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# Modeling Indian Pension Reform using Modgen

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# Institutional Context:



- Modgen is a generic microsimulation language developed and maintained at Statistics Canada
- MicroNPS is a simple model prototype implemented in Modgen; developed at IIASA for exploration of use of MS for study of poverty, health & social security in developing world.
- MicroNPS is currently being used in the context of a TA project of the Asian Development Bank (ADB) on the implementation of the New Pension System (NPS) in India.  
Note: ADB has not reviewed and in no way endorsed the presented work in progress
- MicroNPS is also intended to be used for training and capacity building, e.g. @ Institute for Economic Growth (IEG); Delhi

# Outline:



- What is Modgen?
- MicroNPS as an example of a pension model implemented in Modgen: Look and feel
- How was it done? Code examples

# What is Modgen? - Features

- Discrete or continuous time
- Interacting or non-interacting populations
- Modular development
- Multilingual models possible
- Powerful tabulation facilities
- Standard errors and coefficients of variation for tables
- Export of parameters and tables to Excel
- Unlimited number of dimensions for parameters and tables
- Visualization of individual life courses
- Common user interface for all models
- Scenario management
- Fully documented user interface
- Generation of detailed encyclopaedic model documentation
- Multi-threading and grid-computing possible



# What is Modgen? - Applications

Modgen is available at:

<http://www.statcan.gc.ca/microsimulation/modgen/modgen-eng.htm>

Documentation includes a commented list of models.

- **Pohem (1994)** - Population Health Model (POHEM)
- **LifePaths (1994)** – Large general purpose Canadian model, extensively used for pension
- **XEcon (~1995)** - XEcon is an experimental non-empirical model of interacting firms and consumers.
- **PopModM (2002)** - PopModM was created as a proof of concept for the World Health Organization .
- **IDMM (2002)** - Infectious Disease Microsimulation Model
- **Health Forecasting Model (~2002)** - UCLA School of Public Health.
- **CVMM (~2003)** - The Child Vaccination Model co-developed with London School of Hygiene and Tropical Medicine
- **The HIV microsimulation model (HIVMM)** was co-developed with the WHO and SACEMA
- **DemoSim (2004/2009)** - population projections..
- **RiskPaths (2006)** – **competing risk tarching model**
- **PeriMod (2008)** - McGill University; simulates foetus histories from conception to birth
- **PredatorPrey (2008)** - ecological model of a hypothetical population of plants, herbivores, and predators.
- **Persim (2008)** – personnel planning in public sector
- **CellMM (2008)** – Model demo to replicate differential equation
- **GBD\_CVD (2009)** - “Global Burden of Disease – Cardio Vascular Disease” Harvard School of Public Health.
- **HealthPaths (2009)** – Bootstrapping ms
- **CareMod** - (based on Pohem) costs and benefits of interventions that reduce cancer in Canada.
- **BugMM (2009)** – prototype model simulating an ecological experiment in Zimbabwe: tsetse flies.
- **MicroNPS** – Pension reform in India

# What is Modgen? - Models



- Models are currently established or in development to:
  - Analyze, develop and cost government programs, such as public pension sustainability or post-secondary education
  - Estimate the life time costs of diseases, such as heart disease or lung cancer, and evaluate the potential impacts of public health interventions on those diseases
  - Generate detailed population projections
  - Perform human resources planning for large enterprises
  - Examine the spread of infectious diseases among interacting populations
  - Study foetal growth
- Modgen has also been used as an instructional tool to teach microsimulation itself to social scientists in both Canada and Europe.

# What is Modgen? – Goals



- Facilitate development of dynamic microsimulation models by automating every aspect possible:
  - Interface
  - Event queuing
  - Interactions among actors
  - Tabulation
  - Exploring life histories
- Make it possible to create and maintain a microsimulation model without a professional programmer

Generic! Full flexibility of C++

- Integrated into Microsoft Visual Studio NET C++: “compiler pre-processor”
- Modgen program translated into C++ and then compiled as C++ application

New: Modgen Web: allows running models on web



# MicroNPS

Pension reform for a  
population of 1.2 billion  
A microsimulation  
analysis

Martin Spielauer

# Context: The New Pension System (NPS)

The NPS is a version of the public sector pension plan for “unorganized sector” = 89% of population

- Voluntary but with a minimum contribution of 500Rs / month
- Enhanced investment choices (investment strategy & 6 funds)
- Non-withdrawable
- EET tax regime: contribution & accrued earnings exempt, Taxable at withdrawal (ongoing discussion)
- Low fees compared to existing private plans

## Existing experiences in Asia

- ... overall discouraging
- Irregular and low payments: low accumulations at high management costs
- Public control leading to poor investment return (allocation to state-run development funds)
- Early withdrawals: erode savings if allowed, discourage pension plan enrolment if not allowed
- Disability and survival protection limited

## Indian context

- Dense financial infrastructure
- Same scheme as civil service expected to increase confidence
- Expertise in information technology

## Pilot district activities

- Household survey (n=800) in Mangalore (urban) and Hamirpur (rural) districts; Institutional survey; Focus group discussions
- Some findings: Average work income ~3400 Rs/month (70US\$)  
Average saving capacity reported (Mangalore) 140Rs/month

## MacroNPS model Cell-based model

- Cohort component population projection ~UN
- Fixed rates: mortality decline, rural-urban migration, Imp, interest, wage growth, pension saving
- Used for “sizing the market”; Scenarios on plan enrolment
- Micro-foundation? 5% saving of av. 3600Rs = 180Rs; 500 min.

