

Programmatuur-besprekingen

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De in deze rubriek opgenomen besprekingen hebben ten doel de lezer te informeren over statistische programma's en pakketten die mogelijk voor een breed statistisch publiek zinvol en bruikbaar kunnen zijn. Bijdragen voor deze rubriek mogen de 12 pagina's niet overschrijden. Op z'n minst moeten in een bespreking de volgende zaken aan de orde komen:

1. Administratieve gegevens: naam, versienummer, maker, importeur, prijs.
2. Technische gegevens: type machine, vereist geheugen, harde schijf wel of niet nodig, omvang bestanden.
3. Statistische inhoud: mogelijkheden, kritische beoordeling.
4. Bewerking van gegevens: mogelijkheden, koppeling met andere pakketten.
5. Gebruikersvriendelijkheid: stuurtaal (menu/commando), helpschermen, documentatie.

Bijdragen voor deze rubriek kunnen worden gestuurd naar bovengenoemde redacteur van deze rubriek.

Ook producenten en verkopers van statistische programmatuur kunnen hun produkten ter evaluatie aanbieden.

GUESS: a simulation package for large-scale macroeconomic models

Jan Jacobs and Elmer Sterken*

Abstract

This paper reviews the software package GUESS designed for the analysis of large-scale non-linear macroeconomic models. The package runs on a PC, is menu-driven, uses both Newton and Gauss-Seidel based algorithms for solving and is capable to handle models up to 1000 equations, depending on model structure. The use of GUESS is demonstrated with the IBS-CCSO quarterly macroeconomic model of the Dutch economy.

Product information

Name:	GUESS versie 1.0
Distributor:	iee ProGamma, P.O. Box 841, 9700 AV Groningen, tel.: (+31) (0)50 636900
Price:	Hfl. 600 (US\$ 330) for educational institutions; Hfl. 1200 (US\$ 660) for non-educational institutions
Author:	Siep Kroonenberg, CCSO (Center for Cyclical and Structural Research), Rijksuniversiteit Groningen, P.O. Box 800, 9700 AV Groningen
Hardware:	IBM (or compatible) PC, XT, AT, 386, etc.
Memory:	512 KB or less
Special features:	A coprocessor is not necessary but highly recommended for large-scale models. GUESS fits on a 360KB diskette. In addition to Turbo Pascal, the user will need an ASCII editor to write the model specification, and a spreadsheet program to build the time series database and to inspect simulation results.

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Introduction

Building a macroeconomic model involves specifying and estimating equations, testing simulation performance, trying out alternate specifications, re-estimating equations and again simulating with the model, until acceptable performance of the model as a whole is achieved. Needless to say, this is a time-consuming process, and is only feasible with efficient simulation software.

General purpose econometric packages, such as ESP (Mikros (1987)) or MicroTSP (Lilien and Hall (1989)), are often inadequate for simulation with large-scale macroeconomic models. For acceptable performance, large models require software that generates an executable program from a model specification. Therefore, separate model analysis software is of more practical use.

The PC software package GUESS (*Groningen University Econometric Simulation System*) is such a special-purpose package for simulating with macro-econometric models. Efficiency is ensured by use of an outside compiler (Turbo Pascal) and by optimization of the solution order. To give you an idea of the speed of GUESS: an example model included in the package (Klein's model I, which consists of six equations and runs for 20 periods) is solved almost instantaneously; the quarterly model described in this paper, which contains 174 equations and which we let run for typically 9 periods, takes only seconds on a 33MHz 80386DX. The choice of Turbo Pascal as compiler also ensure very fast compilation; however, for a highly simultaneous model of several hundreds of equations the calculation of the solution order may take a few minutes [see e.g. Van Nes and Ten Cate (1989) for a comparison of compilation times].

GUESS can do nothing about the inherent complexities of model building. However, the mechanics of compiling, simulating and database management have been made as simple as possible. In our view all—or at least most—options that *do* matter have been left in. Simulation options include static and dynamic simulation, and an option to check the fit of the model equations. Procedures such as analyzing alternate scenarios and generating output for reports are largely automated.

GUESS is not the only software package for econometric modelling on a microcomputer. Modellers at the Dutch Central Planning Bureau use SIMPC [Don Econometrics (1987)]. Brillet (1989, 1994) compares four other software packages that are used for econometric modelling. Up to now we have not been able to compare GUESS to these other software packages.

In the next section we discuss simulation with GUESS. The working of GUESS is demonstrated with the quarterly IBS-CCSO model [see Jacobs and Sterken (1993)]. Full details on GUESS are provided in Kroonenberg (1991). Concluding remarks end this software review.

