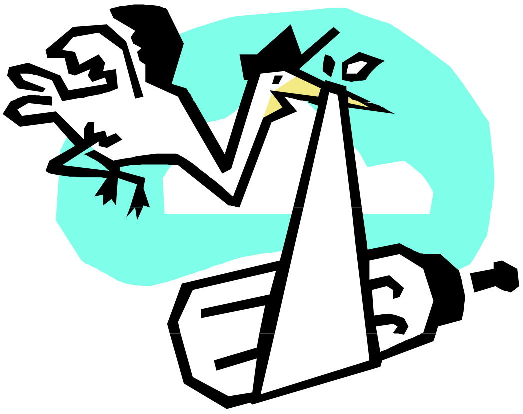
The fertility module for SVERIGE: Documentation V 1.0



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1.0 Microsimulation model history and structure

SVERIGE is a dynamic economic-demographic-environmental spatial microsimulation model for Sweden. By microsimulation is meant that the model represents lifetime events and choices of individual units (or objects) as a combination of structural factors (usually included in discrete choice models as independent variables or used to organise transition matrices) and random disturbance (a Monte Carlo randomisation component). By dynamic is meant that microunit ageing and development occurs in a life cycle pattern, with initial microunit conditions being changed for subsequent periods by counters and sequenced model equations. Its core is based upon CORSIM (Cornell Microsimulation Model), which itself is a modification of Guy Orcutt's DYNASIM (Dynamic Microsimulation Model), the first dynamic microsimulation model of its kind (Caldwell and Keister 1996). CORSIM has since sired other children as well, including a Canadian model named DYNACAD (Dynamic Microsimulation Model for Canada) (Morrison 1997).

SVERIGE will differ in several important respects from its CORSIM parent and DYNACAD sibling. First, SVERIGE is a Swedish model and thus must explain behaviour in a different institutional context than either the CORSIM and DYNACAD North American models. The model core of CORSIM (see figure 1) consists of nine modules (mortality, fertility, marriage, divorce, re-marriage, leaving home, education, employment and earnings, and immigration) that describe the human life cycle. Each module consists of equations that describe the behavioural responses of individuals as a function of their socio-economic characteristics. Although these module equations appear to be informed by economic theory, such as Becker's theories of marriage, divorce, education, fertility, and labour force participation, they are quite sensitive to cultural and institutional peculiarities. Thus, one cannot simply transport the specifications and parameters used by CORSIM to Sweden. For instance, power relations between men and women, the degree of class distributional equity, the elaborateness of social support mechanisms, and the varieties of social groupings (e.g., married couples, cohabitants, families, households) define the social context in which individual decisions are made and constrain the ways in which microactors interact. Therefore, while the life-cycle model that constitutes the CORSIM core will remain the same, the equations that explain transitions between various stages of the life-cycle may vary considerably between the North American and Swedish contexts.

Second, SVERIGE is a spatial model while CORSIM is not. In fact, SVERIGE will be the first national-level spatial microsimulation model. Geographical environment and distance play no role in aspatial models. However, SVERIGE will model individual spatial transitions (such as internal migration) and model life-cycle transitions described by the model core within a spatial context. In addition, certain geographical objects (including land parcels, neighbourhoods, and labour markets) will have attributes that influence the attributes of objects such as individuals, households, employers, and homes (see figure 2. for a full listing of objects and their attributes) and vice versa. For instance, property values, pollution levels, and housing characteristics will change and, in turn, modify choices made by other microactors (or objects) within the microsimulation model. Furthermore, because objects have geographical attributes, the model will be capable of generating geographically detailed reports that may interest regional scientists and policymakers.

Third, SVERIGE is an environmental model. An important premise of the model is that non-production, non-point, household consumption activities generate many unsafe emissions such as heavy metals, carbon monoxide, and sewage. This orientation arose for both empirical and practical reasons. The empirical justification is that if current trends are continued into the future, consumer generated pollution will make up a substantial proportion of overall pollution levels. This is expected to occur because point pollution is technologically and financially easier to reduce than non-point emissions (Tietenberg 1988). There are also practical reasons for not extending the model to production point emissions sources, because to develop modules that explain large firm behaviour would introduce unmanageable complexity and require proprietary firm-level data that are unavailable to the project.

