MULTILEVEL COMPUTER MODEL OF WORLD DEVELOPMENT SYSTEM

User Oriented Descriptions

A SERIES: PART VII. MULTILAYER DECISION MODEL ON THE OIL-SHORTAGE CRISIS FOR NORTH AMERICA

Günther Fischer

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MULTILAYER DECISION MODEL ON THE OIL-SHORTAGE CRISIS FOR NORTH AMERICA

In order to demonstrate the conversational use of multilayer decision models, a model on the decision analysis of the oil shortage crisis in North America has been implemented.

The basic physical components of such a model are the interactor and the computer. The computer contains a programme which has two levels: The decision level and the causal level.

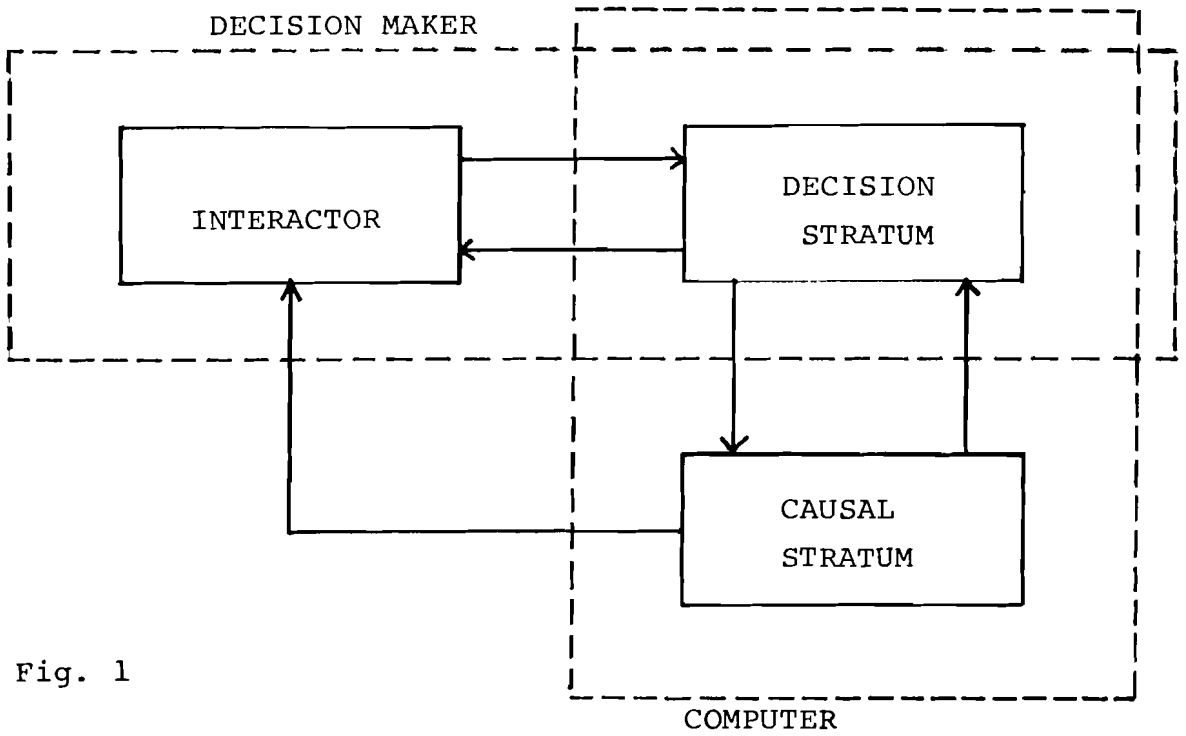

Fig. 1

The interactor together with the decision level programme represent the decision making part of the system. The causal stratum represents the model of the regional economic and the basic energy relationships, as well as a very simple model of population growth to indicate the level of population at any particular time.

The decision stratum contains four levels: The goal layer, the policy layer, the action layer and the implementation layer. Each of the layers is assigned a specific role.

The lower layers' functions are more technical and concerned with more immediate objectives. The final decision is the result of a coordinated response of all layers. Some information may be found in [5]

