gets: An R Package for General-to-Specific (GETS) Modelling and Indicator Saturation Methods

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The *R* package `gets` provides automated...

1. ...GETS modelling of the mean of a regression:

$$y_t = \beta_1 x_{1t} + \cdots + \beta_k x_{kt} + \epsilon_t, \qquad \epsilon_t = \sigma_t z_t, \qquad z_t \sim iid(0,1)$$

2. ...GETS modelling of the (log-)variance of a regression:

$$\ln \sigma_t^2 = \alpha_1 w_{1t} + \cdots + \alpha_l w_{lt}$$

3. ...detection and tests for breaks in the mean-intercept (w/Indicator Saturation (IS) methods)

The main functions of the `gets` package:

1. `arx`: Estimation of AR-X model with (optionally) log-ARCH-X errors
2. `getsm`: Automated GETS modelling of mean specification
3. `getsv`: Automated GETS modelling of variance specification
4. `isat`: Automated GETS modelling of an indicator saturated mean specification

Automated multi-path GETS modelling software:

- Sucarrat (November 2011): `AutoSEARCH`. An `R` package available from the CRAN. Multi-path, single-round, GETS modelling of *both* the mean and variance specifications. Based on code developed for Sucarrat and Escribano (2012): "Automated Model Selection in Finance...", *Ox.Bull.Econ.Stat.* 74, pp. 716-735
- Sucarrat (October 2014): `gets`. An `R` package available on the CRAN. More user-friendly and faster than `AutoSEARCH`, and contains more features (e.g. indicator saturation methods)
- Hoover and Perez (1999): `MATLAB` code. Only 10 paths, not user-friendly and no help-system
- OxMetrics (commercial):
  - Hendry and Krolzig (2001): `PcGets`. Multi-path, multi-round, additional features
  - Doornik (2009): `Autometrics`. Multi-branch, multi-round, additional features

Why `AutoSEARCH/gets`?:

- `PcGets/Autometrics` models the mean:

$$y_t = \phi_0 + \sum_r \phi_r y_{t-r} + \sum_s \eta_s x^m_{s,t} + \epsilon_t, \quad \epsilon_t = \sigma_t z_t, \quad z_t \sim iid(0,1)$$

- In my research, I was interested in GETS modelling of the log-variance:

$$\ln \sigma_t^2 = \alpha_0 + \sum_p \alpha_p \ln \epsilon^2_{t-p} + \sum_d \delta_d x^v_{d,t}$$

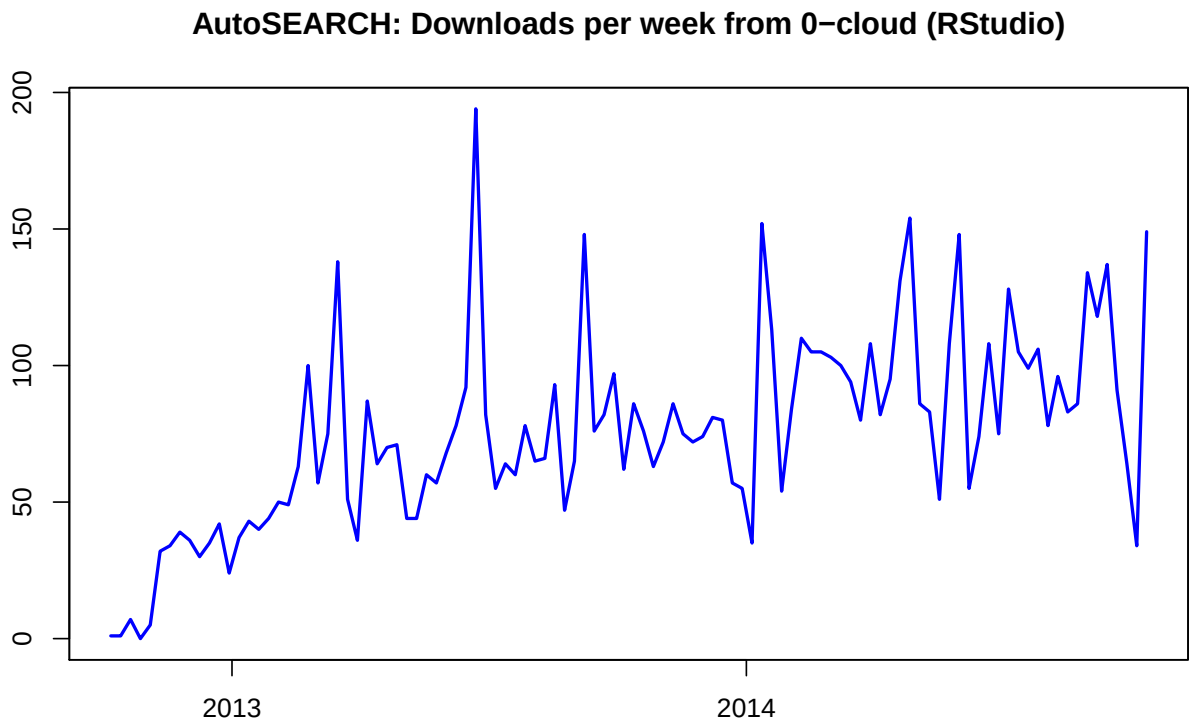
- `PcGets/Autometrics` achieves this by modelling the AR-X representation:

$$\ln \epsilon_t^2 = \phi_0 + \sum_{p=1}^{P} \alpha_p \ln \epsilon^2_{t-p} + \sum_{d=1}^{D} \delta_d x^v_{d,t} + u_t, \quad u_t \sim iid(0, \sigma_u^2),$$

  where $\phi_0 = \alpha_0 + E(\ln z_t^2)$ and $u_t = \ln z_t^2 - E(\ln z_t^2)$, see *e.g.* Bauwens and Sucarrat (2010): "General to Specific Modelling of Exchange Rate Volatility: A Forecast Evaluation", *Int.J.Forecasting* 26, pp. 885-907

- Problems: Uncorrelated and homoscedastic residuals $\widehat{u}_t$ does *not* imply uncorrelated and homoscedastic standardised residuals $\widehat{z}_t$, and likelihood-based comparisons with other models should preferrably be undertaken in terms of the likelihood of $\widehat{\epsilon}_t$ rather than of $\widehat{u}_t$
- This led to Sucarrat and Escribano (2012): "Automated Model Selection in Finance...", *Ox.Bull.Econ.Stat.* 74, pp. 716-735

Does anyone use `AutoSEARCH/gets`?



Main ingredients of GETS modelling:

- Backwards elimination (along multiple paths)
- Regressor significance testing (individual and joint)
- Diagnostics testing
- Information criteria

GETS modelling in 3 steps:

1: Formulate a General Unrestricted Model (GUM) that passes the chosen diagnostics tests

2: Backwards eliminiation of insignificant regressors along multiple paths while at each regressor removal: a) Test for joint insignificance and b) Check the diagnostics

3: Choose the best terminal model according to an information criterion

Model selection properties of GETS modelling:

- k_0: Number of relevant variables
- k_1: Number of irrelevant variables
- $E(\widehat{k}_1/k_1) \to \alpha$: The irrelevance proportion or "gauge" should equal the significance level α
- $E(\widehat{k}_0/k_0) \to 1$: The relevance proportion or "potency"
- The (L)DGP is contained in the final model with probability 1
- The irrelevance proportion (i.e. gauge) is closely related to the Per Comparison Error Rate (PCER)
- The gauge and potency can be viewed as a more detailed (and arguably more intuitive) characterisation of the False Discovery Rate (FDR)

How well does GETS modelling to compared with other model selection algorithms?

- Very well!
- Studies show that it generally does better than step-wise methods
- Studies show that it generally beats the LASSO/shrinkage methods

Selected reading:

- Hendry and Richard (1982): "On the Formulation of Empirical Models in Dynamic Econometrics", *Journal of Econometrics*
- Mizon (1995): "Progressive Modeling of Macroeconomic Time Series: The LSE Methodology", in Hoover (ed.) *Macroeconometrics. Developments, Tensions and Prospects*, Kluwer Academic Publishers
- Hoover and Perez (1999): "Data Mining Reconsidered: Encompassing and the General-to-Specific Approach to Specification Search", *Econometrics Journal*
- Hendry and Krolzig (1999): "Improving on 'Data Mining Reconsidered' by K.D. Hoover and S.J. Perez", *Econometrics Journal*
- Campos, Ericsson and Hendry (eds.) (2005): *General-to-Specific Modeling. Volumes 1 and 2*. Edward Elgar Publishing
- Hendry, Johansen and Santos Hendry et al. (2007): "Automatic selection of indicators in a fully saturated regression", *Computational Statistics*
- Sucarrat and Escribano (2012): "Automated Model Selection in Finance: General-to-Specific Modelling of the Mean and Volatility Specifications", *Oxford Bulletin of Economics and Statistics*
- Hendry and Doornik (2014): *Empirical Model Discovery and Theory Evaluation*. The MIT Press

