APS 425 – Fall 2015

Monthly Foreign Exchange Rates

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Topics

- Data measurement issues
- Univariate time series models
- VAR models

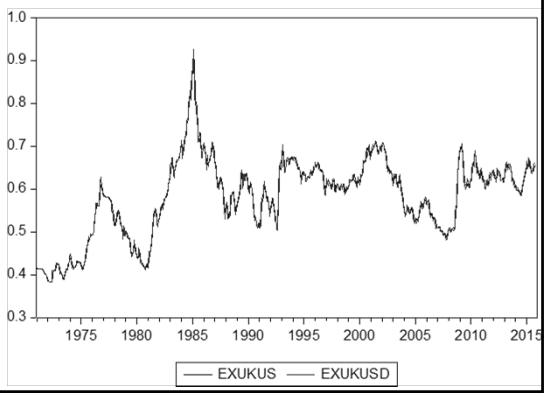
Measurement Issues

- For many government time series, monthly values are reported as the averages of daily numbers
  - e.g. FRED [Federal Reserve Economic Data]
  - http://research.stlouisfed.org/fred2/
- This might make sense for some data, but not for prices of financial assets
- Normal convention with stock prices, bond prices, exchange rates, etc. in financial research is to use end-of-month prices

Pound/Dollar Exchange Rate

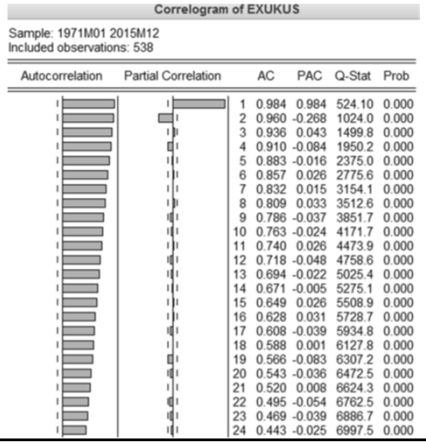
- EXUKUS for FRED (averages of daily values)
- EXUKUSD end-of-month daily values from FRED
- Both from January 1971-September 2015

	EXUKUS	EXUKUSD
Mean	0.583358	0.582871
Median	0.602954	0.601400
Maximum	0.914829	0.926800
Minimum	0.381956	0.382200
Std. Dev.	0.092084	0.092022
Skewness	-0.184166	-0.190691
Kurtosis	3.198269	3.158817
Jarque-Bera	3.915167	3.818844
Probability	0.141199	0.148166
Sum	313.2635	313.0016
Sum Sq. Dev.	4.544990	4.538859
Observations	537	537



Pound/Dollar Exchange Rate

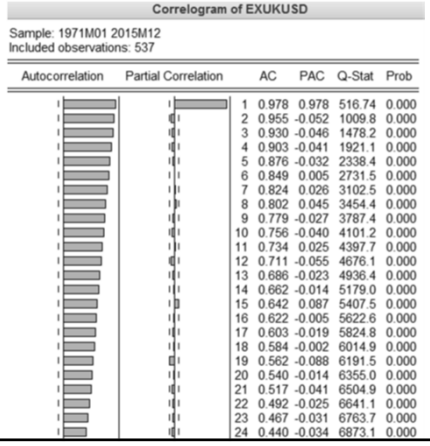
•Summary statistics and graphs look identical, as do autocorrelations of levels:



Correlogram of EXUKUS

Sample: 1971M01 2015M12
Included observations: 538

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.984	0.984	524.10	0.000
		2	0.960	-0.268	1024.0	0.000
		3	0.936	0.043	1499.8	0.000
		4	0.910	-0.084	1950.2	0.000
		5	0.883	-0.016	2375.0	0.000
		6	0.857	0.026	2775.6	0.000
		7	0.832	0.015	3154.1	0.000
		8	0.809	0.033	3512.6	0.000
		9	0.786	-0.037	3851.7	0.000
		10	0.763	-0.024	4171.7	0.000
		11	0.740	0.026	4473.9	0.000
		12	0.718	-0.048	4758.6	0.000
		13	0.694	-0.022	5025.4	0.000
		14	0.671	-0.005	5275.1	0.000
		15	0.649	0.026	5508.9	0.000
		16	0.628	0.031	5728.7	0.000
		17	0.608	-0.039	5934.8	0.000
		18	0.588	0.001	6127.8	0.000
		19	0.566	-0.083	6307.2	0.000
		20	0.543	-0.036	6472.5	0.000
		21	0.520	0.008	6624.3	0.000
		22	0.495	-0.054	6762.5	0.000
		23	0.469	-0.039	6886.7	0.000
		24	0.443	-0.025	6997.5	0.000