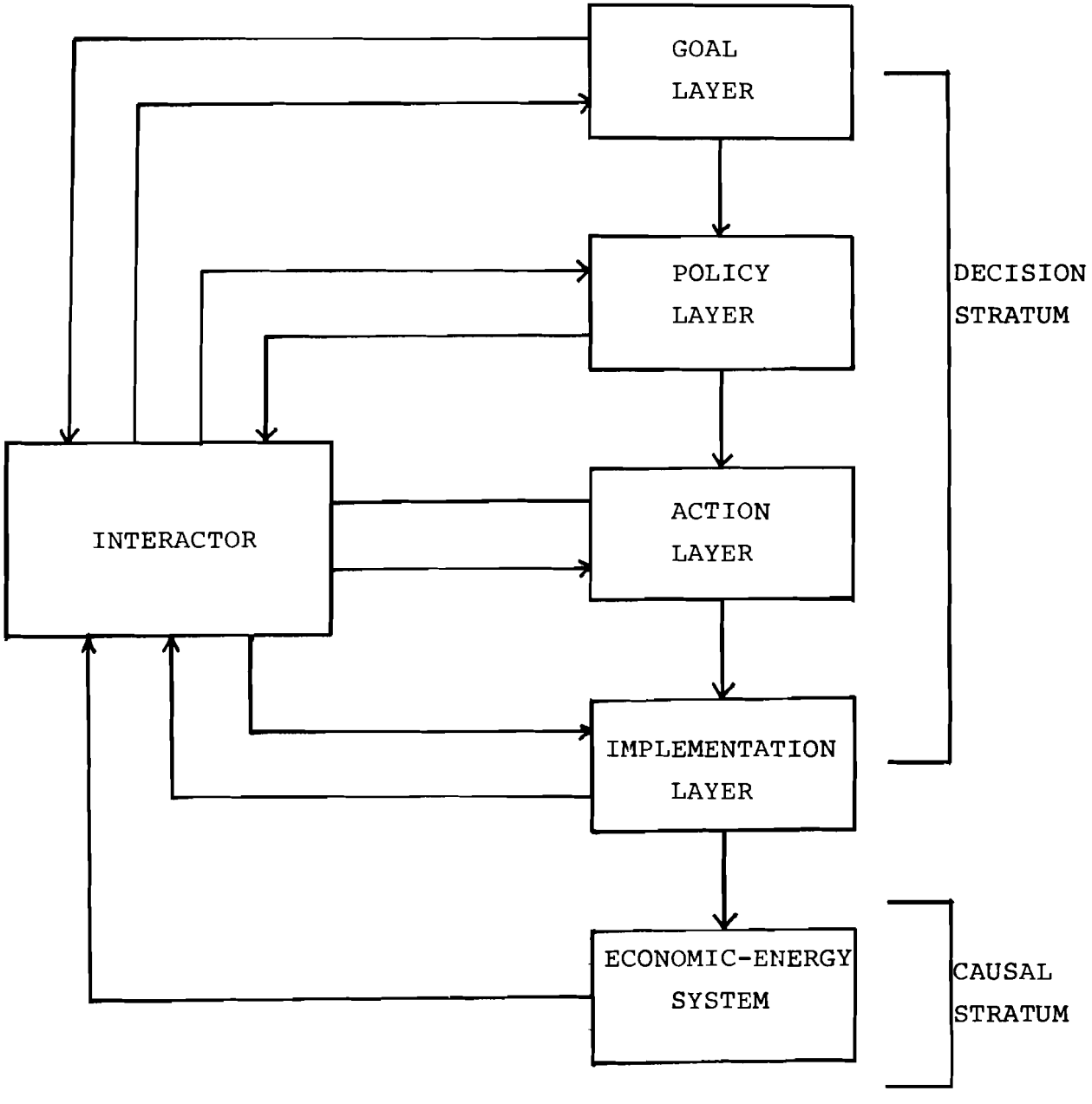

Fig. 2

1. THE COMMAND LANGUAGE

The interactor communicates with the computer by means of an elementary command language. The interactor has two basic classes of inputs: Requesting and Instructing. The computer responds by statements in English with desired data.

1.1. Requests

(1) Requests for information about the available alternatives

Entering one of the following options the model will reproduce the available alternatives of the corresponding layer:

G ␣ OPT	:	For goal layer alternatives
P ␣ OPT	:	For policy layer alternatives
I ␣ OPT	:	For action layer alternatives
I ␣ S ␣ OPT	:	For implementation layer alternatives.

Remark 1: Blanks occuring in the commands are written as ' ␣ '. They must be typed in exactly; otherwise, the model cannot identify a command properly.

Remark 2: Due to our implementation of the model you will not get any information about available alternatives of the policy, action or implementation layer unless you choose the independence goal.

(2) Requests for information about the evolution of the model

You enter

DA
which must be followed either by

NS
if information is needed about the normal situation
or by

NEWST
if information is needed about the actual situation
or by

PER
if information is needed about the perceived situation

PER+DEC
if information is needed about the perceived situation
(with decisions implemented)

Then you have to enter either

EN
in order to get energy indicators
or

ECON
for economic indicators

After that the output of the desired indicators
for the specified situation can be produced by
typing the RETURN-key < CR >

EXAMPLE

In order to get the energy and economic indicators for normal situation you must enter the following commands:

DA < CR >

NS < CR >

EN < CR >

< CR >
Now the model will print the energy indicators.

DA < CR >

NS < CR >

ECON < CR >

< CR >

At this the economic indicators will be printed.

1.2. Instructions

(1) Instructions Concerning the Choice of Alternatives

If the model asks for decisions on offered alternatives for various layers, you must answer with one of the following instructions:

(a) Decisions on the goal layer:

DEC:UTA : i.e. Users technology adaption

DEC:IND : i.e. Independence goal

DEC:IMP : i.e. Dependence on imports

DEC:COP : i.e. International cooperation.

(b) Decisions on the policy layer:

Although the model will offer you four policy options when entering P ␣ OPT you must answer only with:

DEC:LEI : i.e. Limit on economic impact

since the other alternatives are not implemented.

(c) Decisions on implementation measures:

When you enter I ␣ OPT in order to get information about the available alternatives of the action layer, the model will offer you four alternatives, but you have to answer by typing:

DEC:TIOS : i.e. Transfer of investment from other sectors

since the other alternatives are not implemented.

If you try to specify one of the other alternatives the model will answer with:

INVALID COMMAND - TRY AGAIN

(d) Decisions on Implementation Selections:

At your typing I ␣ S ␣ OPT the model will offer three facilities you may choose:

DEC:LIM : i.e. Limit on economic impact

DEC:SIT : i.e. Sources of investment transfer

DEC:NYA : i.e. Number of years of application.

