MICROCOMPUTERS IN POLICY RESEARCH

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4b

KEY TO EXERCISES IN CGE MODELING USING GAMS

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(THE EXERCISES FOR THESE KEYS ARE PUBLISHED SEPARATELY.)

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CONTENTS

EXERCISE 1: GAMS CODE

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  3
  4  *INTRODUCTION=====================================================

     In this file, CGE1 is implemented in GAMS.

 10
 11  *SETS============================================================
 12
 13  SETS
 14
 15  AC global set (SAM accounts and other items)
 16    /AGR-A   agricultural activity
 17     NAGR-A  non-agricultural activity
 18     AGR-C   agricultural commodity
 19     NAGR-C  non-agricultural commodity
 20     LAB     labor
 21     CAP     capital
 22     U-HHD   urban household
 23     R-HHD   rural household
 24     TOTAL   total account in SAM  /
 25
 26  ACNT(AC) all elements in AC except total
 27
 28  A(AC)  activities
 29        /AGR-A, NAGR-A/
 30
 31  C(AC)  commodities
 32        /AGR-C, NAGR-C/
 33
 34  F(AC)  factors
 35        /LAB, CAP/
 36
 37  H(AC)  households
 38        /U-HHD, R-HHD/
 39  ;
 40
 41  ALIAS(AC,ACP); ALIAS(C,CP); ALIAS(F,FP);
 42  ACNT(AC) = YES; ACNT('TOTAL') = NO; ALIAS(ACNT,ACNTP);
 43
```

2

```
44
45  *PARAMETERS=====================================================
46
47  PARAMETERS
48
49  ad(A)       efficiency parameter in the production fn for a
50  alpha(F,A)  share of value-added to factor f in activity a
51  beta(C,H)   share of household consumption spending on commodity c
52  cpi         consumer price index
53  cwts(C)     weight of commodity c in the CPI
54  qfs(F)      supply of factor f
55  shry(H,F)   share for household h in the income of factor f
56  theta(A,C)  yield of output c per unit of activity a
57  ;
58
59  *VARIABLES=====================================================
60
61  VARIABLES
62
63  P(C)     price of commodity c
64  PA(A)    price of activity a
65  Q(C)     output level for commodity c
66  QA(A)    level of activity a
67  QF(F,A)  quantity demanded of factor f from activity a
68  QH(C,H)  quantity consumed of commodity c by household h
69  WF(F)    price of factor f
70  YF(H,F)  income of household h from factor f
71  YH(H)    income of household h
72  ;
73
74  *EQUATIONS=====================================================
75
76  EQUATIONS
77
78  *PRODUCTION AND COMMODITY BLOCK++++++++
79   PRODFN(A)    Cobb-Douglas production function for activity a
80   FACDEM(F,A)  demand for factor f from activity a
81   OUTPUTFN(C)  output of commodity c
82   PADEF(A)     price for activity a
83
84  *INSTITUTION BLOCK++++++++++++++++++++
85   FACTTRNS(H,F)  transfer of income from factor f to h-hold h
86   HHDINC(H)      income of household h
87   HHDEM(C,H)     consumption demand for household h & commodity c
88
89  *SYSTEM CONSTRAINT BLOCK+++++++++++++++
90   FACTEQ(F)  market equilibrium condition for factor f
91   COMEQ(C)   market equilibrium condition for commodity c
92   PNORM      price normalization
93   ;
94
```

```
 95  *PRODUCTION AND COMMODITY BLOCK++++++++
 96
 97   PRODFN(A)..    QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
 98
 99   FACDEM(F,A)..  WF(F) =E= alpha(F,A)*PA(A)*QA(A) / QF(F,A);
100
101   OUTPUTFN(C)..  Q(C) =E= SUM(A, theta(A,C)*QA(A));
102
103   PADEF(A)..     PA(A) =E= SUM(C, theta(A,C)*P(C));
104
105
106  *INSTITUTION BLOCK++++++++++++++++++++
107
108   FACTTRNS(H,F).. YF(H,F) =E= shry(H,F)*WF(F)*SUM(A, QF(F,A));
109
110   HHDINC(H)..     YH(H) =E= SUM(F, YF(H,F));
111
112   HHDEM(C,H)..    QH(C,H) =E= beta(C,H)*YH(H)/P(C);
113
114
115  *SYSTEM CONSTRAINT BLOCK++++++++++++++
116
117   FACTEQ(F)..        SUM(A, QF(F,A)) =E= qfs(F);
118
119   COMEQ('AGR-C').. Q('AGR-C') =E= SUM(H, QH('AGR-C',H));
120
121   PNORM..            SUM(C, cwts(C)*P(C)) =E= cpi;
122
123
124  *MODEL===============================================================
125
126  MODEL
127   CGE1 Simple CGE model /ALL/
128   ;
129
130  *SOCIAL ACCOUNTING MATRIX===========================================
131
132  TABLE SAM(AC,ACP) social accounting matrix
133
134           AGR-A  NAGR-A  AGR-C  NAGR-C  LAB  CAP  U-HHD  R-HHD
135  AGR-A                    125
136  NAGR-A                          150
137  AGR-C                                              50     75
138  NAGR-C                                            100     50
139  LAB       62     55
140  CAP       63     95
141  U-HHD                                   60   90
142  R-HHD                                   57   68
143  ;
144
145
```

```
146  PARAMETER
147   tdiff(AC)  column minus row total for account ac;
148  *This parameter is used to check that the above SAM is balanced.
149           SAM('TOTAL',ACNTP)  = SUM(ACNT, SAM(ACNT,ACNTP));
150           SAM(ACNT,'TOTAL')   = SUM(ACNTP, SAM(ACNT,ACNTP));
151           tdiff(ACNT)         = SAM('TOTAL',ACNT)—SAM(ACNT,'TOTAL');
152
153  DISPLAY SAM, tdiff;
154
155
156  *ASSIGNMENTS FOR PARAMETERS AND VARIABLES========================
157
158  PARAMETERS
159  *The following parameters are used to define initial values of
160  *model variables.
161   P0(C), PA0(A), Q0(C), QA0(A), QF0(F,A), QH0(C,H), WF0(F), YF0(H,F),
162   YH0(H)
163   ;
164
165
166  *PRODUCTION AND COMMODITY BLOCK++++++++
167
168   P0(C)       = 1;
169   PA0(A)      = 1;
170   WF0(F)      = 1;
171
172   Q0(C)       = SAM('TOTAL',C)/P0(C);
173   QA0(A)      = SAM('TOTAL',A)/PA0(A);
174   QF0(F,A)    = SAM(F,A)/WF0(F);
175
176   alpha(F,A)  = SAM(F,A) / SUM(FP, SAM(FP,A));
177   ad(A)       = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
178   theta(A,C)  = (SAM(A,C)/P0(C)) / QA0(A);
179
180
181  *INSTITUTION BLOCK++++++++++++++++++++
182
183   QH0(C,H)   = SAM(C,H)/P0(C);
184   YF0(H,F)   = SAM(H,F);
185   YH0(H)     = SAM('TOTAL',H);
186
187   beta(C,H)  = SAM(C,H)/SUM(CP, SAM(CP,H));
188   shry(H,F)  = SAM(H,F)/SAM('TOTAL',F);
189
190
191  *SYSTEM CONSTRAINT BLOCK++++++++++++++
192
193   cwts(C)  = SUM(H, SAM(C,H)) / SUM((CP,H), SAM(CP,H));
194   cpi      = SUM(C, cwts(C)*P0(C));
195   qfs(F)   = SAM(F,'TOTAL')/WF0(F);
196
```

```
197
198  *INITIALIZING ALL VARIABLES+++++++++++
199
200   P.L(C)      = P0(C);
201   PA.L(A)     = PA0(A);
202   Q.L(C)      = Q0(C);
203   QA.L(A)     = QA0(A);
204   QF.L(F,A)   = QF0(F,A);
205   QH.L(C,H)   = QH0(C,H);
206   YF.L(H,F)   = YF0(H,F);
207   WF.L(F)     = WF0(F);
208   YH.L(H)     = YH0(H);
209
210
211  *DISPLAY++++++++++++++++++++++++++++++
212
213  DISPLAY
214   ad, alpha, beta, cpi, cwts, qfs, shry, theta,
215
216   P.L, PA.L, Q.L, QA.L, QF.L, QH.L, WF.L, YF.L, YH.L
217   ;
218
219
220  *SOLVE STATEMENT FOR BASE=========================================
221
222  *SOLVE CGE1 USING MCP;
223
224
225  *REPORT SETUP AND BASE REPORT=====================================
226
227  *SET AND PARAMETERS FOR REPORTS++++++++
228
229  SET
230   SIM   simulations
231       /BASE   base simulation
232        CINCR  increase in capital stock/
233
234  PARAMETERS
235
236   QFSCAPSIM(SIM)  capital supply for sim'on sim (experiment parameter)
237  *Parameter is used to change the value for the capital stock
238  *parameter before solving the model for simulation sim
239
240   QFSREP(F,SIM)        supply of factor f for simulation sim (value used)
241   PREP(C,SIM)          demander price for commodity c
242   PAREP(A,SIM)         price of activity a
243   QREP(C,SIM)          output level for commodity c
244   QAREP(A,SIM)         level of activity a
245   QFREP(F,A,SIM)       demand for factor f from activity a
246   QHREP(C,H,SIM)       consumption of commodity c by household h
247   WFREP(F,SIM)         price of factor f
```

```
248   YFREP(H,F,SIM)      income of household h from factor f
249   YHREP(H,SIM)        income of household h
250   SAMREP(SIM,AC,ACP)  SAM computed from model solution
251   BALCHK(AC,SIM)      column minus row total for account ac in SAM
252   ;
253
254   QFSCAPSIM('BASE')  = qfs('CAP');
255   QFSCAPSIM('CINCR') = 1.1*qfs('CAP');
256
257 DISPLAY QFSCAPSIM;
258
259
260 LOOP(SIM,
261
262  qfs('CAP') = QFSCAPSIM(SIM);
263
264 SOLVE CGE1 USING MCP;
265
266   QFSREP(F,SIM)   = qfs(F);
267
268   PREP(C,SIM)     = P.L(C);
269   PAREP(A,SIM)    = PA.L(A);
270   QREP(C,SIM)     = Q.L(C);
271   QAREP(A,SIM)    = QA.L(A);
272   QFREP(F,A,SIM)  = QF.L(F,A);
273   QHREP(C,H,SIM)  = QH.L(C,H);
274   WFREP(F,SIM)    = WF.L(F);
275   YFREP(H,F,SIM)  = YF.L(H,F);
276   YHREP(H,SIM)    = YH.L(H);
277
278 *Payments from activities
279   SAMREP(SIM,F,A)  = WF.L(F)*QF.L(F,A);
280 *Payments from commodities
281   SAMREP(SIM,A,C)  = P.L(C)*theta(A,C)*QA.L(A);
282 *Payments from factors
283   SAMREP(SIM,H,F)  = YF.L(H,F);
284 *Payments from households
285   SAMREP(SIM,C,H)  = P.L(C)*QH.L(C,H);
286
287  );
288
289
290 *Computing totals for SAMREP
291  SAMREP(SIM,'TOTAL',ACNTP)  = SUM(ACNT, SAMREP(SIM,ACNT,ACNTP));
292  SAMREP(SIM,ACNT,'TOTAL')   = SUM(ACNTP, SAMREP(SIM,ACNT,ACNTP));
293
294 *Check that SAMREP is balanced
295  BALCHK(ACNT,SIM) = SAMREP(SIM,'TOTAL',ACNT)-SAMREP(SIM,ACNT,'TOTAL');
296
297
298 OPTION QFREP:3:1:1, QHREP:3:1:1, YFREP:3:1:1, SAMREP:3:1:1;
```

```
299
300  DISPLAY
301   QFSREP, PREP, PAREP, QREP, QAREP, QFREP, QHREP, WFREP, YFREP, YHREP,
302   SAMREP, BALCHK
303   ;
304
305
306  *Parameters reporting %-age change from BASE for model variables and
307  *for selected other data.
308  PARAMETERS
309   QFSREPP(F,SIM)       supply of factor f for simulation sim (%ch)
310   PREPP(C,SIM)         demander price for commodity c (%ch)
311   PAREPP(A,SIM)        price of activity a (%ch)
312   QREPP(C,SIM)         output level for commodity c (%ch)
313   QAREPP(A,SIM)        level of activity a (%ch)
314   QFREPP(F,A,SIM)      demand for factor f from activity a (%ch)
315   QHREPP(C,H,SIM)      consumption of commodity c by household h (%ch)
316   YFREPP(H,F,SIM)      income of household h from factor f (%ch)
317   WFREPP(F,SIM)        price of factor f (%ch)
318   YHREPP(H,SIM)        income of household h (%ch)
319   SAMREPP(SIM,AC,ACP)  SAM computed from model solution (%ch by cell)
320   ;
321
322   QFSREPP(F,SIM)   = 100*(QFSREP(F,SIM)/QFSREP(F,'BASE')—1);
323   PREPP(C,SIM)     = 100*(PREP(C,SIM)/PREP(C,'BASE')—1);
324   PAREPP(A,SIM)    = 100*(PAREP(A,SIM)/PAREP(A,'BASE')—1);
325   QREPP(C,SIM)     = 100*(QREP(C,SIM)/QREP(C,'BASE')—1);
326   QAREPP(A,SIM)    = 100*(QAREP(A,SIM)/QAREP(A,'BASE')—1);
327   QFREPP(F,A,SIM)  = 100*(QFREP(F,A,SIM)/QFREP(F,A,'BASE')—1);
328   QHREPP(C,H,SIM)  = 100*(QHREP(C,H,SIM)/QHREP(C,H,'BASE')—1);
329   WFREPP(F,SIM)    = 100*(WFREP(F,SIM)/WFREP(F,'BASE')—1);
330   YFREPP(H,F,SIM)  = 100*(YFREP(H,F,SIM)/YFREP(H,F,'BASE')—1);
331   YHREPP(H,SIM)    = 100*(YHREP(H,SIM)/YHREP(H,'BASE')—1);
332   SAMREPP(SIM,AC,ACP)$SAMREP('BASE',AC,ACP)
333                    = 100*(SAMREP(SIM,AC,ACP)/SAMREP('BASE',AC,ACP)—1);
334
335  OPTION QFREPP:3:1:1, QHREPP:3:1:1, YFREPP:3:1:1, SAMREPP:3:1:1;
336
337
338  DISPLAY
339   QFSREPP, PREPP, PAREPP, QREPP, QAREPP, QFREPP, QHREPP, WFREPP,
340   YFREPP, YHREPP, SAMREPP
341   ;
```

EXERCISE A1: GAMS CODE

```
 3
 4  *INTRODUCTION=================================================

    In this file, the starting point is CGE1. The production function and
    the factor demand functions have been rewritten in "longhand."