Figure 1. The Sverige Model

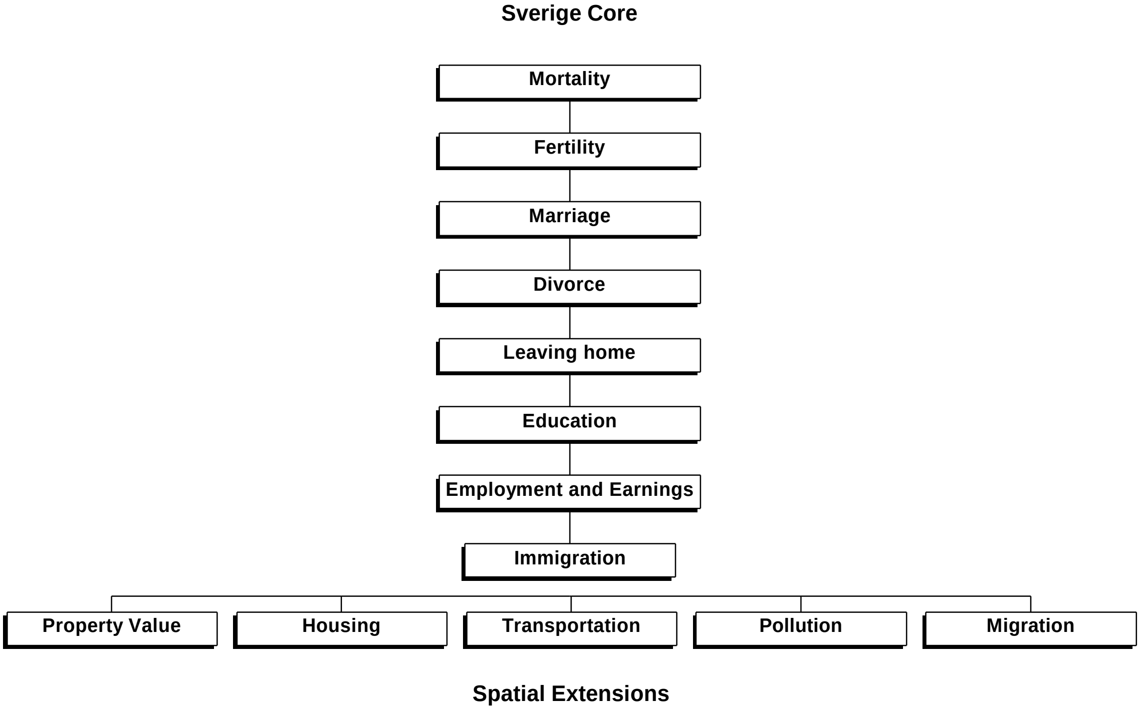
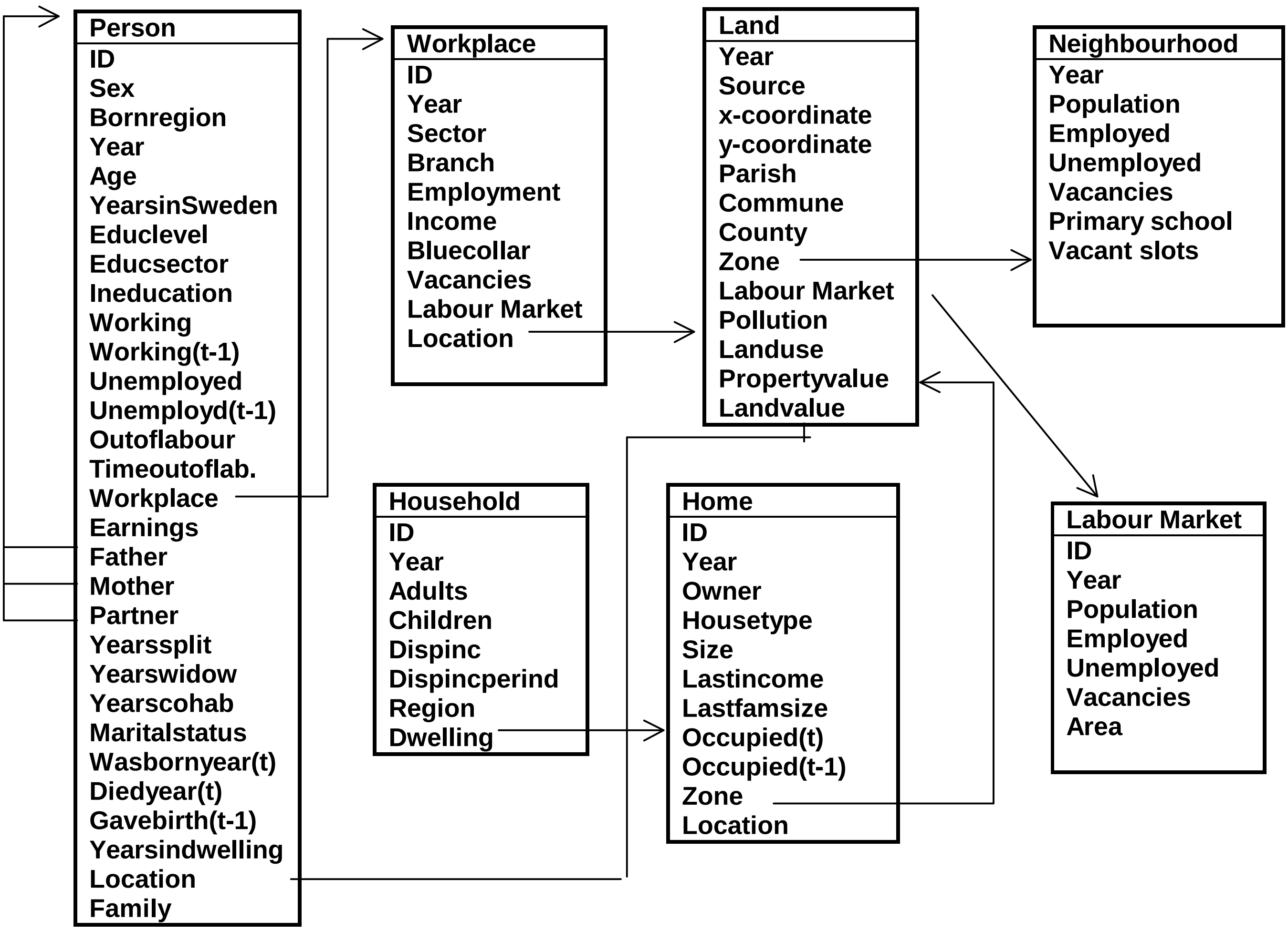


