.59	1.69	1.56	1.72	1.53	1.74	1.51	1.77
85	1.62	1.67	1.60	1.70	1.57	1.72	1.55	1.75	1.52	1.77
90	1.63	1.68	1.61	1.70	1.59	1.73	1.57	1.75	1.54	1.78
95	1.64	1.69	1.62	1.71	1.60	1.73	1.58	1.75	1.56	1.78
100	1.65	1.69	1.63	1.72	1.61	1.74	1.59	1.76	1.57	1.78

Checking the table, it is observed that 0.8627994 is lower than $d_L = 1.57$, then there is evidence for positive autocorrelations in the residuals.

7. Endogeneity

From the discussion in the lectures, you suspect that the presence ***of real GDP, inflation, and lagged dependent variable in the specification in Q5*** may lead to an endogeneity issue

a) Explain and discuss the issue of endogeneity in this question

A variable is endogenous in a model when this variable is correlated with the error term. When the explanatory variable is correlated with perturbance term, estimators are biased and inconsistent.

The model in Q5 introduces the dependent variable lagged one period as explanatory variable. This variable is endogenous itself because this is the variable we seek to explain, but its lagged one period, this variable is correlated hence with the error term lagged one period. The relevant question is whether the lagged dependent variable is correlated with the error term at time t.

	lmt	INFL	lyt	TBILRATE	L. lmt	resid5b
lmt	1.0000					
INFL	0.0869	1.0000				
lyt	0.9732	0.1679	1.0000			
TBILRATE	0.4358	0.5833	0.5303	1.0000		
lmt L1.	0.9999	0.0852	0.9727	0.4337	1.0000	
resid5b	0.0140	0.0000	-0.0000	-0.0000	-0.0000	1.0000

This correlation table shows in its last file that errors in 5 (b) question model is not correlated with any of the explanatory variables. It is uniquely correlated, with the dependent variable.

b) What are the implications of presence of endogeneity for OLS?

Endogeneity causes estimations with high standard errors.

c) How would you account for the presence of endogeneity?

Hausman test: It can be regressed the dependent variable versus the estimated dependent variable and the residuals

8. Two Stages Least Squares

Estimate the model in Q5 using Two Stages Least Squares (TSLS). Answer ALL the following questions:

a) Define the set of instruments used to estimate the model. Justify the reasons for your selected set of instruments

The clearly endogenous variable in the model in point 5 was the lagged dependent variable. I would you the lagged logarithm of GDP instead, and I choose it because it's a real variable and prior it can be thought that is not correlated with error term.

b) Compare the qualitative and statistical interpretation of the TSLS estimated model to the estimated using OLS in Q5. Which model is more consistent and conform to theory?

- First Stage: Regress lm_t against ly_t against

VARIABLES	(1) FirstStage2SLS lmt
lyt	1.607***
	(0.0269)
Constant	-7.557***
	(0.224)
Observations	204
R-squared	0.946

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Both estimates, the intercept and the coefficient of the instrument are significantly different from zero with p-value less than 1%. Then the coefficient can be used because the instrument and the endogenous variable are correlated.

- Second Stage: Regress the following model:

$$lm_t = \delta\beta_0 + \delta\beta_1 inf_t + \delta\beta_2 ly_t + \delta\beta_3 tbilrate_t + (1 - \delta)ly_{t-1} + \delta u_t$$

VARIABLES	(1) SecondStage2SLS lmt
INFL	-0.00824*
	(0.00438)
lyt	0.0550
	(1.213)
TBILRATE	-0.0262***
	(0.00615)
L.lyt	1.648
	(1.213)
Constant	-8.173***
	(0.232)
Observations	203
R-squared	0.957

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

c) Using the specification and TSLS estimates, derive the long run static model. How does it compare to (i) the estimated specification based on equation (1) in Q2-d (ii) to that derived based on (Q5-d)?

