Microsimulation microWB Demo model

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Model overview

microWB is a “simple on purpose” demo model showing some key characteristics and uses of microsimulation

- Not a particular society but using “realistic” parameters
- Population: Female population from Malawi Demographic and Health Survey DHS (male children added for child mortality only)
- Linked lives: mothers’ education has impact on education and mortality of children, the birth order influences migration.
- Minority: an “artificially” created minority with “more traditional” demographic behaviors – “typical” relative risks added to most models

Processes

- Fertility estimated from DHS
- First union formation estimated from DHS
- Migration: initial composition from data, migration decisions based on age, education and birth order are made up for demonstrational purposes
- Education: three levels, depending on mother's education and other characteristics, parameters as found in literature
- Mortality: based on education resp. Mother's education and sex

Model estimates

- Typical Example: First union formation
- Proportional hazard regression model
  - Baseline hazard by age group
  - Relative risks by motherhood, education and minority status

Parameter: Age baseline for first union formation

Columns:

AGE_GROUP

(min,10)	[10,12.5)	[12.5,15)	[15,17.5)	[17.5,20)	[20,22.5)	[22.5,25)	[25,27.5)	[27.5,30)	[30,32.5)	[32.5,35)	[35,37.5)	[37.5,40)	[40,42.5)	[42.5,45)	[45,47.5)	[47.5,50)	[50,max)
0.000	0.008	0.050	0.201	0.413	0.441	0.410	0.404	0.311	0.265	0.183	0.115	0.112	0.479	0.119	0.189	0.000	0.000

Parameter: Relative risks for first union formation

Columns:

Relative risks of first union formation

First period after first birth	Second period after first birth	After second period after first birth	Primary Education	Secondary Education	Minority studied	Urban
1.212	0.927	0.673	0.995	0.393	1.579	0.917

Scenarios

- Base Scenario - Status Quo: demographic pattern as observed today for younger generation, education transmission calibrated resulting in constant attainments over next generations
- Education intervention Scenario 1 - overall increase in odds to graduate from primary and secondary school; relative differences between population groups kept constant
- Education intervention Scenario 2 – closing gaps: the gap between minority and rest as well as between urban and rural population is closed completely, the gap by parental education is reduced by half

- The aggregated effect of both Education Scenarios on the future education composition is the same

Output

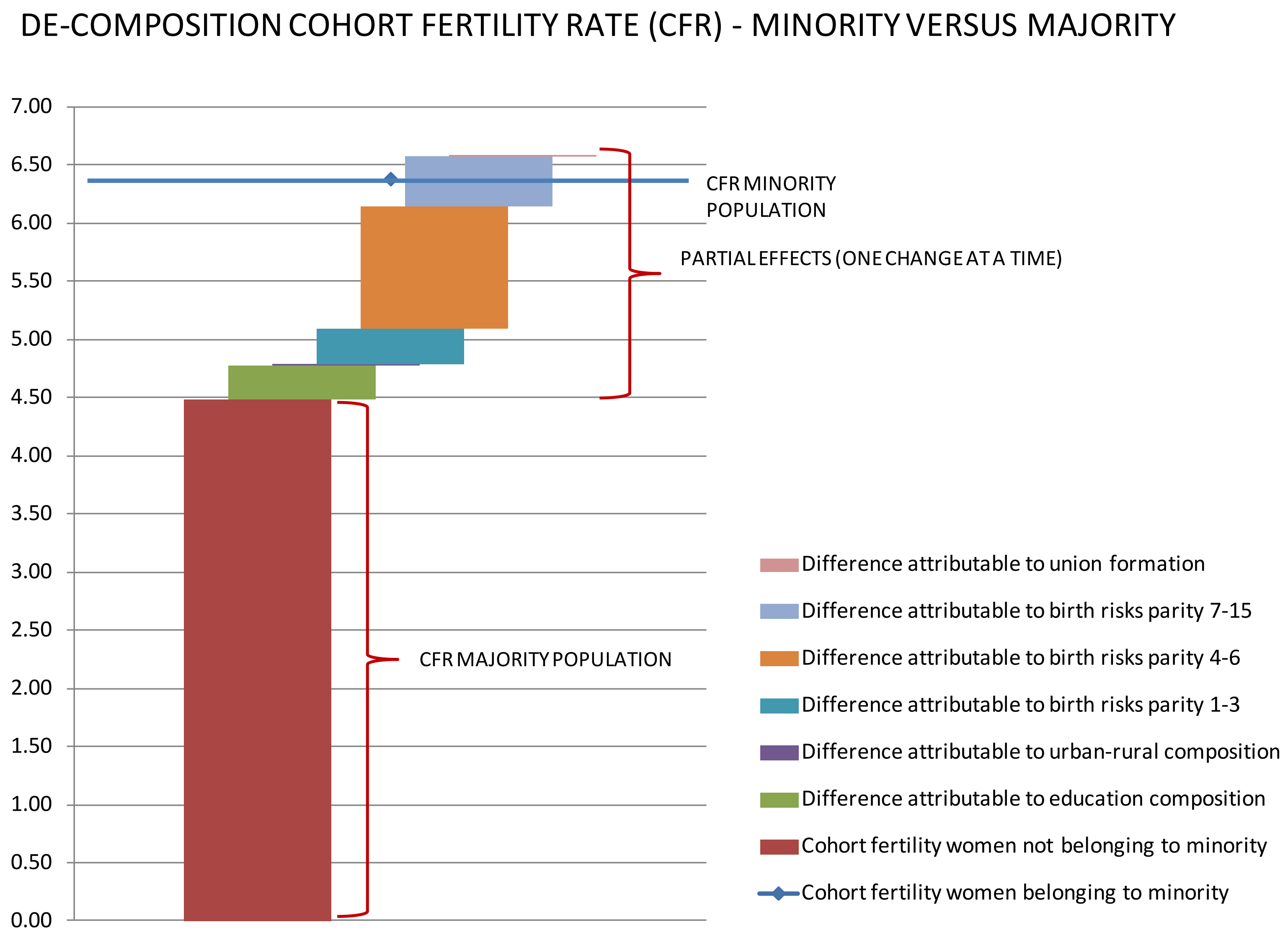
- Decomposition: which processes contribute to which extent to the different cohort fertility between the minority and majority population
- What-if analysis: demographic down-stream effects of educational investments: cohort fertility and experience of child deaths for three generations of women
- Population projection: urban and rural population size in 2100 by minority status for the three scenarios

