Empirical Estimation of Is-Lm Model for the US Economy by Applying Jmulti

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Abstract

The main goal of the paper is to examine how well the dynamics properties of the estimated model of the US economy match to the theoretical prediction to the IS-LM model or with other words to test the theoretical IS-LM model for the US by applying time series estimations (standard VAR and VECM time series models). The interest variables in the models are: real GDP, three month interbank interest rate, and real monetary base. Several pre estimation tests have been made: 1) the Jarque - Bera test of normality shows that the normality of the time series is not problem in these models, but the ARCH LM test of heteroscedasticity indicates that the monetary base and interbank interest rate are heterosedastic; 2) The ADF test for unit root and Johansen test for co integration have been made to identify the optimal number of lags of the variables in the models. The applied post estimation Chow test for VAR model indicated that the model is not stable and therefore we use VECM model. The estimated results based on applying VECM model show that if the system is in disequilibrium alteration in the change of interbank interchange interest rate, log of real GDP, and monetary base will be downward 5.5%, 4.6% and 0.4% respectively. The chow test indicates that the VECM model is stable.

Keywords
IS-LM model, Vector Auto Regression, VECM, JMULTI

1. Introduction

The IS-LM model introduced by John Hicks has played a vital role in explaining a major part of Keynesian macroeconomics since 1937. This model has built a framework for researchers and policy makers to discuss about the effects of economic policy (fiscal and monetary) and the implications of real policy issues. The initial IS-LM model concludes that the government can influence the economy via inflation and unemployment, through a rightward shift of the IS curve by the fiscal policy or by a shift of the LM curve by the monetary policy.

The IS-LM model inherits Keynesian beliefs with regard to efficiency of governmental policies on the economy. Nevertheless, there exists a slight contradiction related to the influence of deficit spending on the economy between the Keynesian and the IS/LM model. Keynes uses deficit spending as a tool to stimulate the aggregate demand, resulting in an increase of the national income. This deficit spending leads to a lower savings rate or to an increase in private fixed investments, which finally causes an increase in fixed investments (Friedman 1978). Keynes hypothesizes that the deficit spending may actually "crowd in," or encourage, the private fixed investment through the accelerator effect, which helps long-term growth (Friedman 1978). Furthermore, Keynesians argue that, provided government deficits

are spent on productive public investments (e.g., infrastructure), the result is a direct increase in the potential output (Friedman 1978).
On the other hand, the IS/LM explains that deficit spending leads to an increase in the interest rate and produces the so-called "crowding out phenomenon," which is the discouragement of private fixed investments that in turn decrease the long-term growth of the supply side, or potential output. In this paper, we empirically analyze this controversial argument of the influence of the government deficit on the economy. While the initial IS/LM continues to play an important role as a policy tool, it has been criticized as an obsolete instrument in the academic community. The main criticism is that this model cannot explain simultaneous occurrences of high inflation and high unemployment rates in the economy. Moreover, the shift in central banks from targeting the money supply to following an interest-rate rule also undermines the importance of this model as a policy tool. Nevertheless, the model has been vigorously revived by the introduction of new "expectation" concepts, while keeping its original simplicity and clearness. The new IS/LM model is a powerful macroeconomic tool, supported not only in academic and government environments, but also in business and other non-academic environments.
The main purpose of this study is to examine how well the dynamics properties of the estimated model of the US economy match to the theoretical prediction to the IS-LM model or with other words to test the theoretical IS-LM model for the US by applying time series estimations. The paper is organized in introduction, three main sections, and general conclusion.

2. Empirical estimation of the IS-LM model

2.1 Data description

The variables that we use in the empirical estimations are U.S. time series data: logarithm of real GDP, *q*, three month interbank interest rate, *i* (three month bankers' acceptance rate), and real monetary base, *m* (log of St. Louis adjusted monetary base/GDP implicit price deflator). The observations for the interest rate and the monetary base are converted to quarterly frequency by averaging the monthly values.[1]
The data are quarterly US data from the time period from the first quartile of 1970 to the last quartile of the 1997. As we can see from the plot the equilibrium between money market and goods market is achieved in the 1985-1986 period. By presenting the descriptive statistics we report the mean minimum and maximum and standard deviation of the interested variables in our models.