Simulation using GUESS

GUESS first converts a model definition into a simulation program, then extracts data matrices from the database, simulates and finally converts the simulation results into human-readable output. Figure 1 shows the main GUESS menu.

```

coMpile Data changeXo Simulate Export comPare rptGen Report

dbase DBALL80.WK1
dir  D:\IBS-CCSO\
F2-colors      F3-dir      Esc-exit/abort      GUESS 1.0
Compile model

```

Figure 1 *The main menu of GUESS*

The lower panel displays the database file (DBALL80.WK1) and the work directory (D:\IBS-CCSO). The model specification needs to be in this directory. The main menu, across the top of the screen, displays the basic options of GUESS.

The input files

The model input consists of a description of the model, in the form of an ASCII-file, and a .WK1 database. Figure 2 lists part of the IBS-CCSO model. The model description is quite straightforward. Equations need not be in any particular order. Each equation requires one variable as left-hand side. Comments can be placed between angle brackets (< ... >). A special feature is the use of run-time coefficients. With special syntax (the 'C' and numbers between '<\$' and '\$>') the reading of constants can be postponed from compile-time to simulation-time. Therefore, run-time coefficients can be changed without recompilation of the model. Lags are specified by a suffix (-i), where i is the length of the lag. Distributed lags can be specified by a suffix [a, b, ..., z], where a represents the weight of the current value, b the weight of the first lag, etc. Weights do not have to add up to 1. The current version of GUESS does not support leads. Also, functions can be used, either

```

< ***** >
< A COUPLE OF BEHAVIOURAL EQUATIONS FOR THE REAL SUBMODEL >
< ***** >

CPKLABS = EXP( LN(CPKLABS(-4))+ C * (LN(LBKLABS) - LN(LBKLABS(-4)))
      + C * (LN(LBKLABS(-1)) - LN(LBKLABS(-5)))
      + C * (LN(NLBKLABS(-1)) - LN(NLBKLABS(-5)))
      + C * (LN(RLABS) - LN(RLABS(-4)))
      + C * (LN(CPKLABS(-4)) - C*LN(LBKLABS[,,,1,1,1,1]/4)
      - C * LN(NLBKLABS[,,,1,1,1,1]/4) ) );

<$ 0.416 0.365 0.173 -0.035 -0.531 0.766 0.277 $>

PC = C * PC(-1) + C * PM + C * WAV +
      C * 100 * TK[1,,, -1]/(1 - TK(-4));
<$ 0.780 0.056 0.164 0.220 $>

< ***** >
< DEFINITIONAL EQUATIONS FOR THE REAL SUBMODEL >
< ***** >

CP = 100*(cpklabs/cpklabs(-4)-1);

PCABS = (1+0.01*PC) * PCABS(-4);

```

Figure 2 *Example of input modelfile*

predefined functions such as `abs`, `sqr`, `sin` etc., or user-defined functions, which must be declared in separate files.

Data input is in the Lotus .WK1 format, where columns correspond to dates and rows to time series. The upper-left corner has no significance. The series names should be placed in the first column and dates in the first row. Dates are strings such as '1980' for annual, '1980q4' for quarterly or '1980m1' for monthly data. Figure 3 displays part of the IBS-CCSO database, the file DBALL80.WK1.

Compilation and data extraction

When the basic input files are ready, GUESS can be put to work. The `coMpile` command generates Pascal source code from the model specification. In addition, symbol tables and a dependency matrix for the endogenous variables are generated. GUESS automatically calls Turbo Pascal to compile this code, together with optional user-supplied code for user functions, into an executable program, combining it with a number of precompiled units. Finally, from the dependency matrix an efficient solution order is computed [see

	A	Y	Z	AA	AB	AC
1		1991q2	1991q3	1991q4	1992q1	1992q2
151	URWWGRABS	1870	1576	1541	1594	1847
152	UWWGRABS	1089	901	1049	1200	1354
153	UWWVGRABS	0	0	0	0	0
154	VOLRWABS	322	320	316	311	304
155	VOLWWABS	205	214	235	262	243
156	VOLWWVABS	0	0	0	0	0
157	UABWGRABS	2987.9	2525.6	2467.7	2494.531	2956.806
158	VOLABWABS	512.2	510.4	502	ERR	ERR
159	LRLP	4.792332	3.879651	5.625990	4.337722	3.810975
160	WERKLABS	490.1378	491.7448	509.4219	504.6009	459.6046

DBALL80.WK1

Figure 3 *The IBS-CCSO database, a Lotus .WK1 file*

Don and Gallo (1987)]. This step may be skipped if the old solution order is still valid; the simulation program contains some checks against an invalid solution order.