(2) Instruction for Running the Model

After having specified your political and implementational goals you may run the model simply by entering:

GO.

At any time you enter GO the model will proceed a time step of three years (or the time step chosen by using DEC:NYA) with an upper limit of year 1990.

(3) Instruction for Restarting the Model at the Initial Year (=1975)

In order to try another policy you may enter:

TOP

with the effect of restarting the model at the initial year 1975.

(4) Instruction for Stopping the Model

In order to terminate a session you must enter:

BYE.

2. NUMERICAL INPUT

Due to your decision on the implementation selection the model will ask you:

FIX LIMIT ON ECONOMIC IMPACT
If you have decided on DEC:LIM your limit value is read with format (I1). In case you have decided on DEC:SIT the model will ask you for changes of investment transfer.

CHANGE % OF INVESTMENT SHIFT FROM AGRICULTURE FROM 0 TO:
Your answer is read with format (I2).

CHANGE % OF INVESTMENT SHIFT FROM INDUSTRY FROM 100 TO:
Your answer is read with format (I2).

CHANGE % OF INVESTMENT SHIFT FROM SERVICES FROM 0 TO:
Again your answer is read with format (I2).

REMARK

Due to the present state of the model only the specified value for "Investment shift from industry" of the above specified values has an effect on the computations of the model.

If you have decided on DEC:NYA the model will ask:
HOW MANY YEARS DO YOU WANT THE MODEL TO RUN?
Your decision is read with format (I1).

3. NUMERICAL OUTPUT

In order to get some information about the evolution of the model you may ask for energy or economic indicators as described before.

(1) Energy Indicators

Asking for inergy indicators you get a listing on a period of ten years. The output consists of six columns. The first of which indicates the year of observation, the other five columns have the titles EC,OC,OCM,FOCM,ECPC.

EC : Total energy consumption
(units are 10^6 metric tons coal equivalent)
OC : Total oil consumption
(units are 10^6 metric tons coal equivalent)
OCM : Oil imports
(units are 10^6 metric tons coal equivalent)
FOCM: Ratio of OCM to OC
ECPC: Energy consumption/capita
(units are metric tons coal equivalent/cap.)

(2) Economic Indicators

Asking for economic indicators you will get a table consisting of seven columns. The first column again shows the year of observation, the other columns are entitled by Y,YPC,DY,DIE,DYE and FDIE.

Y : Gross regional product (units are 10^9 US $)
YPC : Gross regional product/capita
(units are 10^3 US $)
DY : Growth rate of GRP; e.g. DY=0.036
indicates a growth rate of 3.6%
DIE : Reduction of gross investments due to oil
shortage (units are 10^9 US $)

DYE : Reduction of GRP due to oil shortage crisis (units are 10^9 US $)

FDIE : =AI/DIE; gross investments compared to investment reduction.

4. MATHEMATICS OF THE CAUSAL STRATUM

(1) Notation

In order to simplify the documentation of the mathematics of the model the following notation will be used:

POP_t : Total population of the region in year t

POPR : Population growth rate (=0.011)

YM_t : GRP of year t predicted according to the available capital of year t (without reduction)

Y_t : Predicted GRP of year t considering oil crisis

AK_t : Capital available in year t

D : Depreciation of capital estimated from historical data (=1/35)

Q : Ratio of GRP to available capital estimated from historical data (=1/2.8)

AI_t : Gross investment in year t (considering oil crisis)

AIM_t : Gross investments of year t according to YM_t

GI : Ratio of gross investment to GRP estimated from historical data (=0.18)

DYE_t : Reduction of GRP due to the oil shortage crisis

DIE_t : Reduction of gross investment due to the oil shortage crisis

ECN_t : Energy consumption need in year t

ECK : Ratio of energy consumption to GRP estimated from historical data (=2.8)

OCN_t : Oil consumption need

OCK_t : Time series variable to represent the ratio of oil consumption to total energy consumption.

Starting in 1975 the following values for OCK_t are used:
0.53,0.54,0.55,0.56,0.58,0.59,0.60,0.61,0.61,0.62,
0.62,0.63,0.63,0.63,0.62,0.62,0.61,0.61,0.59,0.58,
0.57,0.56

EC_t : Energy consumption (due to oil shortage)

$ECDK_t$: Factor denoting energy consumption deficit; depending on chosen goal

$OCDK_t$: Factor denoting oil consumption deficit

$OCMD_t$: Reduction factor for oil consumption

DEC_t : Energy deficit

YOM_t : Costs of oil imports

OCM_t : Oil imports

$OCMK_t$: Ratio of OCM_t to OCN_t

PR_t : Cost of oil import per unit

PRR : Price growth rate (=0.015)

$DYEK_t$: Ratio of GRP to users' energy consumption assuming a 50% efficiency of energy system (= ½ • GRP_{1970}/EC_{1970} from hist. data)

DIE_t : Change expected in gross investment due to oil shortage

DYE_t : Change expected in gross regional product due to oil shortage

IPERI : Percentage of investment shift from industry.