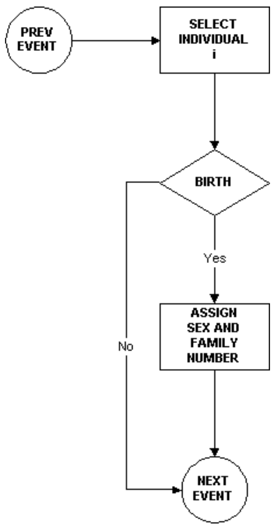
Figure 2. Relations between objects and attributes



2.0 Rationale and role for a fertility module

The primary role of the fertility module is to create new lives for simulation in the microsimulation model. Upon birth, each baby is assigned a sex based on Monte Carlo simulation using a hard-coded probability (see figure 3). During the life-cycle, each individual is aged and characteristics such as education level, employment status, and marital status are changed from null values. Fertility behaviour is influenced directly in the model by a number of individual and household attributes that are generated in the employment and earnings, education, and marriage modules. These variables are discussed below. The module is aligned with fertility rate information from the period 1985-95 grouped by age and marital status. This information was obtained from the SMC/TOPSIM database.

Figure 3. Fertility module structure



3.0 The CORSIM equations

The CORSIM fertility equations for individuals between the ages of 14 and 44 inclusive are discrete choice equations. The occurrence of birth (BIRTHNOW) is estimated for groups defined by age, marital status, and race. They are estimated via logistic regression with subsets of variables listed below.