Output: Decomposition

- Simulated difference in cohort fertility of next generation between minority and majority is ~2 births (6.4 versus 4.5)

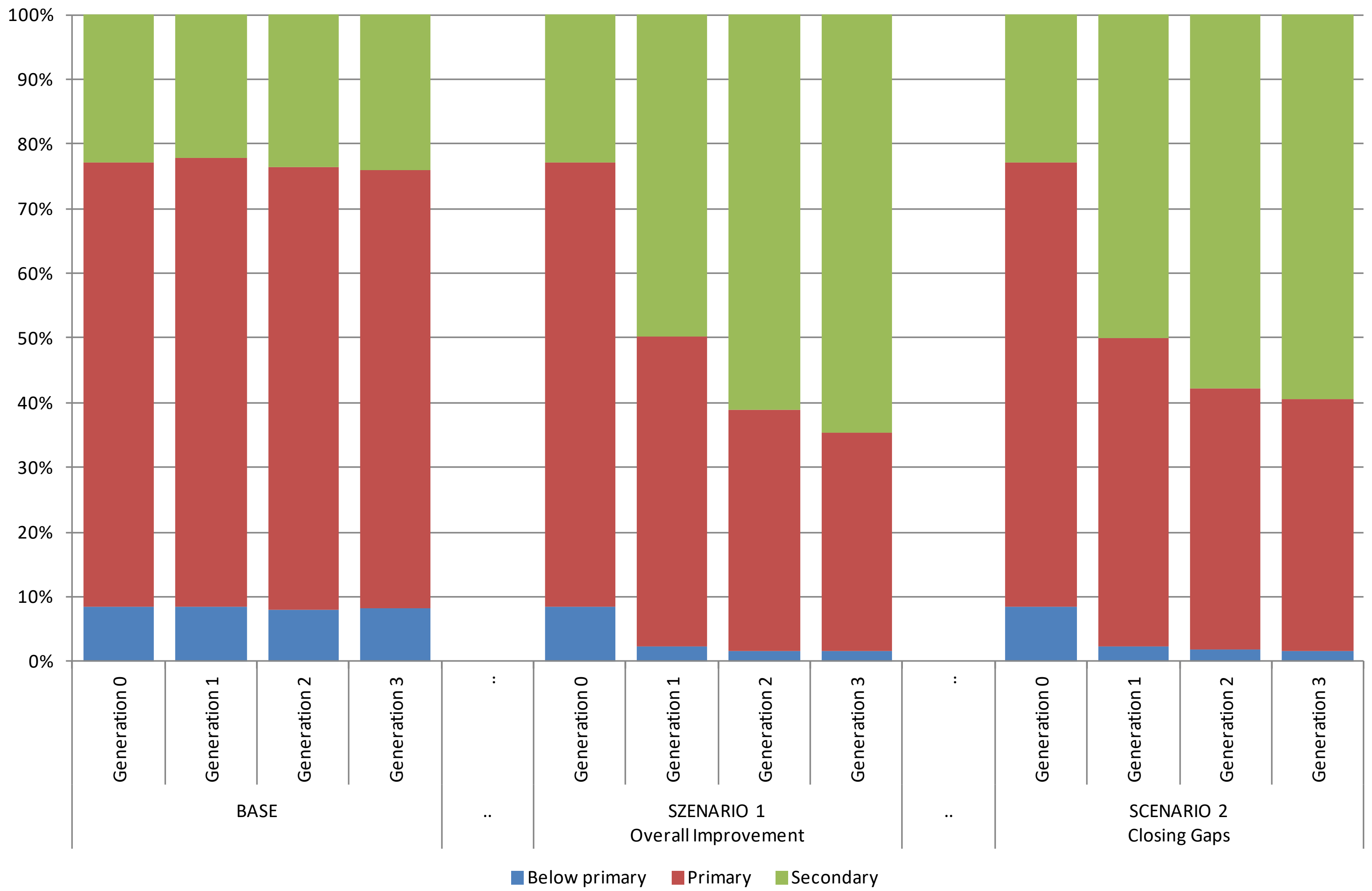
- Analysis example: 60% higher union formation hazards in minority population.
- Simulation:
  - The higher union formation hazard in average leads to a one year earlier union formation but has no effect on differences in cohort fertility
  - Half of the fertility difference can be attributed to differences in 4^{th} to 6^{th} births