Table 1 Descriptive statistics of the variables.

sample range: [1970 Q1, 1997 Q4], T = 112				
DESCRIPTIVE STATISTICS:				
variable	mean	min	max	std. dev.
m	1.00020e+00	7.31711e-01	1.46723e+00	2.30375e-01
q	8.55226e+00	8.19108e+00	8.91000e+00	1.99013e-01
i	7.43699e-02	3.06000e-02	1.68633e-01	2.98795e-02

[1] Original time series are from the Federal Reserve Economic Data (FRED) database.

For the better presentation of the data in its dynamics in the analyzed period we plot the data on the following graph:

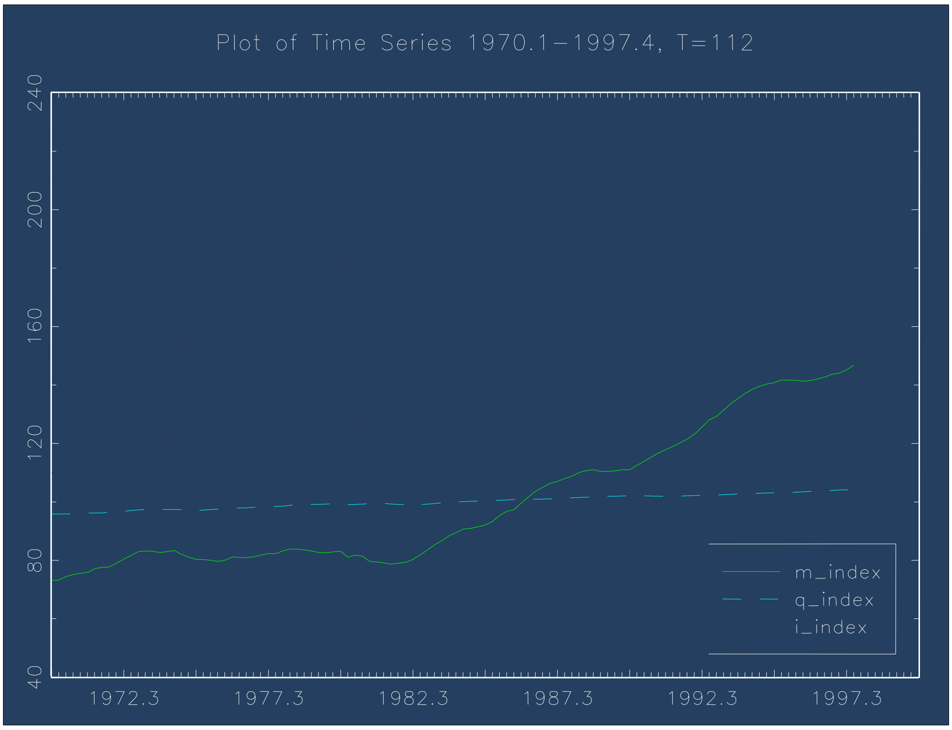

Figure 1 Plot of Time Series 1970Q1 – 1997Q4

2.2 Time series tests

- **The Jarque - Bera test of normality and ARCH LM- test of heteroscedasticity with 2 lags**

Test of normality and test of heteroscedasticity are being conducted:

JARQUE-BERA TEST				
variable	teststat	p-Value(Chi^2)	skewness	kurtosis
m	13.8522	0.0010	0.7255	2.0711
q	5.7531	0.0563	-0.0623	1.8967
i	22.7546	0.0000	1.0181	3.8545
ARCH-LM TEST with 2 lags				
variable	teststat	p-Value(Chi^2)	F stat	p-Value(F)
m	109.7227	0.0000	21765.2393	0.0000
q	108.9136	0.0000	5514.0497	0.0000
i	67.5512	0.0000	87.5248	0.0000

Normality is not a problem in this model, but heteroscedasticity is present. This is because series have unequal variances. Interest rates are volatile, same as monetary base.

