
Introduction to GAMS Syntax

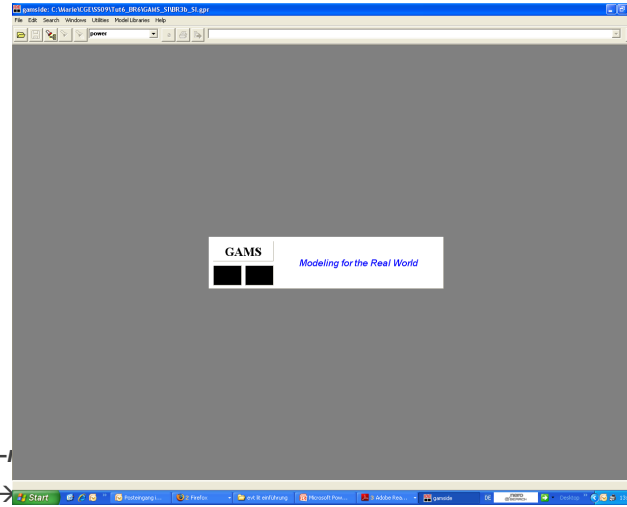
Introduction

- **GAMS (General Algebraic Modeling System)**
 - *Software to solve equations/system of equations*
 - *Often used for solving CGEs*
 - *<http://www.gams.de/> (free trial version for download)*

- **Using GAMS**
 - *Create file with GAMS instructions → helps documenting*
 - *Submit file to GAMS, GAMS solves equations*

- **Two ways**
 - *Set up model in text editor, use DOS (or UNIX) command line instructions to find errors and to run model*
 - *GAMSIDE: a graphical interface to write program, solvers are hidden (IDE: Integrated Development Environment)*

The IDE



file – project –

file – new

Syntax

- **Classes of inputs**
 - **Parameters** (given data, exogenous)
 - **Variables** (decision variables – unknowns, endogenous)
 - **Equations** (constraints and objective function)
 - **Model** (Which equations comprise the model)
 - **Solve** (What kind of problem is to be solved)
- **Syntax (1. declare, 2. set value)**
 - **keyword** name description /value/ ;
 - **Parameter** name description /value/;

 - **Variables** name description ; (only name, no value!)
 - **Parameter** p shifts equation 2 /1/ ;
 - name .. LHS =e= RHS ; (or: =l=, =g=)
 - **Model** model_name /equation_name, .../ ; (or: /all/)
 - **Solve** model_name using solver_name (minimizing variable_name)

Few more words on variables

- **5 types of variables**
 - *VARIABLE* (free) unrestricted variables (default)
 - *POSITIVE VARIABLE* restricts variables to be nonnegative
 - *NEGATIVE VARIABLE*
 - *INTEGER*
 - *BINARY*

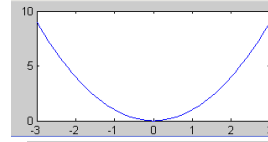
- **Variables have four characteristics:**
 - *upper bound* .up
 - *lower bound* .lo
 - *level or primal value (or initial value)* .l
 - *marginal or dual value* .m

 - *to fix a value* .fx

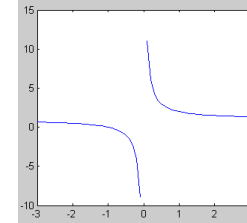
Two-Equations-Example

- *The model*

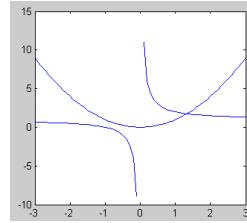
Equation 1: $y=x^2$



Equation 2: $y=\frac{1}{x}+p$



- *For which combination do the equations intersect?*
2 unknowns, 2 equations \bar{y}, \bar{x}



→ [Run Two-Equations-Example.gms](#)

Reading the output

- **Run model (F9) → two output files**
 - *Process window: Status in blue, errors in red*
 - *LST file: solution*
- **LST file: left-hand side can be used to navigate**
- **Contents of LST file:**
 - *Echo print: a copy of input file with line numbers for future reference*
 - **Equation listing**
 - **Column Listing**
 - **Model Statistics**
 - **Solve Summary**
 - **SolEQU**
 - **SolVAR**

Compilation	
Equation Listing	SOLVE intersec Using MCP From line 27
Equation	
Eq1	
Eq2	
Column Listing	SOLVE intersec Using MCP From line 27
Column	
x	
y	
Model Statistics	SOLVE intersec Using MCP From line 27
Solution Report	SOLVE intersec Using MCP From line 27
SolEQU	
SolVAR	
x	
y	
Equation Listing	SOLVE intersec Using MCP From line 31
Equation	
Column Listing	SOLVE intersec Using MCP From line 31
Column	
Model Statistics	SOLVE intersec Using MCP From line 31
Solution Report	SOLVE intersec Using MCP From line 31
SolEQU	
SolVAR	