Output: Decomposition



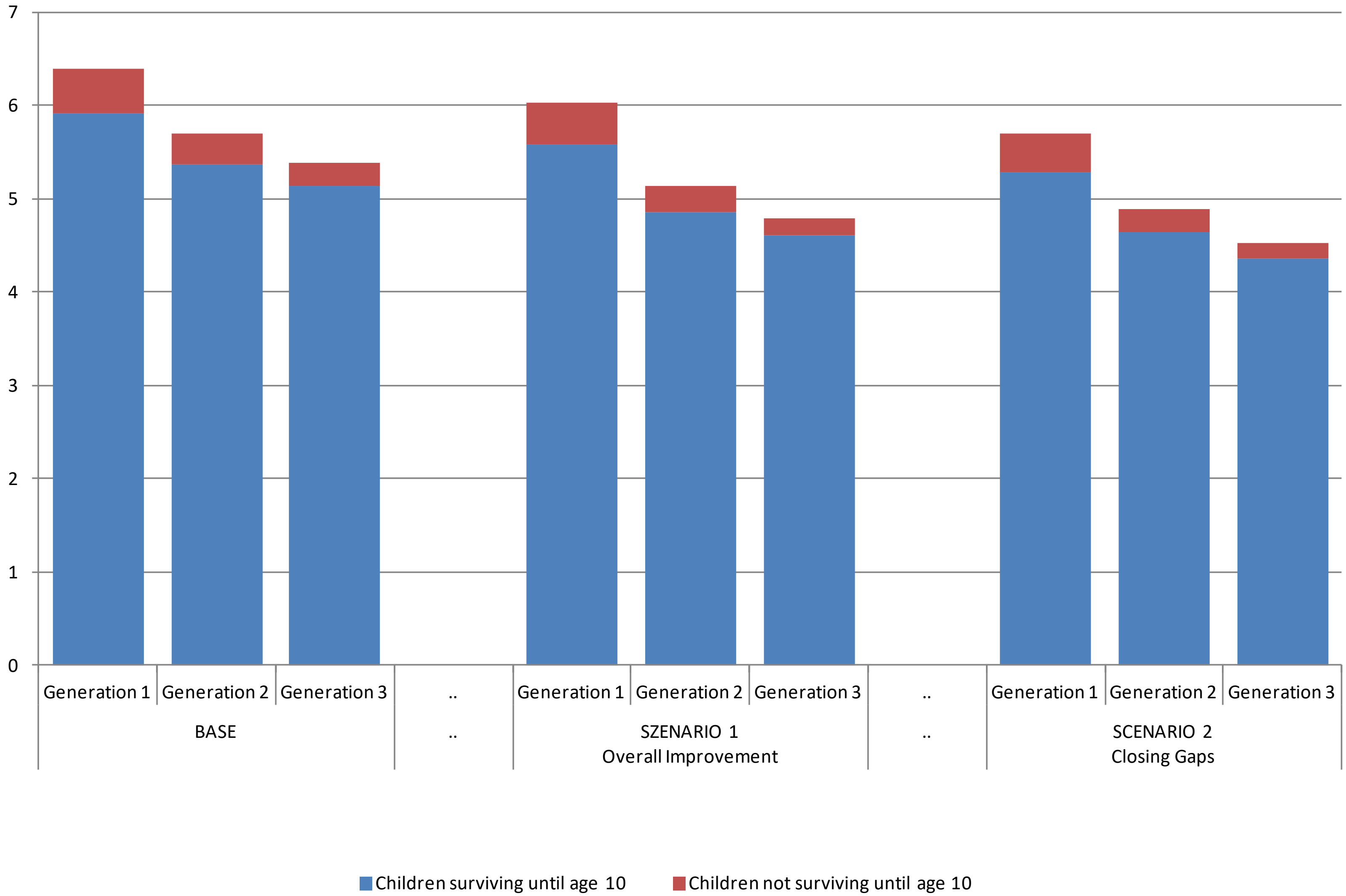
What-if analysis - Education

EDUCATION COMPOSITION BY GENERATION AND POLICY SCENARIO - ALL



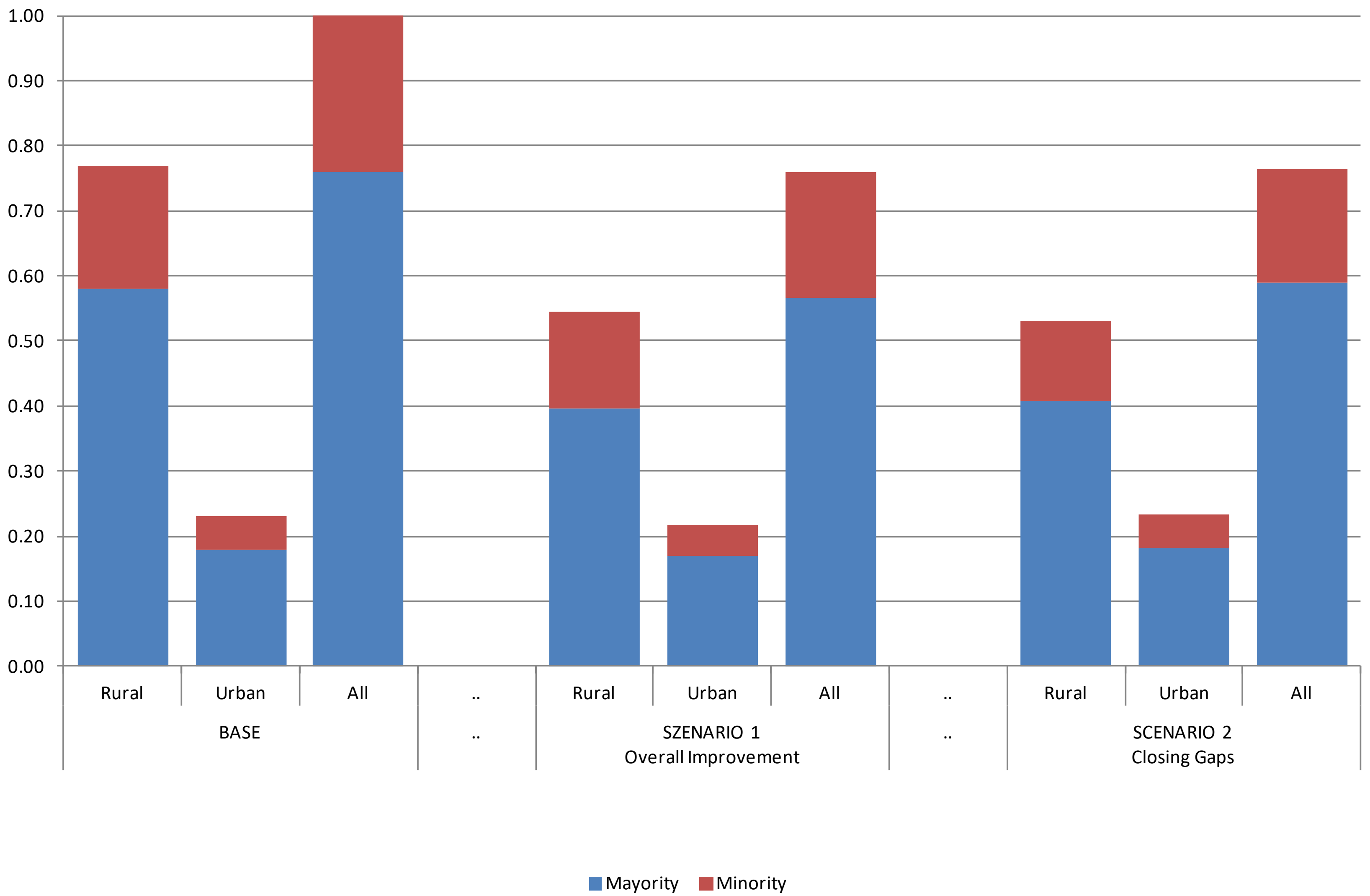