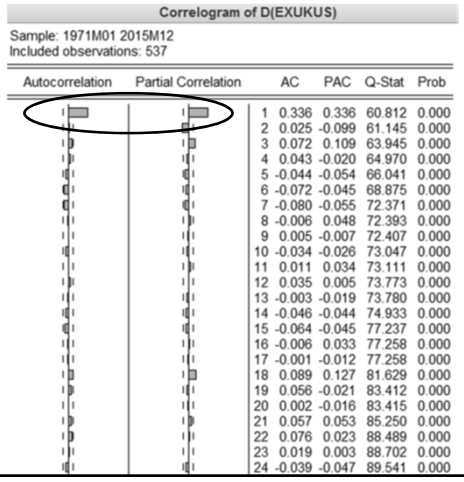
Correlogram of EXUKUSD

Sample: 1971M01 2015M12
Included observations: 537

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.978	0.978	516.74	0.000
		2	0.955	-0.052	1009.8	0.000
		3	0.930	-0.046	1478.2	0.000
		4	0.903	-0.041	1921.1	0.000
		5	0.876	-0.032	2338.4	0.000
		6	0.849	0.005	2731.5	0.000
		7	0.824	0.026	3102.5	0.000
		8	0.802	0.045	3454.4	0.000
		9	0.779	-0.027	3787.4	0.000
		10	0.756	-0.040	4101.2	0.000
		11	0.734	0.025	4397.7	0.000
		12	0.711	-0.055	4676.1	0.000
		13	0.686	-0.023	4936.4	0.000
		14	0.662	-0.014	5179.0	0.000
		15	0.642	0.087	5407.5	0.000
		16	0.622	-0.005	5622.6	0.000
		17	0.603	-0.019	5824.8	0.000
		18	0.584	-0.002	6014.9	0.000
		19	0.562	-0.088	6191.5	0.000
		20	0.540	-0.014	6355.0	0.000
		21	0.517	-0.041	6504.9	0.000
		22	0.492	-0.025	6641.1	0.000
		23	0.467	-0.031	6763.7	0.000
		24	0.440	-0.034	6873.1	0.000

Pound/Dollar Exchange Rate

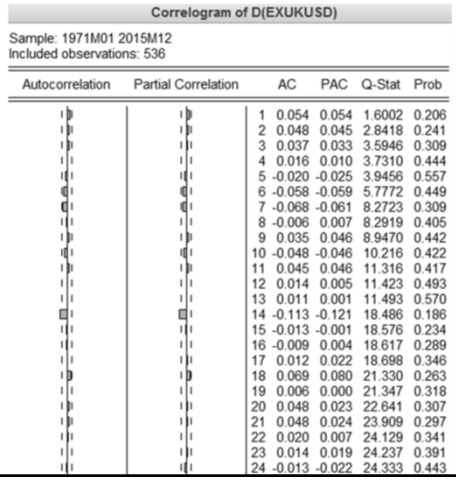
•Autocorrelations of differences show first clue:



Correlogram of D(EXUKUS)

Sample: 1971M01 2015M12
Included observations: 537

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.336	0.336	60.812	0.000
		2	0.025	-0.099	61.145	0.000
		3	0.072	0.109	63.945	0.000
		4	0.043	-0.020	64.970	0.000
		5	-0.044	-0.054	66.041	0.000
		6	-0.072	-0.045	68.875	0.000
		7	-0.080	-0.055	72.371	0.000
		8	-0.006	0.048	72.393	0.000
		9	0.005	-0.007	72.407	0.000
		10	-0.034	-0.026	73.047	0.000
		11	0.011	0.034	73.111	0.000
		12	0.035	0.005	73.773	0.000
		13	-0.003	-0.019	73.780	0.000
		14	-0.046	-0.044	74.933	0.000
		15	-0.064	-0.045	77.237	0.000
		16	-0.006	0.033	77.258	0.000
		17	-0.001	-0.012	77.258	0.000
		18	0.089	0.127	81.629	0.000
		19	0.056	-0.021	83.412	0.000
		20	0.002	-0.016	83.415	0.000
		21	0.057	0.053	85.250	0.000
		22	0.076	0.023	88.489	0.000
		23	0.019	0.003	88.702	0.000
		24	-0.039	-0.047	89.541	0.000



Correlogram of D(EXUKUSD)