(2) Mathematics of the model

(a) Population Model:

There is a very simple demographic model to indicate roughly the level of population

$$POP_{t+1} = POP_t \cdot (1 + POPR)$$

(a) Energy and Economic Model:

The economic model assumes a linear relationship between the gross regional product and the available capital. Thus the model is based on the following formulae:

$$AK_t = AK_{t-1} \cdot (1-D) + AI_{t-1}$$

$$YM_t = Q \cdot AK_t$$

$$AIM_t = GI \cdot YM_t$$

$$Y_t = YM_t - DYE_t$$

$$AI_t = GI \cdot Y_t - DIE_t$$

In order to compute DYE_t and DIE_t the following relationships are used:

$$ECN_t = ECK \cdot YM_t$$

$$OCN_t = OCK_t \cdot ECN_t$$

$$OC_t = (1 - OCMD_t) \cdot OCN_t$$

$$EC_t = ECDK_t \cdot ECN_t$$

$$OCM_t = OCMK_t \cdot OCN_t$$

$$DEC_t = ECN_t - EC_t$$

$$PR_t = PR_{t-1} \cdot (1 + PRR)$$

$$YOM_t = PR_t \cdot OCM_t$$

$$DYE_t = \begin{cases} DYEK \cdot DEC_t & \text{GOAL UTA} \\ DYEK \cdot DEC_t & \text{IND} \\ YOM_t & \text{IMP} \\ 0 & \text{COP} \end{cases}$$

$$DIE_t = \begin{cases} AIM/EC \cdot DEC \cdot \frac{IPERI}{100} \cdot factor & \text{GOAL UTA} \\ AIM/EC \cdot DEC \cdot \frac{IPERI}{100} \cdot factor & \text{IND} \\ 0 & \text{IMP} \\ 0 & \text{COP} \end{cases}$$

5. DATA BASE

To run the model a file called OIL.D or OIL.DAT for UNIX and DOS respectively is needed which contains the command dictionary and a time-series describing the ratio of oil consumption to total energy consumption.

6. CONCLUSIONS

The model on the oil shortage crisis for North America described above is rather to be looked at as a demonstration model for the use of multilayer decision models, since there are quite a lot of rather rough assumptions as well as the fact that there is only a small part of the available alternatives implemented using only very limited implementation selections. Nevertheless, the model could be used to show the interaction between man and the computer in order to demonstrate the facilities of decision supports such a model could offer to the interactor.

```
APR 21 15:22  OIL.D PAGE 1


24
DEC:UTA 1 2
DEC:IND 1 3
DEC:IMP 1 4
DEC:COP 1 5
DEC:LEI 2 2
DEC:TIOS3 2
DEC:LIM 4 2
DEC:SIT 4 3
DEC:NYA 4 4
G OPT   1 1
P OPT   2 1
I OPT   3 1
I S OPT 4 1
DA      0 1
NS      0 2
NEWST   0 3
EN      0 4
ECON    0 5
        0 6
TOP     0 7
BYE     0 8
GO      0 9
PER     010
PER+DEC 011
 0.530
 0.540
 0.550
 0.560
 0.570
 0.580
 0.590
 0.600
 0.600
 0.610
 0.610
 0.620
 0.620
 0.620
 0.630
 0.630
 0.630
 0.630
 0.620
 0.620
 0.610
 0.600
 0.590
 0.580
 0.570
 0.560
```