11
12  *SETS=========================================================
13
14  SETS
15
16  AC global set (SAM accounts and other items)
17    /AGR-A   agricultural activity
18     NAGR-A  non-agricultural activity
19     AGR-C   agricultural commodity
20     NAGR-C  non-agricultural commodity
21     LAB     labor
22     CAP     capital
23     U-HHD   urban household
24     R-HHD   rural household
25     TOTAL   total account in SAM  /
26
27  ACNT(AC) all elements in AC except total
28
29  A(AC)   activities
30        /AGR-A, NAGR-A/
31
32  C(AC)   commodities
33        /AGR-C, NAGR-C/
34
35  F(AC)   factors
36        /LAB, CAP/
37
38  H(AC)   households
39        /U-HHD, R-HHD/
40  ;
41
42  ALIAS(AC,ACP); ALIAS(C,CP); ALIAS(F,FP);
43  ACNT(AC) = YES; ACNT('TOTAL') = NO; ALIAS(ACNT,ACNTP);
```

8

```
44
45
46  *PARAMETERS==================================================
47
48  PARAMETERS
49
50   ad(A)       efficiency parameter in the production fn for a
51   alpha(F,A)  share of value-added to factor f in activity a
52   beta(C,H)   share of household consumption spending on commodity c
53   cpi         consumer price index
54   cwts(C)     weight of commodity c in the CPI
55   qfs(F)      supply of factor f
56   shry(H,F)   share for household h in the income of factor f
57   theta(A,C)  yield of output c per unit of activity a
58   ;
59
60  *VARIABLES===================================================
61
62  VARIABLES
63
64   P(C)     price of commodity c
65   PA(A)    price of activity a
66   Q(C)     output level for commodity c
67   QA(A)    level of activity a
68   QF(F,A)  quantity demanded of factor f from activity a
69   QH(C,H)  quantity consumed of commodity c by household h
70   WF(F)    price of factor f
71   YF(H,F)  income of household h from factor f
72   YH(H)    income of household h
73   ;
74
75  *EQUATIONS===================================================
76
77  EQUATIONS
78
79  *PRODUCTION AND COMMODITY BLOCK++++++++
80   PRODFN1      Cobb-Douglas production function for AGR-A
81   PRODFN2      Cobb-Douglas production function for NAGR-A
82   FACDEM1      demand for LAB from AGR-A
83   FACDEM2      demand for CAP from AGR-A
84   FACDEM3      demand for LAB from NAGR-A
85   FACDEM4      demand for CAP from NAGR-A
86  *PRODFN(A)    Cobb-Douglas production function for activity a
87  *FACDEM(F,A)  demand for factor f from activity a
88   OUTPUTFN(C)  output of commodity c
89   PADEF(A)     price for activity a
90
91  *INSTITUTION BLOCK+++++++++++++++++++++
92   FACTTRNS(H,F)  transfer of income from factor f to h-hold h
93   HHDINC(H)      income of household h
94   HHDEM(C,H)     consumption demand for household h & commodity c
```

```
95
96  *SYSTEM CONSTRAINT BLOCK++++++++++++++
97   FACTEQ(F)  market equilibrium condition for factor f
98   COMEQ(C)   market equilibrium condition for commodity c
99   PNORM      price normalization
100        ;
101
102 *PRODUCTION AND COMMODITY BLOCK++++++++
103
104  PRODFN1..     QA('AGR-A') =E=
105                ad('AGR-A')*QF('LAB','AGR-A')**alpha('LAB','AGR-A')
106                *QF('CAP','AGR-A')**alpha('CAP','AGR-A');
107
108  PRODFN2..     QA('NAGR-A') =E=
109                ad('NAGR-A')*(QF('LAB','NAGR-A')**alpha('LAB','NAGR-A'))
110                *(QF('CAP','NAGR-A')**alpha('CAP','NAGR-A'));
111
112  FACDEM1..     WF('LAB') =E=
113                alpha('LAB','AGR-A')*PA('AGR-A')*QA('AGR-A')
114                / QF('LAB','AGR-A');
115
116  FACDEM2..     WF('CAP') =E=
117                alpha('CAP','AGR-A')*PA('AGR-A')*QA('AGR-A')
118                / QF('CAP','AGR-A');
119
120  FACDEM3..     WF('LAB') =E=
121                alpha('LAB','NAGR-A')*PA('NAGR-A')*QA('NAGR-A')
122                / QF('LAB','NAGR-A');
123
124  FACDEM4..     WF('CAP') =E=
125                alpha('CAP','NAGR-A')*PA('NAGR-A')*QA('NAGR-A')
126                / QF('CAP','NAGR-A');
127
128 *PRODFN(A)..   QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
129 *FACDEM(F,A).. WF(F) =E= alpha(F,A)*PVA(A)*QA(A) / QF(F,A);
130
131  OUTPUTFN(C).. Q(C) =E= SUM(A, theta(A,C)*QA(A));
132
133  PADEF(A)..    PA(A) =E= SUM(C, theta(A,C)*P(C));
134
135
136 *INSTITUTION BLOCK++++++++++++++++++++
137
138  FACTTRNS(H,F).. YF(H,F) =E= shry(H,F)*WF(F)*SUM(A, QF(F,A));
139
140  HHDINC(H)..     YH(H) =E= SUM(F, YF(H,F));
141
142  HHDEM(C,H)..    QH(C,H) =E= beta(C,H)*YH(H)/P(C);
143
144
145 *SYSTEM CONSTRAINT BLOCK++++++++++++++
```

```
146
147  FACTEQ(F)..        SUM(A, QF(F,A)) =E= qfs(F);
148
149  COMEQ('AGR-C').. Q('AGR-C') =E= SUM(H, QH('AGR-C',H));
150
151  PNORM..            SUM(C, cwts(C)*P(C)) =E= cpi;
152
153
154 *MODEL===============================================================
155
156 MODEL
157  CGEA1 Simple CGE model with selected equations in longhand /ALL/
158  ;
159
160 *SOCIAL ACCOUNTING MATRIX============================================
161
162 TABLE SAM(AC,ACP) social accounting matrix
163
164           AGR-A  NAGR-A  AGR-C  NAGR-C  LAB  CAP  U-HHD  R-HHD
165 AGR-A                     125
166 NAGR-A                            150
167 AGR-C                                              50     75
168 NAGR-C                                            100     50
169 LAB       62     55
170 CAP       63     95
171 U-HHD                                        60   90
172 R-HHD                                        57   68
173 ;
174
175
176 PARAMETER
177  tdiff(AC) column minus row total for account ac;
178 *This parameter is used to check that the above SAM is balanced.
179          SAM('TOTAL',ACNTP)  = SUM(ACNT, SAM(ACNT,ACNTP));
180          SAM(ACNT,'TOTAL')   = SUM(ACNTP, SAM(ACNT,ACNTP));
181          tdiff(ACNT)         = SAM('TOTAL',ACNT)—SAM(ACNT,'TOTAL');
182
183 DISPLAY SAM, tdiff;
184
185
186 *ASSIGNMENTS FOR PARAMETERS AND VARIABLES========================
187
188 PARAMETERS
189 *The following parameters are used to define initial values of
190 *model variables.
191  P0(C), PA0(A), Q0(C), QA0(A), QF0(F,A), QH0(C,H), WF0(F), YF0(H,F),
192  YH0(H)
193  ;
194
195
196 *PRODUCTION AND COMMODITY BLOCK++++++++
```

```
197
198   P0(C)        = 1;
199   PA0(A)       = 1;
200   WF0(F)       = 1;
201
202   Q0(C)        = SAM('TOTAL',C)/P0(C);
203   QA0(A)       = SAM('TOTAL',A)/PA0(A);
204   QF0(F,A)     = SAM(F,A)/WF0(F);
205
206   alpha(F,A)  = SAM(F,A) / SUM(FP, SAM(FP,A));
207   ad(A)       = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
208   theta(A,C)  = (SAM(A,C)/P0(C)) / QA0(A);
209
210
211   *INSTITUTION BLOCK+++++++++++++++++++++
212
213   QH0(C,H)   = SAM(C,H)/P0(C);
214   YF0(H,F)   = SAM(H,F);
215   YH0(H)     = SAM('TOTAL',H);
216
217   beta(C,H)  = SAM(C,H)/SUM(CP, SAM(CP,H));
218   shry(H,F)  = SAM(H,F)/SAM('TOTAL',F);
219
220
221   *SYSTEM CONSTRAINT BLOCK++++++++++++++
222
223   cwts(C)  = SUM(H, SAM(C,H)) / SUM((CP,H), SAM(CP,H));
224   cpi      = SUM(C, cwts(C)*P0(C));
225   qfs(F)   = SAM(F,'TOTAL')/WF0(F);
226
227
228   *INITIALIZING ALL VARIABLES+++++++++++
229
230   P.L(C)      = P0(C);
231   PA.L(A)     = PA0(A);
232   Q.L(C)      = Q0(C);
233   QA.L(A)     = QA0(A);
234   QF.L(F,A)   = QF0(F,A);
235   QH.L(C,H)   = QH0(C,H);
236   YF.L(H,F)   = YF0(H,F);
237   WF.L(F)     = WF0(F);
238   YH.L(H)     = YH0(H);
239
240
241   *DISPLAY++++++++++++++++++++++++++++++++
242
243   DISPLAY
244    ad, alpha, beta, cpi, cwts, qfs, shry, theta,
245
246    P.L, PA.L, Q.L, QA.L, QF.L, QH.L, WF.L, YF.L, YH.L
247    ;
```

```
248
249
250  *SOLVE STATEMENT FOR BASE========================================
251
252  *SOLVE CGEA1 USING MCP;
253
254
255  *REPORT SETUP AND BASE REPORT====================================
256
257  *SET AND PARAMETERS FOR REPORTS++++++++
258
259  SET
260   SIM simulations
261      /BASE   base simulation
262       CINCR  increase in capital stock/
263
264  PARAMETERS
265
266   QFSCAPSIM(SIM)  capital supply for sim'on sim (experiment parameter)
267  *Parameter is used to change the value for the capital stock parameter
268  *before solving the model for simulation sim
269
270   QFSREP(F,SIM)        supply of factor f for simulation sim (value used)
271   PREP(C,SIM)          demander price for commodity c
272   PAREP(A,SIM)         price of activity a
273   QREP(C,SIM)          output level for commodity c
274   QAREP(A,SIM)         level of activity a
275   QFREP(F,A,SIM)       demand for factor f from activity a
276   QHREP(C,H,SIM)       consumption of commodity c by household h
277   WFREP(F,SIM)         price of factor f
278   YFREP(H,F,SIM)       income of household h from factor f
279   YHREP(H,SIM)         income of household h
280   SAMREP(SIM,AC,ACP)   SAM computed from model solution
281   BALCHK(AC,SIM)       column minus row total for account ac in SAM
282   ;
283
284  QFSCAPSIM('BASE')   = qfs('CAP');
285  QFSCAPSIM('CINCR')  = 1.1*qfs('CAP');
286
287  DISPLAY QFSCAPSIM;
288
289
290  LOOP(SIM,
291
292   qfs('CAP')  = QFSCAPSIM(SIM);
293
294  SOLVE CGEA1 USING MCP;
295
296   QFSREP(F,SIM)   = qfs(F);
297
298   PREP(C,SIM)     = P.L(C);
```

```
299  PAREP(A,SIM)    = PA.L(A);
300  QREP(C,SIM)     = Q.L(C);
301  QAREP(A,SIM)    = QA.L(A);
302  QFREP(F,A,SIM)  = QF.L(F,A);
303  QHREP(C,H,SIM)  = QH.L(C,H);
304  WFREP(F,SIM)    = WF.L(F);
305  YFREP(H,F,SIM)  = YF.L(H,F);
306  YHREP(H,SIM)    = YH.L(H);
307
308  *Payments from activities
309   SAMREP(SIM,F,A)  = WF.L(F)*QF.L(F,A);
310  *Payments from commodities
311   SAMREP(SIM,A,C)  = P.L(C)*theta(A,C)*QA.L(A);
312  *Payments from factors
313   SAMREP(SIM,H,F)  = YF.L(H,F);
314  *Payments from households
315   SAMREP(SIM,C,H)  = P.L(C)*QH.L(C,H);
316
317   );
318
319
320  *Computing totals for SAMREP
321   SAMREP(SIM,'TOTAL',ACNTP) = SUM(ACNT, SAMREP(SIM,ACNT,ACNTP));
322   SAMREP(SIM,ACNT,'TOTAL') = SUM(ACNTP, SAMREP(SIM,ACNT,ACNTP));
323
324  *Check that SAMREP is balanced
325   BALCHK(ACNT,SIM) = SAMREP(SIM,'TOTAL',ACNT)−SAMREP(SIM,ACNT,'TOTAL');
326
327
328  OPTION QFREP:3:1:1, QHREP:3:1:1, YFREP:3:1:1, SAMREP:3:1:1;
329
330  DISPLAY
331   QFSREP, PREP, PAREP, QREP, QAREP, QFREP, QHREP, WFREP, YFREP, YHREP,
332   SAMREP, BALCHK
333   ;
```

EXERCISE 2: MATHEMATICAL STATEMENT

NOTATION

Sets

$a \in A$ activities
{AGR-A agricultural activity
NAGR-A nonagricultural activity}

$c \in C$ commodities
{AGR-C agricultural commodity
NAGR-C nonagricultural commodity}

$f \in F$ factors
{LAB labor
CAP capital}

$h \in H$ households
{U-HHD urban household
R-HHD rural household}

Parameters

ad_a efficiency parameter in the production function for activity a

cpi consumer price index (CPI)

$cwts_c$ weight of commodity c in the CPI

ica_{ca} qnty of c as intermed. input per unit of output in activity a

qfs_f supply of factor f

$shry_{hf}$ share for household h in the income of factor f

α_{fa} share of value-added for factor f in activity a

β_{ch} share in household h consumption spending of commodity c

θ_{ac} yield of output c per unit of activity a

Variables

P_c market price of commodity c

PA_a price of activity a

PVA_a value-added (or net) price of activity a

Q_c output level in commodity c

QA_a level of activity a

QF_{fa} demand for factor f from activity a

QH_{ch} consumption of commodity c by household h

$QINT_{ca}$ qnty of commodity c as intermediate input in activity a

WF_f price of factor f

YF_{hf} income of household h from factor f

YH_h income of household h

EQUATIONS

Production and Commodity Block

$$QA_a = ad_a \cdot \prod_{f \in F} QF_{fa}^{\alpha_{fa}} \qquad a \in A \tag{1}$$

$$WF_f = \frac{a_{fa} \cdot PVA_a \cdot QA_a}{QF_{fa}} \qquad f \in F, a \in A \tag{2}$$

$$\text{QINT}_{ca} = ica_{ca} \cdot QA_a \qquad c \in C, a \in A \qquad (3)$$

$$PA_a = \sum_{c \in C} \theta_{ac} \cdot P_c \qquad a \in A \qquad (4)$$

$$PVA_a = PA_a - \sum_{c \in C} P_c \cdot ica_{ca} \qquad a \in A \qquad (5)$$

$$Q_c = \sum_{a \in A} \theta_{ac} \cdot QA_a \qquad c \in C \qquad (6)$$

Institution Block

$$YF_{hf} = shry_{hf} \cdot WF_f \cdot \sum_{a \in A} QF_{fa} \qquad h \in H, f \in F \qquad (7)$$

$$YH_h = \sum_{f \in F} YF_{hf} \qquad h \in H \qquad (8)$$

$$QH_{ch} = \frac{\beta_{ch} \cdot YH_h}{P_c} \qquad c \in C, h \in H \qquad (9)$$

System Constraint Block

$$\sum_{a \in A} QF_{fa} = qfs_f \qquad f \in F \qquad (10)$$

$$Q_c = \sum_{h \in H} QH_{ch} + \sum_{a \in A} QINT_{ca} \qquad c \in C \qquad (11)$$

$$\sum_{c \in C} cwts_c \cdot P_c = cpi \qquad (12)$$

EXERCISE 2: GAMS CODE

```
 3
 4  *INTRODUCTION=================================================

    In this file, the starting point is CGE1.
    Intermediate demands are added. A modified SAM is presented.

    The line before any new feature or modification starts with
    "*++".

