Seminar 3: Testing CIP and UIP in *Eviews*

The principal aims of this seminar are to:

- Demonstrate misspecification testing in *Eviews*.
- Demonstrate the use of alternative estimators in *Eviews*.

To achieve these aims you will estimate CIP and UIP relationships for the UK/US foreign exchange market using OLS initially. Then you will subject the model to rigorous misspecification testing (testing whether the assumptions of the Classical Linear Regression Model (CLRM) are compatible with the observed data). This will include tests for:

- Heteroscedasticity.
- Autocorrelation.
- Incorrect functional form.
- Structural instability.
- Endogenous regressors.

The evidence for an endogenous regressor will lead you to re-estimate the model using an Instrumental Variable Estimator (IVE). The session will culminate with the estimation of a Generalized Method of Moments (GMM)/IV model to take account of both the endogenous regressor and heteroscedasticity/autocorrelation in the errors.

The learning outcomes from this analysis will be to develop your understanding of:

- Misspecification testing in *Eviews*.
- The importance of misspecification testing as part of any econometric analysis.
- The consequences of violations of different assumptions of the CLRM.
- Remedies for these violations including the use of alternative (non-OLS) estimators.
- How (and when) to implement these remedies/procedures in *Eviews*.

The data for this exercise are in the file **cip_sem3.wf1** which I sent to you in an email. These data will allow you test both CIP and UIP relationships. This handout goes through the analysis for the CIP relationship in detail. Please attempt the estimation and testing for the UIP relationship in your own time to test your understanding of this analysis. For background on the CIP/UIP relationships read Cuthbertson and Nitzsche (2004) Chapters 24.3, 24.4, 25.1 and 25.2 (and see lecture 4). Further background on IVE can be found in Verbeek Chapter 5.

1. Initial Estimation using OLS

Create a variable for the (log) 3 month forward premium:

Click ***Genr*** on the workfile toolbar and type in:

fp_3m=log(uk_3mfrate)-log(uk_spot_rate)

Estimate the CIP relationship by OLS:

Click ***Quick/Estimate Equation*** on the main toolbar and type in:

fp_3m c uk_3mtbills-us_3mtbills

Dependent Variable: FP_3M

Method: Least Squares
Date: 02/04/07 Time: 21:23
Sample: 5/10/2001 9/30/2005
Included observations: 1147

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.00726	0.000422	-17.20141	0
UK_3MTBILLS-US_3MTBILLS	0.949718	0.016855	56.34583	0

R-squared	0.734945	Mean dependent va	0.01585
Adjusted R-squared	0.734713	S.D. dependent var	0.006551
S.E. of regression	0.003374	Akaike info criterion	-8.543509
Sum squared resid	0.013037	Schwarz criterion	-8.534712
Log likelihood	4901.702	F-statistic	3174.853
Durbin-Watson stat	1.458456	Prob(F-statistic)	0

In your own time, repeat the estimation for the UIP relationship. The dependent variable for UIP is the 3 month (12weeks×5days=60day) holding period return on sterling:

Click ***Genr*** on the workfile toolbar and type in:

uk_spot_3m=log(uk_spot_rate(60))-log(uk_spot_rate)

2. Misspecification testing

The background on these tests can be found in your notes for lecture 3 (and the references therein). Be sure to repeat these tests later for the UIP OLS model.

i.) White test for heteroscedasticity

There is no difference between the tests respectively with and without 'cross terms' in this case because there is only one regressor in the CIP model.

Click ***View/Residual Tests/White Heteroskedasticity (cross terms)*** on the equation toolbar:

White Heteroskedasticity Test:

F-statistic	**3.970368**	**Prob. F(2,1144)**	**0.019127**
Obs*R-squared	**7.906678**	**Prob. Chi-Square(2)**	**0.019191**

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 02/04/07 Time: 21:27
Sample: 5/10/2001 9/30/2005
Included observations: 1147

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.53E-06	7.48E-06	-1.27328	0.2032
UK_3MTBILLS-US_3MTBILLS	0.001787	0.000635	2.813587	0.005
(UK_3MTBILLS-US_3MTBILLS)^2	-0.036016	0.013064	-2.756996	0.0059

R-squared	0.006893	Mean dependent var	1.14E-05
Adjusted R-squared	0.005157	S.D. dependent var	1.94E-05
S.E. of regression	1.94E-05	Akaike info criterion	-18.86498
Sum squared resid	4.28E-07	Schwarz criterion	-18.85178
Log likelihood	10822.06	F-statistic	3.970368
Durbin-Watson stat	1.907598	Prob(F-statistic)	0.019127

