Money Demand in the US

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```
data <- read.csv('mpyr.csv') %>% mutate(
  m = LOGM1,
  p = LOGP,
  y = LOGY,
  mp = m - p,
  r = R,
  year = seq(1900, 1989)
  ) %>% select(year, m, p, y, r, mp) %>% tsibble(index=year)
```

```
data %>% select(-r) %>% pivot_longer(c(m, p, y, mp), names_to = 'type', values_to = 'value') %>%
  ggplot() + geom_line(aes(x=year, y=value, linetype = type, color = type))
```

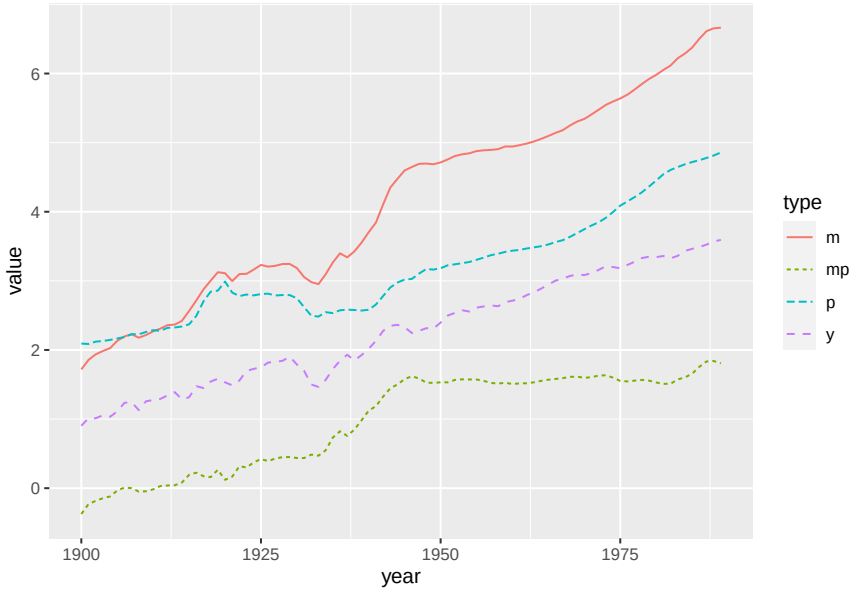

Figure 1: Plot of m, mp, p, and y

```
data %>% select(year, r) %>% autoplot(.vars = r)
```

As seen in Table 1 We can reject the null hypothesis of Y having a unit root, but cannot reject the null for r or mp.

As seen in Figure 3, You can reject the hypothesis of no cointegrating vectors. After doing it on all assumptions, having one seems the most likely.

The implied CI vector is 7.578, -7.39, 0.8517. The coeffients are significant. The income elasticity is doesn't really seem significantly different. The sign is positive for income and negative for interest rate.

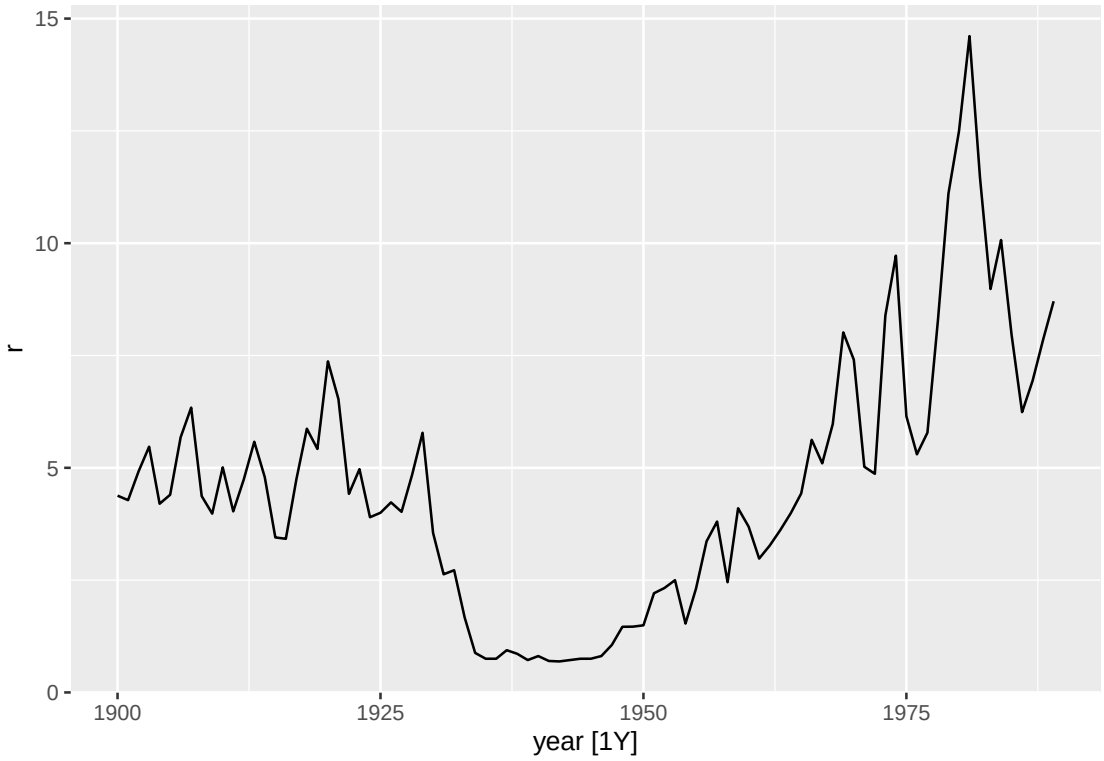

Figure 2: Plot of r

Table 1: Augmented Dickey-fuller results

Variable	t-test	5pct	Prob
r	-1.2889	-2.895	0.6317
y	-3.7999	-3.462	0.0211
mp	-1.4939	-3.463	0.8244

Date: 04/20/22 Time: 21:24
Sample: 1900 1989
Included observations: 88
Series: R MP Y
Lags interval: 1 to 1

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	1	1	1
Max-Eig	0	1	1	1	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Date: 04/20/22 Time: 21:25
Sample (adjusted): 1902 1989
Included observations: 88 after adjustments
Trend assumption: Linear deterministic trend
Series: R MP Y
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.267196	31.91218	29.79707	0.0281
At most 1	0.036673	4.554950	15.49471	0.8541
At most 2	0.014295	1.267067	3.841465	0.2603

Figure 3: Johansen Test Result

Dependent Variable: MP
Method: Least Squares
Date: 04/21/22 Time: 11:31
Sample: 1900 1989
Included observations: 90
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.773709	0.054624	-14.16422	0.0000
Y	0.941838	0.026188	35.96450	0.0000
R	-0.083223	0.011107	-7.492807	0.0000

R-squared	0.964151	Mean dependent var	0.976712
Adjusted R-squared	0.963327	S.D. dependent var	0.693053
S.E. of regression	0.132721	Akaike info criterion	-1.168376
Sum squared resid	1.532484	Schwarz criterion	-1.085049
Log likelihood	55.57691	Hannan-Quinn criter.	-1.134774
F-statistic	1169.934	Durbin-Watson stat	0.556614
Prob(F-statistic)	0.000000	Wald F-statistic	717.0321
Prob(Wald F-statistic)	0.000000		

Figure 4: OLS Result

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-2.220959	87	0.0290
F-statistic	4.932659	(1, 87)	0.0290
Chi-square	4.932659	1	0.0264

Null Hypothesis: C(2)=1
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-1 + C(2)	-0.058162	0.026188