What-if analysis – CFR & mortality

COHORT FERTILITY OF WOMEN SURVIVING TO AGE 15 - MINORITY



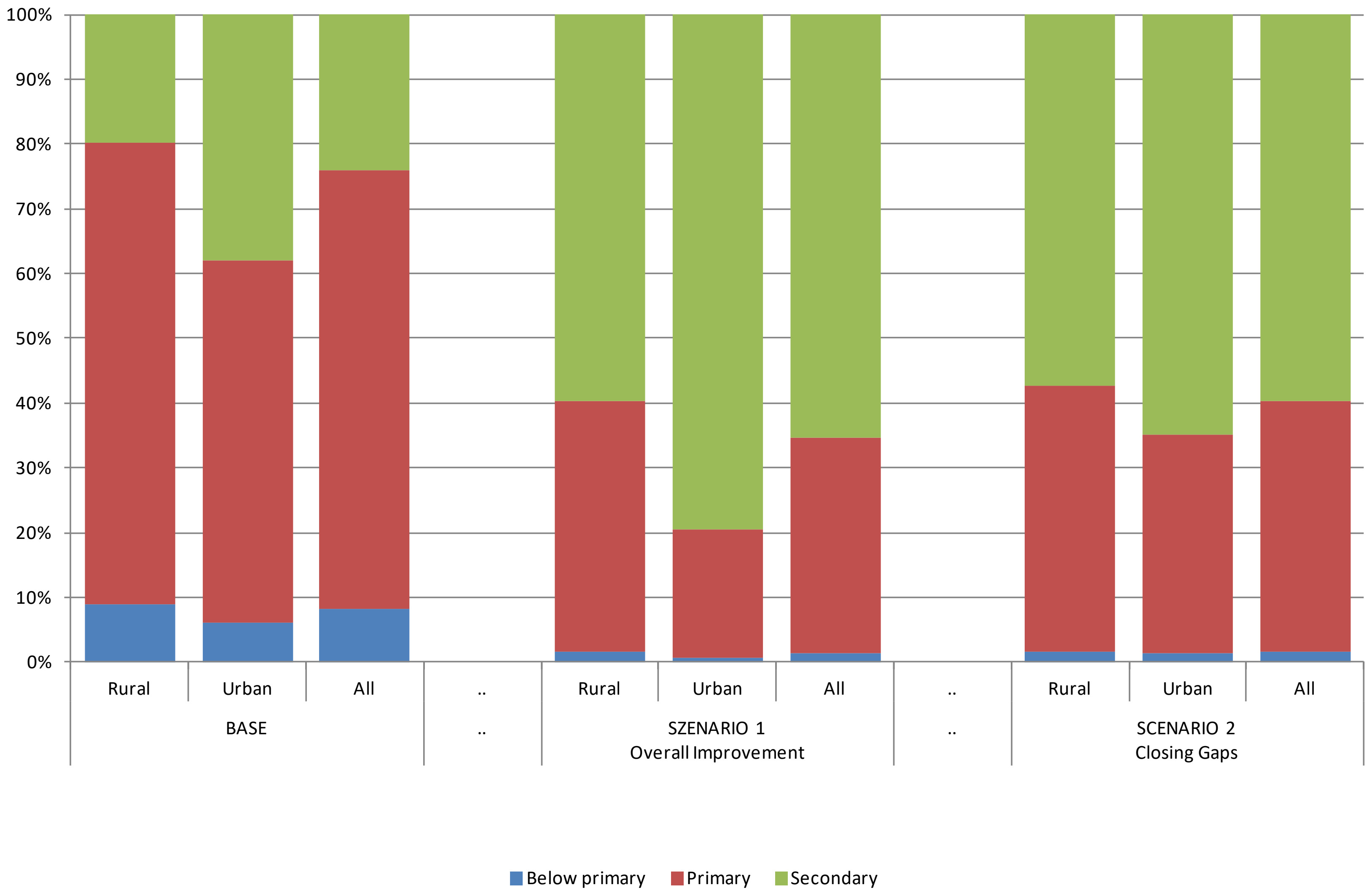
Population projection 2100

FEMALE POPULATION AGE 18-49 IN 2100 (Base Scenario = 1)