(1) $$\Pr \mathbf{ob}(\mathbf{BIRTHNOW} = 1) = \frac{\mathbf{e}^{\mathbf{ß'x}}}{1 + \mathbf{e}^{\mathbf{ß'x}}}$$

$$b'\mathbf{x} = \beta_0 + \beta_1\mathbf{AGE} + \beta_2\mathbf{AGE2} + \beta_3\mathbf{BT} + \beta_4\mathbf{BT\_1} + \beta_5\mathbf{SING} + \beta_6\mathbf{DIVO} + \beta_7\mathbf{FAMIN} + \beta_8\mathbf{LTI} + \beta_9\mathbf{HOMEOWN} + \beta_{10}\mathbf{WORKHPT} + \beta_{11}\mathbf{WORKFT} + \beta_{12}\mathbf{INSCHOOL} + \beta_{13}\mathbf{ELEM} + \beta_{14}\mathbf{SOMHS} + \beta_{15}\mathbf{HS} + \beta_{16}\mathbf{LTHS} + \beta_{17}\mathbf{SOMCO} + \beta_{18}\mathbf{COLL} + \beta_{19}\mathbf{GRAD} + \beta_{20}\mathbf{SOMCO} + \beta_{21}\mathbf{COLL} + \beta_{22}\mathbf{KID1} + \beta_{23}\mathbf{KID2} + \beta_{24}\mathbf{KIDMORE} + \beta_{25}\mathbf{YRSMS} + \beta_{26}\mathbf{YRSMS2}$$

where:

β_0	constant
AGE	age, years
AGE2	square of years
BT	1 iff birth occurred last year
BT_1	1 iff birth occurred two yrs ago
NEITHER	1 iff no birth in last two yrs
SING	respondent is single
DIVO	respondent is divorced
WIDO	respondent is widowed
FAMIN	respondent income + husband income, 1990 $
LTI	natural log of above, ln(1990 $)
HOMEOWN	family owns home
WORK0	1 iff weeks worked = 0
WORKLPT	low part time: 1 iff weeks worked between 1 and 26
WORKHPT	high part time: 1 iff weeks worked between 27 and 47
WORKFT	full time: 1 iff weeks worked > 47
INSCHOOL	1 iff respondent is attending school
ELEM	1 iff education < 9
SOMHS	1 iff education between 9 and 11
HS	1 iff graduated from high school (education = 12)
LTHS	1 iff education < 12
SOMCO	1 iff education between 13 and 15 (some college)
COLL	1 iff education = 16 (graduated from college)
GRAD	1 iff education > 16 (attended some grad school)
KID0	1 iff number of children = 0
KID1	1 iff number of children = 1
KID2	1 iff number of children = 2
KIDMORE	1 iff number of children > 2
YRSMS	number of years at current marital status
YRSMS2	square of above

4.0 Reasons for re-estimating the equations using Swedish data

Unlike DYNACAN, which draws heavily upon CORSIM and adopts many of its internal equations and parameters, new fertility equations are developed here. Initially, the desire was to specify equations that are as similar as possible to CORSIM equations. However, in order to save time, several variables used in CORSIM that were difficult to compute from the SMC/TOPSIM database were dropped from the analysis. The CORSIM equations were estimated using American longitudinal data (National Longitudinal Survey of Market Experience) covering the period 1967-1987. However, the data were analysed in a non-longitudinal fashion with each person-year treated as an independent observation. This procedure yielded fewer than 50,000 observations (Caldwell 1993).