14
15  *SETS=========================================================
16
17  SETS
18
19  AC global set (SAM accounts and other items)
20    /AGR-A   agricultural activity
21     NAGR-A  non-agricultural activity
22     AGR-C   agricultural commodity
23     NAGR-C  non-agricultural commodity
24     LAB     labor
25     CAP     capital
26     U-HHD   urban household
27     R-HHD   rural household
28     TOTAL   total account in SAM  /
29
30  ACNT(AC) all elements in AC except total
31
32  A(AC)  activities
33         /AGR-A, NAGR-A/
34
35  C(AC)  commodities
36         /AGR-C, NAGR-C/
37
38  F(AC)  factors
39         /LAB, CAP/
40
41  H(AC)  households
42         /U-HHD, R-HHD/
43  ;
```

17

```
44
45  ALIAS(AC,ACP); ALIAS(C,CP); ALIAS(F,FP);
46  ACNT(AC) = YES; ACNT('TOTAL') = NO; ALIAS(ACNT,ACNTP);
47
48
49  *PARAMETERS==========================================================
50
51  PARAMETERS
52
53   ad(A)       efficiency parameter in the production fn for a
54   alpha(F,A)  share of value-added to factor f in activity a
55   beta(C,H)   share of household consumption spending on commodity c
56   cpi         consumer price index
57   cwts(C)     weight of commodity c in the CPI
58  *++
59   ica(C,A)    qnty of c as intermediate input per unit of activity a
60   qfs(F)      supply of factor f
61   shry(H,F)   share for household h in the income of factor f
62   theta(A,C)  yield of output c per unit of activity a
63   ;
64
65  *VARIABLES===========================================================
66
67  VARIABLES
68
69   P(C)        price of commodity c
70   PA(A)       price of activity a
71  *++
72   PVA(A)      value-added (or net) price for activity a
73   Q(C)        output level for commodity c
74   QA(A)       level of activity a
75   QF(F,A)     quantity demanded of factor f from activity a
76   QH(C,H)     quantity consumed of commodity c by household h
77  *++
78   QINT(C,A)   qnty of commodity c as intermediate input to activity a
79   WF(F)       price of factor f
80   YF(H,F)     income of household h from factor f
81   YH(H)       income of household h
82   ;
83
84  *EQUATIONS===========================================================
85
86  EQUATIONS
87
88  *PRODUCTION AND COMMODITY BLOCK++++++++
89   PRODFN(A)    Cobb-Douglas production function for activity a
90   FACDEM(F,A)  demand for factor f from activity a
91  *++
92   INTDEM(C,A)  intermediate demand for commodity c from activity a
93   OUTPUTFN(C)  output of commodity c
94   PADEF(A)     price for activity a
```

```
 95  *++
 96   PVADEF(A)     value-added price for activity a
 97
 98  *INSTITUTION BLOCK++++++++++++++++++++
 99   FACTTRNS(H,F)  transfer of income from factor f to h-hold h
100   HHDINC(H)        income of household h
101   HHDEM(C,H)      consumption demand for household h & commodity c
102
103  *SYSTEM CONSTRAINT BLOCK+++++++++++++++
104   FACTEQ(F)  market equilibrium condition for factor f
105   COMEQ(C)    market equilibrium condition for commodity c
106   PNORM      price normalization
107   ;
108
109  *PRODUCTION AND COMMODITY BLOCK++++++++
110
111   PRODFN(A)..    QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
112  *++
113   FACDEM(F,A)..  WF(F) =E= alpha(F,A)*PVA(A)*QA(A) / QF(F,A);
114  *++
115   INTDEM(C,A)..  QINT(C,A) =E= ica(C,A)*QA(A);
116
117   OUTPUTFN(C)..  Q(C) =E= SUM(A, theta(A,C)*QA(A));
118
119   PADEF(A)..     PA(A) =E= SUM(C, theta(A,C)*P(C));
120  *++
121   PVADEF(A)..    PVA(A) =E= PA(A)-SUM(C, P(C)*ica(C,A));
122
123
124  *INSTITUTION BLOCK++++++++++++++++++++
125
126   FACTTRNS(H,F)..  YF(H,F) =E= shry(H,F)*WF(F)*SUM(A, QF(F,A));
127
128   HHDINC(H)..      YH(H) =E= SUM(F, YF(H,F));
129
130   HHDEM(C,H)..     QH(C,H) =E= beta(C,H)*YH(H)/P(C);
131
132
133  *SYSTEM CONSTRAINT BLOCK+++++++++++++++
134
135   FACTEQ(F)..       SUM(A, QF(F,A)) =E= qfs(F);
136  *++
137   COMEQ('AGR-C').. Q('AGR-C') =E=
138                    SUM(H, QH('AGR-C',H)) + SUM(A, QINT('AGR-C',A));
139
140   PNORM..           SUM(C, cwts(C)*P(C)) =E= cpi;
141
142
143  *MODEL=========================================================
144
145  MODEL
```

```
146   CGE2  Model with intermediate demand as new feature
147   /ALL/
148    ;
149
150  *SOCIAL ACCOUNTING MATRIX======================================
151
152  TABLE SAM(AC,ACP) social accounting matrix
153
154          AGR-A  NAGR-A  AGR-C  NAGR-C  LAB  CAP  U-HHD  R-HHD
155  AGR-A                   225
156  NAGR-A                          250
157  AGR-C    60     40                              50     75
158  NAGR-C   40     60                             100     50
159  LAB      62     55
160  CAP      63     95
161  U-HHD                                  60   90
162  R-HHD                                  57   68
163  ;
164
165
166  PARAMETER
167  tdiff(AC) column minus row total for account ac;
168          SAM('TOTAL',ACNTP)  = SUM(ACNT, SAM(ACNT,ACNTP));
169          SAM(ACNT,'TOTAL')   = SUM(ACNTP, SAM(ACNT,ACNTP));
170          tdiff(ACNT)         = SAM('TOTAL',ACNT)—SAM(ACNT,'TOTAL');
171
172  DISPLAY SAM, tdiff;
173
174
175  *ASSIGNMENTS FOR PARAMETERS AND VARIABLES=======================
176
177  PARAMETERS
178  *The following parameters are used to define initial values of
179  *model variables.
180   P0(C), PA0(A), PVA0(A), Q0(C), QA0(A), QF0(F,A), QH0(C,H), QINT0(C,A),
181   WF0(F), YF0(H,F), YH0(H)
182    ;
183
184
185  *PRODUCTION AND COMMODITY BLOCK++++++++
186
187   P0(C)       = 1;
188   PA0(A)      = 1;
189   WF0(F)      = 1;
190
191  *++
192   PVA0(A)     = SUM(F, SAM(F,A)) / (SAM(A,'TOTAL')/PA0(A));
193   Q0(C)       = SAM('TOTAL',C)/P0(C);
194   QA0(A)      = SAM('TOTAL',A)/PA0(A);
195   QF0(F,A)    = SAM(F,A)/WF0(F);
196  *++
```

```
197   QINT0(C,A)  = SAM(C,A)/P0(C);
198
199   alpha(F,A)  = SAM(F,A) / SUM(FP, SAM(FP,A));
200   ad(A)       = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
201   *++
202   ica(C,A)    = (SAM(C,A)/P0(C)) / QA0(A);
203   theta(A,C)  = (SAM(A,C)/P0(C)) / QA0(A);
204
205
206   *INSTITUTION BLOCK+++++++++++++++++++++
207
208   QH0(C,H)    = SAM(C,H)/P0(C);
209   YF0(H,F)    = SAM(H,F);
210   YH0(H)      = SAM('TOTAL',H);
211
212   beta(C,H)   = SAM(C,H)/SUM(CP, SAM(CP,H));
213   shry(H,F)   = SAM(H,F)/SAM('TOTAL',F);
214
215
216   *SYSTEM CONSTRAINT BLOCK++++++++++++++
217
218   cwts(C)  = SUM(H, SAM(C,H)) / SUM((CP,H), SAM(CP,H));
219   cpi      = SUM(C, cwts(C)*P0(C));
220   qfs(F)   = SAM(F,'TOTAL')/WF0(F);
221
222
223   *INITIALIZING ALL VARIABLES+++++++++++
224
225   P.L(C)       = P0(C);
226   PA.L(A)      = PA0(A);
227   *++
228   PVA.L(A)     = PVA0(A);
229   Q.L(C)       = Q0(C);
230   QA.L(A)      = QA0(A);
231   QF.L(F,A)    = QF0(F,A);
232   QH.L(C,H)    = QH0(C,H);
233   *++
234   QINT.L(C,A)  = QINT0(C,A);
235   YF.L(H,F)    = YF0(H,F);
236   WF.L(F)      = WF0(F);
237   YH.L(H)      = YH0(H);
238   ;
239
240
241   *DISPLAY+++++++++++++++++++++++++++++++++++
242
243   DISPLAY
244   ad, alpha, beta, cpi, cwts, ica, qfs, shry, theta,
245
246   P.L, PA.L, PVA.L, Q.L, QA.L, QF.L, QH.L, QINT.L, WF.L, YF.L, YH.L
247   ;
```

```
248
249
250  *SOLVE STATEMENT FOR BASE=========================================
251
252  *SOLVE CGE2 USING MCP;
253
254
255  *REPORT SETUP AND BASE REPORT====================================
256
257  *SET AND PARAMETERS FOR REPORTS++++++++
258
259
260  SET
261   SIM simulations
262      /BASE   base simulation
263       CINCR  increase in capital stock/
264
265
266
267  PARAMETERS
268
269   QFSCAPSIM(SIM)     capital supply for sim'on sim (experiment parameter)
270
271   QFSREP(F,SIM)      supply of factor f for simulation sim (value used)
272   PREP(C,SIM)        demander price for commodity c
273   PAREP(A,SIM)       price of activity a
274   PVAREP(A,SIM)      value-added price for activity a
275   QREP(C,SIM)        output level for commodity c
276   QAREP(A,SIM)       level of activity a
277   QFREP(F,A,SIM)     demand for factor f from activity a
278   QHREP(C,H,SIM)     consumption of commodity c by household h
279   QINTREP(C,A,SIM)   qnty of commodity c as intermed. input for activity a
280   WFREP(F,SIM)       price of factor f
281   YFREP(H,F,SIM)     income of household h from factor f
282   YHREP(H,SIM)       income of household h
283   ;
284
285
286   QFSCAPSIM('BASE')   = qfs('CAP');
287   QFSCAPSIM('CINCR')  = 1.1*qfs('CAP');
288
289  DISPLAY QFSCAPSIM;
290
291
292
293  LOOP(SIM,
294
295   qfs('CAP') = QFSCAPSIM(SIM);
296
297  SOLVE CGE2 USING MCP;
298
```

```
299   QFSREP(F,SIM)      = qfs(F);
300   PREP(C,SIM)        = P.L(C);
301   PAREP(A,SIM)       = PA.L(A);
302   PVAREP(A,SIM)      = PVA.L(A);
303   QREP(C,SIM)        = Q.L(C);
304   QAREP(A,SIM)       = QA.L(A);
305   QFREP(F,A,SIM)     = QF.L(F,A);
306   QHREP(C,H,SIM)     = QH.L(C,H);
307   QINTREP(C,A,SIM)   = QINT.L(C,A);
308   WFREP(F,SIM)       = WF.L(F);
309   YFREP(H,F,SIM)     = YF.L(H,F);
310   YHREP(H,SIM)       = YH.L(H);
311
312   );
313
314   OPTION QFREP:3:1:1, QHREP:3:1:1, YFREP:3:1:1;
315
316   DISPLAY
317    QFSREP, PREP, PAREP, PVAREP, QREP, QAREP, QFREP, QHREP, QINTREP,
318    WFREP, YFREP, YHREP
319    ;
```

EXERCISE 3: MATHEMATICAL STATEMENT

NOTATION

Sets

$a \in A$ activities
{AGR-A agricultural activity
NAGR-A nonagricultural activity}

$c \in C$ commodities
{AGR-C agricultural commodity
NAGR-C nonagricultural commodity}

$f \in F$ factors
{LAB labor
CAP capital}

$h \in H$ households
{U-HHD urban household
R-HHD rural household}

Parameters

ad_a efficiency parameter in the production function for activity a

cpi consumer price index (CPI)

$cwts_c$ weight of commodity c in the CPI

ica_{ca} qnty of c as intermed. input per unit of output in activity a

mps_h marginal (and average) propensity to save for household h

qfs_f supply of factor f

$\underline{pwm_c}$ import price (foreign currency)

$\overline{qinv_c}$ base-year qnty of investment demand for commodity c

$shry_{hf}$ share for household h in the income of factor f

$wfdist_{fa}$ wage distortion factor for factor f in activity a

α_{fa} share of value-added for factor f in activity a

β_{ch} share in household h consumption spending on commodity c

θ_{ac} yield of output c per unit of activity a

Variables

$IADJ$ investment adjustment factor

P_c market price of commodity c

PA_a price of activity a

PVA_a value-added (or net) price of activity a

Q_c output level in commodity c

QA_a level of activity a

QF_{fa} demand for factor f from activity a

QH_{ch} consumption of commodity c by household h

$QINT_{ca}$ qnty of commodity c as intermediate input in activity a

$QINV_c$ quantity of investment demand for commodity c

$WALRAS$ *WALRAS* dummy variable (zero at equilibrium)

WF_f average wage (rental rate) for factor f

$$YF_{hf} \quad \text{income of household } h \text{ from factor } f$$
$$YH_h \quad \text{income of household } h$$

EQUATIONS

$$QA_a = ad_a \cdot \prod_{f \in F} QF_{fa}^{\alpha_{fa}} \qquad a \in A \tag{1}$$

Production and Commodity Block

$$WF_f \cdot wfdist_{fa} = \frac{a_{fa} \cdot PVA_a \cdot QA_a}{QF_{fa}} \qquad f \in F, a \in A \tag{2}$$

$$QINT_{ca} = ica_{ca} \cdot QA_a \qquad c \in C, a \in A \tag{3}$$

$$PA_a = \sum_{c \in C} \theta_{ac} \cdot P_c \qquad a \in A \tag{4}$$

$$PVA_a = PA_a - \sum_{c \in C} P_c \cdot ica_{ca} \qquad a \in A \tag{5}$$

$$Q_c = \sum_{a \in A} \theta_{ac} \cdot QA_a \qquad c \in C \tag{6}$$

Institution Block

$$YF_{hf} = shry_{hf} \cdot \sum_{a \in A} WF_f \cdot wfdist_{fa} \cdot QF_{fa} \qquad h \in H, f \in F \tag{7}$$

$$YH_h = \sum_{f \in F} YF_{hf} \qquad h \in H \tag{8}$$

$$QH_{ch} = \frac{\beta_{ch} \cdot (1 - mps_h) \cdot YH_h}{P_c} \qquad c \in C, h \in H \tag{9}$$

$$QINV_c = \overline{qinv_c} \cdot IADJ \qquad c \in C \tag{10}$$

System Constraint Block

$$\sum_{a \in A} QF_{fa} = qfs_f \qquad f \in F \tag{11}$$

$$Q_c = \sum_{h \in H} QH_{ch} + \sum_{a \in A} QINT_{ca} + QINV_c \qquad c \in C \tag{12}$$

$$\sum_{c \in C} P_c \cdot QINV_c + WALRAS = \sum_{h \in H} mps_h \cdot YH_h \tag{13}$$

$$\sum_{c \in C} cwts_c \cdot P_c = cpi \tag{14}$$

EXERCISE 3: GAMS CODE

```
 3
 4  *INTRODUCTION====================================================

    In this file, the starting point is CGE2.

    The new phenomenona are
    (1) the assumption that, for labor, wages are "distorted"
    (wages are no longer uniform for both activities); and
    (2) the presence of savings and investment.
    A modified SAM is presented (needed due to the addition of savings and
    investment).

    The line before any new feature or modification starts with
    "*++".

    Note that, in GAMS (as opposed to the mathematical statement),
    the household savings rate (mps) is declared as a variable that
    subsequently is fixed. (It was simply specified as a parameter in
    the mathematical statement.) Thus, investment remains savings-driven.
    However, with this specification, it is possible to change to making
    savings investment-driven by simply
    (1) fixing the variable for investment adjustment (IADJ); and
    (2) flexing the savings rate (mps) for one of the households.
    In this setting, variations in a household savings rate would assure
    that the savings value is equal to the investment value. To see how
    this can be done, search for "SAV-INV++".

    Given that the model now includes a fixed variable, the GAMS default
    variable count will now include an item that is not an endogenous
    variable. To overrule this default, the "holdfixed" model attribute
    is specified. As a result, only endogenous variables are included
    in the variable count. To see this, search "HOLDFIXED" (cf. Footnote 7
    in Exercise manual).