VARIABLES	(1) OLSmodel lmt	(2) model5b lmt	(3) FirstStage2SLS lmt	(4) SecondStage2SLS lmt
INFL	-0.00840*	7.07e-05		-0.00824*
	(0.00442)	(0.000299)		(0.00438)
lyt	1.696***	0.0112	1.607***	0.0550
	(0.0296)	(0.00835)	(0.0269)	(1.213)
TBILRATE	-0.0251***	0.000423		-0.0262***
	(0.00616)	(0.000430)		(0.00615)
L.lmt		0.994***		
		(0.00477)		
L.lyt				1.648
				(1.213)
Constant	-8.132***	-0.0470	-7.557***	-8.173***
	(0.233)	(0.0421)	(0.224)	(0.232)

Observations	204	203	204	203
R-squared	0.956	1.000	0.946	0.957

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

9. Spurious regression and Unit roots

Again, from the discussion in lectures, you suspect that the model estimated in Q2 may be spurious due to the presence of unit roots.

a) Perform ADF unit roots test on all variables in equation (1). State clearly the hypothesis being tested, the data generating process, the lag length selection criteria and the critical values. Is there evidence that the data contain unit root?

All ADF test have the null hypothesis that the series have unit roots.

1. lmt

```
Dickey-Fuller test for unit root          Number of obs  = 203
Variable: lmt                             Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test        -------- critical value --------
              statistic           1%           5%          10%
---------------------------------------------------------------
 Z(t)             0.765       -3.476       -2.883       -2.573
---------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9910.
```

Cannot reject the null. We conclude that lmt has unit root

2. INFL

```
Dickey-Fuller test for unit root          Number of obs  = 203
Variable: INFL                            Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test        -------- critical value --------
              statistic           1%           5%          10%
---------------------------------------------------------------
 Z(t)            -6.503       -3.476       -2.883       -2.573
---------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

There is evidence to reject the null, then inflation rate series has not unit root.

3. Lyt

```
Dickey-Fuller test for unit root                   Number of obs  = 203
Variable: lyt                                      Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test          ──────── critical value ─────────
              statistic           1%           5%           10%
──────────────────────────────────────────────────────────────────
 Z(t)            -1.458       -3.476       -2.883        -2.573
──────────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.5541.
```

Cannot reject the null. We conclude that lmt has unit root. Therefore, it is concluded that lyt has unit root

4. TBILRATE

```
Dickey-Fuller test for unit root                   Number of obs  = 203
Variable: TBILRATE                                 Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test          ──────── critical value ─────────
              statistic           1%           5%           10%
──────────────────────────────────────────────────────────────────
 Z(t)            -2.132       -3.476       -2.883        -2.573
──────────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.2319.
```

We cannot reject the null and we conclude that TBILRATE has unit root.

b) What is the order of integration of the variables tested in part (a)?

It is needed to do the DF test to the first differences of such variables for which it were concluded that have a unit roots

- Lmt is integrated of order 1 it is stationary in its first differences.

```
.
. dfuller d.lmt

Dickey-Fuller test for unit root                   Number of obs  = 202
Variable: D.lmt                                    Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test          ──────── critical value ─────────
              statistic           1%           5%           10%
──────────────────────────────────────────────────────────────────
 Z(t)            -7.041       -3.476       -2.883        -2.573
──────────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.0000.
```

- INFL is integrated of order 0
- Lyt is integrated of order 1 it is stationary in its first differences.

```
Dickey-Fuller test for unit root          Number of obs  = 202
Variable: D.lyt                           Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      -------- critical value ---------
              statistic           1%           5%          10%
--------------------------------------------------------------
 Z(t)            -9.933       -3.476       -2.883       -2.573
--------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

- TBILRATE is integrated of order 1 because it is stationary in its first differences.

```
. dfuller d.TBILRATE

Dickey-Fuller test for unit root          Number of obs  = 202
Variable: D.TBILRATE                      Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      -------- critical value ---------
              statistic           1%           5%          10%
--------------------------------------------------------------
 Z(t)           -11.463       -3.476       -2.883       -2.573
--------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

c) Perform the Engle-Granger cointegration test. Are the variables cointegrated? State clearly the hypothesis being tested, the data generating process, the lag length selection criterion and the critical values.

The null hypothesis being tested is that the residuals estimated with equation (1) regression have a Unit Root, i.e., they are non-stationary.

```
. dfuller residuals, lags(0)

Dickey-Fuller test for unit root          Number of obs  = 203
Variable: residuals                       Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      -------- critical value ---------
              statistic           1%           5%          10%
--------------------------------------------------------------
 Z(t)            -1.899       -3.476       -2.883       -2.573
--------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3326.
```

The p value is 33.26% is greater than 1%, 5% and 10% significance levels and therefore we accept the hypothesis than the residuals have a Unit Root and this implies that the variables in the model are not cointegrated.