One might expect there to be differences in U.S. and Swedish fertility behaviour, not the least because the Swedish government is more active in the areas of parental leave, child nurturing, and day-care. For instance, while CORSIM finds employment to have largely an inhibiting influence on American fertility decisions (WORKLPT, WORKHT, WORKFT), the opposite has been observed in Sweden (Hoem and Hoem 1997; Sundstrom and Stafford 1992). This result may stem from the way in which parental leave benefits are tied to working income. Furthermore, negative wage-rate effects and positive income effects on fertility decisions may be much weaker or non-existent in Sweden (Tasiran 1995). There is evidence that the spacing (BT, BT_1) and timing (AGE) of births are influenced by the way parental leave benefits are dispensed for women who elect to have a second child (Hoem 1993) and the relative flatness of Swedish lifetime earnings profiles (1995). Finally, the marital variable (MARRIED, YRSMAR) used in CORSIM is to indicate unions that increase the risk of pregnancy is less relevant in the Swedish context because of the preponderance of co-habitation and correspondingly large number of out-of-wedlock births.

5.0 Data

In order to both replicate the CORSIM estimation procedure as closely as possible and make estimation manageable, a Swedish sample of 458k individuals living in 1990 was chosen. From this sample. 100,723 females within the 14-44 age group were selected. New-borns were assigned to the corresponding females in this group on the basis of family and household IDs. This assignment procedure (and its limitations) is described in section 7.0. The, dependent variable BIRTH indicates whether or not an individual gave birth during the year (1=Yes, 0=No). The independent variables are variables that are associated with the probability of fertility and include age (AGE), socio-economic conditions (ED2, ED3, NINC1-NINC5), and employment status (EMP). The employment status variable indicates only whether an individual worked or not during the year. It does not indicate the amount of time worked because this information could not be extracted from the database at the time the estimations were performed (although a procedure for estimating this is now in place – see Alfredsson and Åstrom 1998). The rationale for including these variables is discussed briefly above and in the CORSIM documentation (Caldwell 1993).

6.0 Alternative specifications of fertility equation

The fertility equations estimated are simplified versions of the CORSIM equations. First, age (AGE) is entered as a quadratic in order to capture the lower fertility rates observed at the lower and upper ends of the age spectrum because of physical barriers to pregnancy. Employment is used to indicate foregone opportunities, but for reasons explained above may have the opposite effect. Education and income variables (ED2, ED3, NINC1-NINC5) are used to indicate socio-economic or class differences in fertility. Presumably, more educated women are both more aware of birth-control options and have more employment opportunities, which decrease the likelihood of making poor family planning decisions and increase the opportunity costs of birth and child-rearing. However, education might also represent higher lifetime earning capabilities that might increase the likelihood of having children.

The income variables are a bit trickier. A higher family income can be disaggregated into both wage (substitution) and income effect components from the standpoint of the child bearing age female. The earnings which accrue to the wife would be viewed as foregone opportunities if she elects to have a child. Hence, a higher family income would be associated with a lower likelihood of having a child. However, if the increased family income originates from male earnings, it is regarded as only improving household economy from the vantage point of the woman. Hence, the working female would be more likely to work less and to have a child. Because of Sweden's liberal parental leave policy, however, the wage (or substitution) effect is likely to play only a minor role. The Swedish government guarantees 80% of the wages of the female during the time she is absent during birth and the initial months of child-nurturing. Therefore, one might anticipate family income changes to have a comparatively larger income effect than they would in the U.S. and hence to induce more "leisure" consumption (pregnancy) than would be the case without parental leave. However, it is a priori difficult to predict what the net magnitude of the effects will be. They may, indeed, cancel out as suggested by Tasiran (1995).

It may be worthwhile at some point in the future to modify the fertility equations both to utilise relevant demographic and socio-economic information produced by the microsimulation model later on and to strengthen the specifications. For instance, a more comprehensive measure of income (combining earnings and transfers) and number of weeks worked would be possible if these variables were modelled. Several variables were dropped because either the input data was too time-consuming to process or preliminary explorations showed they were not significant. For instance, the role of country of origin was tested in an elementary fashion by using a variable that indicated whether a female is an immigrant or not. Although it was found not to be statistically significant, no distinction was made among the countries of origin or the amount of time the immigrant had lived in Sweden, two factors that may be important. Variables used in CORSIM, such birth spacing (BT, BT_1), number of children (KID0, KID1, KID2, KIDMORE), and years of marriage (YRSMAR) were not used because of the difficulties encountered in constructing accurate variables (see section 5.0 for details). However, they might be worthwhile to add at a later date. Finally, no exploration of spatial variation in fertility or geographical driving forces in fertility decisions were made, though it has been suggested elsewhere (e.g., Hogberg et al. 1992) that “urban lifestyle” may have a bearing on fertility decisions.