- **ADF test**

We Augment: $\Delta Y_t = \beta Y_{t-1} + u_t$

1. Constant or "drift" term (α_0)
   - random walk with drift
2. Time trend (T)
   - test H_O: unit root
     - conditional on a deterministic time trend
     - and against H_A: deterministic time trend
3. Lagged values of the dependent variable
   - sufficient for residuals free of autocorrelation

$\Rightarrow$ ADF: $\Delta Y_t = \alpha_0 + \gamma T + \beta Y_{t-1} + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + ... + \delta_3 \Delta Y_{t-n} + u_t$

The main problems with unit root tests are as follows: 1) low power in short time series (trend to under-reject H_0: unit root against H_A: stationary and endemic problem); 2) Critical values for UR tests depend on what the test is conditioned on; 3) Critical values differ with specification of the testing equation (Inclusion/exclusion of drift term, deterministic time trend, lags of the differenced variable and the number of lags); and another problem (terms to control for structural breaks $\Rightarrow$ also change the critical values)

Here is a sample of time series modeling but with time break:

$$y_t = \hat{\mu} + \hat{\theta} DU_t + \hat{\beta}_t + \hat{\gamma} DT_t + \hat{d} D(TB)_t$$
$$+ \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-i} + \hat{e}_t$$

- Same as in any ADF test
  μ_t : constant or estimated "drift" term
  β_t : (deterministic) time trend
  y_{t-1}: 1st lag
  Δy_{t-i}: lagged differences
- To implement empirically
  - subtract y_{t-1} from both sides

  $\Rightarrow \beta_1$ = ([ά-hat] – 1)

We use JMULTI software that adds seasonal dummy variables in the models and adds Trend break dummies.

Definition*:* T_B Time of the break is a period in which a one-time break in structure occurs i.e., a change in the parameters of the trend function .How to identify T_B? (Perron, 1990, p.161) Usually "visual inspection is sufficient", Relate T_B to "major" events (Great Stock or Oil crash) Terms added to the ADF test
$D(TB)_t$ Models a one-time change in the intercept, i.e., in the level of the series a "crash" , = 1 if $t = T_B+1$; otherwise 0, DV=1 for the single period immediately ***after*** the break .
ADF test for monetary base (log of "St. Louis Adjusted Monetary Base"/"GDP Implicit Price Deflator")

Table 2 ADF test for money base.

ADF Test for series:	m
sample range:	[1970 Q4, 1997 Q4], T = 109
lagged differences:	2
intercept, time trend, seasonal dummies	
asymptotic critical values	

reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London

1%	5%	10%
-3.96	-3.41	-3.13

value of test statistic: -1.3650
regression results:

variable	coefficient	t-statistic
x(-1)	-0.0099	-1.3650
dx(-1)	0.5203	5.4222
dx(-2)	0.1756	1.8228
constant	0.0113	1.5284
trend	0.0001	1.9546
sdummy(2)	-0.0009	-0.5206
sdummy(3)	0.0027	1.5531
sdummy(4)	0.0011	0.6533
RSS	0.0040	

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range: [1972 Q4, 1997 Q4], T = 101

	optimal number of lags (searched up to 10 lags of 1. differences)
Akaike Info Criterion	3
Hannan-Quinn Criterion	3
Final Prediction Error	3
Schwarz Criterion	1

From the above tables about the monetary base, this variable is unit root with a drift variable. Coefficient on the trend variable is small 0.0001 but significant above 1.96 t-stats. From the optimal endogenous lags info criteria optimal number of lags for this variable is three lags.

Table 3 ADF test for interest rate.

ADF Test for series: i

sample range: [1970 Q4, 1997 Q4], T = 109
lagged differences: 2
intercept, time trend, seasonal dummies
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London

1%	5%	10%
-3.96	-3.41	-3.13

value of test statistic: -1.9914
regression results:

variable	coefficient	t-statistic
x(-1)	-0.0803	-1.9914
dx(-1)	0.1314	1.3427
dx(-2)	-0.1243	-1.2623
constant	0.0058	1.5563
trend	-0.0000	-0.7589
sdummy(2)	-0.0025	-0.7985

sdummy(3)	0.0020	0.6330
sdummy(4)	0.0006	0.1733
RSS	0.0141	

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range: [1972 Q4, 1997 Q4], T = 101

	optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion	5
Final Prediction Error	5
Schwarz Criterion	0
Hannan-Quinn Criterion	0

The variable, interest rates in US economy has unit root and optimal number of endogenous lags by the info criteria is up to 5 lags.