Outline:

- `arx`: Estimation of AR-X model with (optionally) log-ARCH-X errors
- `getsm`: GETS modelling of mean specification
- `getsv`: GETS modelling of (log)variance specification
- `isat`: GETS modelling of an indicator saturated mean specification
- Future versions: Vignette, further speed improvements, additional features

`arx`: Estimation

The AR-X model with log-ARCH-X errors is given by

$$\begin{aligned} y_t &= \phi_0 + \sum_r \phi_r y_{t-r} + \sum_s \eta_s x_{s,t}^m + \epsilon_t, \qquad \epsilon_t = \sigma_t z_t, \quad z_t \sim iid(0,1) \\ \ln \sigma_t^2 &= \alpha_0 + \sum_p \alpha_p \ln \epsilon_{t-p}^2 + \sum_d \delta_d x_{d,t}^v \end{aligned}$$

Example of `arx`:

```
set.seed(123)
y <- arima.sim(list(ar=0.4), 100)
mod01 <- arx(y, ar=1)
```

Let us make things more interesting...

```
mX <- matrix(rnorm(100*5), 100, 5)
mod02 <- arx(y, mc=TRUE, ar=1:2, mxreg=mX)
mod03 <- arx(y, mc=TRUE, ar=1:2, mxreg=mX, arch=1:3, asym=1,
vxreg=log(mX^2), vcov.type="white")
```

Extraction functions:

```
coef, fitted, plot, print, residuals, summary, vcov
```

`getsm`: Modelling the mean

Usage of `getsm`: Apply on `arx` object

Examples:

```
getsm02 <- getsm(mod02)
getsm02b <- getsm(mod02, t.pval=0.01, wald.pval=0.01)
getsm02c <- getsm(mod02, keep=1)
```

All arguments of `getsm` function (w/defaults):

```
keep = NULL, vcov.type = NULL, t.pval = 0.05, do.pet = TRUE,
wald.pval = 0.05, ar.LjungB = list(lag = NULL, pval = 0.025),
arch.LjungB = list(lag = NULL, pval = 0.025), info.method =
c("sc", "aic", "hq"), include.empty = FALSE, zero.adj = NULL,
vc.adj = NULL, tol = NULL, LAPACK = NULL, max.regs = 1e+05,
verbose = TRUE, print.searchinfo = TRUE, alarm = FALSE
```

Extraction functions:

```
coef, fitted, paths, plot, print, residuals, summary, terminals,
vcov
```

`getsv`: Modelling the variance

Usage of `getsv`: Apply on `arx` object

Examples:

```
getsv03 <- getsv(mod03)
getsv03b <- getsv(mod03, t.pval=0.1, wald.pval=0.1)
getsv03c <- getsv(mod03, keep=1:4)
```

All arguments of `getsv` function (w/defaults):

```
keep = c(1), t.pval = 0.05, do.pet = TRUE, wald.pval = 0.05,
ar.LjungB = list(lag = NULL, pval = 0.025), arch.LjungB =
list(lag = NULL, pval = 0.025), info.method = c("sc", "aic",
"hq"), include.empty = FALSE, zero.adj = NULL, vc.adj = NULL, tol
= NULL, LAPACK = NULL, max.regs = 1e+05, verbose = TRUE, alarm =
FALSE
```

Extraction functions (same as those of `getsm`):

```
coef, fitted, paths, plot, print, residuals, summary, terminals,
vcov
```

`isat`: Indicator Saturation

`isat` function:

- Joint with Felix Pretis, Univ. of Oxford, and James Reade, Univ. of Reading
- GETS modelling of an indicator saturated mean specification
- Indicators: Impulses, steps

Specification:

$$y_t = \phi_0 + \sum_r \phi_r y_{t-r} + \sum_s \eta_s x_{s,t}^m + \textit{indicators} + \epsilon_t,$$

Example of `isat` w/IIS:

```
data(Nile)
isat(Nile, ar=1:2, t.pval=0.01)
```

Example of `isat` w/SIS:

```
isat(Nile, ar=1:2, sis=TRUE, iis=FALSE, t.pval=0.01)
```

Extraction functions (same as those of `getsm`):

coef, fitted, paths, plot, print, residuals, summary, terminals, vcov

Future versions

Future versions:

- Vignette (a draft available as http://www.sucarrat.net/R/gets.pdf)
- Further speed improvements
- More variance-covariance matrix options
- More flexible block specification and search options in `isat`
- Multiple rounds?
- From multi-path to multi-branch?
- GETS density modelling?
- New bugs (surprise!)

Thanks!

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