Restrictions are linear in coefficients.

Figure 5: Wald Result

Dependent Variable: MP
Method: Dynamic Least Squares (DOLS)
Date: 04/21/22 Time: 11:39
Sample (adjusted): 1903 1987
Included observations: 85 after adjustments
Cointegrating equation deterministics: C
Static OLS leads and lags specification
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y	0.970315	0.025821	37.57890	0.0000
R	-0.096408	0.009942	-9.697103	0.0000
D(R(-1))	0.052410	0.009931	5.277154	0.0000
D(R(-2))	0.011398	0.009987	1.141289	0.2574
D(R(1))	-0.010239	0.009172	-1.116371	0.2679
D(R(2))	-0.041875	0.006813	-6.146005	0.0000
D(Y(-1))	-0.292429	0.256981	-1.137939	0.2588
D(Y(-2))	-0.192079	0.239981	-0.800392	0.4260
D(Y(1))	0.076399	0.234639	0.325601	0.7456
D(Y(2))	0.226457	0.304996	0.742494	0.4601
C	-0.770409	0.063535	-12.12578	0.0000

R-squared	0.975348	Mean dependent var	1.000538
Adjusted R-squared	0.972016	S.D. dependent var	0.660435
S.E. of regression	0.110480	Sum squared resid	0.903230

Figure 6: DOLS Result

As seen in Figures 4-6:

Yes, the elasticity is significantly different than one in OLS. Close to 1, but significantly different. With DOLS, this is not the case, and a coefficient of 1 is within error bars.

Chow Breakpoint Test: 1946
Null Hypothesis: No breaks at specified breakpoints

Equation Sample: 1900 1989

F-statistic	48.19815	Prob. F(3,84)	0.0000
Log likelihood ratio	90.10194	Prob. Chi-Square(3)	0.0000

Figure 7: Chow breakpoint Result

Chow Forecast Test
Equation: UNTITLED
Test predictions for observations from 1946 to 1989
Specification: MP C Y R

	Value	df	Probability
F-statistic	2.642691	(44, 43)	0.0009
Likelihood ratio	117.8508	44	0.0000

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	1.118763	44	0.025426
Restricted SSR	1.532484	87	0.017615
Unrestricted SSR	0.413721	43	0.009621

LR test summary:

	Value
Restricted LogL	55.57691
Unrestricted LogL	114.5023

Unrestricted log likelihood adjusts test equation results to account for observations in forecast sample

Unrestricted Test Equation:
Dependent Variable: MP
Method: Least Squares
Date: 04/21/22 Time: 11:47
Sample: 1900 1945
Included observations: 46
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.777537	0.132405	-5.872419	0.0000
Y	0.929365	0.077245	12.03132	0.0000
R	-0.083729	0.011619	-7.206415	0.0000

R-squared	0.960664	Mean dependent var	0.394018
Adjusted R-squared	0.958835	S.D. dependent var	0.483453
S.E. of regression	0.098089	Akaike info criterion	-1.742893
Sum squared resid	0.413721	Schwarz criterion	-1.623634
Log likelihood	43.08654	Hannan-Quinn criter.	-1.698218
F-statistic	525.0781	Durbin-Watson stat	0.684334
Prob(F-statistic)	0.000000	Wald F-statistic	165.5635
Prob(Wald F-statistic)	0.000000		

Figure 8: Chow forecast Result

As seen in Figure 7 and 8, Yes, there is evidence for a structural break at 1946.