Table 4 ADF test for log of real GDP.

ADF Test for series: q

sample range: [1970 Q4, 1997 Q4], T = 109
lagged differences: 2
intercept, time trend, seasonal dummies
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London

1%	5%	10%
-3.96	-3.41	-3.13

value of test statistic: -3.3346
regression results:

variable	coefficient	t-statistic
x(-1)	-0.1182	-3.3346
dx(-1)	0.2972	3.1691
dx(-2)	0.2157	2.2363
constant	1.0142	3.3470
trend	0.0007	3.3096
sdummy(2)	0.0011	0.5058
sdummy(3)	0.0004	0.2040
sdummy(4)	-0.0008	-0.3685
RSS	0.0060	

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range: [1972 Q4, 1997 Q4], T = 101

	optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion	2
Final Prediction Error	2
Schwarz Criterion	1
Hannan-Quinn Criterion	1

This variable has unit root with a drift term since the coefficient on the trend term is significant, and optimal number of lags are maximum up to 2.

- **Testing for cointegration**

The equilibrium matrix in the error-correction model. Procedure is as follows: calculate the rank of Π , i.e., number of independent rows or columns there exist 3 possibilities

1. Rank(Π) = 0

– VECM reduces to a VAR in 1st differences

– 1st differences are I(0) $\Rightarrow$ no cointegration

2. Rank(Π) = 2 This Occurs only when both variables stationary and what follows no common trend $\Rightarrow$ independent $\Rightarrow$ variables over-differenced and correct model is in levels, not 1st differences

1. Rank(Π) = 1 One independent row $\Rightarrow$ determinant of Π = 0

(Product of Diagonal 1) – (Product of Diagonal 2) = 0

One co-integrating vector (r), each term in Π is assumed non-zero and long-run or equilibrium coefficient on Y or Z.

- Procedure is as follows : Decompose Π into 2 q×r matrices where α = matrix of short-run "adjustment" coefficients in the EC Model

β' = each row is one of the r.

Table 5 Johansen Trace test for money base and log of real GDP.

Johansen Trace Test for: m i q					
unrestricted dummies: D[1982 Q1] D[1982 Q2]					
restricted dummies: S[1982 Q1]					
sample range: [1970 Q3, 1997 Q4], T = 110					
included lags (levels): 2					
dimension of the process: 3					
intercept included					
seasonal dummies included					
response surface computed:					
r0	LR	pval	90%	95%	99%
0	89.03	0.0000	37.61	39.81	44.17
1	25.98	0.0242	22.29	24.18	28.00
2	8.89	0.2126	11.02	12.82	16.66

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA	
sample range: [1972 Q4, 1997 Q4], T = 101	
	optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion	6
Final Prediction Error	2
Schwarz Criterion	2
Hannan-Quinn Criterion	2

Since there is unit root between these variables, they are cointegrated of order 1 I(1) as Johansen test shows. Optimal number of endogenous lags by info criteria is 2.

- **ARIMA for three months interest rate (i) variable**

Three months interbank interest rate is being tested for optimal lags by Hannan and Rissanen test. And the optimal number of lags is (1,0).

Table 5 Hannan-Risaanen Model Selection for interest rate.

OPTIMAL LAGS FROM HANNAN-RISSANEN MODEL SELECTION
(Hannan & Rissanen, 1982, Biometrika 69)

original variable: i
order of differencing (d): 0
adjusted sample range: [1972 Q4, 1997 Q4], T = 101
optimal lags p, q (searched all combinations where max(p,q) <= 3)
Akaike Info Criterion: p=1, q=0
Hannan-Quinn Criterion: p=1, q=0
Schwarz Criterion: p=1, q=0

For 1st difference of the variable optimal number of lags is zero (0,0).

Table 6 Hannan-Risaanen Model Selection for first difference interest rate.