7.0 Special data problems: Imputing births, family size, and length of marital relationships

A basic problem with the SMC database is that it is a longitudinal database which does not always explicitly identify family relationships. If two individuals are married, one can use the family (LOPNR) ID to identify the spouse. However, children and sibling relationships can be inferred from the database only by making stringent assumptions about the history of individual families. Because divorce, separation, death, and family re-formation frequently occur, it is treacherous to use current family and household characteristics to make judgements about a natural family relationships, particularly if the natural family relationship commenced before the coverage of this database (1985-95). Another complicating factor is the frequency of “out-of-wedlock” births in Swedish families because of the preponderance of live-in (SAMBO) boyfriends and girlfriends. In this situation, it is necessary to use a household ID to properly identify household members.

The problem with assigning births is that mothers are not specifically identified with individual births. Instead, families are assigned births. Each new-born is assigned a PID (personal ID number) and a family ID number (LOPNR). Often the new-born is assigned the family ID of the mother, particularly since most births occur to unmarried women. In this instance, the assignment is easy and flawless (provided adoptions do not camouflage the assignment). However, in a family with two parents, the child is usually assigned the personal ID of the male family head as family ID. There are instances, also, when new-borns are assigned the unmarried, head of household’s ID as a family ID (LOPNR). In these latter cases, one must employ a routine to assign the birth to a fertility age female in the family or household. This assignment will not be flawless. Take, for instance, the situation where a birth occurs in a family or household which is dissolved and reformed within the same year. The child acquires the father’s ID number as its LOPNR. Now, assume that the father gains custody of the child (granted, this is an unusual situation but it may occur if the mother died) and either establishes another SAMBO or MARRIED relationship when the statistical records are made or remains divorced. In this situation, assigning the birth to the oldest fertility age female means that either a child over the age of 13 or the step-mother would be incorrectly assigned as the mother.

Yet, there are several situations when no assignment (even an incorrect one) is possible. Some babies have unique family IDs (e.g., orphans) and cannot be identified with an adult. Others share family IDs with only other young children. Some new-borns have PIDs of a male that is unmarried or who is not cohabiting with a female. These latter assignment problems were not very common. In the 458k sample, there were 6,675 births in 1990. 3,736 of these were to unmarried mothers and 2,848 were to married mothers. 91 births (or fewer than 2%) could not be assigned for reasons described here. They were ignored in the subsequent analysis.

Imputing the number of children that a given mother had and determining the number of years a couple has been married or cohabited is even more perilous. The database begins in 1985. Because of this, numbers of older children cannot be successfully estimated for relationships that began before that year. If a marriage or cohabitation was dissolved (because of death, divorce, or separation) before 1985 and the father was given custody of the children (a rare situation, to be sure), the real mother simply cannot be determined. Likewise, if mature children left the household before 1985, there is no way to identify their parents or siblings. Marital and cohabitation duration are equally difficult to extract. If a marriage began before 1985, it is simply impossible to determine how many years had accumulated during that period.

If the data problems elaborated on here were to be ignored, a considerable amount of measurement error would be introduced. If the fertility regressions were divided into separate groups based on age and marital status, however, certain cohort equations would be wrought with more measurement error than others. CORSIM equations are broken down by age and marital status. Based on the explanations above, it is easy to see that input data for mothers 30+ would be much less reliable than for younger mothers. It would be much more difficult to ascertain length of marital relationships and family sizes for this group. If, however, they were estimated as a whole, it could make it more difficult to separate the influence of age from other confounding influences, including those introduced by variable measurement error. Because of these obstacles and the difficulties in assembling input data, it is recommended that the family size and marital length variables simply be dropped from this analysis.