After generating velocity, there is one cointegrating vector. Hasn't changed, tells you that v and r are cointegrated. Looking at Figure 10, there seems to be evidence that there is a structural break around that time.

Yes, there is evidence for a structural break at 1946. The money demand in the US seems to be stable. Income elasticity appears to be if not 1, pretty close to one at the very least. More accurate models (ie, DOLS) have it being within error bars of 1. The interest semielasticity appears to be around -.1, or slightly smaller. Either way within margin of error of -.10.

Date: 04/21/22 Time: 11:51
Sample (adjusted): 1902 1989
Included observations: 88 after adjustments
Trend assumption: Linear deterministic trend
Series: V R
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.276999	28.83084	15.49471	0.0003
At most 1	0.003274	0.288557	3.841465	0.5911

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Figure 9: Johansen V R Result

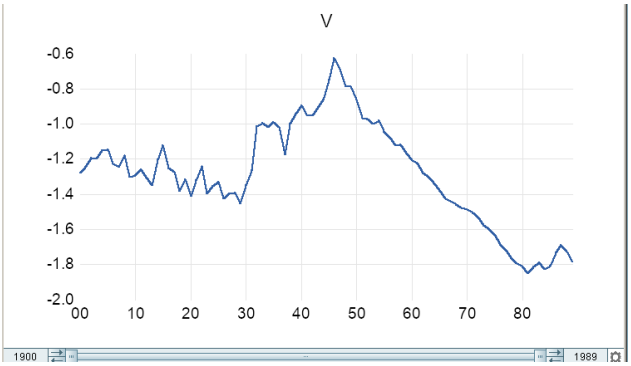

Figure 10: V Graph

Chow Breakpoint Test: 1946
Null Hypothesis: No breaks at specified breakpoints

Equation Sample: 1900 1989

F-statistic	1.362224	Prob. F(2,86)	0.2616
Log likelihood ratio	2.806937	Prob. Chi-Square(2)	0.2457

Figure 11: V Chow BP

Chow Forecast Test
Equation: UNTITLED
Test predictions for observations from 1946 to 1989
Specification: V C R

	Value	df	Probability
F-statistic	2.895471	(44, 44)	0.0003
Likelihood ratio	122.3833	44	0.0000

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	1.254168	44	0.028504
Restricted SSR	1.687316	88	0.019174
Unrestricted SSR	0.433148	44	0.009844

LR test summary:

	Value
Restricted LogL	51.24570
Unrestricted LogL	112.4374

Unrestricted log likelihood adjusts test equation results to account for observations in forecast sample

Unrestricted Test Equation:
Dependent Variable: V
Method: Least Squares
Date: 04/21/22 Time: 12:05
Sample: 1900 1945
Included observations: 46
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.920534	0.040005	-23.01051	0.0000
R	-0.075053	0.010027	-7.484914	0.0000

R-squared	0.691211	Mean dependent var	-1.189777
Adjusted R-squared	0.684193	S.D. dependent var	0.176555
S.E. of regression	0.099218	Akaike info criterion	-1.740483
Sum squared resid	0.433148	Schwarz criterion	-1.660977
Log likelihood	42.03111	Hannan-Quinn criter.	-1.710700
F-statistic	98.49202	Durbin-Watson stat	0.642767
Prob(F-statistic)	0.000000	Wald F-statistic	56.02393
Prob(Wald F-statistic)	0.000000		

Figure 12: V Chow Forecast

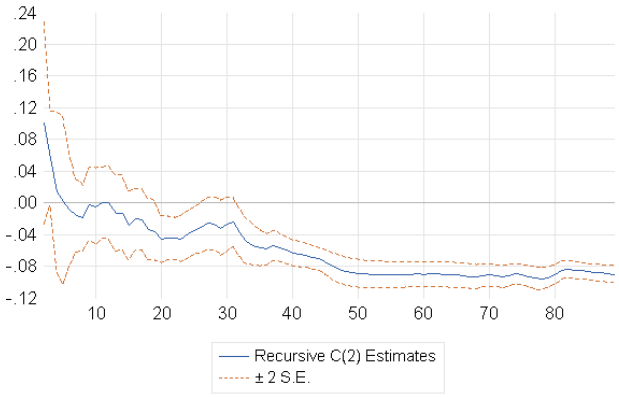

Figure 13: Recursive Estimates