$TITLE: M4-3a.GMS: modeling health insurance
* with moral hazard, adverse selection modeled as a NLP
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$ONTEXT
MODELING DEMAND FOR HEALTH INSURANCE
|---Sick
|--Do not buy Insurance--choose effort --|
|---Healthy
Income---|
+ Type |
|---Sick
|-- Buy Insurance --choose effort---|
|---Healthy

$OFFTEXT

PARAMETERS
| TYPE risk type: probability of good health at effort = 0
| RISKAV average riskiness at effort = 0
| M0 income in the first time period
| MH income in the second time period when healthy
| MS income in the second time period when sick (before insurance)
| ACUF actuarially fairness 1 = actuarily fair ACUF < 1 unfair
| BETA needed to make the consumption concave(diminishing returns)
| INS0, PNS0, ALPHA0, EFFORT0, PROFIT0 store results for single type
| INS1, PNS1, ALPHA1, EFFORT1, PROFIT1 store results for type 1 (safe)
| INS2, PNS2, ALPHA2, EFFORT2, PROFIT2 store results for type 2 (risky)
PROFIT  profit of the insurance firm selling to both types;

ACUF=1.0;
BETA = 0.5;
M0 = 10;
MH = 10;
MS = 4;
TYPE = 0.5;
RISKAV = 1-TYPE;

NONNEGATIVE VARIABLES
INS  insurance purchased
PNS  payoff from insurance when sick
ALPHA  probability of good health
EFFORT  effort spent to insure good health: diet exercise and such;

VARIABLES

U  expected utility;

EQUATIONS

UTILITY  the utility of having or not having insurance
INSURANCE  the amount of insurance purchased (INS) and the payoff (PNS)
MORALHAZ  relationship between effort and probability of being healthy;
* the coefficient 0.06 is chosen so that effort is marginally non-optimal
* in the benchmark with actuarially fair insurance

UTILITY.. U =E= (M0-INS)**BETA
          + ALPHA*MH**BETA + (1-ALPHA)*(MS+PNS)**BETA
          - (0.06)*(EFFORT + EFFORT**2);

INSURANCE.. INS*ACUF =E= PNS*RISKAV;

MORALHAZ.. ALPHA =E= TYPE + 0.15*EFFORT;

MODEL OPTIMIZE /UTILITY, INSURANCE, MORALHAZ/;

U.L = 1;
INS.L =2;
PNS.L = 1;
ALPHA.L = 0.5;
EFFORT.L = 0;

*solve first for single type
TYPE = 0.5;

SOLVE OPTIMIZE USING NLP MAXIMIZING U;
INS0 = INS.L;
PNS0 = PNS.L;
ALPHA0 = ALPHA.L;
EFFORT0 = EFFORT.L;

PROFIT0 = INS0 - (1 - ALPHA0)*PNS0;

DISPLAY INS0, PNS0, ALPHA0, EFFORT0, PROFIT0;

*now assume two types, solve first for the safe type
TYPE = 0.55;
RISKAV = ((1-0.55)+(1-0.45))/2;

SOLVE OPTIMIZE USING NLP MAXIMIZING U;

INS1 = INS.L;
PNS1 = PNS.L;
ALPHA1 = ALPHA.L;
EFFORT1 = EFFORT.L;

PROFIT1 = INS1 - (1 - ALPHA1)*PNS1;

DISPLAY INS1, PNS1, ALPHA1, EFFORT1, PROFIT1;

*solve for the risky type
TYPE = 0.45;
**SOLVE**  OPTIMIZE USING NLP MAXIMIZING \( U \);

\[
\text{INS2} = \text{INS.L}; \\
\text{PNS2} = \text{PNS.L}; \\
\text{ALPHA2} = \text{ALPHA.L}; \\
\text{EFFORT2} = \text{EFFORT.L}; \\
\]

\[
\text{PROFIT2} = \text{INS2} - (1 - \text{ALPHA2}) \times \text{PNS2}; \\
\]