OPTIMAL LAGS FROM HANNAN-RISSANEN MODEL SELECTION

(Hannan & Rissanen, 1982, Biometrika 69)
original variable: i
order of differencing (d): 1
adjusted sample range: [1973 Q1, 1997 Q4], T = 100
optimal lags p, q (searched all combinations where max(p,q) <= 3)
Akaike Info Criterion: p=0, q=0
Hannan-Quinn Criterion: p=0, q=0
Schwarz Criterion: p=0, q=0

- **ARIMA for monetary base variable m (log of "St. Louis Adjusted Monetary Base"/"GDP Implicit Price Deflator")**

The result indicates that this variable is first difference variable. And the optimal number of lags is (1, 1).

Table 7 Hannan-Risaanen Model Selection for money base.

OPTIMAL LAGS FROM HANNAN-RISSANEN MODEL SELECTION

(Hannan & Rissanen, 1982, Biometrika 69)
original variable: m
order of differencing (d): 1
adjusted sample range: [1973 Q1, 1997 Q4], T = 100
optimal lags p, q (searched all combinations where max(p,q) <= 3)
Akaike Info Criterion: p=1, q=1
Hannan-Quinn Criterion: p=1, q=1
Schwarz Criterion: p=1, q=1

Model: ARIMA(0,1,0)

Final Results:
Iterations Until Convergence: 1
Log Likelihood: 378.975787 Number of Residuals: 111
AIC : -747.951574 Error Variance : 0.000066376
SBC : -734.403923 Standard Error : 0.008147132
DF: 106 Adj. SSE: 0.007035831 SSE: 0.007035831
Dependent Variable: m

	Coefficients	Std. Errors	T-Ratio	Approx. Prob.
CONST	0.00086107	0.00208108	0.41376	0.67989
S1	-0.00148637	0.00219761	-0.67636	0.50029
S2	0.00107037	0.00217795	0.49146	0.62412
S3	0.00111285	0.00217755	0.51106	0.61037
TREND	0.00009783	0.00002414	4.05246	0.00010

The above table presents ARIMA (1, 0) model for St. Louis monetary base adjusted for CPI deflator. Trend is only variable that is significant while others including seasonal dummies and constant are not significant. This is unit root with a drift variable.

- **ARIMA for real GDP variable (log of real US GDP)**

The result indicates that this variable is 1st difference variable optimal lags (1, 0). In the ARIMA model for log of real US GDP only constant term is significant.

Table 8 Hannan-Risaanen Model Selection for log of real GDP

OPTIMAL LAGS FROM HANNAN-RISSANEN MODEL SELECTION				
(Hannan & Rissanen, 1982, Biometrika 69)				
original variable: q				
order of differencing (d): 1				
adjusted sample range: [1973 Q1, 1997 Q4], T = 100				
optimal lags p, q (searched all combinations where max(p,q) <= 3)				
Akaike Info Criterion: p=1, q=0				
Hannan-Quinn Criterion: p=1, q=0				
Schwarz Criterion: p=1, q=0				
Model: ARIMA(0,1,0)				
Final Results:				
Iterations Until Convergence: 1				
Log Likelihood: 374.802067		Number of Residuals: 111		
AIC : -739.604135		Error Variance : 0.000071560		
SBC : -726.056484		Standard Error : 0.008459306		
DF: 106	Adj. SSE: 0.007585344	SSE: 0.007585344		
Dependent Variable: q				
	Coefficients	Std. Errors	T-Ratio	Approx. Prob.
CONST	0.00624187	0.00216082	2.88866	0.00469
S1	0.00104755	0.00228182	0.45909	0.64711
S2	0.00040380	0.00226140	0.17856	0.85862
S3	-0.00030865	0.00226098	-0.13651	0.89168
TREND	-0.00000097	0.00002506	-0.03875	0.96916

2.3 VAR time series model

VAR is model the analyzed the relationship between two or more variables modelled as a VAR.Vector Auto - Regression where each variable regressed on lags of itself and the other variables, *X* = vector of q variables of interest, both endogenous and exogenous variables, distinction determined by the analysis