Model Statistics

- *This output provides details on the size and nonlinearity of the model.*

MODEL STATISTICS

BLOCKS OF EQUATIONS	2	SINGLE EQUATIONS	2
BLOCKS OF VARIABLES	2	SINGLE VARIABLES	2
NON ZERO ELEMENTS	4	NON LINEAR N-Z	2
DERIVATIVE POOL	7	CONSTANT POOL	16
CODE LENGTH	18		

- *rows and columns in the problem generated.*
- *The CODE LENGTH entry reports on the complexity of the nonlinearity of the model and is really telling how much code GAMS passes to the nonlinear solver which describes all the nonlinear terms in the model.*

idual

Solution Report – Solve Summary

- **Most important:**
 - *Solver Status: 1 normal completion (2 iteration interrupt (→ option iterlim) , 3 resource interrupt (→ Use option reslim) , ...)*
 - *Model Status: 1 optimal (2 Locally optimal, 4 infeasible, ...)*

```

                                S O L V E   S U M M A R Y

MODEL   intersec
TYPE    MCP
SOLVER  PATH                      FROM LINE  28

**** SOLVER STATUS      1 NORMAL COMPLETION
**** MODEL STATUS      1 OPTIMAL

RESOURCE USAGE, LIMIT      0.046      1000.000
ITERATION COUNT, LIMIT     3          10000
EVALUATION ERRORS          0           0
    
```

SoIEQU

	LOWER	LEVEL	UPPER	MARGINAL
---- EQU Eq1	.	.	.	1.325
---- EQU Eq2	1.000	1.000	1.000	1.755

- *Equation marker ----*
- *EQU - Equation identifier*
- *Lower bound (.lo) – RHS on =G= or =E= equations*
- *Level value (.l) – value of Left hand side variables*
- *Upper bound (.up) – RHS on =L= or =E= equations*
- *Marginal (.m) – dual variable, shadow price or in MCPs only complementary variable value*

- *Values returned within GAMS have full machine accuracy*
- *The single dots '.' represent zeros.*
- *EPS: very close to but different from zero*

SoIVAR

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR x	-INF	1.325	+INF	.
---- VAR y	-INF	1.755	+INF	.

x independent variable

y dependent variable

- **Variable marker ----**
- **VAR - Variable identifier**
- **Lower bound (.lo) – often zero or minus infinity**
- **Level value (.l) – solution value**
- **Upper bound (.up) – often plus infinity**
- **Marginal (.m) –in MCPs only slack in complementary equations (equation level for the equation $AX \leq b$ is the term AX whereas a slack is $b-AX$)**

Dealing with errors

- Two types of errors: compilation vs. execution
- Compilation error:
 - Process window: Status in blue, errors in red
 - LST file: errors recorded in echo print
 - Marked by **** in the beginning of the line
 - \$654 - code to identify error, explanation after echo print (in this case at end of output), \$ exactly below point where GAMS thinks that error occurred
 - fix first one first, ignore others
- Typical compilation errors
 - Forget ;
 - Spelling mistakes or using reserved words
- Example: [Run Two-Equations-Example.gms](#)
 - WITHOUT ';' after Eq1.. y=e=x**2
 - Put 'xx' as independent variable

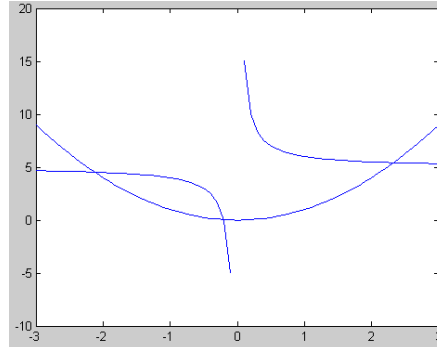
```

14 Equations
15 Eq1
16 Eq2;
17
18 Eq1.. y=e=x**2;
19 Eq2.. y=e=1/x+p;
20
21 Model intersec /Eq1, Eq2/;
****                               $140
22
23 * Set initial values of variable
24 x.L=2;
25 y.L=1;
26
27
28 Solve intersec using mcp
****                               $257
29
30 *Counterfactuals
31 p = 1.5;
32 SOLVE intersec using mcp;
****                               $257
33
34
35
36
37
38
39
GAMS Rev 228 x86/MS Windows
Two-Equations-Example
Error Messages

140 Unknown symbol
257 Solve statement not checked becau
**** 3 ERROR(S)  0 WARNING(S)
    
```

Dealing with errors

- Execution error: blue (status) in process window (no LST file)
- Typical execution errors because of arithmetic problems
 - Exponentiating a negative constant to a real power
 - Dividing by zero
 - Constraint where we set zero equal to one which results in an infeasible constraint
- Example
 - run *Two-Equations-Example* with $p=5$ and
 - and no starting values
 - Starting values $x.L=-3; y.L=0.01;$
 - (Starting values $x.L=0.01; y.L=-3;$)