# Assessing NPS: Microsimulation

- Initial idea: model calculations for stylized individual life-courses scenarios; expected pensions, IRR, etc: “Microsimulation for one individual”
- Extended to cohort ms model; then to population ms
- Add distributional analysis into otherwise highly stylized modeling
- Add simple behavioural models for saving (boundary conditions, e.g. survival)
- Ability to reproduce macro scenarios and test/change/refine assumptions & models

## Behaviours

- Fertility: distribution of “family types” by urban/rural & education
- Partnership & partner matching by age and education
- Mortality by sex and rural/urban; UN projections
- Rural-urban migration: 1%, urbanisation 30% -> 50%
- Education: by urban/rural and sex
- Labour market participation: age, sex, urban/rural; assumptions on duration in given state
- Wages & income mobility: Gini 0.36 log-normal; persons stay with parameterized probability in given decile
- Pension saving: saving rate accounting for subsistence minimum
- Sickness and disability: age specific rates; distribution of costs

## Pension

- Fees and operating costs
- IRR, distribution of benefits, Poverty

MicroNPS - C:\IIASA\MicroNPS\_V11\Szenarios\Base.sce

Scenario Edit View Window Help

Parameter Groups

- General Demography
  - Population by year of birth (alive at age 18 resp. 2010)
  - Rural-Urban migration rate
  - Mortality rate
  - Mortality decrease by year
- Family Demography
  - Family type definitions
  - Family type distribution
  - Age when moving out of parents' household
  - Average age difference between spouses (for partner matching by education)
- Health and Disability
  - Health risks
- Income
  - Median income at productivity 1 in 2010
  - Income growth
  - Income mobility between deciles
  - Existence minimum per aequivalence person
  - Aequivalence scale and alimony
- Labor
  - Labor market participation and mobility
  - Age profile of labor productivity
- Saving and Pension
  - Pension saving rate (proportion of income put into pension saving if above minimum contribution)
  - Maximale pension saving rate (max. proportion of income put into pension saving to meet minimum)
  - Interest on pension savings
  - Minimum contribution to pension scheme
  - Pension conversion factor
  - Proportion of population entering plan when becoming eligible
- NPS fees
  - Monthly account maintenance fee
  - Average transaction fee
  - Account opening fee
  - Management fee
- Education
  - Education distribution
- Table Groups
  - Total population and life expectancy
  - Fertility
  - Sickness and disability
  - Income and Poverty
    - Time spent in poverty age 18+ by age group

Model Run Progress

Reading Parameters:

Parameter: Population by year of birth

Municipality type: Rows: Columns:  
Rural Year of Birth Sex

	Female	Male
1955	18427	18427
1956	18427	18427
1957	18427	18427
1958	18427	18427
1959	18427	18427
1960	18427	18427
1961	21192	21192
1962	21192	21192
1963	21192	21192
1964	21192	21192
1965	21192	21192
1966	23962	23962
1967	23962	23962
1968	23962	23962
1969	23962	23962
1970	23962	23962
1971	27092	27092
1972	27092	27092
1973	27092	27092
1974	27092	27092
1975	27092	27092
1976	27092	27092
1977	27092	27092
1978	27092	27092
1979	27092	27092
1980	27092	27092
1981	27092	27092

Parameter: Rural-Urban migration rate

Columns: Age range

	28	29	30	31	32	33	34	35
	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Parameter: Mortality rate

Municipality type: Rows: Columns:  
Rural Age range Sex

	Female	Male
0	0.06057	0.05926
1	0.00629	0.00395
2	0.00629	0.00395
3	0.00629	0.00395
4	0.00629	0.00395
5	0.00155	0.00134
6	0.00155	0.00134
7	0.00155	0.00134
8	0.00155	0.00134
9	0.00155	0.00134
10	0.00106	0.00098
11	0.00106	0.00098
12	0.00106	0.00098
13	0.00106	0.00098
14	0.00106	0.00098
15	0.00175	0.00156
16	0.00175	0.00156
17	0.00175	0.00156
18	0.00175	0.00156
19	0.00175	0.00156
20	0.00247	0.00226

Parameter: Mort...