Education projection 2100

EDUCATION DISTRIBUTION FEMALE POPULATION AGE 18-49 IN 2100



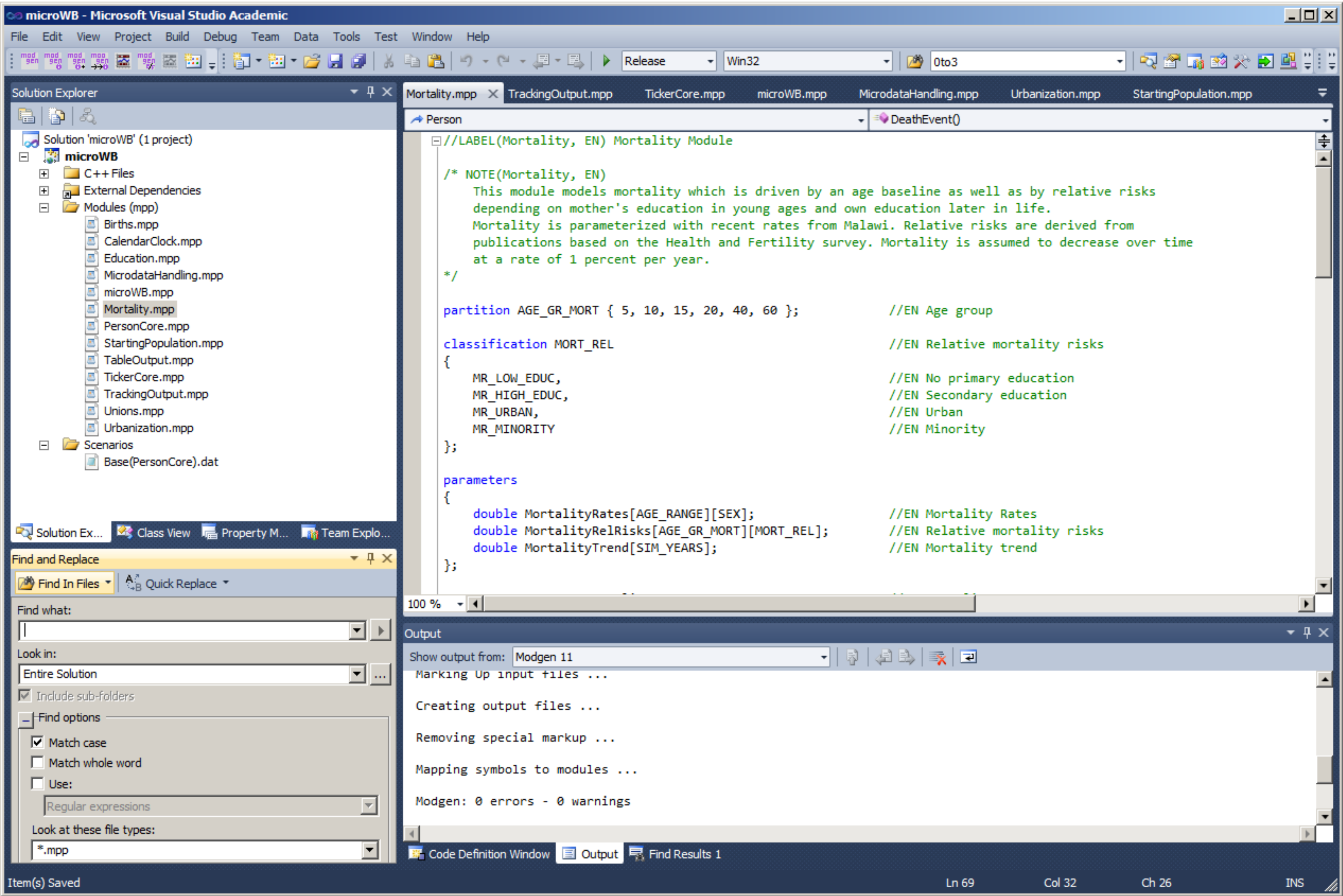
Implementation overview

- Implemented in Modgen, a freely available programming language developed and maintained at Statistics Canada and used in dozens of applications around the globe
- Modgen creates a stand-alone model executable program with a complete visual interface and detailed model documentation.
- Many of the underlying mechanisms like event queuing are hidden.
- Modgen translates Modgen code into C++. This allows to combine the strengths of the generic C++ language with specialized microsimulation language concepts and functions.
- Modgen includes a powerful tabling language and tools for visualizations.