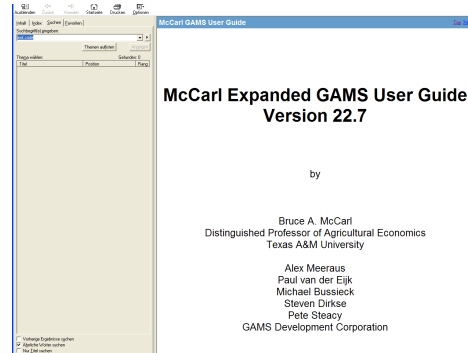
Formulation of complementarity problems

- Associate each equation with particular variable
- To build equations : Greater-or-equal relationship (=G=)
- To build the model:
`model modelname /equ1.var1, equ2.var2, .../ ;`
(always pairs of equation and associated variable)
- Interpretation Output:
Either level or marginal of a variable is zero

Good to know

“Developing a model is like writing a paper or an essay ; many drafts and rewrites are required until the arguments are presented in the most effective way for the reader and meet all the requirements of proper English. GAMS acts like a personal assistant with knowledge of mathematical modeling and of the syntactic and semantic details of the language.”

GAMS – A user’s guide



Appendix

GAMS-Reserved Words

abort	eps	integer	not	sameas	sum
acronym	eq	le	option	scalar	system
acronyms	equation	loop	options	scalars	table
alias	equations	lt	or	semicont	then
all	file	maximizing	ord	semiint	until
and	files	minimizing	parameter	set	using
assign	for	model	parameters	sets	variable
binary	free	models	positive	smax	variables
card	ge	na	prod	smin	while
diag	gt	ne	putpage	solve	xor
display	if	negative	puttl	sos1	yes
else	inf	no	repeat	sos2	

The reserved non-alphanumeric symbols are:

.. =l= =g= =e= =n= =x= =c= -- ++ **

Equation Listing

- *Is GAMS solving the equations I want him to solve?*
- *Attention: Non-Linear Equations*

- *What we wrote into the model*
 - *Eq1.. y=e=x**2;*
 - *Eq2.. y=e=1/x+p;*
 - *x.l=1, y.l=2*
- *What the Listing says:*

```

---- Eq1  =E=
Eq1..  - (4) *x + y =E= 0 ; (LHS = -3, INFES = 3 ****)

---- Eq2  =E=
Eq2..  (0.25) *x + y =E= 1 ; (LHS = 0.5, INFES = 0.5 ****)

```

Steps to approximate nonlinear equations (as GAMS does it)

- Re-write equations:** *Equation 1* | *Equation 2*
variables = constant | Eq1 $\rightarrow y - x^2 = 0$ | Eq2 $\rightarrow y - \frac{1}{x} = 1$
- Find coefficients \bar{x}, \bar{y} for** $\bar{x} * x + \bar{y} * y = \text{const.}$, $x_0 = 2, y_0 = 1$

$\bar{x} = \frac{\partial \text{Eq}}{\partial x} \Big _{x=x_0}$,	$\bar{x} = -2 * 2 = -4,$	$\bar{x} = -(-\frac{1}{1^2}) = 1$
---	--------------------------	-----------------------------------

$\bar{y} = \frac{\partial \text{Eq}}{\partial y} \Big _{y=y_0}$,	$\bar{y} = 1,$	$\bar{y} = 1$
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We therefore have

- Calculate LHS (from Re-written equations at values given)**
 $-4 * x + y = 0$ | $x + y = 1$

- Calculate INFES (deviation LHS from RHS)**
 $1 - 4 = -3$ | $1 - 0.5 = 0.5$

$0 - (-3) = 3$	$1 - 0.5 = 0.5$
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Check with Equation Listing

---- Eq1 =E=

Eq1.. - (4)*x + y =E= 0 ; (LHS = -3, INFES = 3 ****)

---- Eq2 =E=	$-4 * x + y = 0$	$y - x^2 = -3$	$y - x^2 = 0$	$0 - (-3) = 3$
	$x + y = 1$	$y - \frac{1}{x} = 0.5$	$y - \frac{1}{x} = 1$	$1 - 0.5 = 0.5$

Eq2.. (0.25)*x + y =E= 1 ; (LHS = 0.5, INFES = 0.5 ****)

Column Listing

- Shows coefficients of variables

```

-----
Column Listing      SOLVE intersec Using MCP From line 28

---- x independent variable

x
      (.LO, .L, .UP, .M = -INF, 2, +INF, 0)
(-4)  Eq1
      (0.25) Eq2

---- y dependent variable

y
      (.LO, .L, .UP, .M = -INF, 1, +INF, 0)
      1      Eq1
      1      Eq2
    
```

Corresponding constraint nonlinear, value of coefficient depends on activity levels of one or more of the variables listing is not algebraic, but shows the partial derivative of each variable evaluated at their current level values