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```
      REAL IDICT,I1,I2
      LOGICAL   IDA,INS,INW,IEN,IFCON,IPR,IPRD
      DIMENSION OCMD1(26),OCMD2(2 ),OCMD3(26)
      DIMENSION IDICT(2,70), NDL( 0), NDLN(70)
      DIMENSION OCKF(26), ECRT(26 , OCRT(26), OCMRT(26), FOCMRT(26),
     &  ECPCRT(26)
      DIMENSION ECPT(26),OCPT(26) OCMPT(26),FOCMPT(26),ECPCPT(26),
     &  YPT(26),DIEPT(26),YPCPT(26) DYPT(26),DYEPT(26),FDIEPT(26)
      DIMENSION YRT(26), YPCRT(26 , DYRT(26), DIERT(26), DYERT(26),
     &  FDIERT(26)
      DIMENSION YAT(26), YPCAT(26 , DYAT(26), DIEAT(26), DYEAT(26),
     &  FDIEAT(26)
      DIMENSION ECAT(26), OCAT(26 , OCMAT(26), FOCMAT(26), ECPCAT(26)
      COMMON Q, GI, D, ECK, OCKF, OCDKF, DYEK, PRR, AKTRK, DIEK
      COMMON GC, GG, GM,POPR
      COMMON AK, AIM, PR, AKTRAC, OC
      COMMON C, G, AM, X
      COMMON EC,OCM,Y,YL,DIE,DYE, I
      COMMON IPER,IPERA,IPERI,IPES
      CALL SETFIL(1,"OIL.D ")
      PRINT 610
  610 FORMAT(1H ,///,30X,'*MULTI- AYER DECISION MODEL*',
     &  /,40X,'-OIL SHORTAGE-',/,40 ,'-NORTH AMERICA-')
      PRINT 611
  611 FORMAT(1H ,//,' ')
C     READ IN DICTIONARY
      READ(1,100) NDICT
  100 FORMAT (I2)
      DO 1 I=1, NDICT
      READ (1,911) IDICT(1,I), ID CT(2,I),NDL(I), NDLN(I)
  911 FORMAT (2A4, I1, I2)
    1 CONTINUE
C     READ IN ECO DATA
      DO 2 I=1,26
      READ (1,923) OCKF(I)
    2 CONTINUE
  923 FORMAT (F10.0)
      Q=1./2.8
      D=1./35.
      GI=0.18
      ECK=2.8
      DYEK=0.5*(1043./3024.)
      DIEK=0.5*(171./3024.)
      PRR=0.015
      AKTRK=0.9
      GC=553./856.
      GG=160./856.
      GM=59./856.
      POPR=0.011
C     STATE VARIABLES
C  IOP
   87 CONTINUE
      INCR1=0
      INCR=3
      P1=0.
      P2=0.05/25.
```

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```
      P3=0.08/25.
      DO 411 I=1,26
      J=I-1
      OCMD1(I)=0.
      OCMD2(I)=0.05+J*P2
      OCMD3(I)=0.08+J*P3
  411 CONTINUE
      AKN=3042.344
      PRN=(12./(0.10*1612.))*(1.- RR)
      AKTRAN=0.
      POPN=239.156
      YLN=1049.80
      IAYR=1975
      IOAYR=IAYR
C
      IGOAL=2
      IPOL=2
      IMES=2
C     REFERENCE GENERATOR
      OCOKF=1.
      IPER=5
      IPERA=0
      IPERS=0
      IPERB=4
      IPERI=100
      CALL RUN(IAYR,OCMD1,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,0,
     &ECRT,OCRT,OCMRT,FOCMRT,ECPC T,YRT,YPCRT,DYRT,DYERT,DIERT,FDIERT)
      CALL RUN(IAYR,OCMD2,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,0,
     &ECPT,OCPT,OCMPT,FOCMPT,ECPC T,YPT,YPCPT,DYPT,DYEPT,DIEPT,FDIEPT)
   10 PRINT    500, IAYR
  500 FORMAT(15X,'THIS IS YEAR',  5)
      GO TO 999
 1010 LAYER=1
  101 PRINT    108
  108  FORMAT(/,10X,'-GOAL LAYER: )
      GO TO 999
  401 LAYER=1
      GO TO (1001, 1002, 1002, 10 2, 1002), LCMD
 1001 PRINT    106
  106 FORMAT(/,20X, 'ALTERNATIVE  OALS:')
      PRINT    107
  107 FORMAT(/,15X,'1.USERS TECHN LOGY ADAPTATION',3X,'UTA',/,
     &15X,'2.INDEPENDENCE',18X,'I D',/,15X,'3.DEPENDENCE ON IMPORTS',
     &9X,'IMP',/,15X,'4.INTERNATI NAL COOPERATION',5X,'COP')
      GO TO 101
 1002 IGOAL=LCMD-1
 2010 LAYER=2
  102 PRINT    208
  208 FORMAT(/,10X,'-POLICY LAYER ')
      GO TO 999
  402 LAYER=2
      GO TO (2001, 2002, 2002, 20 2, 2002), LCMD
 2001 GO TO (2010, 2012, 2013, 20 4), IGOAL
 2012 PRINT    206
  206 FORMAT(/, 20X, 'POLICY OPTI NS-IND GOAL:')
      PRINT    207
```