**DISPLAY**  \( \text{INS0, PNS0, ALPHA0, EFFORT0, PROFIT0} \);

**DISPLAY**  \( \text{INS1, PNS1, ALPHA1, EFFORT1, PROFIT1} \);

**DISPLAY**  \( \text{INS2, PNS2, ALPHA2, EFFORT2, PROFIT2} \);

\[
\text{PROFIT} = \text{PROFIT1} + \text{PROFIT2}; \\
\]

**DISPLAY**  \( \text{PROFIT} \);

\*
exit
*

* generate some scenarios

**SETS**  \( I /I1*I8/ \);

**PARAMETERS**

\[
\text{RESULTS}(I, *) ;
\]
TYPE = 0.5;
RISKAV = 1-TYPE;

**SOLVE** OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I1", "INS") = INS.L;
RESULTS("I1", "ALPHA") = ALPHA.L;
RESULTS("I1", "EFFORT") = EFFORT.L;
RESULTS("I1", "ACUF") = ACUF;
RESULTS("I1", "IS") = MS;
RESULTS("I1", "BETA") = BETA;

*Actuarially unfair added
ACUF = 0.8;

**SOLVE** OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I2", "INS") = INS.L;
RESULTS("I2", "ALPHA") = ALPHA.L;
RESULTS("I2", "EFFORT") = EFFORT.L;
RESULTS("I2", "ACUF") = ACUF;
RESULTS("I2", "IS") = MS;
RESULTS("I2", "BETA") = BETA;

*Loss from getting sick is higher
ACUF = 1.0;
MS = 2;
SOLVE OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I3", "INS") = INS.L;
RESULTS("I3", "ALPHA") = ALPHA.L;
RESULTS("I3", "EFFORT") = EFFORT.L;
RESULTS("I3", "ACUF") = ACUF;
RESULTS("I3", "IS") = MS;
RESULTS("I3", "BETA") = BETA;

ACUF = 0.8;
MS = 2;

SOLVE OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I4", "INS") = INS.L;
RESULTS("I4", "ALPHA") = ALPHA.L;
RESULTS("I4", "EFFORT") = EFFORT.L;
RESULTS("I4", "ACUF") = ACUF;
RESULTS("I4", "IS") = MS;
RESULTS("I4", "BETA") = BETA;

*Risk aversion is higher, actuarially fair

MS = 4;
BETA = 0.4;
ACUF = 1.0;
INS.L = 2.5;
SOLVE  OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I5", "INS")  = INS.L;
RESULTS("I5", "ALPHA")  = ALPHA.L;
RESULTS("I5", "EFFORT") = EFFORT.L;
RESULTS("I5", "ACUF") = ACUF;
RESULTS("I5", "IS")  = MS;
RESULTS("I5", "BETA")  = BETA;

*Risk aversion higher, actuarily unfair

MS = 4;
BETA = 0.4;
ACUF = 0.8;

SOLVE  OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I6", "INS")  = INS.L;
RESULTS("I6", "ALPHA")  = ALPHA.L;
RESULTS("I6", "EFFORT") = EFFORT.L;
RESULTS("I6", "ACUF") = ACUF;
RESULTS("I6", "IS")  = MS;
RESULTS("I6", "BETA")  = BETA;

*Risk aversion is higher, actuarily fair, lower MS

MS = 2;
BETA = 0.4;
ACUF = 1.0;

SOLVE OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I7", "INS")  = INS.L;
RESULTS("I7", "ALPHA")  = ALPHA.L;
RESULTS("I7", "EFFORT") = EFFORT.L;
RESULTS("I7", "ACUF") = ACUF;
RESULTS("I7", "IS")  = MS;
RESULTS("I7", "BETA")  = BETA;

*Risk aversion higher, actuarily unfair, lower MS

MS = 2;
BETA = 0.4;
ACUF = 0.8;

SOLVE OPTIMIZE USING NLP MAXIMIZING U;
RESULTS("I8", "INS")  = INS.L;
RESULTS("I8", "ALPHA")  = ALPHA.L;
RESULTS("I8", "EFFORT") = EFFORT.L;
RESULTS("I8", "ACUF") = ACUF;
RESULTS("I8", "IS")  = MS;
RESULTS("I8", "BETA")  = BETA;

DISPLAY  RESULTS;