0.01

File View Group View

Ready NUM 16%

MicroNPS Encyclopedic Documentation

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**MicroNPS 2.1.0.0 - Encyclopedic Documentation**

**Module: Income**

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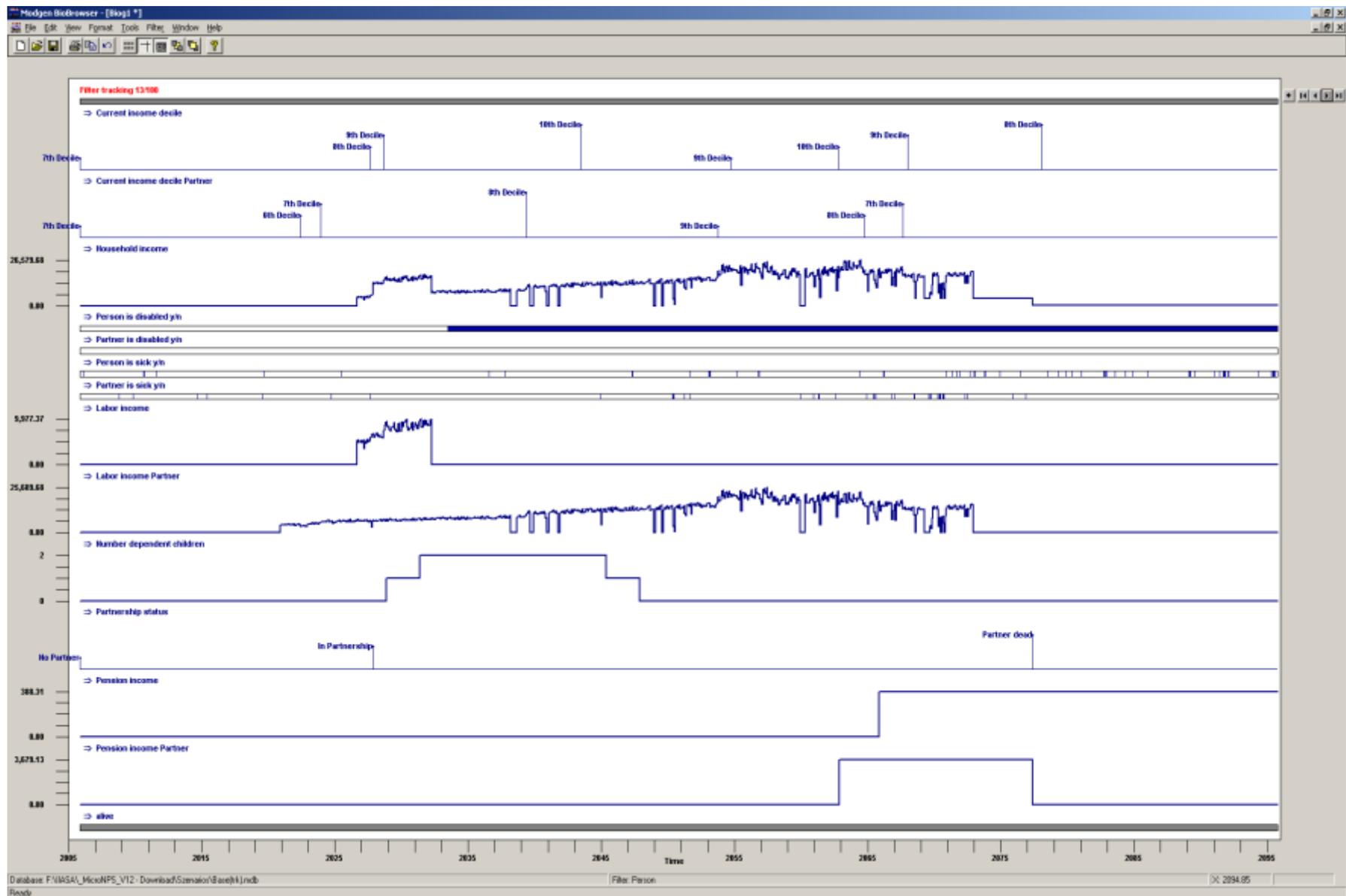
<a href="#">IncomeGrowth</a>	Income growth
<a href="#">IncomeMobility</a>	Income mobility between deciles
<a href="#">LaborMarketParticipation</a>	Labor market participation and mobility
<a href="#">MedianIncome</a>	Median income at productivity 1 in 2010
<a href="#">Productivity</a>	Age profile of labor productivity