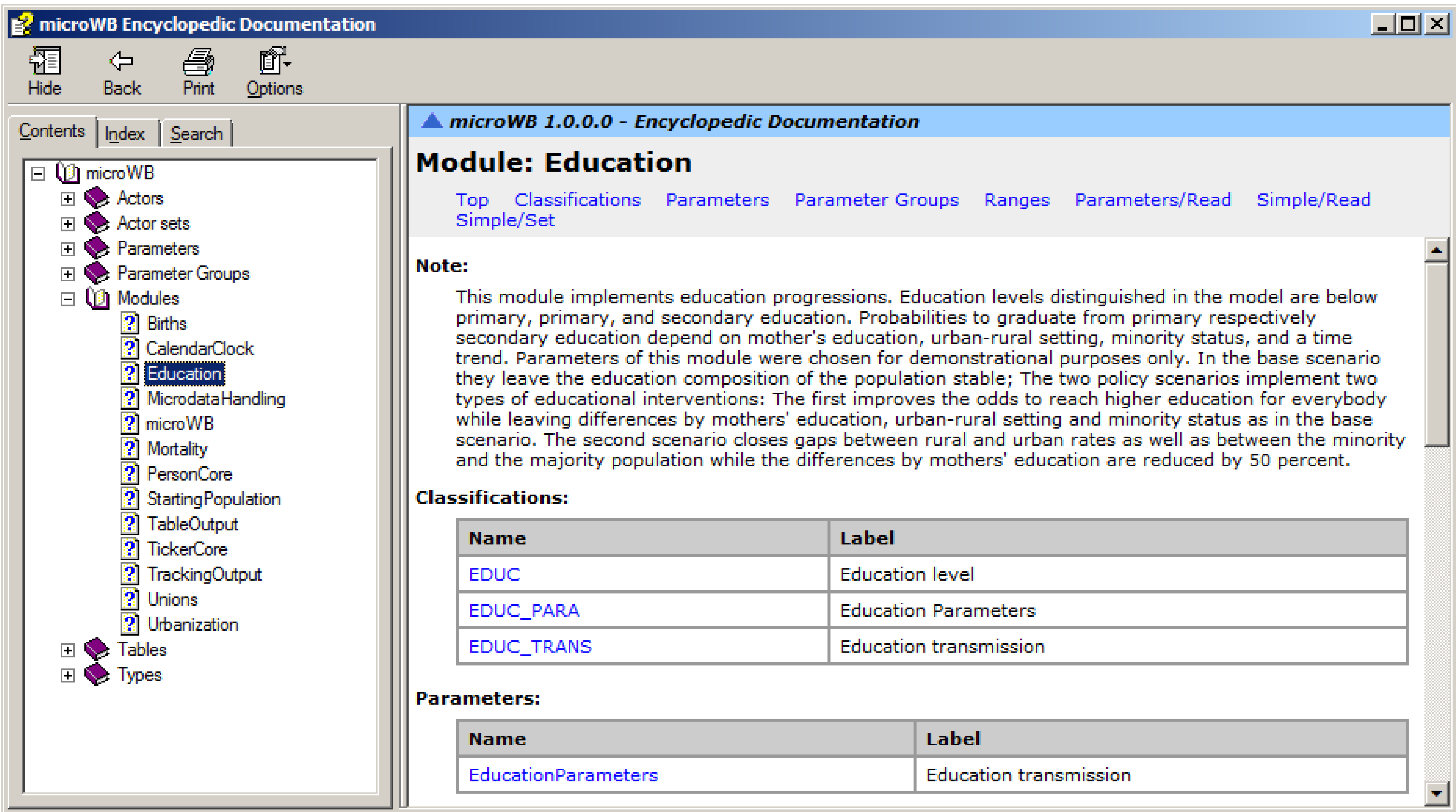
Modgen: Features

- All approaches: Discrete, continuous; interacting or non-interacting populations
- Fast: compiled language, pre-compiled to C++
- Multilingual models possible
- Export of parameters and tables to Excel
- Unlimited dimensions for parameters and tables
- Visualization of individual life courses
- Common fully documented user interface
- Scenario management
- Automated generation of model documentation
- Multi-threading and grid-computing possible