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  207  FORMAT(/,15X,'1.MINIMAL TRA SITION TIME',11X,'MTT',/,15X,
     &     '2.LIMIT ON ECONOMIC IMPACT ,10X,'LEI',/,15X,
     &     '3.CONSERVATION DURING TRAN ITION',4X,'CDT',/,15X,
     &     '4.IMPORT DURING TRANSITION ,10X,'IDT',/,15X,
     &     '5.MIXED POLICY',22X,'MP')
       GO TO 102
 2011  CONTINUE
 2013  CONTINUE
 2014  CONTINUE
       GO TO 102
 2002  IPOL=LCMD-1
 3010  LAYER=3
  103  PRINT    308
  308  FORMAT(/,10X,'-ACTION LAYER ')
       GO TO 999
  403  LAYER=3
       GO TO (3001, 3002, 3002, 30 2, 3002, 3002), LCMD
 3001  GO TO (3011, 3012, 3013, 30 4), IPOL
 3011  PRINT    306
  306  FORMAT(/,20X, 'IMPLEMENTATI N MEASURES-IND GOAL-LEI POL:')
       PRINT    307
  307  FORMAT(/,15X,'1.INCREASE OF TOTAL INVESTMENT',16X,'ITS',/,
     &     15X,'2.TRANSFER OF INVESTME T FROM OTHER SECTORS',3X,'TIOS',
     &     /,15X,'3.REDUCTION OF CONSU PTION',20X,'RC',/,15X,
     &     '4.MIXED STRATEGY',50X,'MS'
       GO TO 103
 3012  CONTINUE
 3013  CONTINUE
 3014  CONTINUE
       GO TO 103
 3002  IMES=LCMD-1
 4010  LAYER=4
  104  PRINT    408
  408  FORMAT(/,10X,'-IMPLEMENTATI N LAYER:')
       GO TO 999
  404  LAYER=4
       GO TO (4001, 4002, 4002, 40 2, 4002, 4002), LCMD
 4001  GO TO (4011, 4012, 4013, 40 4), IMES
 4011  PRINT    406
  406  FORMAT(/,20X,'IMPLEMENTATIO  SELECTIONS-IND GOAL-LEI POL-TIOS MES
     &     ')
       PRINT    407
  407   FORMAT(/,15X,'1.LIMIT ON E ONOMIC IMPACT',9X,'LIM',/,
     &     15X,'2.SOURCES OF INVESTMEN  TRANSFER',3X,'SIT',/,
     &     15X,'3.NUMBER OF YEARS OF A PLICATION',3X,'NYA')
       GOTO 104
 4012  CONTINUE
 4013  CONTINUE
 4014  CONTINUE
       GO TO 104
 4002  IMPS=LCMD-1
       GO TO (7002, 5001, 7002, 70 2), IGOAL
 5001  GO TO (6002, 6002, 6002, 60 2, 6002), IPOL
 6002  GO TO (7002, 7002, 7002, 70 2), IMES
 7002  GO TO (8001, 8002,72), IMPS
 8001  CONTINUE
```

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```
      PRINT    105
  105 FORMAT(1H ,/,5X,'FIX LIMIT  N ECONOMIC IMPACT:')
      READ    924, IPERB
  924 FORMAT(I1)
  922 FORMAT (I2)
      IPER=8
      GOTO 999
 8002 CONTINUE
      PRINT 620,IPERA
  620 FORMAT(1H ,/,5X,'CHANGE % O  INVESTMENT SHIFT FROM AGRICULTURE F',
     &'ROM',I3,1X,'TO:')
      READ    922, IPERA
      PRINT 621,IPERI
  621 FORMAT(1H ,/,5X,'CHANGE % O  INVESTMENT SHIFT FROM INDUSTRY FROM'
     &,1X,I3,1X,'TO:')
      READ    922, IPERI
      PRINT 622,IPERS
  622 FORMAT(1H ,/,5X,'CHANGE % O  INVESTMENT SHIFT FROM SERVICES FROM'
     &,I3,1X,'TO:')
      READ 922,IPERS
      GOTO 999
 5002 CONTINUE
      CALL RUN(IAYR,OCMD3,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,1,
     &ECAT,OCAT,OCMAT,FOCMAT,ECPC T,YAT,YPCAT,OYAT,OYEAT,DIEAT,FDIEAT)
      IOAYR=IAYR
      IAYR=IAYR+INCR
C  NEXT CYCLE
      IXX=IAYR-1975+1
      P1=P2
      P2=P3
      P3=P3+P3*0.05
      DO 503 I=1,26
      J=I-1-(INCP+INCR1)
      OCMD1(I)=OCMD3(IXX)+J*P1
      OCMD2(I)=OCMD3(IXX)+J*P2
      OCMD3(I)=OCMD3(IXX)+J*P3
  503 CONTINUE
      INCR1=INCR1+INCR
      CALL RUN(IAYR,OCMD1,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,0,
     &ECRT,OCRT,OCMRT,FOCMRT,ECPC T,YRT,YPCRT,OYRT,OYERT,DIERT,FDIERT)
      CALL RUN(IAYR,OCMD2,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,0,
     &ECPT,OCPT,OCMPT,FOCMPT,ECPC T,YPT,YPCPT,OYPT,OYEPT,DIEPT,FDIEPT)
      GOTO 10
C
C     READ IN AND DECODE A COMMAN  TO THE PROPER LAYER
C
  999 ILLEG=0
      IDA=.FALSE.
      INS=IDA
      INW=INS
      IEN=IDA
      IECON=IEN
      IPR=IECON
      IPRD=IPR
   11 CONTINUE
      PRINT 650
```