**Parameter Groups:**

Name	Label
<a href="#">P04_Income</a>	Income
<a href="#">P05_Labor</a>	Labor

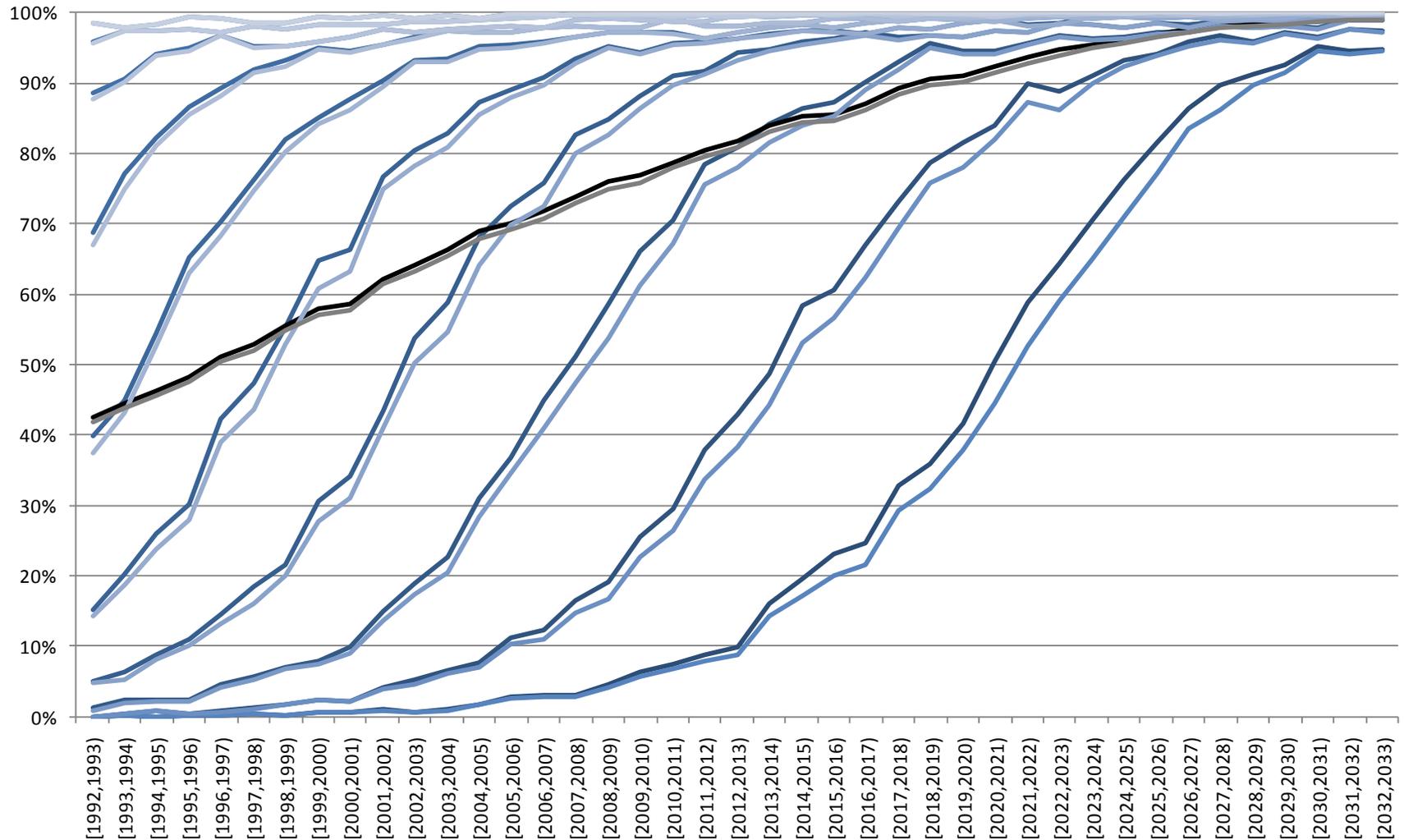
**Parameters referenced in the module:**

Name	Label
<a href="#">aequi_scale</a>	Aequivalence scale and alimony
<a href="#">ExistenceMinimum</a>	Existence minimum per equivalence person
<a href="#">ExistenceMinimum</a>	Existence minimum per equivalence person
<a href="#">IncomeGrowth</a>	Income growth