Q: What do you infer from the results of this test?
Q: What are the consequences of your findings for your previous OLS estimates of CIP?

ii.) Breusch-Godfrey LM test for autocorrelation

Click ***View/Residual Tests/Serial Correlation LM Test*** on the equation toolbar:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	**80.44297**	**Prob. F(2,1143)**	**0**
Obs*R-squared	**141.5279**	**Prob. Chi-Square(2**	**0**

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 02/04/07 Time: 21:29
Sample: 5/10/2001 9/30/2005
Included observations: 1147
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.14E-06	0.000396	0.010478	0.9916
UK_3MTBILLS-US_3MTBILLS	-0.000162	0.015795	-0.010237	0.9918
RESID(-1)	0.207766	0.028768	7.222137	0
RESID(-2)	0.232529	0.028769	8.082623	0

R-squared	0.12339	Mean dependent va	-1.99E-18
Adjusted R-squared	0.121089	S.D. dependent var	0.003373
S.E. of regression	0.003162	Akaike info criterion	-8.671714
Sum squared resid	0.011428	Schwarz criterion	-8.654121
Log likelihood	4977.228	F-statistic	53.62865
Durbin-Watson stat	2.114047	Prob(F-statistic)	0

Q: What do you infer from the results of this test?
Q: What are the consequences of your findings for your previous OLS estimates of CIP?

iii.) Ramsey's RESET test for incorrect functional form

The Eviews version of this test regresses the dependent variable on the original regressors and the fitted terms. Sometimes the test is carried out by regressing the model residuals on the original regressors and fitted terms. The two versions of the test are equivalent.

Including 2 fitted terms will test the null of a linear functional form against the alternative of a cubic functional form

Click ***View/Stability Tests/Ramsey RESET Test*** on the equation toolbar:

Number of Fitted Terms: 2

Ramsey RESET Test:

F-statistic	**31.97472**	**Prob. F(2,1143)**	**0**
Log likelihood ratio	**62.44229**	**Prob. Chi-Square(2**	**0**

Test Equation:
Dependent Variable: FP_3M

Method: Least Squares
Date: 02/04/07 Time: 21:32
Sample: 5/10/2001 9/30/2005
Included observations: 1147

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001262	0.003222	-0.391601	0.6954
UK_3MTBILLS-US_3MTBILLS	0.592863	0.272955	2.172019	0.0301
FITTED^2	1.963279	21.04378	0.093295	0.9257
FITTED^3	389.9774	463.1432	0.842023	0.4

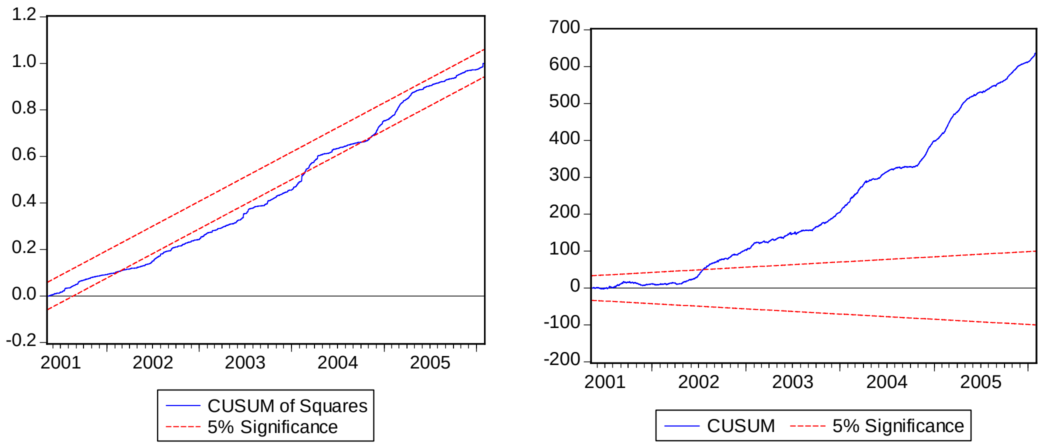
R-squared	0.748988	Mean dependent va	0.01585
Adjusted R-squared	0.74833	S.D. dependent var	0.006551
S.E. of regression	0.003287	Akaike info criterion	-8.594461
Sum squared resid	0.012346	Schwarz criterion	-8.576868
Log likelihood	4932.924	F-statistic	1136.858
Durbin-Watson stat	1.537418	Prob(F-statistic)	0

Q: What do you infer from the results of this test?
Q: What are the consequences of your findings for your previous OLS estimates of CIP?

