

# *Manual for the VCC Program\**

*Ekkehart Schlicht*

## 1 Purpose

This program is a console version of the VC program that permits easy batch processing. It estimates the time-varying coefficients  $a'_t = (a_{1,t}, a_{2,t}, \dots, a_{n,t})$  of the regression

$$y_t = a'_t \cdot x_t + u_t, \quad (1.1)$$

with  $y_t$  and  $x_t$  denoting the observations at time  $t = 1, 2, \dots, T$ . The disturbance  $u_t$  is normally distributed with mean 0 and variance  $\sigma^2$ . The coefficients are assumed to be generated by a random walk

$$a_{i,t} = a_{i,t-1} + v_{i,t}, \quad t = 2, 3, \dots, T; \quad i = 1, 2, \dots, n. \quad (1.2)$$

with disturbances  $v_{i,t}$  normally distributed with means 0 and variances  $\sigma_i^2$ . The program estimates the variances  $\sigma^2, \sigma_1^2, \sigma_2^2, \dots, \sigma_n^2$  and the expectations of the coefficients  $a_1, a_2, \dots, a_T$  along with their standard deviations and confidence bands. If desired, it calculates the covariance matrix of the coefficients.

## 2 Standard Usage

### 2.1 Usage

The program is called from a command window. Standard usage is

*vcc input file*

For more advanced purposes, various switches can be added. The available switches are displayed if you type *vcc* or *vcc -h*. These switches will be explained in Section 3 below.

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\*version 5.7, November 2005. Address: Department of Economics, University of Munich, Schackstr. 4, 80539 Munich, Germany, [schlicht@lmu.de](mailto:schlicht@lmu.de).

## 2.2 Standard Input Format

The program requires input data in the .CSV format (comma separated values).<sup>1</sup> (An example input file OkunGER.csv is provided that contains data for estimating Okun's law for Germany.) The first row of the input file is reserved for data description - one label for each cell. No cell should be left empty. The number of cells in the first row tells the program how many cells to expect in the subsequent rows. The following rows give the data:

Each row contains

- cell 1 time index, such a year or month, ignored by the program, but must be non-empty and can't contain a comma.
- cell 2 dependent variable (typically  $y(t)$ ),
- cell 3 first independent variable ( $x_1(t)$ ),
- cell 4 second independent variable ( $x_2(t)$ ),
- cell 5 third independent variable ( $x_3(t)$ ),
- etc...

Unless the switch - *ni* (no intercept) is checked (see below), the program assumes that a constant term for the estimation of the intercept, such as such as  $x'_1 = (1, 1, \dots, 1)$  is not supplied and generates the corresponding variable "intercept" itself.

## 2.3 Output

If the input file is OK, the iteration starts. The number of iterations and the precision achieved so far is displayed in the command window. (Precision is measured by the maximum relative deviation of expected from theoretical variances). If the required precision (default=0.00001) or the maximum number of iterations (default=100000) is achieved, the program stops and writes the result of its calculations to an output file, again in CSV format.

The output file will contain the original data and, in additional columns, the associated calculated coefficients (*a\_var*), with their standard errors (*stderr\_var*), lower bound (*lb\_var* = *a\_var* - 2\**stderr\_var*), and upper bound (*ub\_var* = *a\_var* + 2\**stderr\_var*).

At the end a list of the initial variances and the computed variances is given.

- cell 1 variance of disturbance in the equation  $\sigma^2$ ,
- cell 2 variance of the first coefficient  $\sigma_1^2$ ,
- cell 3 variance of the second coefficient  $\sigma_2^2$ ,
- etc...

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<sup>1</sup>Note that the English number format is presupposed, with a decimal dot denoting decimals, and a comma separating values. Other formats (the German one, for instance) use other conventions and need to be transformed accordingly.

Further, information on initial variances, frozen variances (see below) and achieved precision is provided.

### 3 Advanced Options

#### 3.1 Advanced Input Format

The Advanced Input Format includes initial values for the variances in its second row. Otherwise it is identical to the Standard Input Format. (An example file OkunGER-adv.csv is provided in the package).

