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$TITLE: M4-3a.GMS: modeling health insurance
*    with moral hazzard, adverse selection modeled as a NLP
* COPYRIGHT JAMES R. MARKUSEN AND DAVID WHITEHILL

$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     acutuarially 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)
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 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 puchased (INS) and the payoff (PNS)
 MORALHAZ  relationship between effort and probability of being healthy;
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* the coefficient 0.06 is chosen so that effort is marginally non-optima»
l
* in the benchmark with actuarily 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;
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```
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;

INS2 = INS.L;
PNS2 = PNS.L;
ALPHA2 = ALPHA.L;
EFFORT2 = EFFORT.L;

PROFIT2 = INS2 - (1 - ALPHA2)*PNS2;

DISPLAY INS0, PNS0, ALPHA0, EFFORT0, PROFIT0;
DISPLAY INS1, PNS1, ALPHA1, EFFORT1, PROFIT1;
DISPLAY INS2, PNS2, ALPHA2, EFFORT2, PROFIT2;

PROFIT = PROFIT1 + PROFIT2;
DISPLAY PROFIT;

*$exit

* generate some scenarios

SETS I /I1*I8/;

PARAMETERS
 RESULTS(I, *);
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```
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, actuarily 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;
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```
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;
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