iv.) CUSUM/CUSUMSQ tests (for parameter instability)

Click ***View/Stability Tests/Recursive Estimates (OLS only)*** on the equation toolbar:

Select ***CUSUM Test*** (repeat for CUSUM of Squares Test):



Q: What do you infer from the results of this test?
Q: What are the consequences of your findings for your previous OLS estimates of CIP?

v.) Durbin-Wu-Hausman test (for endogenous regressors) (see e.g., Gujarati 19.4 and Verbeek 5.3)

Suppose the model is given by

$$Y_t = \beta_1 + \beta_2 X_{2t} + \varepsilon_t$$

The investigator suspects the regressor is endogenous: $\text{cov}(X_{2t}, \varepsilon_t) \neq 0$. However, the investigator also has a set of instrumental variables (IVs) which are correlated with X_2 but uncorrelated with ε (i.e., they are exogenous). To test his/her suspicions that X_2 is endogenous the investigator carries out the following procedure

Step 1: Regress X_2 on the IVs:

$$X_{2t} = \pi_1 + \pi_2 Z_{2t} + \ldots + \pi_m Z_{mt} + v_t$$

Obtain the residuals $\hat{v}_t$.

Step 2: Regress Y on X_2 and $\hat{v}$

$$Y_{2t} = \beta_1 + \beta_2 X_{2t} + \lambda \hat{v}_t + \varepsilon_t$$

Perform a *t*-test on the coefficient of $\hat{v}$ (test $H_0 : \lambda = 0$). If the null is not rejected then this provides evidence that X_2 is exogenous; if the null is rejected then it suggests X_2 is endogenous.

This procedure is part of a general testing procedure known as a Hausman test. In this particular context, the intuition is that if X_2 is exogenous then both OLS and 2SLS are consistent (both the estimators converge to the same value - β_2 - in large samples). However if X_2 is endogenous then only the 2SLS estimator converges on β_2 (because OLS is inconsistent): therefore the difference between the OLS and 2SLS estimators of β_2 is non-zero in large samples if X_2 is endogenous. The coefficient λ measures this difference so if λ is statistically significant then it suggests X_2 is endogenous.

Another way of thinking about it is that $\hat{v}$ measures the stochastic component of X. If X is exogenous this stochastic component is uncorrelated with Y ($\text{cov}(Y, v) = \text{cov}(\varepsilon, X_2) = 0 \Rightarrow \lambda = 0$).

Now we will apply the Hausman test to the CIP model.

Step 1: Regress the interest differential on the exogenous/instrumental variables. Use UK and US GDP growth as instruments.

Click ***Quick/Estimate Equation*** on the main toolbar and type in:

uk_3mtbills-us_3mtbills c log(uk_gdp)-log(uk_gdp(-1)) log(us_gdp)-log(us_gdp(-1))

Dependent Variable: UK_3MTBILLS-US_3MTBILLS
Method: Least Squares
Date: 02/04/07 Time: 10:32
Sample (adjusted): 5/10/2001 9/30/2005
Included observations: 1147 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.021028	0.000308	68.28002	0
LOG(UK_GDP)-LOG(UK_GDP(-1))	0.074852	0.112879	0.663112	0.5074
LOG(US_GDP)-LOG(US_GDP(-1))	30.36716	2.396153	12.6733	0

R-squared	0.123163	Mean dependent va	0.024334
Adjusted R-squared	0.12163	S.D. dependent var	0.005914
S.E. of regression	0.005542	Akaike info criterion	-7.550163
Sum squared resid	0.035142	Schwarz criterion	-7.536968
Log likelihood	4333.019	F-statistic	80.34477
Durbin-Watson stat	0.007271	Prob(F-statistic)	0

Save the residuals:

Click ***Proc/Make Residual Series*** on the equation toolbar.

Name for residual series: resid_haus

Step 2: Regress the 3 month forward premium on the interest differential and resid_haus

Click ***Quick/Estimate Equation*** on the main toolbar and type in:

fp_3m c uk_3mtbills-us_3mtbills resid_haus

Dependent Variable: FP_3M
Method: Least Squares
Date: 02/04/07 Time: 10:39
Sample (adjusted): 5/10/2001 9/30/2005
Included observations: 1147 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.010745	0.001168	-9.197338	0
UK_3MTBILLS-US_3MTBILLS	1.092911	0.047836	22.84721	0
RESID_HAUS	**-0.163305**	**0.051085**	**-3.196747**	**0.0014**

R-squared	0.737291	Mean dependent va	0.01585
Adjusted R-squared	0.736832	S.D. dependent var	0.006551
S.E. of regression	0.003361	Akaike info criterion	-8.550659
Sum squared resid	0.012922	Schwarz criterion	-8.537464
Log likelihood	4906.803	F-statistic	1605.317
Durbin-Watson stat	1.473166	Prob(F-statistic)	0

Q: What do you infer from the results of this test?
Q: What are the consequences of your findings for your previous OLS estimates of CIP?
Q: What is a possible solution?