The second line contains

-cell 1: time index, such a year or month, ignored by the program, but must be non-empty and can't contain a comma,

- cell 1 arbitrary label, such as "vars",
- cell 2 initial value of the variance of the disturbance in the equation  $\sigma^2$ ,
- cell 3 initial value of the variance of the first coefficient  $\sigma_1^2$ ,
- cell 4 initial value of the variance of the second coefficient  $\sigma_2^2$ ,  
etc...

Note the following:

- If an initial variance is given as *zero*, it will be changed to  $10^{-10}$  and will be frozen at that value. (No re-evaluation during iterations.) This enforces the corresponding coefficient to be (nearly) constant.
- If an initial variance is given as a *negative* value, its absolute value will be taken as the relevant variance, and this variance will be frozen throughout the calculations.

### 3.2 Command-Line Switches

The following command-line switches are available:

- *h* Help screen, provides the list of available switches
- *ni* Don't add an intercept term.
- *r* Take random initial values for variances
- *v* Take initial variances from the input file.  
Requires advanced input format and switch - *ni*.  
Negative variance inputs will be frozen to their absolute values.  
Zero variances will be frozen close to zero.
- *ml* Use maximum likelihood estimator instead of moments estimator.
- *f* Don't estimate variances, just filter.  
Requires advanced input format and switch - *ni*.
- *cv* Calculate complete covariance matrix.
- *s* Slow down adjustment speed to improve numerical stability.
- *p n* Set precision *n*. Default is 5 which means  $10^{-5}$ .
- *it n* Set maximum number of iterations *n*. Default is 100000.

## 4 Notes

Calculations use the moments estimator described in SCHLICHT (1989) and SCHLICHT and LUDSTECK (forthcoming) or, alternatively, the related maximum likelihood estimator described there as well. A Mathematica implementation is provided by LUDSTECK (2004) and a windows implementation by SCHLICHT (2004). The latter package contains also some material that describes some additional aspects of the program. Some theoretical background material may be found in SCHLICHT (1977, 1985).

Version 5.2: Option - *r* (Take random initial values for variances) added to facilitate checking for uniqueness. (If these look strange, note that these values are not normalized, as only the variance ratios matter for the actual estimation.)

Standard initial variances:  $\sigma^2 = 10$  and  $\sigma_i^2 = 1$  for all *i*.

Version 5.7: Option - *ml* (Use maximum likelihood estimator instead of moments estimator) added.

The most recent version is online at [www.lrz.de/~ekkehart](http://www.lrz.de/~ekkehart).

## References

LUDSTECK, J. 2004, "VC - An estimator for linear (time series and panel) models with time-varying coefficients," online at <http://library.wolfram>.

com/infocenter/MathSource/5195/, Mathematica package for the VC filter with extensions.

- SCHLICHT, E. 1977, *Grundlagen der ökonomischen Analyse*, Reinbek: Rowohlt, online at <http://epub.ub.uni-muenchen.de/view/subjects/05.html>, proposes the time-varying coefficients model and the Kalman filter as a consequence of a famous controversy between Keynes and Tinbergen.
- 1985, *Isolation and Aggregation in Economics*, Springer-Verlag Berlin-Heidelberg-New York, online at <http://epub.ub.uni-muenchen.de/view/subjects/05.html>, proposes orthogonal parametrization.
  - 1989, “Variance Estimation in a Random Coefficients Model,” Paper presented at the econometric society european meeting munich, online at <http://www.lrz.de/~ekkehart>, proposes the moments estimator.
  - 2004, “VC - A Program for Estimating Time-Varying Coefficients,” online at <http://epub.ub.uni-muenchen.de/view/subjects/software.html>, Windows version of VC filter.
- SCHLICHT, E. and J. LUDSTECK forthcoming, “Variance Estimation in a Random Coefficients Model,” Discussion paper, online at <http://epub.ub.uni-muenchen.de/view/subjects/software.html>, gives a comprehensive and updated background for the VC method, including some simulation results.