# Illustration: Pension > Subsistence minimum

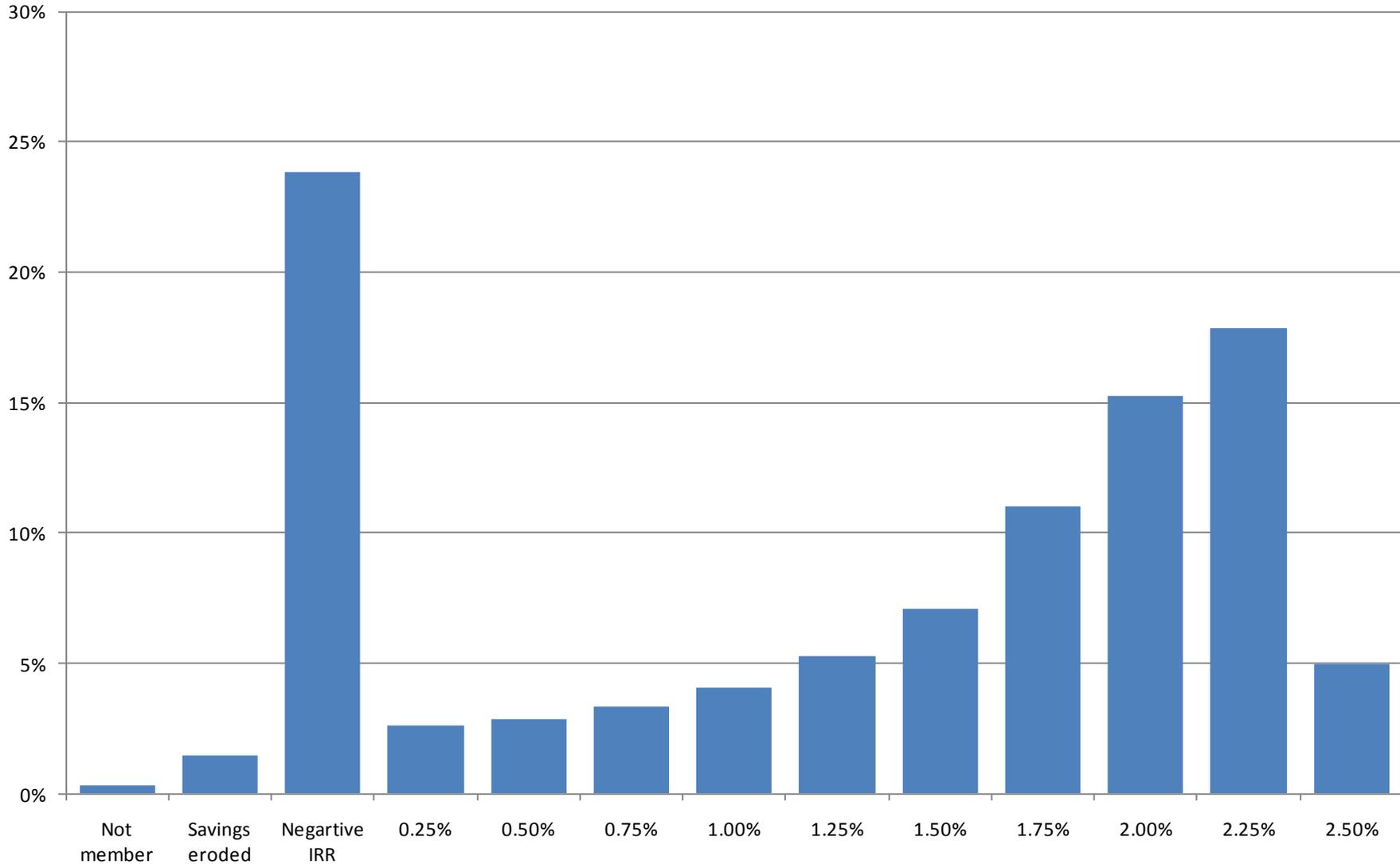
**Population age 65 with Household Pension Income above Poverty Line by Initial Income Decile and Year of Birth: Base vs. Health Expenditure Scenario**