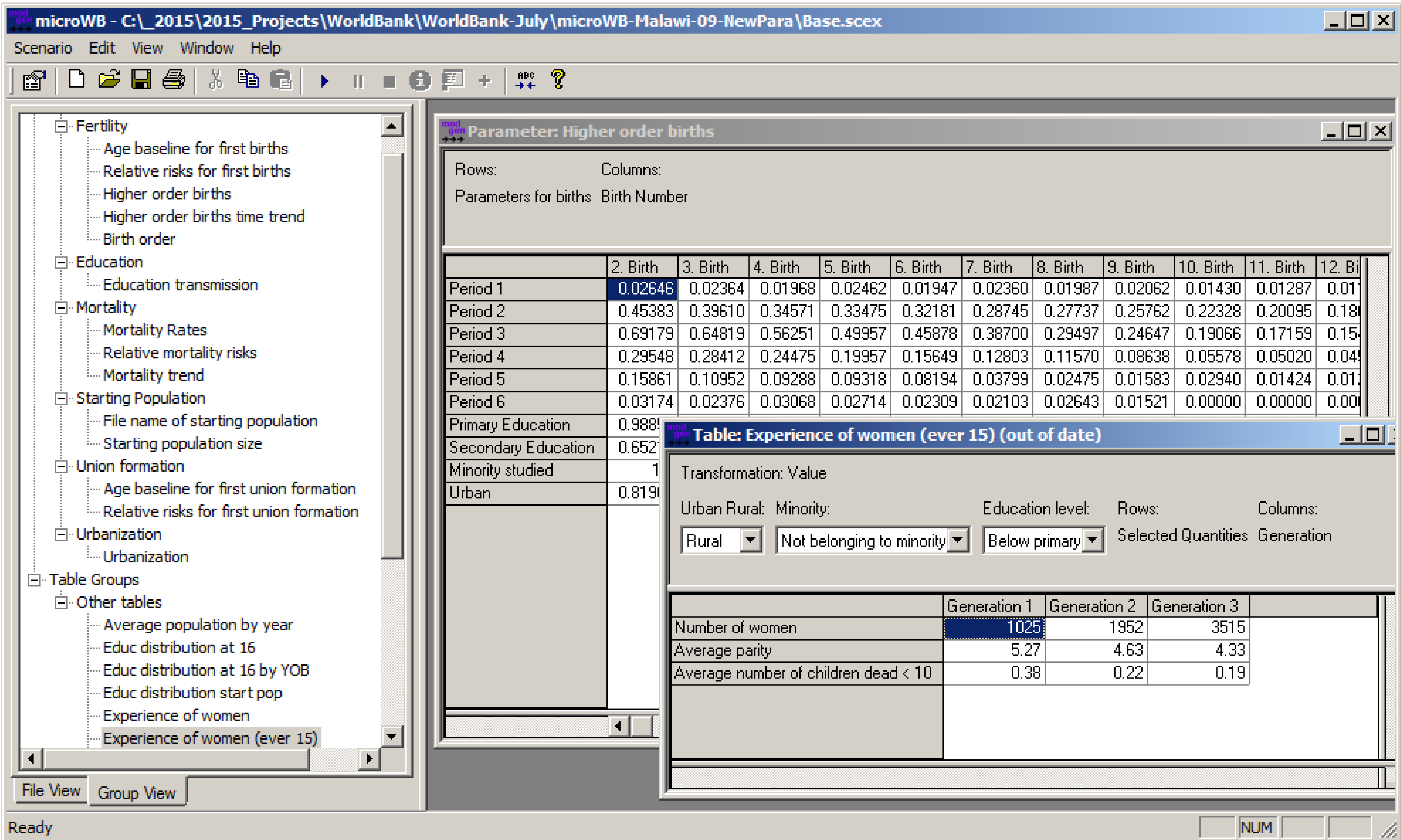
Programming interface



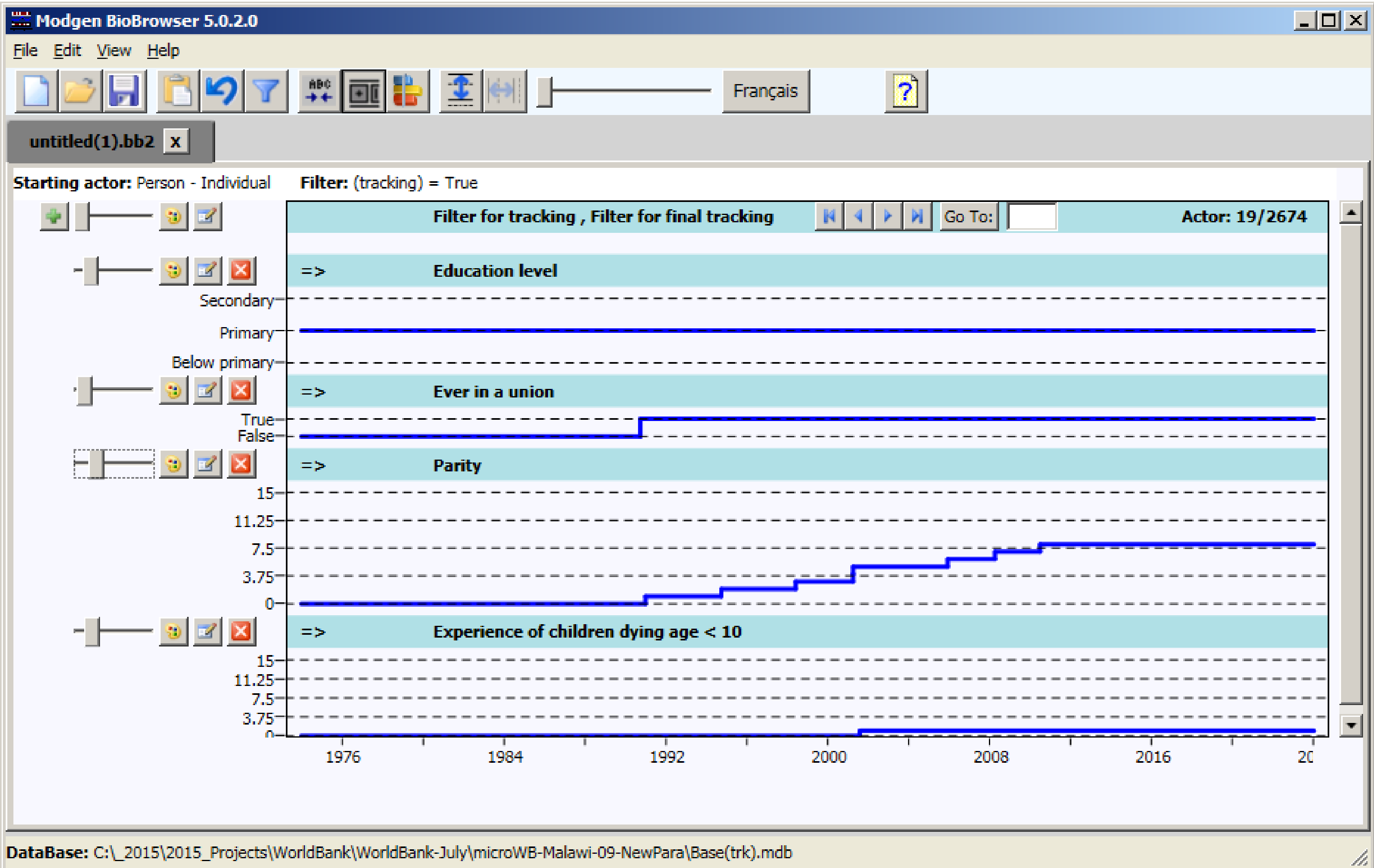
Model documentation



User Interface



BioBrowser


Modgen BioBrowser 5.0.2.0
File Edit View Help
Français
untitled(1).bb2 x
Starting actor: Person - Individual
Filter: (tracking) = True
Filter for tracking , Filter for final tracking
Go To:
Actor: 19/2674
=> Education level
Secondary
Primary
Below primary
=> Ever in a union
True
False
=> Parity
15
11.25
7.5
3.75
0
=> Experience of children dying age < 10
15
11.25
7.5
3.75
1976
1984
1992
2000
2008
2016
DataBase: C:_2015\2015_Projects\WorldBank\WorldBank-July\microWB-Malawi-09-NewPara\Base(trk).mdb