Sample: 1971M01 2015M12
Included observations: 536

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.054	0.054	1.6002	0.206
		2	0.048	0.045	2.8418	0.241
		3	0.037	0.033	3.5946	0.309
		4	0.016	0.010	3.7310	0.444
		5	-0.020	-0.025	3.9456	0.557
		6	-0.058	-0.059	5.7772	0.449
		7	-0.068	-0.061	8.2723	0.309
		8	-0.006	0.007	8.2919	0.405
		9	0.035	0.046	8.9470	0.442
		10	-0.048	-0.046	10.216	0.422
		11	0.045	0.046	11.316	0.417
		12	0.014	0.005	11.423	0.493
		13	0.011	0.001	11.493	0.570
		14	-0.113	-0.121	18.486	0.186
		15	-0.013	-0.001	18.576	0.234
		16	-0.009	0.004	18.617	0.289
		17	0.012	0.022	18.698	0.346
		18	0.069	0.080	21.330	0.263
		19	0.006	0.000	21.347	0.318
		20	0.048	0.023	22.641	0.307
		21	0.048	0.024	23.909	0.297
		22	0.020	0.007	24.129	0.341
		23	0.014	0.019	24.237	0.391
		24	-0.013	-0.022	24.333	0.443

Pound/Dollar Exchange Rate

- Time averaging the data for EXUKUS creates an IMA(1,1) process, even though the underlying data is a random walk (EXUKUSD) – "Working effect"
  - named for Holbrook Working, *Econometrica*, 28 (1960) 916-918

Dependent Variable: D(EXUKUS)
Method: ARMA Conditional Least Squares (Marquardt - EViews legacy)
Sample (adjusted): 1971M02 2015M10
Included observations: 537 after adjustments
Convergence achieved after 4 iterations
White heteroskedasticity-consistent standard errors & covariance
MA Backcast: 1971M01

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000448	0.000799	0.558861	0.5765
MA(1)	0.384703	0.054899	7.007448	0.0000

R-squared	0.127553	Mean dependent var	0.000447
Adjusted R-squared	0.125922	S.D. dependent var	0.014311
S.E. of regression	0.013379	Akaike info criterion	-5.786476
Sum squared resid	0.095770	Schwarz criterion	-5.770514
Log likelihood	1555.669	Hannan-Quinn criter.	-5.780232
F-statistic	78.21778	Durbin-Watson stat	2.004658
Prob(F-statistic)	0.000000		

Dependent Variable: D(EXUKUSD)
Method: ARMA Conditional Least Squares (Marquardt - EViews legacy)
Sample (adjusted): 1971M02 2015M09
Included observations: 536 after adjustments
Convergence achieved after 6 iterations
White heteroskedasticity-consistent standard errors & covariance
MA Backcast: 1971M01

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000463	0.000791	0.585929	0.5582
MA(1)	0.050117	0.058477	0.857043	0.3918

R-squared	0.002726	Mean dependent var	0.000462
Adjusted R-squared	0.000859	S.D. dependent var	0.017441
S.E. of regression	0.017434	Akaike info criterion	-5.257085
Sum squared resid	0.162303	Schwarz criterion	-5.241100
Log likelihood	1410.899	Hannan-Quinn criter.	-5.250831
F-statistic	1.459828	Durbin-Watson stat	1.994960
Prob(F-statistic)	0.227492		

Pound/Dollar Exchange Rate

- Cross-correlations show the strongest relation is between EXUKUS and EXUKUSD(-1)

Cross Correlogram of EXUKUS and EXUKUSD

Sample: 1971M01 2015M12
Included observations: 537
Correlations are asymptotically consistent approximations

EXUKUS,EXUKUSD(-i)	EXUKUS,EXUKUSD(+i)	i	lag	lead
		0	0.9947	0.9947
		1	0.9900	0.9718
		2	0.9673	0.9466
		3	0.9440	0.9211
		4	0.9189	0.8947
		5	0.8912	0.8676
		6	0.8640	0.8418

Pound/Dollar Exchange Rate

•VAR(2) model for EXUKUS and EXUKUSD shows how time-averaging makes EXUKUS seem to be predictable

Vector Autoregression Estimates

Vector Autoregression Estimates
Sample (adjusted): 1971M03 2015M09
Included observations: 535 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	EXUKUS	EXUKUSD
EXUKUS(-1)	0.007098	-0.088166
	(0.09520)	(0.16030)
	[0.07456]	[-0.54999]
EXUKUS(-2)	-0.048149	-0.175146
	(0.04692)	(0.07900)
	[-1.02620]	[-2.21694]
EXUKUSD(-1)	1.020276	1.082155
	(0.05638)	(0.09493)
	[18.0959]	[11.3989]
EXUKUSD(-2)	0.011905	0.158962
	(0.07037)	(0.11849)
	[0.16918]	[1.34159]
C	0.006126	0.013532
	(0.00287)	(0.00484)
	[2.13326]	[2.79849]