39
40  *SETS===========================================================
41
42  SETS
43
```

```
44  AC global set (SAM accounts and other items)
45    /AGR-A    agricultural activity
46     NAGR-A   non-agricultural activity
47     AGR-C    agricultural commodity
48     NAGR-C   non-agricultural commodity
49     LAB      labor
50     CAP      capital
51     U-HHD    urban household
52     R-HHD    rural household
53  *++
54     S-I      savings-investment
55     TOTAL    total account in SAM  /
56
57  ACNT(AC) all elements in AC except total
58
59  A(AC)  activities
60         /AGR-A, NAGR-A/
61
62  C(AC)  commodities
63         /AGR-C, NAGR-C/
64
65  F(AC)  factors
66         /LAB, CAP/
67
68  H(AC)  households
69         /U-HHD, R-HHD/
70  ;
71
72  ALIAS(AC,ACP); ALIAS(C,CP); ALIAS(F,FP);
73  ACNT(AC) = YES; ACNT('TOTAL') = NO; ALIAS(ACNT,ACNTP);
74
75
76  *PARAMETERS=======================================================
77
78  PARAMETERS
79
80   ad(A)        efficiency parameter in the production fn for a
81   alpha(F,A)   share of value-added to factor f in activity a
82   beta(C,H)    share of household consumption spending on commodity c
83   cpi          consumer price index
84   cwts(C)      weight of commodity c in the CPI
85   ica(C,A)     qnty of c as intermediate input per unit of activity a
86   qfs(F)       supply of factor f
87  *++
88   qinvbar(C)   base-year qnty of investment demand for commodity c
89   shry(H,F)    share for household h in the income of factor f
90   theta(A,C)   yield of output c per unit of activity a
91  *++
92   wfdist(F,A)  wage distortion factor for factor f in activity a
93   ;
94
```

```
 95   *VARIABLES=======================================================
 96
 97   VARIABLES
 98   *++
 99    IADJ        investment adjustment factor
100   *++
101    MPS(H)      marginal (and average) propensity to save for household h
102    P(C)        price of commodity c
103    PA(A)       price of activity a
104    PVA(A)      value-added (or net) price for activity a
105    Q(C)        output level for commodity c
106    QA(A)       level of activity a
107    QF(F,A)     quantity demanded of factor f from activity a
108    QH(C,H)     quantity consumed of commodity c by household h
109    QINT(C,A)   qnty of commodity c as intermediate input to activity a
110   *++
111    QINV(C)     quantity of investment demand for commodity c
112   *++
113    WALRAS      dummy variable (zero at equilibrium)
114    WF(F)       average price of factor f
115    YF(H,F)     income of household h from factor f
116    YH(H)       income of household h
117    ;
118
119   *EQUATIONS=======================================================
120
121   EQUATIONS
122
123   *PRODUCTION AND COMMODITY BLOCK++++++++
124    PRODFN(A)    Cobb-Douglas production function for activity a
125    FACDEM(F,A)  demand for factor f from activity a
126    INTDEM(C,A)  intermediate demand for commodity c from activity a
127    OUTPUTFN(C)  output of commodity c
128    PADEF(A)     price for activity a
129    PVADEF(A)    value-added price for activity a
130
131   *INSTITUTION BLOCK++++++++++++++++++++
132    FACTTRNS(H,F)  transfer of income from factor f to h-hold h
133    HHDINC(H)      income of household h
134    HHDEM(C,H)     consumption demand for household h & commodity c
135   *++
136    INVDEM(C)      investment demand for commodity c
137
138   *SYSTEM CONSTRAINT BLOCK++++++++++++++
139    FACTEQ(F)  market equilibrium condition for factor f
140    COMEQ(C)   market equilibrium condition for commodity c
141   *++
142    SAVINV     savings-investment balance
143    PNORM      price normalization
144    ;
145
```

```
146
147   *PRODUCTION AND COMMODITY BLOCK++++++++
148
149    PRODFN(A)..     QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
150   *++
151    FACDEM(F,A)..  WF(F)*wfdist(F,A) =E= alpha(F,A)*PVA(A)*QA(A) / QF(F,A);
152
153    INTDEM(C,A)..  QINT(C,A) =E= ica(C,A)*QA(A);
154
155    OUTPUTFN(C)..  Q(C) =E= SUM(A, theta(A,C)*QA(A));
156
157    PADEF(A)..      PA(A) =E= SUM(C, theta(A,C)*P(C));
158
159    PVADEF(A)..     PVA(A) =E= PA(A)—SUM(C, P(C)*ica(C,A));
160
161
162   *INSTITUTION BLOCK+++++++++++++++++++
163   *++
164    FACTTRNS(H,F)..  YF(H,F)
165                     =E= shry(H,F)*SUM(A, WF(F)*wfdist(F,A)*QF(F,A));
166
167    HHDINC(H)..      YH(H) =E= SUM(F, YF(H,F));
168   *++
169    HHDEM(C,H)..     QH(C,H) =E= beta(C,H)*(1—MPS(H))*YH(H)/P(C);
170   *++
171    INVDEM(C)..      QINV(C) =E= qinvbar(C)*IADJ;
172
173
174   *SYSTEM CONSTRAINT BLOCK++++++++++++++
175
176    FACTEQ(F)..  SUM(A, QF(F,A)) =E= qfs(F);
177   *++
178    COMEQ(C)..   Q(C) =E= SUM(H, QH(C,H)) + SUM(A, QINT(C,A)) + QINV(C)
   ;
179   *++
180    SAVINV..     SUM(C, P(C)*QINV(C)) + WALRAS =E= SUM(H, MPS(H)*YH(H))
   ;
181
182    PNORM..      SUM(C, cwts(C)*P(C)) =E= cpi;
183
184
185   *MODEL=======================================================
186
187   MODEL
188
189    CGE3  Model with savings-investment and wage distortions
190    /ALL/
191    ;
192
193   *SOCIAL ACCOUNTING MATRIX======================================
194
```

```
195  TABLE SAM(AC,ACP) social accounting matrix
196
197          AGR-A  NAGR-A  AGR-C  NAGR-C  LAB  CAP  U-HHD  R-HHD  S-I
198  AGR-A                   250
199  NAGR-A                          305
200  AGR-C    60     40                               50     75     25
201  NAGR-C   40     60                              100     50     55
202  LAB      72     80
203  CAP      78    125
204  U-HHD                                  80   120
205  R-HHD                                  72    83
206  S-I                                              50     30
207  ;
208
209  PARAMETER
210   tdiff(AC) column minus row total for account AC;
211          SAM('TOTAL',ACNTP)  = SUM(ACNT, SAM(ACNT,ACNTP));
212          SAM(ACNT,'TOTAL')   = SUM(ACNTP, SAM(ACNT,ACNTP));
213          tdiff(ACNT)         = SAM('TOTAL',ACNT)—SAM(ACNT,'TOTAL');
214
215  DISPLAY SAM, tdiff;
216
217
218  *ASSIGNMENTS FOR PARAMETERS AND VARIABLES=======================
219
220  PARAMETERS
221  *The following parameters are used to define initial values of
222  *model variables.
223   IADJ0, MPS0(H), P0(C), PA0(A), PVA0(A), Q0(C), QA0(A), QF0(F,A),
224   QH0(C,H), QINT0(C,A), QINV0(C), WF0(F), YF0(H,F), YH0(H)
225   ;
226
227
228  *++
229  *FACTOR EMPLOYMENT AND PRICES+++++++++
230  *This section is new. It includes all items related to factor
231  *prices and quantities.
232
233
234  PARAMETERS
235   labor(A)      quantity of labor employed by activity (no. of workers)
236                 /AGR-A 100, NAGR-A 50/
237
238   wfa(F,A)      wage for factor f in activity a (only for calibration)
239   costgap(F,A)  gap calibrated factor cost—SAM value (should be zero)
240   ;
241
242  *Defining factor employment and supply
243   QF0('LAB',A)  = labor(A);
244   QF0('CAP',A)  = SAM('CAP',A);
245   qfs(F)        = SUM(A, QF0(F,A));
```

```
246
247  *Computing activity-specific wage
248   wfa(F,A)      = SAM(F,A)/QF0(F,A);
249
250  *Computing average wage
251   WF0(F)        = SUM(A, SAM(F,A))/SUM(A, QF0(F,A));
252
253  *Computing wage distortion factors
254   wfdist(F,A)   = wfa(F,A) / WF0(F);
255
256  *Checking calibration
257   costgap(F,A)  = WF0(F)*wfdist(F,A)*QF0(F,A)—SAM(F,A);
258
259  DISPLAY wfa, costgap;
260
261
262  *PRODUCTION AND COMMODITY BLOCK++++++++
263
264   P0(C)         = 1;
265   PA0(A)        = 1;
266
267   PVA0(A)       = SUM(F, SAM(F,A)) / (SAM(A,'TOTAL')/PA0(A));
268   Q0(C)         = SAM('TOTAL',C)/P0(C);
269   QA0(A)        = SAM('TOTAL',A)/PA0(A);
270   QINT0(C,A)    = SAM(C,A)/P0(C);
271
272   alpha(F,A)    = SAM(F,A) / SUM(FP, SAM(FP,A));
273   ad(A)         = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
274   ica(C,A)      = (SAM(C,A)/P0(C)) / QA0(A);
275   theta(A,C)    = (SAM(A,C)/P0(C)) / QA0(A);
276
277
278  *INSTITUTION BLOCK++++++++++++++++++++
279
280  *++
281   IADJ0         = 1;
282  *++
283   MPS0(H)       = SAM('S-I',H)/SAM('TOTAL',H);
284   QH0(C,H)      = SAM(C,H)/P0(C);
285  *++
286   QINV0(C)      = SAM(C,'S-I')/P0(C);
287   YF0(H,F)      = SAM(H,F);
288   YH0(H)        = SAM('TOTAL',H);
289
290   beta(C,H)     = SAM(C,H)/SUM(CP, SAM(CP,H));
291  *++
292   qinvbar(C)    = SAM(C,'S-I')/P0(C);
293  *++
294   shry(H,F)     = SAM(H,F)/SAM('TOTAL',F);
295
296
```

```
297  *SYSTEM CONSTRAINT BLOCK++++++++++++++
298
299   cwts(C)  = SUM(H, SAM(C,H))/SUM((CP,H), SAM(CP,H));
300   cpi      = SUM(C, cwts(C)*P0(C));
301
302
303  *INITIALIZATION==================================================
304
305  *++
306   IADJ.L       = IADJ0;
307  *++
308   MPS.L(H)     = MPS0(H);
309   P.L(C)       = P0(C);
310   PA.L(A)      = PA0(A);
311   PVA.L(A)     = PVA0(A);
312   Q.L(C)       = Q0(C);
313   QA.L(A)      = QA0(A);
314   QF.L(F,A)    = QF0(F,A);
315   QH.L(C,H)    = QH0(C,H);
316   QINT.L(C,A)  = QINT0(C,A);
317  *++
318   QINV.L(C)    = QINV0(C);
319   WF.L(F)      = WF0(F);
320   YF.L(H,F)    = YF0(H,F);
321   YH.L(H)      = YH0(H);
322
323
324  *DISPLAY+++++++++++++++++++++++++++++++
325
326  DISPLAY
327   ad, alpha, beta, cpi, cwts, ica, qfs, qinvbar, shry, theta, wfdist
328
329   IADJ.L, MPS.L, P.L, PA.L, PVA.L, Q.L, QA.L, QF.L, QH.L, QINT.L, QINV.L,
330   WF.L, YF.L, YH.L
331   ;
332
333
334  *SELECTING CLOSURE FOR SAVINGS-INVESTMENT BALANCE
335
336  *Savings-driven investment
337   MPS.FX(H) = MPS0(H);
338
339  *SAV-INV++
340  *If the ontext-offtext is removed from the following group of lines
341  *savings becomes investment-driven with the savings rate of the urban
342  *household as the adjusting variable.
     IADJ.FX           = IADJ0;
     MPS.LO('U-HHD')   = -INF;
     MPS.UP('U-HHD')   = +INF;
     MPS.L('U-HHD')    = MPS0('U-HHD');
349
```

```
350  *SOLVE STATEMENT FOR BASE=========================================
351
352   CGE3.HOLDFIXED = 1;
353
354  *SOLVE CGE3 USING MCP;
355
356
357  *REPORT SETUP AND BASE REPORT====================================
358
359  *SET AND PARAMETERS FOR REPORTS++++++++
360
361
362  SET
363   SIM  simulations
364      /BASE   base simulation
365       CINCR  increase in capital stock/
366
367
368  PARAMETERS
369
370   QFSCAPSIM(SIM)    supply of capital for simulation sim
371   QFSREP(F,SIM)     supply of factor f for sim (check)
372
373   IADJREP(SIM)      investment adjustment factor
374   MPSREP(H,SIM)     marginal (and avg) propensity to save for household h
375   PREP(C,SIM)       demander price for commodity c
376   PAREP(A,SIM)      price of activity a
377   PVAREP(A,SIM)     value-added price for activity a
378   QREP(C,SIM)       output level for commodity c
379   QAREP(A,SIM)      level of activity a
380   QFREP(F,A,SIM)    demand for factor f from activity a
381   QHREP(C,H,SIM)    consumption of commodity c by household h
382   QINTREP(C,A,SIM)  qnty of commodity c as intermed. input for activity a
383   QINVREP(C,SIM)    quantity of investment by commodity of origin c
384   WFREP(F,SIM)      average price of factor f
385   WFAREP(F,A,SIM)   price of factor f for activity a
386   YFREP(H,F,SIM)    income of household h from factor f
387   YHREP(H,SIM)      income of household h
388   WALRASREP(SIM)    dummy variable (zero at equilibrium)
389   ;
390
391   QFSCAPSIM('BASE')  = qfs('CAP');
392   QFSCAPSIM('CINCR') = 1.1*qfs('CAP');
393
394  DISPLAY QFSCAPSIM;
395
396
397  LOOP(SIM,
398
399   qfs('CAP')  = QFSCAPSIM(SIM);
400
```