- Π = matrix of coefficients
- *k* = maximum lag
- ε = an error term (“white noise”)

$$X_t = \Pi_{t-1} X_{t-1} + \Pi_{t-2} X_{t-2} + \ldots + \Pi_{t-k} X_{t-k} + \varepsilon_t$$

$$
\begin{bmatrix} m(t) \\ q(t) \\ i(t) \end{bmatrix} = \begin{bmatrix} 1.213 & -0.235 & -0.187 \\ -0.202 & 1.142 & -0.094 \\ 0.577 & 0.804 & 1.017 \end{bmatrix} \begin{bmatrix} m(t-1) \\ q(t-1) \\ i(t-1) \end{bmatrix} + \begin{bmatrix} -0.174 & 0.391 & 0.064 \\ -0.165 & 1.198 & -0.271 \\ -0.890 & -0.620 & -0.220 \end{bmatrix} \begin{bmatrix} m(t-2) \\ q(t-2) \\ i(t-2) \end{bmatrix}
$$

$$
+ \begin{bmatrix} 0.044 & -0.180 & -0.085 \\ 0.410 & 0.060 & 0.263 \\ 0.563 & -0.013 & 0.400 \end{bmatrix} \begin{bmatrix} m(t-3) \\ q(t-3) \\ i(t-3) \end{bmatrix} + \begin{bmatrix} -0.035 & 0.015 & 0.099 \\ -0.133 & -0.074 & -0.255 \\ 0.146 & -0.158 & 0.069 \end{bmatrix} \begin{bmatrix} m(t-4) \\ q(t-4) \\ i(t-4) \end{bmatrix} +
$$

$$
\begin{bmatrix} -0.086 & 0.044 & -0.120 \\ 0.173 & 0.006 & 0.179 \\ -0.691 & 0.011 & 0.155 \end{bmatrix} \begin{bmatrix} m(t-5) \\ q(t-5) \\ i(t-5) \end{bmatrix} + \begin{bmatrix} 0.015 & -0.050 & 0.163 \\ -0.132 & -0.063 & -0.067 \\ 0.312 & 0.147 & -0.394 \end{bmatrix} \begin{bmatrix} m(t-6) \\ q(t-6) \\ i(t-6) \end{bmatrix} +
$$

$$
\begin{bmatrix} 0.147 & -0.001 & 0.001 & 0.001 & 0.000 \\ 1.00 & -0.002 & -0.001 & -0.003 & 0.001 \\ -1.408 & -0.003 & 0.000 & -0.004 & -0.001 \end{bmatrix} \begin{bmatrix} CONST \\ S1(t) \\ S2(t) \\ S3(t) \\ TREND(t) \end{bmatrix} + \begin{bmatrix} u1(t) \\ u2(t) \\ u3(t) \end{bmatrix}
$$

This VAR model contains data form 1971 Q3 to 1997Q4. The CUSUM test below shows that m, q and i equations do not leave the margins of normal distribution.