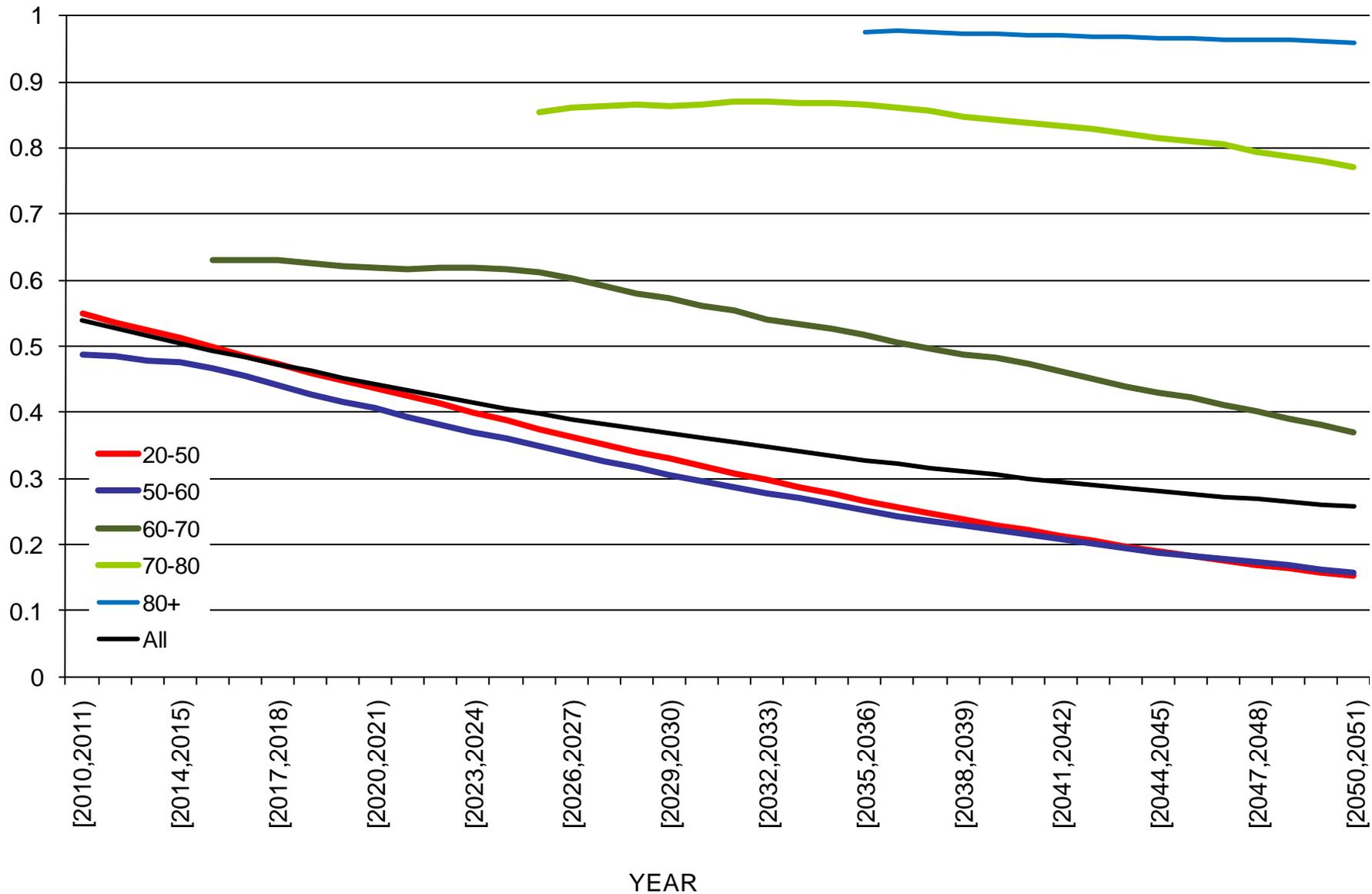


# Illustration: Expected IRR

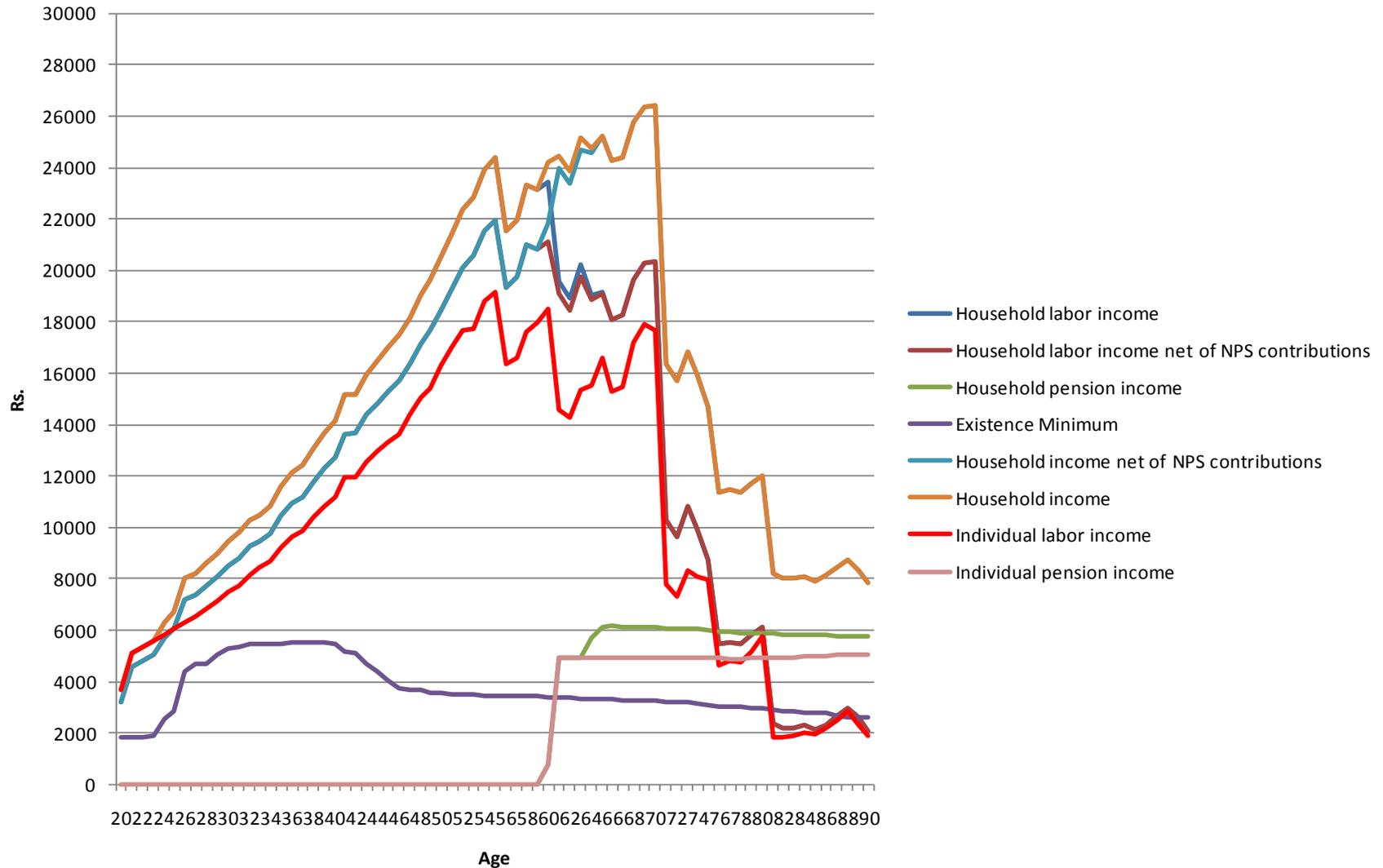
## IRR - 1992 BIRTH COHORT - ALL (2.5% WAGE GROWTH, 2.5% INTEREST)