```
401
402   SOLVE CGE3 USING MCP;
403
404
405   QFSREP(F,SIM)      = qfs(F);
406
407   MPSREP(H,SIM)      = MPS.L(H);
408   IADJREP(SIM)       = IADJ.L;
409   PREP(C,SIM)        = P.L(C);
410   PAREP(A,SIM)       = PA.L(A);
411   PVAREP(A,SIM)      = PVA.L(A);
412   QREP(C,SIM)        = Q.L(C);
413   QAREP(A,SIM)       = QA.L(A);
414   QFREP(F,A,SIM)     = QF.L(F,A);
415   QHREP(C,H,SIM)     = QH.L(C,H);
416   QINTREP(C,A,SIM)   = QINT.L(C,A);
417   QINVREP(C,SIM)     = QINV.L(C);
418   WFREP(F,SIM)       = WF.L(F);
419   WFAREP(F,A,SIM)    = WF.L(F)*wfdist(F,A);
420   YFREP(H,F,SIM)     = YF.L(H,F);
421   YHREP(H,SIM)       = YH.L(H);
422   WALRASREP(SIM)     = WALRAS.L;
423   );
424
425  OPTION QFREP:3:1:1, QHREP:3:1:1, WFAREP:3:1:1, YFREP:3:1:1;
426
427  DISPLAY
428   QFSREP, IADJREP, MPSREP, PREP, PAREP, PVAREP, QREP, QAREP, QFREP,
429   QHREP, QINTREP, QINVREP, WFREP, WFAREP, YFREP, YHREP, WALRASREP
430   ;
```

EXERCISE 4: MATHEMATICAL STATEMENT

NOTATION	$a \in A$	activities
		{AGR-A agricultural activity
Sets		NAGR-A nonagricultural activity}
	$c \in C$	commodities
		{AGR-C agricultural commodity
		NAGR-C nonagricultural commodity}
	$f \in F$	factors
		{LAB labor
		CAP capital}
	$i \in I$	institutions
		{U-HHD urban household
		R-HHD rural household
		GOV government
	$h \in H\,(\subset I)$	households
		{U-HHD urban household
		R-HHD rural household}

Parameters	ad_a	efficiency parameter in the production function for activity a
	cpi	consumer price index (CPI)
	$cwts_c$	weight of commodity c in the CPI
	ica_{ca}	qnty of c as intermed. input per unit of output in activity a
	mps_h	marginal (and average) propensity to save for household h
	$\overline{qg_c}$	government demand for commodity c
	$\overline{qinv_c}$	base-year qnty of investment demand for commodity c
	$shry_{hf}$	share for household h in the income of factor f
	tq_c	rate of sales tax for commodity c
	$tr_{ii'}$	transfers from institution i' to institution i
	ty_h	rate of income tax for household h
	α_{fa}	share of value-added for factor f in activity a
	β_{ch}	share in household h consumption spending on commodity c
	θ_{ac}	yield of output c per unit of activity a

Variables	EG	government expenditure
	$IADJ$	investment adjustment factor
	P_c	market price of commodity c
	PA_a	price of activity a
	PVA_c	value-added (or net) price of activity a
	PX_c	producer price (excluding sales tax) of commodity c

Q_c	output level in commodity c
QA_a	level of activity a
QF_{fa}	demand for factor f from activity a
QFS_f	supply of factor f
QH_{ch}	consumption of commodity c by household h
$QINT_{ca}$	qnty of commodity c as intermediate input in activity a
$QINV_c$	quantity of investment demand for commodity c
$WALRAS$	dummy variable (zero at equilibrium)
WF_f	average wage (rental rate) of factor f
$WFDIST_{fa}$	wage distortion factor for factor f in activity a
YF_{hf}	income of household h from factor f
YG	government revenue
YH_h	income of household h

EQUATIONS

Price, Production, and Commodity Block

$$QA_a = ad_a \cdot \prod_{f \in F} QF_{fa}^{\alpha_{fa}} \qquad a \in A \tag{1}$$

$$WF_f \cdot wfdist_{fa} = \frac{a_{fa} \cdot PVA_a \cdot QA_a}{QF_{fa}} \qquad f \in F, a \in A \tag{2}$$

$$QINT_{ca} = ica_{ca} \cdot QA_a \qquad c \in C, a \in A \tag{3}$$

$$Q_c = \sum_{a \in A} \theta_{ac} \cdot QA_a \qquad c \in C \tag{4}$$

$$P_c = (1 + tq_c) \cdot PX_c \qquad c \in C \tag{5}$$

$$PA_a = \sum_{c \in C} \theta_{ac} \cdot P_c \qquad a \in A \tag{6}$$

$$PVA_a = PA_a - \sum_{c \in C} P_c \cdot ica_{ca} \qquad a \in A \tag{7}$$

Institution Block

$$YF_{hf} = shry_{hf} \cdot \sum_{a \in A} WF_f \cdot WFDIST_{fa} \cdot QF_{fa} \qquad h \in H, f \in F \tag{8}$$

$$YH_h = \sum_{f \in F} YF_{hf} + tr_{h,gov} \qquad h \in H \tag{9}$$

$$QH_{ch} = \frac{\beta_{ch} \cdot (1 - mps_h) \cdot (1 - ty_h) \cdot YH_h}{P_c} \qquad c \in C, h \in H \tag{10}$$

$$QINV_c = \overline{qinv_c} \cdot IADJ \qquad c \in C \tag{11}$$

$$YG = \sum_{h \in H} ty_h \cdot YH_h + \sum_{c \in C} tq_c \cdot PX_c \cdot Q_c \tag{12}$$

$$EG = \sum_{c \in C} P_c \cdot qg_c + \sum_{h \in H} tr_{h,gov} \tag{13}$$

System Constraint Block

$$\sum_{a \in A} QF_{fa} = QFS_f \quad f \in F \tag{14}$$

$$Q_c = \sum_{h \in H} QH_{ch} + \sum_{a \in A} QINT_{ca} + QINV_c + qg_c \quad c \in C \tag{15}$$

$$\sum_{c \in C} P_c \cdot QINV_c + WALRAS = \sum_{h \in H} mps_h \cdot (1 - ty_h) \cdot YH_h + (YG - EG) \tag{16}$$

$$\sum_{c \in C} cwts_c \cdot P_c = cpi \tag{17}$$

Given the assumption that labor is unemployed with a fixed wage while capital is fully employed and activity-specific, the following variables are fixed at base values:

$WFDIST_{lab,a}$, WF_{lab}, $QF_{cap,a}$ and WF_{cap}.

EXERCISE 4: GAMS CODE

```
 3
 4  *INTRODUCTION==================================================

    In this file, the starting point is CGE3.
    Additions: A government (and a new SAM), and labor unemployment with an
    infinitely elastic supply of labor at a wage that is fixed in real
    (and nominal) terms.

    The line before any new feature or modification starts with
    "*++".

16
17  *SETS=========================================================
18
19  SETS
20
21  AC global set (SAM accounts and other items)
22    /AGR-A   agricultural activity
23     NAGR-A  non-agricultural activity
24     AGR-C   agricultural commodity
25     NAGR-C  non-agricultural commodity
26     LAB     labor
27     CAP     capital
28     U-HHD   urban household
29     R-HHD   rural household
30  *++
31     GOV     government
32     S-I     savings-investment
33  *++
34     YTAX    income tax
35  *++
36     STAX    sales tax
37     TOTAL   total account in SAM  /
38
39  ACNT(AC) all elements in AC except total
40
41   A(AC) activities
42         /AGR-A, NAGR-A/
43
```

```
44   C(AC)  commodities
45          /AGR-C, NAGR-C/
46
47   F(AC) factors
48          /LAB, CAP/
49
50  *++
51   I(AC) institutions
52          /U-HHD, R-HHD, GOV/
53
54   H(I)  households
55          /U-HHD, R-HHD/
56   ;
57
58   ALIAS(AC,ACP); ALIAS(C,CP); ALIAS(F,FP); ALIAS(I,IP);
59   ACNT(AC) = YES; ACNT('TOTAL') = NO; ALIAS(ACNT,ACNTP);
60
61
62  *PARAMETERS===================================================
63
64   PARAMETERS
65
66   ad(A)      efficiency parameter in the production fn for activity a
67   alpha(F,A) share of value-added to factor f in activity a
68   beta(C,H)  share of household consumption spending on commodity c
69   cpi        consumer price index
70   cwts(C)    weight of commodity c in the CPI
71   ica(C,A)   qnty of c as intermediate input per unit of activity a
72  *++
73   qg(C)      government demand for commodity c
74   qinvbar(C) base-year qnty of investment demand for commodity c
75   shry(H,F)  share for household h in the income of factor f
76   theta(A,C) yield of output c per unit of activity a
77  *++
78   tq(C)      rate of sales tax for commodity c
79  *++
80   tr(I,IP)   transfer from institution ip to institution i
81  *++
82   ty(H)      rate of income tax for household h
83   ;
84
85  *VARIABLES===================================================
86
87   VARIABLES
88  *++
89   EG         government expenditures
90   IADJ       investment adjustment factor
91   MPS(H)     marginal (and average) propensity to save for household h
92   P(C)       demander price for commodity c
93   PA(A)      price of activity a
94   PVA(A)     value-added (or net) price for activity a
```

```
 95  *++
 96   PX(C)         producer price for commodity c
 97   Q(C)          output level for commodity c
 98   QA(A)         level of activity a
 99   QF(F,A)       quantity demanded of factor f from activity a
100  *++
101   QFS(F)        supply of factor f
102   QH(C,H)       quantity consumed of commodity c by household h
103   QINT(C,A)     qnty of commodity c as intermediate input to activity a
104   QINV(C)       quantity of investment demand for commodity c
105   WALRAS        dummy variable (zero at equilibrium)
106   WF(F)         average price of factor f
107  *++
108   WFDIST(F,A)   wage distortion factor for factor f in activity a
109
110   YF(H,F)       income of household h from factor f
111  *++
112   YG            government revenue
113   YH(H)         income of household h
114   ;
115
116  *EQUATIONS===========================================================
117
118  EQUATIONS
119
120  *PRICE, PRODUCTION AND COMMODITY BLOCK++++++++
121   PRODFN(A)     Cobb-Douglas production function for activity a
122   FACDEM(F,A)   demand for factor f from activity a
123   INTDEM(C,A)   intermediate demand for commodity c from activity a
124   OUTPUTFN(C)   output of commodity c
125  *++
126   PDEF(C)       demander price for commodity c
127   PADEF(A)      price for activity a
128   PVADEF(A)     value-added price for activity a
129
130  *INSTITUTION BLOCK++++++++++++++++++++
131   FACTTRNS(H,F)  transfer of income from factor f to h-hold h
132   HHDINC(H)      income of household h
133   HHDEM(C,H)     consumption demand for household h & commodity c
134   INVDEM(C)      investment demand for commodity c
135  *++
136   GOVREV         government revenue
137  *++
138   GOVEXP         government expenditures
139
140  *SYSTEM CONSTRAINT BLOCK+++++++++++++++
141   FACTEQ(F)  market equilibrium condition for factor f
142   COMEQ(C)   market equilibrium condition for commodity c
143   SAVINV     savings-investment balance
144   PNORM      price normalization
145   ;
```

```
146
147
148  *PRICE, PRODUCTION AND COMMODITY BLOCK++++++++
149
150   PRODFN(A)..    QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
151
152   FACDEM(F,A)..  WF(F)*WFDIST(F,A) =E= alpha(F,A)*PVA(A)*QA(A) / QF(F,A);
153
154   INTDEM(C,A)..  QINT(C,A) =E= ica(C,A)*QA(A);
155
156   OUTPUTFN(C)..  Q(C) =E= SUM(A, theta(A,C)*QA(A));
157  *++
158   PDEF(C)..      P(C) =E= (1 + tq(C))*PX(C);
159  *++
160   PADEF(A)..     PA(A) =E= SUM(C, theta(A,C)*PX(C));
161
162   PVADEF(A)..    PVA(A) =E= PA(A)—SUM(C, P(C)*ica(C,A));
163
164
165  *INSTITUTION BLOCK++++++++++++++++++
166
167   FACTTRNS(H,F).. YF(H,F)
168                   =E= shry(H,F)*SUM(A, WF(F)*WFDIST(F,A)*QF(F,A));
169  *++
170   HHDINC(H)..    YH(H) =E= SUM(F, YF(H,F)) + tr(H,'GOV');
171  *++
172   HHDEM(C,H)..   QH(C,H) =E=
173                   beta(C,H)*(1—MPS(H))*(1—ty(H))*YH(H)/P(C);
174
175   INVDEM(C)..    QINV(C) =E= qinvbar(C)*IADJ;
176  *++
177   GOVREV..       YG =E= SUM(H, ty(H)*YH(H)) + SUM(C, tq(C)*PX(C)*Q(C));
178  *++
179   GOVEXP..       EG =E= SUM(C, P(C)*qg(C)) + SUM(H, tr(H,'GOV'));
180
181
182  *SYSTEM CONSTRAINT BLOCK++++++++++++++
183  *++
184   FACTEQ(F)..  SUM(A, QF(F,A)) =E= QFS(F);
185  *++
186   COMEQ(C)..   Q(C) =E= SUM(H, QH(C,H)) + SUM(A, QINT(C,A))
187                + QINV(C) + qg(C);
188  *++
189   SAVINV..     SUM(C, P(C)*QINV(C)) + WALRAS =E=
190                SUM(H, MPS(H)*(1—ty(H))*YH(H)) + (YG—EG);
191
192   PNORM..      SUM(C, cwts(C)*P(C)) =E= cpi;
193
194
195  *MODEL===========================================================
196
```

```
197  MODELS
198
199   CGE4 Model with gov't and flexible factor market treatment
200   /ALL/
201   ;
202
203  *SOCIAL ACCOUNTING MATRIX======================================
204
205  TABLE SAM(AC,ACP) social accounting matrix
206
207           AGR-A  NAGR-A  AGR-C  NAGR-C  LAB   CAP
208  AGR-A                    255
209  NAGR-A                           350
210  AGR-C    66     44
211  NAGR-C   44     66
212  LAB      72     105
213  CAP      73     135
214  U-HHD                                   95    125
215  R-HHD                                   82    83
216  GOV
217  S-I
218  YTAX
219  STAX                     25     33
220
221
222  +        U-HHD  R-HHD   GOV   S-I   YTAX  STAX
223  AGR-A
224  NAGR-A
225  AGR-C    55     77      11    27
226  NAGR-C   110    55      47    61
227  LAB
228  CAP
229  U-HHD                   25
230  R-HHD                    5
231  GOV                           25    58
232  S-I      60     33      -5
233  YTAX     20     5
234  STAX
235  ;
236
237  PARAMETER
238   tdiff(AC) column minus row total for account AC;
239          SAM('TOTAL',ACNTP)  = SUM(ACNT, SAM(ACNT,ACNTP));
240          SAM(ACNT,'TOTAL')   = SUM(ACNTP, SAM(ACNT,ACNTP));
241          tdiff(ACNT)         = SAM('TOTAL',ACNT)—SAM(ACNT,'TOTAL');
242
243  DISPLAY SAM, tdiff;
244
245
246  *ASSIGNMENTS FOR PARAMETERS AND VARIABLES=======================
247
```

```
248  PARAMETERS
249  *The following parameters are used to define initial values of
250  *model variables.
251   EG0, IADJ0, MPS0(H), P0(C), PA0(A), PVA0(A), PX0(C), Q0(C), QA0(A),
252   QF0(F,A), QFS0(F), QH0(C,H), QINT0(C,A), QINV0(C), WF0(F),
253   WFDIST0(F,A), YF0(H,F), YG0, YH0(H)
254   ;
255
256
257  *FACTOR EMPLOYMENT AND PRICES++++++++++
258
259
260  PARAMETERS
261   labor(A)        quantity of labor employed by activity (no. of workers)
262                   /AGR-A 100, NAGR-A 50/
263
264   wfa(F,A)        wage for factor f in activity a (only for calibration)
265   costgap(F,A)  gap calibrated factor cost—SAM value (should be zero)
266   ;
267
268  *Defining factor employment and supply
269   QF0('LAB',A)  = labor(A);
270   QF0('CAP',A)  = SAM('CAP',A);
271  *++
272   QFS0(F)        = SUM(A, QF0(F,A));
273
274  *Computing activity-specific wage
275   wfa(F,A)       = SAM(F,A)/QF0(F,A);
276
277  *Computing average wage
278   WF0(F)         = SUM(A, SAM(F,A))/SUM(A, QF0(F,A));
279
280  *Computing wage distortion factors
281   WFDIST0(F,A)  = wfa(F,A) / WF0(F);
282
283  *Checking calibration
284   costgap(F,A)  = WF0(F)*WFDIST0(F,A)*QF0(F,A)—SAM(F,A);
285
286  DISPLAY wfa, costgap;
287
288
289  *PRICE, PRODUCTION AND COMMODITY BLOCK++++++++
290
291   PA0(A)        = 1;
292  *++
293   PX0(C)        = 1;
294   PVA0(A)       = SUM(F, SAM(F,A)) / (SAM(A,'TOTAL')/PA0(A));
295
296  *++
297   tq(C)         = SAM('STAX',C)/SUM(A, SAM(A,C) );
298  *++
```