3. Two-Stage Least Squares Model

A possible solution to the endogeneity found in the CIP model is to estimate the relationship using an IV estimator such as 2SLS (see lecture 4). This is estimated in *Eviews* as follows:

Click ***Quick/Estimate Equation*** on the main toolbar.
Select Method: **TSLS**

Type into the ***Equation specification*** dialog box:

fp_3m c uk_3mtbills-us_3mtbills

Type into the ***Instrument list***:

log(uk_gdp)-log(uk_gdp(-1)) log(us_gdp)-log(us_gdp(-1))

Dependent Variable: FP_3M
Method: Two-Stage Least Squares
Date: 02/04/07 Time: 11:07
Sample (adjusted): 5/10/2001 9/30/2005
Included observations: 1147 after adjustments
Instrument list: LOG(UK_GDP)-LOG(UK_GDP(-1)) LOG(US_GDP)
-LOG(US_GDP(-1))

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.010745	0.001209	-8.884795	0
UK_3MTBILLS-US_3MTBILLS	1.092911	0.049518	22.07082	0

R-squared	0.718237	Mean dependent va	0.01585
Adjusted R-squared	0.717991	S.D. dependent var	0.006551
S.E. of regression	0.003479	Sum squared resid	0.013859
Durbin-Watson stat	1.372406	Second-stage SSR	0.04329

Q: Compare the 2SLS point estimates with the previous OLS estimates. Why are they different?
Q: Are the inferences in this model (*t*-stats) valid? If not, why not?

4. GMM/IV Model

The 2SLS point estimates are valid (unlike the OLS estimates) given the endogeneity of the interest differential. However inferences in the 2SLS model are still invalid because of the heteroscedasticity and autocorrelation problems found earlier. Therefore we will finish the session by estimating a GMM/IV model with a Newey-West Heteroscedasticity and Autocorrelation Consistent (HAC) variance-covariance matrix. The GMM estimator weights the sample moments using the inverse of the variance-covariance matrix of the sample moments (see lecture 4). Estimating this variance-covariance matrix with a Newey-West estimator ensures it is estimated consistently in the presence of heteroscedasticity and autocorrelation.

Click ***Quick/Estimate Equation*** on the main toolbar.
Select Method: **GMM**

Type into the ***Equation specification*** dialog box:

fp_3m c uk_3mtbills-us_3mtbills

Type into the ***Instrument list***:

log(uk_gdp)-log(uk_gdp(-1)) log(us_gdp)-log(us_gdp(-1))

By default the weighting matrix is Time-Series HAC (as desired) and there is also no need to change the 'kernel' options (the default is to use Bartlett weights for the autocorrelations – see lecture 4). Therefore just click 'OK':

Dependent Variable: FP_3M
Method: Generalized Method of Moments
Date: 02/04/07 Time: 21:18
Sample (adjusted): 5/10/2001 9/30/2005
Included observations: 1147 after adjustments
Kernel: Bartlett, Bandwidth: Fixed (6), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 3 weight matrices, 4 total coef iterations
Instrument list: LOG(UK_GDP)-LOG(UK_GDP(-1)) LOG(US_GDP)
-LOG(US_GDP(-1))

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.010432	0.002108	-4.948753	0
UK_3MTBILLS-US_3MTBILLS	1.079274	0.085354	12.64472	0

R-squared	0.721259	Mean dependent va	0.01585
Adjusted R-squared	0.721016	S.D. dependent var	0.006551
S.E. of regression	0.00346	Sum squared resid	0.01371
Durbin-Watson stat	1.387221	**J-statistic**	0.000482

The J-statistic is an important statistic which will be used to test the validity of the instrumental variables (see below).

Name this equation CIP_GMM. This will save the equation in your workfile for future reference (see below).

Q: Compare the *t*-stats for the 2SLS and GMM models. What effect has the use of the Newey-West HAC variance-covariance matrix had on inferences in the CIP model?