The next step is extracting time series from the database. The Data command uses the previously created symbol tables to select the appropriate time series from the database. The intermediate datamatrix file format is binary for efficient processing. Separate files exist for endogenous and exogenous series.

Simulation

For simulating, we go to the Simulate submenu and select the Simulate command. Several options can be set, see figure 4. In a *static* simulation, lagged values of endogenous variables are taken from the database (STATIC simulation); in a *dynamic* simulation, model-generated values are used for lagged endogenous variables. The model is solved iteratively by either a Gauss-Seidel or a Newton method; details are given in the Appendix.

The simulation interval can be chosen as a subset of the feasible interval, which is determined by the availability of data. For historical tracking this will be the sample period. In forecasting experiments the simulation interval is restricted to the extra sample period of the exogenous variables.

What-if analysis involves running the same model with different values for the exogenous variables and/or model parameters. For the first, the changeXo-command is included. In order to facilitate the making of alternate forecasts, this command updates an exogenous datamatrix with data from an alternate database. Of course, the user can also generate an alternate exogenous datamatrix 'from scratch' from an alternate database. The second

coMpile Data changeXo Simulate Export comPare rptGen Report																															
<table border="1"> <tr> <td colspan="4">Simulate</td> </tr> <tr> <td colspan="4">Check fit</td> </tr> <tr> <td>Option</td> <td colspan="3">[DYNAMIC]</td> </tr> <tr> <td>Trace</td> <td colspan="3">[NO]</td> </tr> <tr> <td>exo File</td> <td colspan="3">[EXO.DMX]</td> </tr> <tr> <td>sim Results</td> <td colspan="3">[RES.DMX]</td> </tr> <tr> <td>Model file</td> <td colspan="3">[MODFIN.DAT]</td> </tr> </table>				Simulate				Check fit				Option	[DYNAMIC]			Trace	[NO]			exo File	[EXO.DMX]			sim Results	[RES.DMX]			Model file	[MODFIN.DAT]		
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Simulate with a compiled model																															

Figure 4 *The Simulation menu*

type of what-if analysis, changing model parameters, can be done by editing the model inputfile. If run-time parameters are used, with parameters 'C' and parameter values between '<\$' and '\$>', the model need not be recompiled.

The Check fit command does not iterate; it evaluates each equation just once, using values from the database for each lagged or current variable on the right-hand side. This option can be used as a check on the correctness and mutual consistency of model and data. In particular, identities should hold exactly in a Check Fit 'simulation'.

Generating output

The simulation program writes a datamatrix of simulated series. The Export, comPare, rptGen and Report menus incorporate several options for generating human-readable output from such datamatrices: simulation output can be compared against either the datamatrix of observed series or the outcomes of another forecast or simulation with the same model.

The Export option will write both observed and simulated time series of the endogenous variables side-by-side to a spreadsheet, optionally with graphs. Figure 5 displays part of a .WK1 file that is generated by the Export command for a historical tracking experiment with the IBS-CCSO model for the 1986q1-1992q2 period. Figure 6 shows a typical time series graph of one of the key variables of the IBS-CCSO model real private consumption (in levels) CPKLABS. The graph displays the database version of CPKLABS, viz. the Realizations, against the version generated by a dynamic tracking simulation, the Generated data.

	A	B	V	W	X	Y
1			1990Q4	1991Q1	1991Q2	1991Q3
200	BPRGRABS	ENDO.DMX	134900	130700	140300	131900
201	BPRGRABS	RESSTA.DM129616.2	128074.8	138577.9	130523.7	
202	BPRKLABS	ENDO.DMX	106232.6	102627.0	108620.6	101020.8
203	BPRKLABS	RESSTA.DM103538.0	102116.9	106021.7	100688.3	
204	PBPRABS	ENDO.DMX	126.9854	127.3543	129.1651	130.5671
205	PBPRABS	RESSTA.DM125.1870	125.4198	130.7070	129.6314	
206	CP	ENDO.DMX	4.6	3.6	3	3.2
207	CP	RESSTA.DM3.253737	2.947439	0.920461	2.104541	
208	CPGRABS	ENDO.DMX	79300	79200	79700	80600
209	CPGRABS	RESSTA.DM77861.68	77343.44	79565.69	79116.95	
210	VGRABS	ENDO.DMX	121452.6	118169.9	122882.2	118980.5
211	VGRABS	RESSTA.DM116133.0	115544.8	121160.1	117604.3	
212	EXXA	ENDO.DMX	4.263006	3.834275	4.427499	4.578179