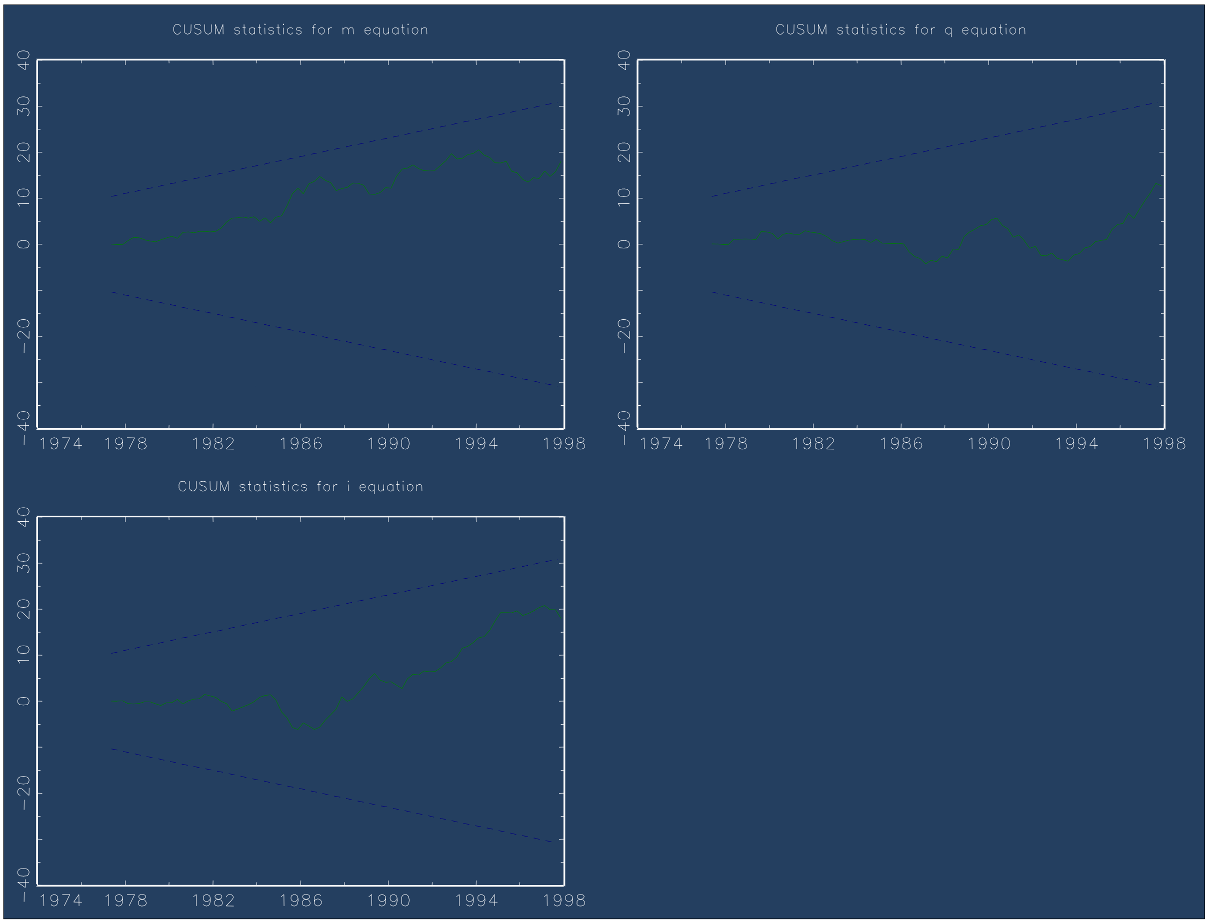

Figure 2 CUSUM test for normal distribution for interest rate, money base and real interest rate

- **CHOW test for VAR**

Chow test for VAR shows structural stability of the model and if the model is not stable we should continue testing.

Table 9 Chow test for structural break in VAR.

CHOW TEST FOR STRUCTURAL BREAK	
On the reliability of Chow-type tests..., B. Candelon, H. Lütkepohl, Economic Letters 73 (2001), 155-160	
sample range:	[1971 Q3, 1997 Q4], T = 106
tested break date:	1978 Q1 (26 observations before break)
break point Chow test:	555.1126
bootstrapped p-value:	0.0000
asymptotic chi^2 p-value:	0.0000
degrees of freedom:	75
sample split Chow test:	213.1091
bootstrapped p-value:	0.0000
asymptotic chi^2 p-value:	0.0000
degrees of freedom:	69
Chow forecast test:	25.6641
bootstrapped p-value:	0.0000
asymptotic F p-value:	0.0103
degrees of freedom:	240, 3

From the above table for Chow test, break point chow test showed that the model is not stable, also sample split test showed that, while chow forecast test is only significant at 10%, this means we have to continue with VECM model.
VECM model

2.4 VECM time series model

The VECM time series model that we use to test the theoretical IS-LM model in the paper is presented by the following equations:

$$\begin{aligned}
\Delta Y_t &= -(1-\Pi_{11})\Delta Y_{t-1} + \Pi_{12}\Delta Z_{t-1} && \text{Differences} \\
&\quad -(1-\Pi_{11}-\Pi_{13})Y_{t-2} + (\Pi_{12}+\Pi_{14})Z_{t-2} && \text{Levels} \\
&\quad +\mu_1 + \varepsilon_{1t} && (1') \\
\Delta Z_t &= \Pi_{21}\Delta Y_{t-1} - (1-\Pi_{22})\Delta Z_{t-1} && \text{Differences} \\
&\quad +(\Pi_{21}+\Pi_{23})Y_{t-2} - (1-\Pi_{22}-\Pi_{24})Z_{t-2} && \text{Levels} \\
&\quad +\mu_2 + \varepsilon_{2t} && (2')
\end{aligned}$$