# MicroNPS: Time in poverty by age group and year



## Life-Course Income and Pension by Type for the 2002 Birth Cohort; Male, 6th Earning Decile



ing) - Microsoft Visual Studio

Project Build Debug Tools Test Window Help



Tables.mpp\* Health.mpp

```

table Person Tab12_IncomeTypes //EN Average income by type at birthdays
[ integer_age >= 18 && integer_time >= 2010 ]
{
    sex+ * //EN Sex
    StartDecile+ * //EN Start decile
    split(time_of_birth, COHORTSIMYEAR)+ * //EN Year of birth

    {
        value_in(HHLaborIncome) / unit, //EN Household labor income
        value_in(HHNetLaborIncome) / unit, //EN Household labor income net pension contribut
        value_in(HHPensionIncome) / unit, //EN Household pension income
        value_in(SurviveIncome) / unit, //EN Survival minimum
        value_in(HHNetIncome) / unit, //EN Household net income
        value_in(HHIncome) / unit, //EN Household income
        value_in(AequiIncome) / unit, //EN Aequivalence income
        value_in(LaborIncome) / unit, //EN Individual labor income
        value_in(PensionIncome) / unit //EN Individual pension income
    }
    * split(integer_age, AGE1) //EN Age
};

```

Value	Type	Call Stack	Name
		Call Stack	
		Breakpoints	
		Output	

# A typical module: (1) Gen. Definitions

```
range LIFE //EN Age range
{
    0, 100
};
```

```
range YOBB //EN Year of Birth
{
    1955, 2032
};
```

```
classification SEX //EN Sex
{
    FEMALE, //EN Female
    MALE //EN Male
};
```

# A typical module: (2) Parameters

```
parameters
```

```
{  
    double MortalityRate[MUNICIP][LIFE][SEX]; //EN Mortality rate  
    double MortalityDecrease; //EN Mortality decrease  
};
```

The screenshot shows the MicroNPS software interface. The main window is titled "MicroNPS - C:\\_IIASA\_MicroNPS\_V15\Szenarios\Base.sce". The interface includes a menu bar (Scenario, Edit, View, Window, Help), a toolbar with various icons, and a left-hand pane for "Parameter Groups".

The "Parameter Groups" pane is expanded to show "Mortality rate" under the "General Demography" group. The "Mortality rate" parameter is selected, and its configuration is shown in the main window. The "Municipality type" is set to "Urban". The "Age range" and "Sex" are also visible.

The "Mortality rate" parameter is displayed as a table with the following data:

	Female	Male
0	0.06057	0.05926
1	0.00629	0.00395
2	0.00629	0.00395
3	0.00629	0.00395
4	0.00629	0.00395
5	0.00155	0.00134
6	0.00155	0.00134
7	0.00155	0.00134
8	0.00155	0.00134
9	0.00155	0.00134
10	0.00106	0.00098
11	0.00106	0.00098

The "Mortality decrease by year" parameter is also visible in the main window, with a value of 0.01.

# A typical module: (3) Actor definitions

```
actor Person
{
  // Simple States

      logical alive = {TRUE};

// Events

      event timeMortalityEvent, MortalityEvent;

// Functions

      double LifeExpectancy(int nYob, int nSex, int nMunicip, int nMinExp);

// Derived states (automatically updated)

      //EN HH is poor (below survival income)
      logical isPoorHH = (SurviveIncome > HHIncome);

      //EN Current integer age
      integer integer_age = self_scheduling_int(age);
};
```