R-squared	0.987534	0.964608
Adj. R-squared	0.987440	0.964341
Sum sq. resids	0.055943	0.158606
S.E. equation	0.010274	0.017299
F-statistic	10496.82	3611.332
Log likelihood	1692.689	1413.930
Akaike AIC	-6.309116	-5.267028
Schwarz SC	-6.269095	-5.227007
Mean dependent	0.583989	0.583503
S.D. dependent	0.091674	0.091609

Pound/Dollar Exchange Rate

•VAR(2) model for D(EXUKUS) and D(EXUKUSD) makes it clear that the end-of-period exchange rate is a random walk (so differences are unpredictable)

Vector Autoregression Estimates

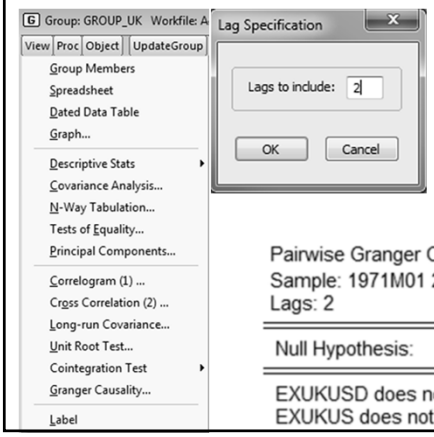
Vector Autoregression Estimates
Sample (adjusted): 1971M04 2015M09
Included observations: 534 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(EXUKUS)	D(EXUKUSD)
D(EXUKUS(-1))	-0.474611	0.120463
	(0.07903)	(0.12580)
	[-6.00534]	[0.95760]
D(EXUKUS(-2))	-0.144823	-0.032556
	(0.04849)	(0.07718)
	[-2.98658]	[-0.42179]
D(EXUKUSD(-1))	0.765020	-0.010833
	(0.05082)	(0.08089)
	[15.0539]	[-0.13392]
D(EXUKUSD(-2))	0.299839	0.005945
	(0.06009)	(0.09564)
	[4.98995]	[0.06216]
C	0.000245	0.000429
	(0.00048)	(0.00076)
	[0.51508]	[0.56661]

R-squared	0.419387	0.007962
Adj. R-squared	0.414997	0.000461
Sum sq. resids	0.063724	0.161450
S.E. equation	0.010975	0.017470
F-statistic	95.52647	1.061418
Log likelihood	1654.256	1406.042
Akaike AIC	-6.176988	-5.247349
Schwarz SC	-6.136909	-5.207271
Mean dependent	0.000447	0.000464
S.D. dependent	0.014350	0.017474

Pound/Dollar Exchange Rate

- "Granger Causality Test" shows that lags of EXUKUSD predict EXUKUS, but not vice versa



Pairwise Granger Causality Tests
Sample: 1971M01 2015M12
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
EXUKUSD does not Granger Cause EXUKUS	535	189.427	9.E-63
EXUKUS does not Granger Cause EXUKUSD		2.63748	0.0725

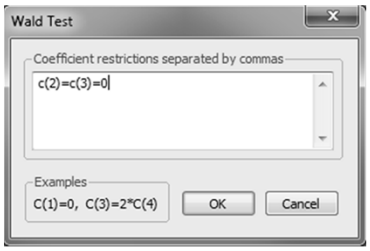
Pound/Dollar Exchange Rate

- Note that the "Granger Causality Test" from the pull-down menu does not use heteroskedasticity correction

Dependent Variable: D(EXUKUS)
Method: Least Squares
Sample (adjusted): 1971M04 2015M10
Included observations: 535 after adjustments
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000239	0.000470	0.508229	0.6115
D(EXUKUSD(-1))	0.764574	0.056231	13.59713	0.0000
D(EXUKUSD(-2))	0.299142	0.066038	4.529884	0.0000
D(EXUKUS(-1))	-0.474169	0.090146	-5.260003	0.0000
D(EXUKUS(-2))	-0.144313	0.060814	-2.373016	0.0180

R-squared	0.419361	Mean dependent var	0.000453
Adjusted R-squared	0.414979	S.D. dependent var	0.014337
S.E. of regression	0.010966	Akaike info criterion	-6.178736
Sum squared resid	0.063734	Schwarz criterion	-6.138714
Log likelihood	1657.812	Hannan-Quinn criter.	-6.163077
F-statistic	95.69683	Durbin-Watson stat	2.076429
Prob(F-statistic)	0.000000	Wald F-statistic	66.75563
Prob(Wald F-statistic)	0.000000		



Wald Test:
Equation: EQ_UKUS3

Test Statistic	Value	df	Probability
F-statistic	136.0313	(2, 530)	0.0000
Chi-square	272.0626	2	0.0000

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