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```
  650  FORMAT(1H ,' ')
       READ 1333,I1,I2
 1333  FORMAT(2A4)
       DO 33 I=1, NDICT
       IF((I1.EQ.IDICT(1,I)).AND.( 2.EQ.IDICT(2,I))) GOTO 4
   33  CONTINUE
  410  ILLEG=ILLEG+1
       IF(ILLEG-3)5,5,5
    5  PRINT    1044
 1044  FORMAT(/, 10X, 'INVALID COM AND-TRY AGAIN')
       GOTO 11
    4  ICMDL=NDL(I)
       LCMD=NDLN(I)
C      COMMANDS
       ICM=ICMDL+1
       GO TO (8, 401, 402, 403, 40 , 410, 410, 410, 410),ICM
C      GENERAL COMMANDS
    8  GO TO (81, 82, 83, 84, 85,  6,87,77,5002,60,61), LCMD
   72  PRINT 623
  623  FORMAT(1H ,/,5X,'HOW MANY Y ARS DO YOU WANT THE MODEL TO RUN ?')
        READ 73,INCR
   73   FORMAT(I1)
        GOTO 999
   81   IDA=.TRUE.
       GO TO 11
   82  INS=.TRUE.
       GO TO 11
   83  INW=.TRUE.
       GO TO 11
   84  IEN=.TRUE.
       GO TO 11
   85  IECON=.TRUE.
       GO TO 11
   60  IPR=.TRUE.
       GOTO 11
   61  IPRD=.TRUE.
       GOTO 11
   86  IF(INS.AND.IEN) GOTO 92
       IF(INS.AND.IECON) GOTO 93
       IF(INW.AND.IEN) GOTO 97
       IF(INW.AND.IECON) GOTO 98
       IF(IPR.AND.IEN) GOTO 99
       IF(IPR.AND.IECON) GOTO 62
       IF(IPRD.AND.IEN) GOTO 63
       IF(IPRD.AND.IECON) GOTO 64
   92  PRINT    1033
 1033  FORMAT (20X, 'DEVELOPMENT A ALYSIS:')
       PRINT     1034
 1034  FORMAT(22X, '-NORMAL SITUAT ON')
       PRINT    1035
 1035  FORMAT(22X, '-ENERGY INDICA ORS')
       PRINT    1036
 1036  FORMAT(///, 15X, 'EC ', 10X  'OC ', 10X, 'OCM', 10X, 'FOCM ', 9
&      X, 'ECPC ')
       MIAYR=IAYR+10
       DO 44 IYR=IAYR, MIAYR
```

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```
      I=IYR-IAYR+1
      PRINT    1037, IYR, ECRT(I)  OCRT(I), OCMRT(I), FOCMRT(I),
     &    ECPCRT(I)
 1037 FORMAT(1H ,I5, 8F13.3)
 44   CONTINUE
      GOTO 999
 93   PRINT    1033
      PRINT    1034
      PRINT    1038
 1038 FORMAT(22X,'-ECONOMIC INDIC TORS')
      PRINT    1049
 1049 FORMAT(///, 15X, 'Y  ', 10X  'YPC', 10X, 'DY ', 10X, 'DIE', 10X
     &  , 'DYE', 10X, 'FDIE')
      MIAYR=IAYR+10
      DO 55 IYR=IAYR, MIAYR
      I=IYR-IAYR+1
 55   PRINT    1037, IYR, YRT(I), YPCRT(I), DYRT(I), DIERT(I), DYERT(
     &  I), FDIERT(I)
      GOTO 999
 97   PRINT    1033
      PRINT    1039
 1039 FORMAT(22X,'-ACTUAL SITUATI N')
      PRINT    1035
      PRINT    1036
      MIAYR=IOAYR+10
      DO 6 IYR=IOAYR,MIAYR
      I=IYR-IOAYR+1
 6    PRINT    1037, IYR, ECAT(I)  OCAT(I), OCMAT(I), FOCMAT(I), ECPC
     &  AT(I)
      GOTO 999
 98   PRINT     1033
      PRINT    1039
      PRINT    1038
      PRINT    1049
      MIAYR=IOAYR+10
      DO 7 IYR=IOAYR, MIAYR
      I=IYR-IOAYR+1
 7    PRINT    1037, IYR, YAT(I), YPCAT(I), DYAT(I), DIEAT(I), DYEAT(
     &  I), FDIEAT(I)
      GOTO 999
 99    PRINT 1033
      PRINT 1050
 1050  FORMAT(22X,'-PERCEIVED SIT ATION')
      PRINT 1035
      PRINT 1036
 603  MIAYR=IAYR+10
      DO 602 IYR=IAYR,MIAYR
      I=IYR-IAYR+1
 600  PRINT 1037,IYR,ECPT(I),OCPT I),OCMPT(I),FOCMPT(I),ECPCPT(I)
      GOTO 999
 62   PRINT 1033
      PRINT 1050
      PRINT 1038
      PRINT 1049
 602  MIAYR=IAYR+10
      DO 601 IYR=IAYR,MIAYR
```

