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Engle R F III. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica* **50**:987-1008, 1982. [University of California, San Diego, CA]

Autoregressive conditional heteroscedasticity is a statistical forecasting model for volatility. Variance forecasts are calculated conditional on the past values of these and other random variables. Unknown parameters are estimated by maximum likelihood; moments of such random variables are derived. [The *SSCI*® and the *SCI*® indicate that this paper has been cited in more than 430 publications.]

ARCH

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The autoregressive conditional heteroscedasticity (ARCH) model was developed while I was on sabbatical at the London School of Economics (LSE) in the spring of 1979. Having morning coffee, lunch, and afternoon tea with David Hendry, as well as Sargan, Durbin, Gorman, Mizon, and many others contributed greatly to the process. My (hopeless) goal was to improve rational expectations macro models by introducing time varying second moments. I was armed with the ideas of conditioning in Kalman filter models as developed by Adrian Pagan, with my own work on least means (LM) tests, and with a test my colleague Clive Granger had developed for bilinearity. In fact, Clive had suggested that I look at the autocorrelogram of the squared residuals from a model I had on the computer one day, and I was amazed at how significant they were.

I sought a conditional model for which autocorrelations of squared residuals were the LM test. The answer was the ARCH model, and the test is now better known as the ARCH test. David proposed the acronym and agreed to have Frank Srba program the first version to be applied to UK inflation data. We also began a Monte Carlo evaluation of the procedure. I presented the new paper at an LSE workshop and at the Athens meetings of the Econometric Society.

Although the reception in Europe was very promising, ARCH gained popularity only slowly in the US. The paper was published in 1982 but was not initially picked up by other econometricians. I had time to work out extensions with my graduate students.

Tim Boilerslev was a gifted graduate student when David visited in about 1985, and the idea for generalized ARCH (GARCH) was born. Shortly thereafter we discovered the integrated GARCH model, several nonlinear forms, and conditional fat-tailed distributions. The new formulation in Boilerslev[1] was very attractive and was used by Kenneth R. French, G. William Schwert, and Robert F. Stambaugh,[2] who along with Engle, David M. Lilien, and Russell P. Robins[3] introduced the model to finance where it has its greatest impact. Today, the ARCH model is widely used in financial applications to forecast volatility, hedge risky positions, price options, and optimize portfolios. A special issue of the *Journal of Econometrics*[4] and a new *Handbook of Econometrics* chapter[5] provide hundreds of references to recent applications.

1. **Bollerslev** T. Generalized autoregressive conditional heteroskedasticity. *J. Econometrics* 31:307-27. 1986. (Cited 140 times.)
2. **French K R, Schwert G W & Stambaugh R** F. Expected stock returns and volatility. *J. Finan. Econ.* 19:3-30, 1987. (Cited 110 times.)
3. **Engle R F III, Lilien D M & Robins R** P. Estimating time varying risk premia in the term structure: the AKCH-M model. *Econometrica* 55:391-407, 1987. (Cited 95 times.)
4. **Engle R F III & Rothschild M,** eds. ARCH models in finance. (Whole issue.) *J. Econometrics* 52(1-2). 1992. 311 p.
5. **Boilerslev T, Engle R F m & Nelson D.** ARCH models. (Engle R F IE & McFadden D, eds.) *Handbook of econometrics. Volume IV*. Amsterdam, The Netherlands: North Holland. (In press.)

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