A framework for heteroskedasticity-robust specification and misspecification testing functions for linear models in R

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Extending `lmtest`

- Integrating the existing toolbox for econometric model specification with flexible testing functions, robust vs.:
  - heteroskedasticity
  - autocorrelation
  - (non-normality)
- Providing SW counterparts to conceptual *objects,* not just procedures

Providing the versions behaving best in practically relevant settings

- Heteroskedasticity is a frequent concern
  - Cross-sectional data
  - Financial time series
- Sometimes you would want to model the second moment as well, but sometimes you're just concerned with the conditional mean: here heteroskedasticity and autocorrelation are just nuisances

Providing the versions behaving best in practically relevant settings

- screening tests are known to have little power, thus one is advised to *use robust testing in the first place:*
  - Hansen characterizes this as best practice
  - Long and Ervin show the superior properties of *doing robust testing in the first place* against the two-step strategy of *screening for hetero, then choosing the test accordingly*

Providing the versions behaving best in practically relevant settings

- asymptotics are of little use in many real-world applications if small-sample properties are poor
  - MacKinnon and White (1985) developed small-sample versions of HC covariance matrix estimators with very good properties
  - yet the use of the original, suboptimal HC0 version is widespread (Long and Ervin, 2000)

A comprehensive approach

Specification testing:

		$\mathcal{M}_m$	restriction test →	test
		H_0: $R\beta=0$		for H_0

Misspecification testing:

$\mathcal{M}_m$	translate →	$\mathcal{M}_{aux}$	restriction test →	test
H_0		$R\beta=0$		for H_0

Non-nested model comparison:

$\mathcal{M}_m$	translate →	$\mathcal{M}_{encomp}$	restriction test →	test
$\mathcal{M}_{alternative}$		$R\beta=0$		for H_0

Design principles: theory-driven, high-level approach

Translating the conceptual approach to restriction testing (Wald-LM-LR) into software through an object-oriented approach:

- explicitly dealing with parameter and covariance estimators through their software counterparts
  - you don't need to know what's inside the box
  - computationally more intensive, but this isn't a limitation nowadays in most settings

Design principles: modularity

- Reusing tools, e.g. *vcovs* from `sandwich`
- Making the restriction testing functions reusable as computing tools for tests based on auxiliary models
  - ease of maintenance
  - ready to be reused

Design principles: flexibility

Plugging in the appropriate tool for the problem at hand (sensible defaults, but the useR can choose, or e.g. run multiple tests)

- Example: Robust restrictions testing
  - a Wald test robust vs. heteroskedasticity and autocorrelation of residuals can be implemented plugging in the relevant vcov matrix.
- Example: Robust misspecification tests
  - robust Wald and LM tests can be plugged into misspecification tests (e.g. Breusch-Godfrey) or non-nested tests (e.g. J-test)

What is (will be) available

Specification testing:

- **`coeftest(), waldtest(), lrtest()`** `(scoretest())`

Non-nested models comparison:

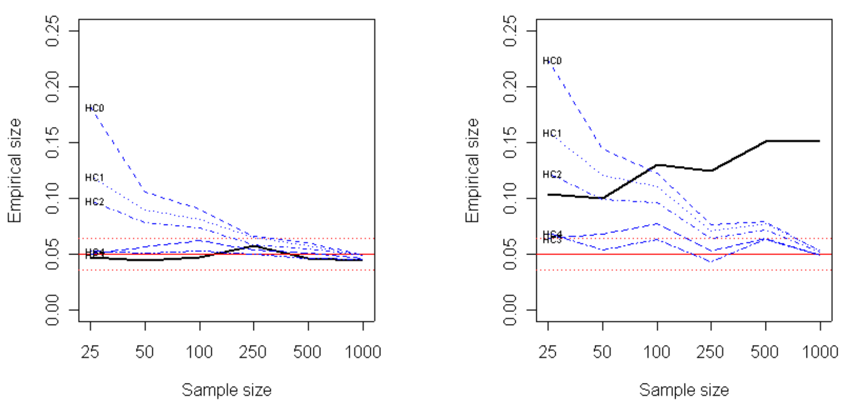
- **`encomptest(), jtest()`**

Misspecification/endogeneity

- **`grangertest()`** `(bgtest(), reset(), dwhtest(), whitetest()...)`

Is this practically relevant? 1.

Assessment of small-sample behaviour and HC-robustness of restriction tests under different conditions (Montecarlo)



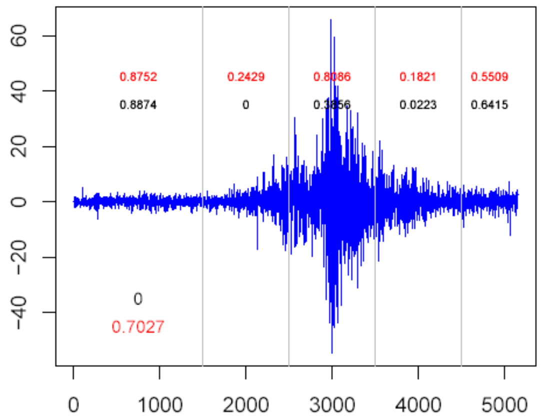
Is this practically relevant? 2.

Motivating example for higher-level misspecification tests: testing serial correlation on highly heteroskedastic financial data (no scientific evidence, just an example)

- the standard test rejects the hypothesis of no correlation at any level on some “evidently heteroskedastic” subsamples
- the results of the HC-robust test “look far more stable”
- *is the standard test being fooled by heteroskedasticity into false positives?*

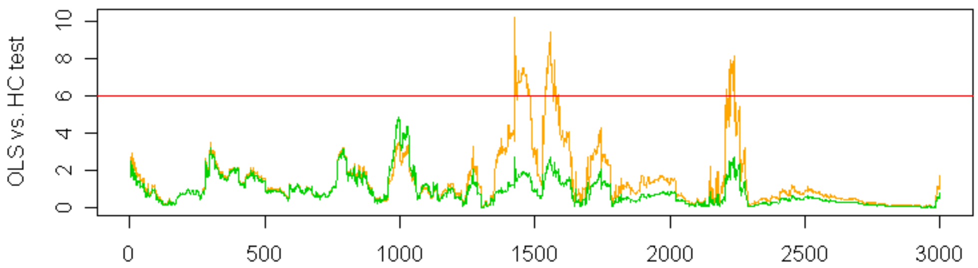
Breusch-Godfrey tests on subsamples

Model on stock returns, d(tel)~d(sp)+d(nasdaq)



Standard vs. HC-consistent BG test

3-year rolling window, std.=orange, HC=green



Estimated error heteroskedasticity

Log of ratio of 5%-35% to 65%-95% quantiles' variance