RESSTA.WK1

Figure 5 Lotus .WK1 output file

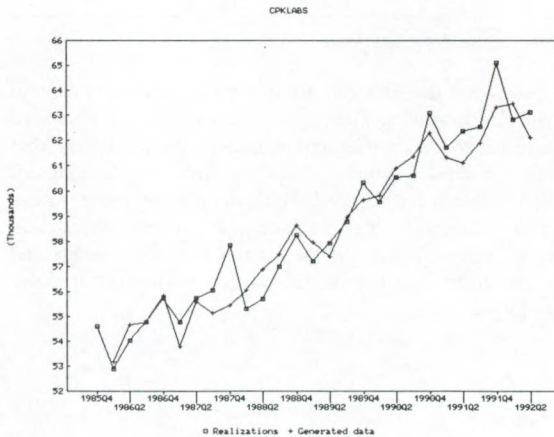


Figure 6 Lotus time series graph from the Export command

The `comPare` option will compute statistics (only when a simulation is compared with observed data) and residuals or differences. If desired, one can limit `comPare`- and `Export` output to a selection of series; especially for large-scale models a helpful option. Values for several statistics are listed: the coefficient of determination R^2 , the Root Mean Squared Error (RMSE), the Mean Absolute Error (MAE), the Durbin-Watson (DW), a Theil-coefficient and the Mean Relative Absolute Error (MRAE); see Kroonenberg (1991) for the exact definitions. The statistics give a quick-and-dirty indication of the quality of historical tracking. Figure 7 displays text output of the `comPare`-command for the historical tracking experiment.

```
*** S T A T S ***
*** GUESS      1.0 ***

Static simulation
time range : 1986q1 -1992q2      modified theil coefficient

equation      r-sq      rmse      mae      dw      theil      mrae
-----
1 CPKLABS      0.929    875.229    705.389    1.751    0.494    1.193
2 PC           0.122      1.416      1.138    2.961    0.880  144.816
3 CP          undef      1.520      1.227    1.729    0.659  127.091
4 PCABS       0.872      1.689      1.365    2.962    0.705    1.123
-----
```

Figure 7 *Output of the Compare command*

With the Report generator, the user can automatically generate tables of the most important simulation results. The report writer program is compiled from a report specification by the `rptGen`-command, in the same way that a simulation program is compiled from a model specification. Optionally, explanatory texts and labels can be included. A report-writing program can run in two modes: in 'forecast-mode' it reads results from a single simulation run and prints either all values in the interval or the first, the average and the last value; in 'variant-mode' it prints the outcome of an alternate scenario against some baseline forecast.

Concluding remarks

GUESS is a PC-based simulation system for nonlinear macroeconomic models. It is implemented as an user-friendly 'front-end' program with which you can run the various tasks which comprise econometric model simulation with just a few keystrokes. To this end, this front-end program runs a number of separate programs, including Turbo Pascal.

The current version of GUESS lacks a number of features. GUESS does not (yet) support model-consistent expectations and stochastic simulation; interfacing with estimation software is rather awkward, estimation outcomes have to be copied by hand. In spite of these shortcomings we have used GUESS for a couple of years and are quite satisfied. In our opinion the package deserves a wider audience.

Appendix: Solution methods

The model is solved iteratively by either a Gauss-Seidel or a Newton method, using an optimized solution order. This optimization of the solution order consists of finding a small—as implemented in GUESS maybe not absolutely minimal—subset of the endogenous variables from which all endogenous variables can be computed recursively. Such a set is called a FeedBack Node set or FBN. The use of a small FBN makes both Gauss-Seidel and Newton vastly more efficient.

The Gauss-Seidel algorithm initializes the FBN variables initially from the previous period, and for subsequent iterations from the previous iteration. Then the model is computed recursively, including the FBN variables. This is iterated until convergence is reached.

With the Newton algorithm, the FBN variables are also initially copied from the previous period. At each iteration, new values for the FBN are determined by the Newton algorithm for finding zeroes. The function for which a zero must be found is

$$(\text{current values of the FBN variables}) - (\text{values of the FBN variables after one model evaluation})$$

The Newton algorithm requires a Jacobian, *i.e.* a matrix of partial derivatives. This Jacobian is computed at the first iteration in the first period, and updated only when performance of the existing Jacobian deteriorates too much; it is not usually updated at the start of a new period. Since convergence on the FBN does not absolutely guarantee convergence on all variables, the Newton stage is followed by a Gauss-Seidel stage.

Note that, for non-linear models, there is no guarantee that either Newton or Gauss-Seidel will converge, or even that a model solution is unique.

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