In matrices

$$\begin{bmatrix} \Delta Y_t \\ \Delta Z_t \end{bmatrix} = \underbrace{\begin{bmatrix} -(1-\Pi_{11}) & \Pi_{12} \\ \Pi_{21} & -(1-\Pi_{22}) \end{bmatrix}}_{\equiv \Gamma} \begin{bmatrix} \Delta Y_{t-1} \\ \Delta Z_{t-1} \end{bmatrix} \qquad \text{Differences}$$

$$+ \underbrace{\begin{bmatrix} -(1-\Pi_{11}-\Pi_{13} & (\Pi_{12}+\Pi_{14}) \\ (\Pi_{21}+\Pi_{23}) & -(1-\Pi_{22}-\Pi_{24}) \end{bmatrix}}_{\equiv \Pi} \begin{bmatrix} Y_{t-2} \\ Z_{t-2} \end{bmatrix} \qquad \text{Levels}$$

$$+ \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$\begin{bmatrix} dm(t) \\ dq(t) \\ di(t) \end{bmatrix} = \begin{bmatrix} -0.055 \\ -0.046 \\ -0.004 \end{bmatrix} \begin{bmatrix} 1.000 & 0.856 & 4.292 \end{bmatrix} \begin{bmatrix} m(t-1) \\ q(t-1) \\ i(t-1) \end{bmatrix}$$

$$+ \begin{bmatrix} -8.063 & -0.027 & -0.029 & -0.020 & -0.012 \end{bmatrix} \begin{bmatrix} CONST \\ S1(t) \\ S2(t) \\ S3(t) \\ TREND(t) \end{bmatrix} + \begin{bmatrix} u1(t) \\ u2(t) \\ u3(t) \end{bmatrix}$$

The estimated results of the VECM model indicate that if the system is in disequilibrium alteration of the interbank interchange interest rate, log of real US GDP, and monetary base will be downward 5.5%, 4.6% and 0.4%, respectively.

- **Chow test for VECM**

These results below show that CHOW test implies stability here which means that VECM models are stable.

Table 10 Chow test for structural break in VECM.

CHOW TEST FOR STRUCTURAL BREAK	
On the reliability of Chow-type tests..., B. Candelon, H. Lütkepohl, Economic Letters 73 (2001), 155-160	
sample range:	[1970 Q2, 1997 Q4], T = 111
tested break date:	1973 Q2 (12 observations before break)
break point Chow test:	19.7045
bootstrapped p-value:	0.1200
asymptotic chi^2 p-value:	0.0198
degrees of freedom:	9
sample split Chow test:	6.6088
bootstrapped p-value:	0.1000
asymptotic chi^2 p-value:	0.0855
degrees of freedom:	3
Chow forecast test:	0.2300
bootstrapped p-value:	0.4900
asymptotic F p-value:	0.9997
degrees of freedom:	297, 6

3. Conclusions

The main purpose of this paper has been to examine how well the dynamics properties of the estimated models of the US economy match to the theoretical prediction to the IS-LM model or with other words to test the theoretical IS-LM model for the US by applying time series estimations (standard VAR and VECM time series models). The interest variables in the models are: real GDP, three month interbank interest rate, and real monetary base. Several pre estimation tests have been made: 1) the Jarque - Bera test of normality shows that the normality of the time series is not problem in these models, but the ARCH LM test of heteroscedasticity indicates that the monetary base and interbank interest rate are heterosedastic; 2) The ADF test for unit root and Johansen test for co integration have been made to identify the optimal number of lags of the variables in the models. The applied post estimation Chow test for VAR model indicated that the model is not stable and therefore we use VECM model. The estimated results based on applying VECM model show that if the macroeconomic system is in disequilibrium (when the economy is out of its balanced path) alteration of the interbank interchange interest rate, log of real GDP, and monetary base will be downward 5.5%, 4.6% and 0.4% respectively. The chow test indicates that the VECM model is stable.

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