```
299  P0(C)        = PX0(C)*(1 + tq(C));
300
301  Q0(C)        = SAM('TOTAL',C)/P0(C);
302  QA0(A)       = SAM('TOTAL',A)/PA0(A);
303  QINT0(C,A)   = SAM(C,A)/P0(C);
304
305  alpha(F,A)   = SAM(F,A) / SUM(FP, SAM(FP,A));
306  ad(A)        = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
307  ica(C,A)     = (SAM(C,A)/P0(C)) / QA0(A);
308  *++
309  theta(A,C)   = (SAM(A,C)/PX0(C)) / QA0(A);
310
311
312  *INSTITUTION BLOCK++++++++++++++++++++
313  *++
314  EG0          = SAM('TOTAL','GOV')—SAM('S-I','GOV');
315  IADJ0        = 1;
316  *++
317  MPS0(H)      = SAM('S-I',H) / (SAM('TOTAL',H)—SAM('YTAX',H));
318  QH0(C,H)     = SAM(C,H)/P0(C);
319  QINV0(C)     = SAM(C,'S-I')/P0(C);
320  YF0(H,F)     = SAM(H,F);
321  *++
322  YG0          = SAM('GOV','TOTAL');
323  YH0(H)       = SAM('TOTAL',H);
324
325  beta(C,H)    = SAM(C,H)/SUM(CP, SAM(CP,H));
326  *++
327  qg(C)        = SAM(C,'GOV')/P0(C);
328  qinvbar(C)   = SAM(C,'S-I')/P0(C);
329  shry(H,F)    = SAM(H,F)/SAM('TOTAL',F);
330  *++
331  tr(H,'GOV')  = SAM(H,'GOV');
332  *++
333  ty(H)        = SAM('YTAX',H) / SAM('TOTAL',H);
334
335
336  *SYSTEM CONSTRAINT BLOCK++++++++++++++
337
338  cwts(C)  = SUM(H, SAM(C,H)) / SUM((CP,H), SAM(CP,H));
339  cpi      = SUM(C, cwts(C)*P0(C));
340
341
342  *INITIALIZATION OF VARIABLES++++++++++
343
344  EG.L         = EG0;
345  IADJ.L       = IADJ0;
346  MPS.L(H)     = MPS0(H);
347  P.L(C)       = P0(C);
348  PA.L(A)      = PA0(A);
349  PVA.L(A)     = PVA0(A);
```

```
350  PX.L(C)         = PX0(C);
351  Q.L(C)          = Q0(C);
352  QA.L(A)         = QA0(A);
353  QF.L(F,A)       = QF0(F,A);
354  QFS.L(F)        = QFS0(F);
355  QH.L(C,H)       = QH0(C,H);
356  QINT.L(C,A)     = QINT0(C,A);
357  QINV.L(C)       = QINV0(C);
358  WF.L(F)         = WF0(F);
359  WFDIST.L(F,A)   = WFDIST0(F,A);
360  YF.L(H,F)       = YF0(H,F);
361  YG.L            = YG0;
362  YH.L(H)         = YH0(H);
363
364
365  *DISPLAY+++++++++++++++++++++++++++++++
366
367  DISPLAY
368   ad, alpha, beta, cpi, cwts, ica, shry, qg, qinvbar, theta, tr, ty
369
370   EG.L, IADJ.L, MPS.L, P.L, PA.L, PVA.L, PX.L, Q.L, QA.L, QF.L, QFS.L,
371   QH.L, QINT.L, QINV.L, WF.L, WFDIST.L, YF.L, YG.L, YH.L
372   ;
373
374
375  *SELECTING CLOSURES+++++++++++++++++++
376
377  *SAVINGS-INVESTMENT BALANCE
378
379  SCALAR
380   SICLOS savings-investment closure /1/
381  *Select 1 or 2
382  *if SICLOS = 1, savings is investment-driven
383  *if SICLOS = 2, investment is savings-driven
384
385  IF(SICLOS EQ 1,
386  *Investment-driven savings—MPS('U-HHD') is flexible, permitting
387  *the savings value to adjust.
388   IADJ.FX         = IADJ0;
389   MPS.FX('R-HHD') = MPS0('R-HHD');
390   MPS.LO('U-HHD') = -INF;
391   MPS.UP('U-HHD') = +INF;
392   MPS.L('U-HHD')  = MPS0('U-HHD');
393   );
394
395  IF(SICLOS EQ 2,
396  *Savings-driven investment—IADJ is flexible, permitting
397  *investment quantities and the investment value to adjust.
398   MPS.FX(H) = MPS0(H);
399   IADJ.LO   = -INF;
400   IADJ.UP   = +INF;
```

```
401  IADJ.L     = IADJ0;
402  );
403
404
405  *FACTOR MARKETS
406  *For each factor, fix (A + 1) quantity and-or price variables
407
408  SCALARS
409   CAPCLOS  closure for capital market /2/
410  *Select 1 or 2
411  *if CAPCLOS = 1, capital is mobile and fully employed
412  *if CAPCLOS = 2, capital is activity-specific and fully employed
413
414   LABCLOS  closure for labor market /2/
415  *Select 1 or 2
416  *if LABCLOS = 1, labor is mobile and fully employed
417  *if LABCLOS = 2, labor is mobile and unemployed (fixed wages)
418
419
420  IF(CAPCLOS EQ 1,
421  *Capital is fully employed and mobile. WF('CAP') is the market-clearing
422  *variable for the unified capital market.
423
424   WFDIST.FX('CAP',A)  = WFDIST0('CAP',A);
425
426   WF.LO('CAP')        = -INF;
427   WF.UP('CAP')        = +INF;
428   WF.L('CAP')         = WF0('CAP');
429
430   QF.LO('CAP',A)      = -INF;
431   QF.UP('CAP',A)      = +INF;
432   QF.L('CAP',A)       = QF0('CAP',A);
433
434   QFS.FX('CAP')       = QFS0('CAP');
435   );
436
437  IF(CAPCLOS EQ 2,
438  *Capital is fully employed and activity-specific.
439  *WFDIST('CAP',A) is the market-clearing variable, one for
440  *each segment of the capital market.
441
442   WFDIST.LO('CAP',A)  = -INF;
443   WFDIST.UP('CAP',A)  = +INF;
444   WFDIST.L('CAP',A)   = WFDIST0('CAP',A);
445
446   WF.FX('CAP')        = WF0('CAP');
447
448   QF.FX('CAP',A)      = QF0('CAP',A);
449
450   QFS.LO('CAP')       = -INF;
451   QFS.UP('CAP')       = +INF;
```

```
452  QFS.L('CAP')        = QFS0('CAP');
453  );
454
455  IF(LABCLOS EQ 1,
456  *Labor is fully employed and mobile. WF('LAB') is the market-clearing
457  *variable for the unified capital market.
458
459  WFDIST.FX('LAB',A)  = WFDIST0('LAB',A);
460
461  WF.LO('LAB')        = -INF;
462  WF.UP('LAB')        = +INF;
463  WF.L('LAB')         = WF0('LAB');
464
465  QF.LO('LAB',A)      = -INF;
466  QF.UP('LAB',A)      = +INF;
467  QF.L('LAB',A)       = QF0('LAB',A);
468
469  QFS.FX('LAB')       = QFS0('LAB');
470  );
471
472  IF(LABCLOS EQ 2,
473  *Labor is unemployed and mobile. For each activity, the wage,
474  *WFDIST('LAB',A)*WF('LAB'), is fixed. QFS('LAB') is the market-clear-
ing
475  *variable for the unified labor market.
476
477  WFDIST.FX('LAB',A)  = WFDIST0('LAB',A);
478
479  WF.FX('LAB')        = WF0('LAB');
480
481  QF.LO('LAB',A)      = -INF;
482  QF.UP('LAB',A)      = +INF;
483  QF.L('LAB',A)       = QF0('LAB',A);
484
485  QFS.LO('LAB')       = -INF;
486  QFS.UP('LAB')       = +INF;
487  QFS.L('LAB')        = QFS0('LAB');
488  );
489
490  DISPLAY SICLOS, CAPCLOS, LABCLOS;
491
492
493  *SOLVE STATEMENT FOR BASE=======================================
494
495  CGE4.HOLDFIXED  = 1;
496
497  *SOLVE CGE4 USING MCP;
498
499
500  *REPORT SETUP AND BASE REPORT===================================
501
```

```
502  *SET AND PARAMETERS FOR REPORTS++++++++
503
504  *++
505  SET
506   SIM simulations
507      /BASE   base simulation
508       QGINCR  increase in government consumption /
509       ;
510
511  PARAMETERS
512  *++
513   QGSIM(C,SIM)         government consumption of c for sim
514  *++
515   QGREP(C,SIM)         government consumption of c for sim (check)
516
517   EGREP(SIM)           government expenditures
518   IADJREP(SIM)         investment adjustment factor
519   MPSREP(H,SIM)        marginal (and avg) propensity to save for household h
520   PREP(C,SIM)          demander price for commodity c
521   PAREP(A,SIM)         price of activity a
522   PVAREP(A,SIM)        value-added price for activity a
523   PXREP(C,SIM)         producer price (excl. sales tax) for commodity c
524   QREP(C,SIM)          output level for commodity c
525   QAREP(A,SIM)         level of activity a
526   QFREP(F,A,SIM)       demand for factor f from activity a
527   QFSREP(F,SIM)        supply of factor f for sim
528   QHREP(C,H,SIM)       consumption of commodity c by household h
529   QINTREP(C,A,SIM)     qnty of commodity c as intermed. input for activity a
530   QINVREP(C,SIM)       quantity of investment by commodity of origin c
531   WFREP(F,SIM)         average price of factor f
532   WFAREP(F,A,SIM)      price of factor f for activity a
533   WFDISTREP(F,A,SIM)   wage distortion factor for factor f in activity a
534   YFREP(H,F,SIM)       income of household h from factor f
535   YGREP(SIM)           government revenue
536   YHREP(H,SIM)         income of household h
537   WALRASREP(SIM)       dummy variable (zero at equilibrium)
538   ;
539
540  *++
541   QGSIM(C,'BASE')    = qg(C);
542   QGSIM(C,'QGINCR')  = 1.2*qg(C);
543
544  DISPLAY QGSIM;
545
546
547  LOOP(SIM,
548  *++
549   qg(C)  = QGSIM(C,SIM);
550
551  SOLVE CGE4 USING MCP;
552
```

```
553  *++
554   QGREP(C,SIM)          = qg(c);
555
556   EGREP(SIM)            = EG.L;
557   IADJREP(SIM)          = IADJ.L;
558   MPSREP(H,SIM)         = MPS.L(H);
559   PREP(C,SIM)           = P.L(C);
560   PAREP(A,SIM)          = PA.L(A);
561   PVAREP(A,SIM)         = PVA.L(A);
562   PXREP(C,SIM)          = PX.L(C);
563   QREP(C,SIM)           = Q.L(C);
564   QAREP(A,SIM)          = QA.L(A);
565   QFREP(F,A,SIM)        = QF.L(F,A);
566   QFSREP(F,SIM)         = QFS.L(F);
567   QHREP(C,H,SIM)        = QH.L(C,H);
568   QINTREP(C,A,SIM)      = QINT.L(C,A);
569   QINVREP(C,SIM)        = QINV.L(C);
570   WFREP(F,SIM)          = WF.L(F);
571   WFAREP(F,A,SIM)       = WF.L(F)*WFDIST.L(F,A);
572   WFDISTREP(F,A,SIM)    = WFDIST.L(F,A);
573   YFREP(H,F,SIM)        = YF.L(H,F);
574   YGREP(SIM)            = YG.L;
575   YHREP(H,SIM)          = YH.L(H);
576   WALRASREP(SIM)        = WALRAS.L;
577   );
578
579  OPTION QFREP:3:1:1, QHREP:3:1:1, QINTREP:3:1:1, WFAREP:3:1:1,
580         WFAREP:3:1:1, WFDISTREP:3:1:1, YFREP:3:1:1
581  ;
582
583  DISPLAY
584   QGREP, EGREP, IADJREP, MPSREP, PREP, PAREP, PVAREP, PXREP, QREP,
585   QAREP, QFREP, QFSREP, QHREP, QINTREP, QINVREP, WFREP, WFAREP,
586   WFDISTREP, YFREP, YGREP, YHREP, WALRASREP
587   ;
```

EXERCISE 5: GAMS CODE

```
  4  *INTRODUCTION====================================================

     In this file, the starting point is CGE4.
     The new feature is that the rest of the world has been added. A
     CET-Armington specification is used for foreign trade.

     The line before any new feature or modification starts with
     "*++". However, in the section where values are assigned
     to variables and parameters, changes are not signalled.

     In the experiment, the impact of a doubling of (initially positive)
     foreign savings is explored.

 19
 20  *SETS============================================================
 21
 22  SETS
 23
 24  AC global set (SAM accounts and other items)
 25    /AGR-A   agricultural activity
 26     NAGR-A  non-agricultural activity
 27     AGR-C   agricultural commodity
 28     NAGR-C  non-agricultural commodity
 29     LAB     labor
 30     CAP     capital
 31     U-HHD   urban household
 32     R-HHD   rural household
 33     GOV     government
 34     S-I     savings-investment
 35     YTAX    income tax
 36     STAX    sales tax
 37  *++
 38     TAR     import tariff
 39  *++
 40     ROW     rest of world
 41     TOTAL   total account in SAM  /
 42
 43   ACNT(AC) all elements in AC except total
```

```
44
45  A(AC)    activities
46           /AGR-A, NAGR-A/
47
48  C(AC)    commodities
49           /AGR-C, NAGR-C/
50 *++
51  CE(C)    exported commodities
52           /AGR-C/
53 *++
54  CNE(C)   non-exported commodities
55           /NAGR-C/
56 *++
57  CM(C)    imported commodities
58           /NAGR-C/
59 *++
60  CNM(C)   non-imported commodities
61           /AGR-C/
62
63  F(AC)    factors
64           /LAB, CAP/
65
66  I(AC)    institutions
67           /U-HHD, R-HHD, GOV, ROW/
68
69  H(I)     households
70           /U-HHD, R-HHD/
71     ;
72
73 ALIAS(AC,ACP); ALIAS(C,CP); ALIAS(F,FP); ALIAS(I,IP);
74 ACNT(AC) = YES; ACNT('TOTAL') = NO; ALIAS(ACNT,ACNTP);
75
76
77 *PARAMETERS=======================================================
78
79  PARAMETERS
80
81  ad(A)        efficiency parameter in the production fn for a
82  alpha(F,A)   share of value-added to factor f in activity a
83 *++
84  aq(C)        Armington function shift parameter for commodity c
85 *++
86  at(C)        CET function shift parameter for commodity c
87  beta(C,H)    share of household consumption spending on commodity c
88  cpi          consumer price index
89  cwts(C)      weight of commodity c in the CPI
90 *++
91  deltaq(C)    Armington function share parameter for commodity c
92 *++
93  deltat(C)    CET function share parameter for commodity c
94  ica(C,A)     qnty of c as intermediate input per unit of activity a
```

```
 95  *++
 96   pwe(C)       export price for c (foreign currency)
 97  *++
 98   pwm(C)       import price for c (foreign currency)
 99   qg(C)        government demand for commodity c
100   qinvbar(C)   base-year qnty of investment demand for commodity c
101  *++
102   rhoq(C)      Armington function exponent for commodity c
103  *++
104   rhot(C)      CET function exponent for commodity c
105   shry(H,F)    share for household h in the income of factor f
106  *++
107   te(C)        export subsidy rate for commodity c
108   theta(A,C)   yield of output c per unit of activity a
109  *++
110   tm(C)        import tariff rate for commodity c
111   tq(C)        rate of sales tax for commodity c
112   tr(I,IP)     transfer from institution ip to institution i
113   ty(H)        rate of income tax for household h
114   ;
115
116  *VARIABLES=======================================================
117
118  VARIABLES
119
120   EG           government expenditures
121  *++
122   EXR          exchange rate (dom. currency per unit of for. currency)
123  *++
124   FSAV         foreign savings (foreign currency)
125   IADJ         investment adjustment factor
126   MPS(H)       marginal (and average) propensity to save for household h
127   PA(A)        price of activity a
128  *++
129   PD(C)        domestic price of domestic output c
130  *++
131   PE(C)        export price for c (domestic currency)
132  *++
133   PM(C)        import price for c (domestic currency)
134  *++
135   PQ(C)        composite commodity price for c
136   PVA(A)       value-added price for activity a
137   PX(C)        producer price for commodity c
138   QA(A)        level of activity a
139  *++
140   QD(C)        quantity sold domestically of domestic output c
141  *++
142   QE(C)        quantity of exports for commodity c
143   QF(F,A)      quantity demanded of factor f from activity a
144   QFS(F)       supply of factor f
145   QH(C,H)      quantity consumed of commodity c by household h
```