Sargan Test of instrumental validity (see Verbeek 5.5.3)

The GMM/IV estimators are based on the assumption that the instruments are uncorrelated with the error term: $E(Z'\varepsilon)=0$ (see lecture 4). It is important to test this assumption since if it does not hold then the GMM/IV estimators are inconsistent. In this context, the Sargan test is based on the following statistic:

$$T\left(\frac{1}{T}\hat{\varepsilon}'Z\right)W_T\left(\frac{1}{T}Z'\hat{\varepsilon}\right)=TJ_T\left(\hat{\beta}_{GMM}\right)$$

Recall from lecture 4 that GMM chooses $\hat{\beta}_{GMM}$ to minimize the following objective function: $\left(T^{-1}\hat{\varepsilon}'Z\right)W_T\left(T^{-1}Z'\hat{\varepsilon}\right)$. The statistic $J_T\left(\hat{\beta}_{GMM}\right)$ (the 'J' statistic: see GMM estimation output above) is therefore simply the minimized value of this objective function. If the instruments are uncorrelated with the errors then the sample moment restrictions $\left(T^{-1}Z'\hat{\varepsilon}\right)$, and hence the J-statistic, should be close to zero. In fact, under the null hypothesis that the instruments are uncorrelated with the errors, the Sargan test has the following distribution:

$$TJ_T\left(\hat{\beta}_{GMM}\right)\sim\chi^2(m-k)$$

From the above null distribution it is apparent that the Sargan test is only valid when the number of instruments (m) is greater than the number of endogenous variables (k) (i.e., when the model is over-identified). This is why the Sargan test is often referred to as a test of over-identifying restrictions. If the model is just/exactly identified (m=k) the J-statistic equals zero by construction and so is uninformative about whether the population moment conditions are true.

If the Sargan test rejects the null then it suggests that some or all of the instruments are invalid (i.e., they are correlated with the error term). In that case we will need to think of re-estimating the model using a different set of instruments.

Now implement the Sargan test in Eviews. The following commands assume you have saved the GMM equation in your workfile and named it **cip_gmm**:

In the command window type in:

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scalar sargan=cip_gmm.@regobs*cip_gmm.@jstat
scalar sargan_pval=1-@cchisq(sargan,1)
```

Double-click on sargan_pval to see the p-value of the test (look at the bottom of the Eviews window to see this value).

This line computes $TJ_T\left(\hat{\beta}_{GMM}\right)$

This line computes the p-value of the test based on a $\chi^2(1)$ distribution. Note that there are 2 instruments and 1 endogenous regressor in the GMM model so $m-k=1$.

Q: What do you conclude about the validity of the instruments based on this result?

Test the CIP restrictions

The GMM model has remedied the problems in the OLS model caused by the endogenous regressor and invalid inferences due to heteroscedasticity/autocorrelation in the errors. We can therefore more confidently test the CIP restrictions in the GMM model than we could in the OLS model. The final piece of analysis is therefore to test the CIP restrictions in the GMM model (intercept=0 and slope coefficient=unity):

Click ***View/Coefficient Tests/Wald Coefficient Restrictions*** on the GMM equation toolbar.

Type in: c(1)=0, c(2)=1

Wald Test:
Equation: CIP

Test Statistic	Value	df	Probability
F-statistic	1206.578	(2, 1145)	0
Chi-square	2413.155	2	0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.010432	0.002108
-1 + C(2)	0.079274	0.085354

Restrictions are linear in coefficients.

Q: What do you infer about the CIP relationship based on this test?

Conclusions

The OLS model for CIP suffered from a number of problems: heteroscedasticity; autocorrelation; incorrect functional form, parameter instability; and an endogenous regressor. <u>Accordingly no reliance can be placed on either the point estimates or inferences from this model</u>.

Re-estimation of the model using GMM/IV with a Newey-West HAC variance-covariance matrix provides remedies for the problems of endogeneity (which leads to biased/inconsistent point estimators in the OLS model) and heteroscedaticity/autocorrelation (which leads to invalid inferences in the OLS model). The Sargan test suggests that the instruments (UK and US GDP growth) used in the GMM/IV model are uncorrelated with the error term. Therefore they are valid instruments for estimating the model.

Finally, the GMM/IV model rejects the coefficient restrictions implied by CIP. This suggests it may be possible to earn abnormal riskless profits from covered interest arbitrage. However no account has been taken of transactions costs so it’s unclear whether this is evidence of a violation of the EMH (see lecture 4, Appendix 2 for an interpretation of a CIP equation; see also Cuthbertson and Nitzsche 25.1 for criticisms of regression tests of CIP).

References

Cuthbertson and Nitzsche (2004). *Quantitative Financial Economics*. Second Edition. Wiley: Chichester.
Verbeek (2004). *A Guide to Modern Econometrics*. Second Edition. Wiley: Chichester.