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```
      I=IYR-IAYR+1
  601 PRINT 1037,IYR,YPT(I),YPCPT I),DYPT(I),DIEPT(I),DYEPT(I),
     & FDIEPT(I)
      GOTO 999
   63 PRINT 1033
      PRINT 1050
      PRINT 1060
 1060 FORMAT(22X,'-DECISION IMPLE ENTED')
      PRINT 1035
      PRINT 1036
      CALL RUN(IAYR,OCMD2,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,0,
     & ECPT,OCPT,OCMPT,FOCMPT,ECPC T,YPT,YPCPT,DYPT,DYEPT,DIEPT,FDIEPT)
      GOTO 603
   64  PRINT 1033
      PRINT 1050
      PRINT 1060
      PRINT 1038
      PRINT 1049
      CALL RUN(IAYR,OCMD2,AKTRAN, KN,PRN,POPN,YLN,INCR,IGOAL,0,
     & ECPT,OCPT,OCMPT,FOCMPT,ECPC T,YPT,YPCPT,DYPT,DYEPT,DIEPT,FDIEPT)
      GOTO 602
   77 CONTINUE
      STOP
      END
        SUBROUTINE RUN(IAYR,OCMDT AKTRAS,AKS,PRS,POPS,YLS,INCR,IGOAL,IFL
     & ,ECT,OCT,OCMT,FOCMT,ECPCT,Y ,YPCT,DYT,DYET,DIET,FDIET)
        DIMENSION OCMDT(26),OCKF( 6),ECT(26),OCT(26),OCMT(26),FOCMT(26),
     & ECPCT(26),YT(26),YPCT(26),D T(26),DYET(26),DIET(26),FDIET(26)
      COMMON N,GI,D,ECK,OCKF,OCDK ,DYEK,PRR,AKTRK,DIEK
      COMMON GC,GG,GM,POPR
      COMMON AK,AIM,PR,AKTRAC,OC
      COMMON L,G,AM,X
      COMMON EC,OCM,Y,YL,DIE,DYE, I
      COMMON IPER,IPERA,IPERI,IPE S
C
      POP=POPS
      YL=YLS
      AK=AKS
      PR=PRS
      AKTRAC=AKTRAS
C
       MIAYR=IAYR+10
       DO 99 IYR=IAYR,MIAYR
      I=IYR-IAYR+1
      CALL ECONR(IGOAL,OCMDT,IYR)
      ECT(I)=EC
      OCT(I)=OC
      OCMT(I)=OCM
      FOCMT(I)=OCM/OC
      ECPCT(I)=EC/POP
      YT(I)=Y
      YPCT(I)=Y/POP
      DYT(I)=(Y-YL)/YL
      DYET(I)=DYE
      DIET(I)=DIE
      IF(DIE-1.E-4) 5,5,6
```

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```
    5   FDIET(I)=0.
        GOTO 7
    6   FDIET(I)=AI/DIE
    7   CONTINUE
        YL=Y
        AK=AK*(1.-D)+AI
        POP=POP*(1.+POPR)
        BENCH=IAYR+INCR-1
        IF(IYR.NE.BENCH) GOTO 99
        IF(IFL.NE.1) GOTO 99
        AKS=AK
        AKTRAS=AKTRAC
        PRS=PR
        YLS=YL
        POPS=POP
   99   CONTINUE
        RETURN
        END
          SUBROUTINE ECONR(IG,OCMD, YR)
          DIMENSION OCMD(26),OCKF(2 )
        COMMON Q, GI, D, ECK, OCKF, OCDKF, DYEK, PRR, AKTRK, DIEK
        COMMON GC, GG, GM,POPR
        COMMON AK, AIM, PR, AKTRAC, DC
        COMMON C, G, AM, X
        COMMON EC,OCM,Y,YL,DIE,DYE, I
        COMMON IPER,IPERA,IPERI,IPE S
C
        YM=Q*AK
        AIM=GI*YM
        GOTO (1,2,3,3),IG
C  CONSERVATION GOAL
    1   ECN=ECK*YM
        OCK=OCKF(IYR-1974)
        OCN=OCK*ECN
        OCDK=OCDKF-OCMD(IYR-1974)
        OC=OCDK*OCN
        OCMK=(0.2/25.)*(IYR-1975)+0 10
        OCM=OCMK*OCN
        ECDK=OCDK
        EC=ECDK*ECN
        DEC=ECN-EC
        DYE=DYEK*DEC
        DIE=4.*(AIM/EC)*DEC*AIG(1., .3,IYR,1985)
        GOTO 100
C  INDEPENDENCE GOAL
    2   ECN=ECK*YM
        OCK=OCKF(IYR-1974)
        OCN=OCK*ECN
        OCDK=OCDKF-OCMD(IYR-1974)
        OC=OCDK*OCN
        OCMK=(0.2/25.)*(IYR-1975)+0 10
        OCM=OCMK*OCN
        ECDK=AIG(OCDK,1.,IYR,1975+I ER)
        EC=ECDK*ECN
        DEC=ECN-EC
        DYE=DYEK*DEC
```

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```
      DIE=4.*(AIM/EC)*DEC*AIG(1.,.3,IYR,1985)
      GOTO 100
C  NORMAL DEVELOPMENT GOAL
 3    ECN=ECK*YM
      OCK=OCKF(IYR-1974)
      OCN=OCK*ECN
      OC=OCN
      EC=ECN
      OCMK=(0.2/25.)*(IYR-1975)+0.10
      OCM=OCMK*OC
      PR=PR*(1.+PRR)
      YOM=PR*OCM
      GOTO (31,31,31,4),IG
 31   DYE=YOM
      DIE=0.
      GOTO 100
C  COOPERATION GOAL
 4    AKTR=AKTRK*YOM
      AKTRAC=AKTRAC+AKTR
      FKR=AKTRAC/AK
      DYE=0.
      DIE=0.
100   Y=YM-DYE
      DIE=DIE*(IPERI/100)
      AI=GI*Y-DIE
      C=GC*Y
      G=GG*Y
      AM=GM*Y
      X=Y-C-G-AI+AM
      RETURN
      END
      FUNCTION AIG(X1,X2,IYR,IYR1
      IF(IYR-IYR1) 1,2,2
 1    AIG=X1
 3    RETURN
 2    AIG=X2
      GOTO 3
      END
```

References

[1] Oehmen, K.H., and Paul, W. "Construction of Population Submodels." IIASA Symposium Proceedings SP-74-3, pp. B362-B480.

[2] Clapham, W.B., Shook, T., and Warshaw, M.W. "A Regionalized Food Model for the Global System." IIASA Symposium Proceedings SP-74-3, pp. B500-B554.

[3] Mesarovič, M.D., Richardson, J.M. Jr., Shook, T., and Warshaw, M.W. "The Structural Description and Sensitivity Analysis of the Food Submodel." IIASA Symposium Proceedings SP-74-3, pp. B556-B626.

[4] Gottwald, M., and Pestel, R. "Environmental Impact Assessment." IIASA Symposium Proceedings SP-74-5 pp. B1122-B1276.

[5] Rechenmann, F. "Conversational Use of Multi-Layer Decision Models." IIASA Symposium Proceedings SP-74-6, pp. C232-C246.

[6] Cardenas, M.A., and Huerta, J.M. "Submodel of Global Water Cycle on Regional Basis." IIASA Symposium Proceedings SP-74-5, pp. B1278-B1391.

[7] Heyes, R.P., Jerdonek, R.A., and Kuper, A.B. "Global Energy Submodel." IIASA Symposium Proceedings SP-74-5, pp. B1084-B1119.

[8] Bossel, H. "Energy Supply Submodel." IIASA Symposium Proceedings SP-74-4, pp. B834-B970.