Code: dimensions & parameters

```
range        AGE_RANGE { 0, 100 };                              //EN Age range
range        SIM_YEARS { 2011, 2150 };                          //EN Simulated years

partition    AGE_GR_MORT { 5, 10, 15, 20, 40, 60 };             //EN Age group

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

classification MORT_REL                                         //EN Relative mortality risks
{
    MR_LOW_EDUC,                                                //EN No primary education
    MR_HIGH_EDUC,                                               //EN Secondary education
    MR_URBAN,                                                   //EN Urban
    MR_MINORITY                                                 //EN Minority
};

parameters
{
    double MortalityRates[AGE_RANGE][SEX];                      //EN Mortality Rates
    double MortalityRelRisks[AGE_GR_MORT][MORT_REL];            //EN Relative mortality risks
    double MortalityTrend[SIM_YEARS];                           //EN Mortality trend
};
```

... resulting parameter tables

Parameter: Mortality Rates

Rows: Age range
Columns: SEX

	Male	Female
0	0.0501	0.04147
1	0.00659	0.00623
2	0.00659	0.00623
3	0.00659	0.00623
4	0.00659	0.00623
5	0.0025	0.003
6		
7		
8		
9		
10		
11		

Parameter: Relative mortality risks

Rows: Age group
Columns: Relative mortality risks

	No primary education	Secondary education	Urban	Minority
(min,5)	1.1	0.60	0.86	1.25
[5,10)	1.1	0.60	0.86	1.25
[10,15)	1.0	1.0	1.0	1.0

Parameter: Mortality trend

Columns: Simulated years

2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.990	0.980	0.970	0.961	0.951	0.941	0.932	0.923	0.914	0.904	0.895	0.886	0.878	0.869	0.860	0.851

Declaration of states and events

```
actor Person
{
    logical alive    = { TRUE };                                  //EN Alive
    logical ever_15 = ( integer_age >= 15 );                      //EN Person 15+
    int     age_gr_mort = self_scheduling_split(age, AGE_GR_MORT); //EN Age  group
    event   timeDeathEvent, DeathEvent;                           //EN Death event
};
```

Implementation of events

```
TIME Person::timeDeathEvent()
{
    TIME dReturnValue = TIME_INFINITE;
    // baseline hazard
    double dHazard = MortalityRates[integer_age][sex];
    // relative risks
    if ( urban_rural == UR_URBAN )  dHazard = dHazard * MortalityRelRisks[age_gr_mort][MR_URBAN];
    if ( minority == M_MINORITY )   dHazard = dHazard * MortalityRelRisks[age_gr_mort][MR_MINORITY];
    if (( integer_age < 20 && mother_educ == E_NON) || ( integer_age >= 20 && educ == E_NON))
        dHazard = dHazard * MortalityRelRisks[age_gr_mort][MR_LOW_EDUC];
    else if  (( integer_age < 20 && mother_educ == E_SEC) || ( integer_age >= 20 && educ == E_SEC))
        dHazard = dHazard * MortalityRelRisks[age_gr_mort][MR_HIGH_EDUC];
    // time trend
    if ( calendar_year >= MIN(SIM_YEARS) ) dHazard = dHazard * MortalityTrend[RANGE_POS(SIM_YEARS,calendar_year)];

    if ( (( person_type == PT_START && calendar_year >= 2010 ) || ( person_type == PT_SIM && calendar_year >= 1995 )) && dHazard > 0.0 )
    {
        dReturnValue = WAIT( -log(RandUniform(5)) / dHazard );
    }
    if ( dReturnValue > time_of_birth + MAX(AGE_RANGE))
    {
        dReturnValue = time_of_birth + MAX(AGE_RANGE);
    }
    return dReturnValue;
}
```

```
void Person::DeathEvent()
{
     alive = FALSE;
     if ( lMother != NULL && age <= 10 ) //age <=10 and the mother is still alive
     {
         //increment the mother's counter of experienced child death events
         lMother->child_deaths10++;
     }
     Finish();
}
```

Table definitions

```
table Person DeadChildren10_ever15_3GEN     //EN Experience of women (ever 15) 3 GEN
[ trigger_transitions(alive,TRUE,FALSE) && sex == FEMALE && generation >= 1  && generation <= 3 && ever_15 ]
{
    urban_rural+ *
    minority+ *
    educ+ *
    {
        unit,                                        //EN Number of women
        value_in(parity)/unit,                       //EN Average parity decimals=2
        value_in(child_deaths10)/unit                //EN Average number of children dead < 10 decimals=2
    }
    * gen1to3
};
```

… resulting table

Table: Experience of women (ever 15) 3 GEN

Transformation: Value

Urban Rural: Rural | Minority: Not belonging to minority | Education level: Below primary | Rows: Selected Quantities | Columns: Generation

	Generation 1	Generation 2	Generation 3
Number of women	1025	1887	1046
Average parity	5.27	4.63	4.29
Average number of children dead < 10	0.38	0.23	0.20

Infos

- Modgen is freely available from Statistics Canada but it requires the Microsoft Visual Studio 10 Package
- An open-source implementation of Modgen openM++ is available (soon)
- The model and its code is available for training purposes; there is also a paper draft documenting the model