```
146  QINT(C,A)    qnty of commodity c as intermediate input to activity a
147  QINV(C)      quantity of investment demand for commodity c
148  *++
149  QM(C)        quantity of imports of commodity c
150  *++
151  QQ(C)        quantity of goods supplied domestically (composite supply)
152  *++
153  QX(C)        quantity of domestic output of commodity c
154  WALRAS       dummy variable (zero at equilibrium)
155  WF(F)        average price of factor f
156  WFDIST(F,A)  wage distortion factor for factor f in activity a
157  YF(H,F)      transfer of income to household h from factor f
158  YG           government revenue
159  YH(H)        income of household h
160  ;
161
162  *EQUATIONS========================================================
163
164  EQUATIONS
165
166  *PRICE BLOCK+++++++++++++++++++++++++++
167  *++
168  PMDEF(C)   import price for commodity c (domestic currency)
169  *++
170  PEDEF(C)   export price for commodity c (domestic currency)
171  *++
172  ABSORB(C)  absorption for commodity c
173  *++
174  OUTVAL(C)  output value for commodity c
175  PADEF(A)   price for activity a
176  PVADEF(A)  value-added price for activity a
177
178  *PRODUCTION AND COMMODITY BLOCK++++++++
179  PRODFN(A)    Cobb-Douglas production function for activity a
180  FACDEM(F,A)  demand for factor f from activity a
181  INTDEM(C,A)  intermediate demand for commodity c from activity a
182  OUTPUTFN(C)  output of commodity c
183  *++
184  ARMING(C)    composite supply (Armington) function for commodity c
185  *++
186  IMPDOMRAT(C) import-domestic demand ratio for commodity c
187  *++
188  ARMNM(C)     composite supply for non-imported commodity c
189  *++
190  CET(C)       output transformation (CET) function for commodity c
191  *++
192  EXPDOMRAT(C) export-domestic supply ratio for commodity c
193  *++
194  CETNE(C)     output transformation for non-exported commodity c
195
196
```

```
197  *INSTITUTION BLOCK+++++++++++++++++++++
198   FACTTRNS(H,F)   transfer of income from factor f to h-hold h
199   HHDINC(H)         income of household h
200   HHDEM(C,H)       consumption demand for household h & commodity c
201   INVDEM(C)         investment demand for commodity c
202   GOVREV            government revenue
203   GOVEXP            government expenditures
204
205  *SYSTEM CONSTRAINT BLOCK+++++++++++++++
206   FACTEQ(F)   market equilibrium condition for factor f
207   COMEQ(C)    market equilibrium condition for composite commodity c
208  *++
209   CURACC      current account balance for RoW
210   SAVINV      savings-investment balance
211   PNORM       price normalization
212   ;
213
214  *PRICE BLOCK++++++++++++++++++++++++++++
215  *++
216   PMDEF(C)$CM(C)..  PM(C) =E= (1 + tm(C))*EXR*pwm(C);
217  *++
218   PEDEF(C)$CE(C)..  PE(C) =E= (1—te(C))*EXR*pwe(C);
219  *++
220   ABSORB(C)..       PQ(C)*QQ(C)
221                     =E= (PD(C)*QD(C) + (PM(C)*QM(C))$CM(C))*(1 + tq(C));
222  *++
223   OUTVAL(C)..       PX(C)*QX(C) =E= PD(C)*QD(C) + (PE(C)*QE(C))$CE(C);
224
225   PADEF(A)..        PA(A) =E= SUM(C, PX(C)*theta(A,C));
226  *++
227   PVADEF(A)..       PVA(A) =E= PA(A)—SUM(C, PQ(C)*ica(C,A));
228
229
230  *PRODUCTION AND COMMODITY BLOCK++++++++
231
232   PRODFN(A)..           QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
233
234   FACDEM(F,A)..         WF(F)*WFDIST(F,A) =E= alpha(F,A)*PVA(A)*QA(A)
235                         /QF(F,A);
236
237   INTDEM(C,A)..         QINT(C,A) =E= ica(C,A)*QA(A);
238
239   OUTPUTFN(C)..         QX(C) =E= SUM(A, theta(A,C)*QA(A));
240  *++
241   ARMING(C)$CM(C)..     QQ(C) =E= aq(C)*(deltaq(C)*QM(C)**(-rhoq(C))
242                         + (1-deltaq(C))*QD(C)**(-rhoq(C)))**(-1/rhoq(C));
243  *++
244   IMPDOMRAT(C)$CM(C)..  QM(C)/QD(C) =E=
245                         ( (PD(C)/PM(C))
246                         *(deltaq(C)/(1-deltaq(C))) )**(1/(1 + rhoq(C)));
247  *++
```

```
248   ARMNM(C)$CNM(C)..      QQ(C) =E= QD(C);
249  *++
250   CET(C)$CE(C)..         QX(C) =E= at(C)*(deltat(C)*QE(C)**rhot(C)
251                          + (1-deltat(C))*QD(C)**rhot(C) )**(1/rhot(C));
252  *++
253   EXPDOMRAT(C)$CE(C).. QE(C)/QD(C) =E= ( PE(C)/PD(C)
254                          *(1-deltat(C))/deltat(C) )**(1/(rhot(C)-1) );
255  *++
256   CETNE(C)$CNE(C)..      QX(C) =E= QD(C);
257
258
259  *INSTITUTION BLOCK+++++++++++++++++++
260
261   FACTTRNS(H,F)..  YF(H,F)
262                   =E= shry(H,F)*SUM(A, WF(F)*WFDIST(F,A)*QF(F,A));
263
264  *++
265   HHDINC(H)..      YH(H) =E= SUM(F, YF(H,F)) + tr(H,'GOV')
266                   + EXR*tr(H,'ROW');
267
268   HHDEM(C,H)..     QH(C,H) =E=
269                   beta(C,H)*(1—MPS(H))*(1—ty(H))*YH(H)/PQ(C);
270
271   INVDEM(C)..      QINV(C) =E= qinvbar(C)*IADJ;
272  *++
273   GOVREV..         YG =E= SUM(H, ty(H)*YH(H))
274                   + EXR*tr('GOV','ROW')
275                   + SUM(C, tq(C)*(PD(C)*QD(C) + (PM(C)*QM(C))$CM(C)))
276                   + SUM(C$CM(C), tm(C)*EXR*pwm(C)*QM(C))
277                   + SUM(C$CE(C), te(C)*EXR*pwe(C)*QE(C))
278                   ;
279
280   GOVEXP..         EG =E= SUM(C, PQ(C)*qg(C)) + SUM(H, tr(H,'GOV'));
281                   ;
282
283
284  *SYSTEM CONSTRAINT BLOCK++++++++++++++
285
286   FACTEQ(F)..  SUM(A, QF(F,A)) =E= QFS(F);
287  *++
288   COMEQ(C)..   QQ(C) =E= SUM(A, QINT(C,A)) + SUM(H, QH(C,H))
289                + qg(C) + QINV(C);
290  *++
291   CURACC..     SUM(C$CE(C), pwe(C)*QE(C)) + SUM(I, tr(I,'ROW'))
292                + FSAV =E= SUM(C$CM(C), pwm(C)*QM(C));
293  *++
294   SAVINV..     SUM(H, MPS(H)*(1—ty(H))*YH(H)) + (YG—EG)
295                + EXR*FSAV =E= SUM(C, PQ(C)*QINV(C)) + WALRAS;
296
297   PNORM..      SUM(C, PQ(C)*cwts(C)) =E= cpi;
298
```

```
299
300  *MODEL==============================================================
301
302  MODELS
303
304   CGE5 Open-economy model
305   /ALL/
306   ;
307
308  *SOCIAL ACCOUNTING MATRIX=========================================
309
310  TABLE SAM(AC,ACP) social accounting matrix
311
312            AGR-A   NAGR-A   AGR-C   NAGR-C   LAB   CAP
313  AGR-A                       279
314  NAGR-A                                394
315  AGR-C     84       55
316  NAGR-C    50       99
317  LAB       72      105
318  CAP       73      135
319  U-HHD                                        95    125
320  R-HHD                                        82     83
321  GOV
322  S-I
323  YTAX
324  STAX                        10       20
325  TAR                                  39
326  ROW                                 105
327
328  +         U-HHD   R-HHD   GOV   S-I   YTAX   STAX   TAR   ROW
329  AGR-A
330  NAGR-A
331  AGR-C      30      49      13    28                        30
332  NAGR-C    165      92      67    85
333  LAB
334  CAP
335  U-HHD                      25                              40
336  R-HHD                       5                              16
337  GOV                                    25     30    39     15
338  S-I        70      40      -1     4
339  YTAX       20       5
340  ;
341
342  PARAMETER
343   tdiff(AC) column minus row total for account AC;
344            SAM('TOTAL',ACNTP)  = SUM(ACNT, SAM(ACNT,ACNTP));
345            SAM(ACNT,'TOTAL')   = SUM(ACNTP, SAM(ACNT,ACNTP));
346            tdiff(ACNT)         = SAM('TOTAL',ACNT)—SAM(ACNT,'TOTAL');
347
348  DISPLAY SAM, tdiff;
349
```

```
350
351  *ASSIGNMENTS FOR PARAMETERS AND VARIABLES========================
352
353  PARAMETERS
354  *The following parameters are used to define initial values of
355  *model variables.
356   EG0, EXR0, FSAV0, IADJ0, MPS0(H), PA0(A), PD0(C), PE0(C), PM0(C),
357   PQ0(C), PVA0(A), PX0(C), QA0(A), QD0(C), QE0(C), QF0(F,A), QFS0(F),
358   QH0(C,H), QINT0(C,A), QINV0(C), QM0(C), QQ0(C), QX0(C), WF0(F),
359   WFDIST0(F,A), YF0(H,F), YG0, YH0(H)
360   ;
361
362
363  *FACTOR EMPLOYMENT AND PRICES++++++++++
364
365
366  PARAMETERS
367   labor(A)      quantity of labor employed by activity (no. of workers)
368                 /AGR-A 100, NAGR-A 50/
369
370   wfa(F,A)      wage for factor f in activity a (only for calibration)
371   costgap(F,A)  gap calibrated factor cost-SAM value (should be zero)
372   ;
373
374  *Defining factor employment and supply
375   QF0('LAB',A)  = labor(A);
376   QF0('CAP',A)  = SAM('CAP',A);
377   QFS0(F)       = SUM(A, QF0(F,A));
378
379  *Computing activity-specific wage
380   wfa(F,A)      = SAM(F,A)/QF0(F,A);
381
382  *Computing average wage
383   WF0(F)        = SUM(A, SAM(F,A))/SUM(A, QF0(F,A));
384
385  *Computing wage distortion factors
386   WFDIST0(F,A)  = wfa(F,A) / WF0(F);
387
388  *Checking calibration
389   costgap(F,A)  = WF0(F)*WFDIST0(F,A)*QF0(F,A)-SAM(F,A);
390
391  DISPLAY wfa, costgap;
392
393
394
395  *PRICE BLOCK+++++++++++++++++++++++++++++
396
397  PARAMETERS
398   sigmaq(C) elasticity of substitution bt. dom goods and imports for c
399   sigmat(C) elasticity of transformation bt. dom sales and exports for c
400   ;
```

```
401
402   EXR0          = 1;
403   PA0(A)        = 1;
404   PD0(C)        = 1;
405   PE0(C)        = 1;
406   PM0(C)        = 1;
407   PX0(C)        = 1;
408
409   PVA0(A)       = SUM(F, SAM(F,A)) / (SAM(A,'TOTAL')/PA0(A));
410
411   tq(C)         = SAM('STAX',C)
412                   /(SAM('TAR',C) + SAM('ROW',C) + SUM(A, SAM(A,C))
413                      - SAM(C,'ROW') );
414   PQ0(C)        = 1 + tq(C);
415
416   QA0(A)        = SAM('TOTAL',A)/PA0(A);
417   QD0(C)        = (SUM(A, SAM(A,C))—SAM(C,'ROW'))/PD0(C);
418   QE0(C)        = SAM(C,'ROW')/PE0(C);
419   QM0(C)        = (SAM('ROW',C) + SAM('TAR',C))/PM0(C);
420   QQ0(C)        = (SAM('TOTAL',C)—SAM(C,'ROW'))/PQ0(C);
421   QX0(C)        = SUM(A, SAM(A,C))/PX0(C);
422
423   ica(C,A)      = (SAM(C,A)/PQ0(C)) / QA0(A);
424   theta(A,C)    = (SAM(A,C)/PX0(C)) / QA0(A);
425
426   te(C)         = 0;
427   pwe(C)        = PE0(C)/((1 + te(C))*EXR0);
428
429   tm(C)$CM(C)   = SAM('TAR',C)/SAM('ROW',C);
430   pwm(C)$CM(C)  = PM0(C) / ( EXR0*(1 + tm(C)) );
431
432
433  *PRODUCTION AND COMMODITY BLOCK++++++++
434
435   QINT0(C,A)      = SAM(C,A)/PQ0(C);
436
437   alpha(F,A)      = SAM(F,A) / SUM(FP, SAM(FP,A));
438   ad(A)           = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
439
440   sigmat(C)       = 2.0;
441   sigmaq(C)       = 0.7;
442   rhot(C)         = 1/sigmat(C) + 1;
443   rhoq(C)         = 1/sigmaq(C)—1;
444
445   deltat(C)$CE(C) = 1/(1 + (PD0(C)/PE0(C))*(QE0(C)/QD0(C))**(rhot(C)-
1));
446
447   at(C)$CE(C)     = QX0(C) / ( deltat(C)*QE0(C)**rhot(C)
448                     + (1-deltat(C))*QD0(C)**rhot(C) )**(1/rhot(C));
449
450   deltaq(C)$CM(C) = 1/(1 + (PD0(C)/PM0(C))*(QD0(C)/QM0(C))**(1+rhoq(C)));
```

```
451
452  aq(C)$CM(C)        = QQ0(C) / (deltaq(C)*QM0(C)**(-rhoq(C))
453                        + (1-deltaq(C))*QD0(C)**(-rhoq(C)))**(-1/rhoq(C));
454
455
456  *INSTITUTION BLOCK++++++++++++++++++++
457
458  EG0            = SAM('TOTAL','GOV')—SAM('S-I','GOV');
459  FSAV0          = SAM('S-I','ROW')/EXR0;
460  IADJ0          = 1;
461  MPS0(H)        = SAM('S-I',H) / (SAM('TOTAL',H)—SAM('YTAX',H));
462  QH0(C,H)       = SAM(C,H)/PQ0(C);
463  QINV0(C)       = SAM(C,'S-I')/PQ0(C);
464  YF0(H,F)       = SAM(H,F);
465  YG0            = SAM('GOV','TOTAL');
466  YH0(H)         = SAM('TOTAL',H);
467
468  beta(C,H)     = SAM(C,H)/SUM(CP, SAM(CP,H));
469  qg(C)         = SAM(C,'GOV')/PQ0(C);
470  qinvbar(C)    = SAM(C,'S-I')/PQ0(C);
471  shry(H,F)     = SAM(H,F) / SAM('TOTAL',F);
472  tr(H,'GOV')   = SAM(H,'GOV');
473  tr(I,'ROW')   = SAM(I,'ROW')/EXR0;
474  ty(H)         = SAM('YTAX',H) / SAM('TOTAL',H);
475
476
477  *SYSTEM CONSTRAINT BLOCK++++++++++++++
478
479  cwts(C)  = SUM(H, SAM(C,H)) / SUM((CP,H), SAM(CP,H));
480  cpi      = SUM(C, cwts(C)*PQ0(C));
481
482
483  *INITIALIZATION================================================
484
485  EG.L           = EG0;
486  EXR.L          = EXR0;
487  FSAV.L         = FSAV0;
488  IADJ.L         = IADJ0;
489  MPS.L(H)       = MPS0(H);
490  PA.L(A)        = PA0(A);
491  PD.L(C)        = PD0(C);
492  PE.L(C)        = PE0(C);
493  PM.L(C)        = PM0(C);
494  PQ.L(C)        = PQ0(C);
495  PVA.L(A)       = PVA0(A);
496  PX.L(C)        = PX0(C);
497  QA.L(A)        = QA0(A);
498  QD.L(C)        = QD0(C);
499  QE.L(C)        = QE0(C);
500  QF.L(F,A)      = QF0(F,A);
501  QFS.L(F)       = QFS0(F);
```