# A typical module: (4) Events

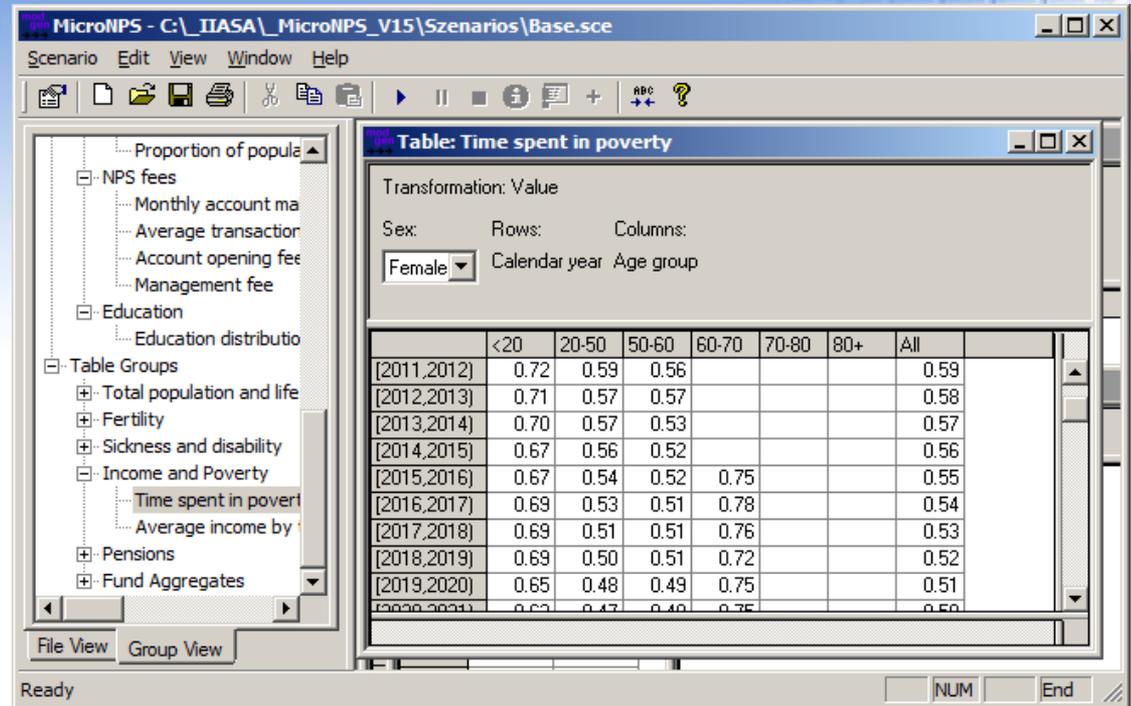


Education.mpp PersonCore.mpp Income.mpp **Mortality.mpp** Tables.mpp Health.mpp

```
TIME Person::timeMortalityEvent ()
{
    TIME tEventTime = TIME_INFINITE;
    if ( integer_age < MAX(LIFE) && integer_age >= 18 && integer_time >= 2010)
    {
        double MortalityHazard = MortalityRate[municip][integer_age][sex] * pow((1-MortalityDec:
        tEventTime = WAIT( - TIME( log( RandUniform(1) ) / MortalityHazard) );
    }
    else if (integer_age >= MAX(LIFE))
    {
        tEventTime = WAIT(0);
    }
    return tEventTime;
}

void Person::MortalityEvent()
{
    alive = FALSE;
    TotalPensionSavings = 0;
    Finish();
}
```

# A typical module: (5) Tables



The screenshot shows the MicroNPS software interface. The main window displays a table titled "Table: Time spent in poverty". The table has a dropdown menu for "Sex" set to "Female". The columns represent age groups: <20, 20-50, 50-60, 60-70, 70-80, 80+, and All. The rows represent time periods from [2011,2012] to [2019,2020]. The status bar at the bottom shows "Ready" and "NUM End".

	<20	20-50	50-60	60-70	70-80	80+	All
[2011,2012]	0.72	0.59	0.56				0.59
[2012,2013]	0.71	0.57	0.57				0.58
[2013,2014]	0.70	0.57	0.53				0.57
[2014,2015]	0.67	0.56	0.52				0.56
[2015,2016]	0.67	0.54	0.52	0.75			0.55
[2016,2017]	0.69	0.53	0.51	0.78			0.54
[2017,2018]	0.69	0.51	0.51	0.76			0.53
[2018,2019]	0.69	0.50	0.51	0.72			0.52
[2019,2020]	0.65	0.48	0.49	0.75			0.51

```
table Person Tab11_PoorPerson //EN Time spent in poverty
[ integer_age >= 18 && integer_time >= 2010 ]
{
  sex+ * //EN Sex
  {
    duration(isPoorHH, TRUE) / duration() //EN Poverty rate decimals=2
  }
  * split(integer_time, CALSIMYEAR) //EN Calendar year
  * age_class+ //EN Age group
};
```

# Summary & Conclusions



Information on Modgen is available at:

<http://www.statcan.gc.ca/microsimulation/modgen/modgen-eng.htm>

- Developer's guide
- Commented list of models using Modgen
- Documented example models
- Software download: Modgen & examples

Teaching material also at: [www.spielauer.ca](http://www.spielauer.ca)

For programming MS VS08 is required, a free 90 day trial can be downloaded at [www.microsoft.com](http://www.microsoft.com) (the academic license is 100\$)

STC provides technical assistance, supports prototype development, open for project partnerships, technical centre & subscriptions

Modgen web goes public soon