```
502  QH.L(C,H)       = QH0(C,H);
503  QINT.L(C,A)     = QINT0(C,A);
504  QINV.L(C)       = QINV0(C);
505  QM.L(C)         = QM0(C);
506  QQ.L(C)         = QQ0(C);
507  QX.L(C)         = QX0(C);
508  WF.L(F)         = WF0(F);
509  WFDIST.L(F,A)   = WFDIST0(F,A);
510  YF.L(H,F)       = YF0(H,F);
511  YG.L            = YG0;
512  YH.L(H)         = YH0(H);
513
514  *DISPLAY++++++++++++++++++++++++++++++
515
516
517  DISPLAY
518   ad,   alpha, aq, at,   beta, deltaq, deltat, cpi, cwts,  ica,
519   pwe, pwm,   shry, theta, qg, qinvbar, rhoq,
520   rhot, te,  sigmaq, sigmat, tm,   tq, tr,    ty,
521
522   EG.L, EXR.L, FSAV.L, IADJ.L, MPS.L, PA.L, PD.L, PE.L, PM.L,
523   PQ.L, PVA.L, PX.L,      QA.L, QD.L, QE.L, QF.L, QFS.L, QH.L, QINT.L,
524   QINV.L, QM.L, QQ.L,    QX.L, WF.L, WFDIST.L, YF.L, YG.L, YH.L
525   ;
526
527
528  *SELECTING CLOSURES++++++++++++++++++
529
530  *SAVINGS-INVESTMENT BALANCE
531
532  SCALAR
533   SICLOS savings-investment closure /1/
534  *Select 1 or 2
535  *if SICLOS = 1, savings is investment-driven
536  *if SICLOS = 2, investment is savings-driven
537
538  IF(SICLOS EQ 1,
539  *Investment-driven savings—MPS('U-HHD') is flexible, permitting
540  *the savings value to adjust.
541   IADJ.FX         = IADJ0;
542   MPS.FX('R-HHD') = MPS0('R-HHD');
543   MPS.LO('U-HHD') = -INF;
544   MPS.UP('U-HHD') = +INF;
545   MPS.L('U-HHD')  = MPS0('U-HHD');
546   );
547
548  IF(SICLOS EQ 2,
549  *Savings-driven investment—IADJ is flexible, permitting
550  *investment quantities and the investment value to adjust.
551   MPS.FX(H)  = MPS0(H);
552   IADJ.LO    = -INF;
```

```
553  IADJ.UP   = +INF;
554  IADJ.L    = IADJ0;
555  );
556
557
558  *FACTOR MARKETS
559  *For each factor, fix (A + 1) quantity and-or price variables
560
561  SCALARS
562   CAPCLOS     closure for capital market /2/
563  *Select 1 or 2
564  *if CAPCLOS = 1, capital is mobile and fully employed
565  *if CAPCLOS = 2, capital is activity-specific and fully employed
566
567   LABCLOS     closure for labor market /2/
568  *Select 1 or 2
569  *if LABCLOS = 1, labor is mobile and fully employed
570  *if LABCLOS = 2, labor is mobile and unemployed (fixed wages)
571
572
573  IF(CAPCLOS EQ 1,
574  *Capital is fully employed and mobile. WF('CAP') is the market-clear-
ing
575  *variable for the unified capital market.
576
577   WFDIST.FX('CAP',A)  = WFDIST0('CAP',A);
578
579   WF.LO('CAP')         = -INF;
580   WF.UP('CAP')         = +INF;
581   WF.L('CAP')          = WF0('CAP');
582
583   QF.LO('CAP',A)       = -INF;
584   QF.UP('CAP',A)       = +INF;
585   QF.L('CAP',A)        = QF0('CAP',A);
586
587   QFS.FX('CAP')        = QFS0('CAP');
588   );
589
590  IF(CAPCLOS EQ 2,
591  *Capital is fully employed and activity-specific.
592  *WFDIST('CAP',A) is the market-clearing variable, one for
593  *each segment of the capital market.
594
595   WFDIST.LO('CAP',A)  = -INF;
596   WFDIST.UP('CAP',A)  = +INF;
597   WFDIST.L('CAP',A)   = WFDIST0('CAP',A);
598
599   WF.FX('CAP')         = WF0('CAP');
600
601   QF.FX('CAP',A)       = QF0('CAP',A);
602
```

```
603  QFS.LO('CAP')      = -INF;
604  QFS.UP('CAP')      = +INF;
605  QFS.L('CAP')       = QFS0('CAP');
606  );
607
608  IF(LABCLOS EQ 1,
609  *Labor is fully employed and mobile. WF('LAB') is the market-clearing
610  *variable for the unified capital market.
611
612  WFDIST.FX('LAB',A)  = WFDIST0('LAB',A);
613
614  WF.LO('LAB')        = -INF;
615  WF.UP('LAB')        = +INF;
616  WF.L('LAB')         = WF0('LAB');
617
618  QF.LO('LAB',A)      = -INF;
619  QF.UP('LAB',A)      = +INF;
620  QF.L('LAB',A)       = QF0('LAB',A);
621
622  QFS.FX('LAB')       = QFS0('LAB');
623  );
624
625  IF(LABCLOS EQ 2,
626  *Labor is unemployed and mobile. For each activity, the wage,
627  *WFDIST('LAB',A)*WF('LAB'), is fixed. QFS('LAB') is the market-clearing
628  *variable for the unified labor market.
629
630  WFDIST.FX('LAB',A)  = WFDIST0('LAB',A);
631
632  WF.FX('LAB')        = WF0('LAB');
633
634  QF.LO('LAB',A)      = -INF;
635  QF.UP('LAB',A)      = +INF;
636  QF.L('LAB',A)       = QF0('LAB',A);
637
638  QFS.LO('LAB')       = -INF;
639  QFS.UP('LAB')       = +INF;
640  QFS.L('LAB')        = QFS0('LAB');
641  );
642
643
644  *THE FOREIGN EXCHANGE MARKET
645
646  SCALAR
647   ROWCLOS rest-of-world closure /1/
648  *Select 1 or 2
649  *if ROWCLOS = 1, exchange rate is flexible
650  *if ROWCLOS = 2, foreign savings is flexible
651   ;
652
653  IF(ROWCLOS EQ 1,
```

```
654  *Foreign savings is fixed. A flexible exchange rate clears
655  *the current account of the balance of payments.
656   FSAV.FX  = FSAV0;
657   EXR.LO   = -INF;
658   EXR.UP   = +INF;
659   EXR.L    = EXR0;
660   );
661
662  IF(ROWCLOS EQ 2,
663  *The exchange rate is fixed. Flexible foreign savings clears
664  *the current account of the balance of payments.
665   EXR.FX   = EXR0;
666   FSAV.LO  = -INF;
667   FSAV.UP  = +INF;
668   FSAV.L   = FSAV0;
669   );
670
671
672  DISPLAY SICLOS, CAPCLOS, LABCLOS, ROWCLOS;
673
674
675  *SOLVE STATEMENT FOR BASE=========================================
676
677   CGE5.HOLDFIXED = 1;
678
679  *SOLVE CGE5 USING MCP;
680
681
682  *REPORT SETUP AND BASE REPORT=====================================
683
684  *SET AND PARAMETERS FOR REPORTS++++++++
685
686
687  SET
688   SIM simulations
689      /BASE     base simulation
690       PWEINCR  increase in agricultural export price/
691
692   ACGDP GDP items
693   /
694   GDPMP1  GDP at market prices (from spending side)
695   PRVCON  private consumption
696   GOVCON  government consumption
697   INVEST  investment
698   EXP     exports of goods and services
699   IMP     imports of goods and services
700   NITAX   net indirect taxes
701   GDPFC   GDP at factor prices
702   GDPMP2  GDP at market prices (from income side)
703   GDPGAP  gap bt alternative calculations for GDP at market prices
704   /
```

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705
706   ACGDP1(ACGDP)  components of GDP at market prices
707   /
708   PRVCON  private consumption
709   GOVCON  government consumption
710   INVEST  investment
711   EXP     exports of goods and services
712   IMP     imports of goods and services
713   /
714
715
716  PARAMETERS
717
718   PWEAGRSIM(SIM)        agr'al export price (for curr) (experiment par.)
719   PWEREP(C,SIM)         export price for commodity c (value used)
720
721   EGREP(SIM)            government expenditures
722   EXRREP(SIM)           exchange rate (dom. cur. per unit of for. cur.)
723   FSAVREP(SIM)          foreign savings (foreign currency)
724   IADJREP(SIM)          investment adjustment factor
725   MPSREP(H,SIM)         marginal (and avg) propensity to save for household h
726   PAREP(A,SIM)          price of activity a
727   PDREP(C,SIM)          domestic price of domestic output c
728   PEREP(C,SIM)          export price for c (domestic currency)
729   PMREP(C,SIM)          import price for c (domestic currency)
730   PQREP(C,SIM)          composite commodity price for c
731   PVAREP(A,SIM)         value-added price for activity a
732   PXREP(C,SIM)          producer price for commodity c
733   QAREP(A,SIM)          level of activity a
734   QDREP(C,SIM)          quantity sold domestically of domestic output c
735   QEREP(C,SIM)          quantity of exports for commodity c
736   QFREP(F,A,SIM)        demand for factor f from activity a
737   QFSREP(F,SIM)         supply of factor f for sim
738   QHREP(C,H,SIM)        consumption of commodity c by household h
739   QINTREP(C,A,SIM)      qnty of commodity c as intermed. input for activity
a
740   QINVREP(C,SIM)        quantity of investment by commodity of origin c
741   QMREP(C,SIM)          quantity of imports for commodity c
742   QQREP(C,SIM)          quantity of goods supplied domestically ("composite
                                                                   supply")
743   QXREP(C,SIM)          quantity of domestic output of commodity c
744   WFREP(F,SIM)          average price of factor f
745   WFAREP(F,A,SIM)       price of factor f for activity a
746   WFDISTREP(F,A,SIM)    wage distortion factor for factor f in activity a
747   YFREP(H,F,SIM)        income of household h from factor f
748   YGREP(SIM)            government revenue
749   YHREP(H,SIM)          income of household h
750   WALRASREP(SIM)        dummy variable (zero at equilibrium)
751
752   GDPREP(*,SIM)         nominal GDP data
753   ;
```

```
754
755   PWEAGRSIM('BASE')      = pwe('AGR-C');
756   PWEAGRSIM('PWEINCR')   = 1.25*pwe('AGR-C');
757
758  DISPLAY PWEAGRSIM;
759
760
761  LOOP(SIM,
762
763   pwe('AGR-C') = PWEAGRSIM(SIM);
764
765
766   SOLVE CGE5 USING MCP;
767
768
769   PWEREP(CE,SIM)        = pwe(CE);
770
771   EGREP(SIM)            = EG.L;
772   EXRREP(SIM)           = EXR.L;
773   FSAVREP(SIM)          = FSAV.L;
774   IADJREP(SIM)          = IADJ.L;
775   MPSREP(H,SIM)         = MPS.L(H);
776   PAREP(A,SIM)          = PA.L(A);
777   PDREP(C,SIM)          = PD.L(C);
778   PEREP(CE,SIM)         = PE.L(CE);
779   PMREP(CM,SIM)         = PM.L(CM);
780   PQREP(C,SIM)          = PQ.L(C);
781   PVAREP(A,SIM)         = PVA.L(A);
782   PXREP(C,SIM)          = PX.L(C);
783   QAREP(A,SIM)          = QA.L(A);
784   QDREP(C,SIM)          = QD.L(C);
785   QEREP(CE,SIM)         = QE.L(CE);
786   QFREP(F,A,SIM)        = QF.L(F,A);
787   QFSREP(F,SIM)         = QFS.L(F);
788   QHREP(C,H,SIM)        = QH.L(C,H);
789   QINTREP(C,A,SIM)      = QINT.L(C,A);
790   QINVREP(C,SIM)        = QINV.L(C);
791   QMREP(CM,SIM)         = QM.L(CM);
792   QQREP(C,SIM)          = QQ.L(C);
793   QXREP(C,SIM)          = QX.L(C);
794   WFREP(F,SIM)          = WF.L(F);
795   WFAREP(F,A,SIM)       = WF.L(F)*WFDIST.L(F,A);
796   WFDISTREP(F,A,SIM)    = WFDIST.L(F,A);
797   YFREP(H,F,SIM)        = YF.L(H,F);
798   YGREP(SIM)            = YG.L;
799   YHREP(H,SIM)          = YH.L(H);
800
801   WALRASREP(SIM)        = WALRAS.L;
802
803  *GDP data
804   GDPREP('PRVCON',SIM) = SUM((C,H), PQ.L(C)*QH.L(C,H)) ;
```

```
805   GDPREP('GOVCON',SIM)  = SUM(C, PQ.L(C)*qg(C));
806   GDPREP('INVEST',SIM)  = SUM(C, PQ.L(C)*QINV.L(C));
807   GDPREP('EXP',SIM)     = SUM(C, EXR.L*pwe(C)*QE.L(C));
808   GDPREP('IMP',SIM)     = - SUM(C, EXR.L*pwm(C)*QM.L(C));
809   GDPREP('GDPFC',SIM)   = SUM((F,A), WF.L(F)*WFDIST.L(F,A)*QF.L(F,A));
810   GDPREP('NITAX',SIM)
811    = SUM(C, tq(C)*(PD.L(C)*QD.L(C) + (PM.L(C)*QM.L(C))$CM(C)))
812    + SUM(C$CM(C), tm(C)*EXR.L*pwm(C)*QM.L(C))
813    + SUM(C$CE(C), te(C)*EXR.L*pwe(C)*QE.L(C));
814
815    );
816
817  *Processing GDP data
818   GDPREP('GDPMP1',SIM) = SUM(ACGDP1, GDPREP(ACGDP1,SIM));
819   GDPREP('GDPMP2',SIM) = GDPREP('GDPFC',SIM) + GDPREP('NITAX',SIM);
820   GDPREP('GDPGAP',SIM) = GDPREP('GDPMP1',SIM)—GDPREP('GDPMP2',SIM);
821
822
823  OPTION QFREP:3:1:1, QHREP:3:1:1, QINTREP:3:1:1, WFAREP:3:1:1,
824         WFAREP:3:1:1, WFDISTREP:3:1:1, YFREP:3:1:1
825         ;
826
827  DISPLAY
828   PWEREP, EGREP, EXRREP, FSAVREP, IADJREP, MPSREP, PAREP, PDREP, PEREP,
829   PMREP, PQREP, PVAREP, PXREP, QAREP, QDREP, QEREP, QFREP, QFSREP, QHREP,
830   QINTREP, QINVREP, QMREP, QQREP, QXREP, WFREP, WFAREP, WFDISTREP, YFREP,
831   YGREP, YHREP, WALRASREP, GDPREP
832   ;
```