8.0 Results

Appendix A. reports the results for logistic regressions for the occurrence of birth (BIRTH). The very disaggregate groupings used for estimating CORSIM equations were consolidated into two groups based on marital status alone (married and unmarried). In addition, a variable called SAMBO, which represents legally recognised unions outside of marriage, was added to the unmarried equation in order to capture the effect of cohabitation. The decision to use only two groups was made on the basis of model fit and collinearity diagnostic statistics. In addition, the expectation is that married females' fertility decisions differ from unmarried females because the marriage decision in Sweden itself appears to be closely linked with the decision to have children.

(2) $b'\mathbf{x}=\beta_0+\beta_1\mathbf{AGE}+\beta_2\mathbf{AGE2}+\beta_3\mathbf{ED2}+\beta_4\mathbf{ED3}+\beta_5\mathbf{NINC1}+\beta_6\mathbf{NINC2}+\beta_7\mathbf{NINC3}+\beta_8\mathbf{NINC4}+\beta_9\mathbf{NINC5}+\beta_{10}\mathbf{SAMBO}+\beta_{11}\mathbf{EMP}$

where:

AGE	age in years
AGE2	square of age
ED1	highest educational level less than high school (SUN=1 or 9).
ED2	highest educational level high school (SUN=2,3, or 4).
ED3	highest educational level college (SUN=5,6, or 7).
NINC1	family earnings (ARBINK) less than 600 (100s of SEK).[1]
NINC2	family earnings between 600 and 999 (1=Yes, 0=No).
NINC3	family earnings between 1000 and 1399 (1=Yes, 0=No).
NINC4	family earnings between 1400 and 1799 (1=Yes, 0=No).
NINC5	family earnings between 1800 and 2199. (1=Yes, 0=No).
NINC6	family earnings equal or above 2200 (1=Yes, 0=No).
SAMBO	cohabiting (1=yes, 0=No)
EMP	employed during the year (LON>0 or FORINK>0 or SYSS=1) (1=Yes, 0=No).

The regressions provide mixed results. AGE and AGE2 are statistically significant for each equation and indicate that the greatest likelihood of child-bearing for each group is in the late 20s. Employment is associated with a lower likelihood of giving birth; this result is the same as CORSIM and does not indicate that fertility decisions are affected by the way in which parental leave assistance is tied to current wages. A higher level of education (ED3) is positively associated with fertility likelihood, a result that may reflect wealth or income effects that arise from higher expected lifetime earnings capabilities; however this result is obtained only for married females. The earnings dummy variables show two different patterns. For unmarried females, lower family earnings are generally associated with higher fertility likelihood, indicating that substitution effects are dominant. This result makes sense since the family earnings will consist of individual earnings only. However, for married females, higher incomes are associated with higher fertility, indicating that income effects are dominant. SAMBO is a large and statistically significant for the non-married equation, indicating that single females have much lower fertility risk than females who have cohabited for durations of one year or more. The measures of model fit obtained for each of these equations are much better than those obtained for the CORSIM equations.

ENDNOTES

[1] Family earnings were computed only for those family members between the ages of 16 and 65 in order to produce an earnings measure that is consistent with that generated by the employment and earnings module (see Alfredsson and Åström 1998). ARBINK from the SMC/TOPSIM database was used as the earnings variable.

Appendix A. Regression Results

Married

The LOGISTIC Procedure

Data Set: WORK.TEST1
Response Variable: BIRTH
Response Levels: 2
Number of Observations: 38059
Link Function: Logit

Response Profile

Ordered Value	BIRTH	Count
1	1	3727
2	0	34332

WARNING: 186 observation(s) were deleted due to missing values for the response or explanatory variables.

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	24398.115	20155.146	.
SC	24406.662	20249.162	.
-2 LOGL	24396.115	20133.146	4262.969 with 10 DF (p=0.0001)
Score	.	.	3981.651 with 10 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	-5.2557	0.5736	83.9547	0.0001	.	.
AGE	0.4264	0.0371	132.3073	0.0001	1.469093	1.532
AGE2	-0.00978	0.000597	268.5318	0.0001	-2.309256	0.990
NINC1	-0.7801	0.1272	37.6303	0.0001	-0.067133	0.458
NINC2	-0.5275	0.1058	24.8789	0.0001	-0.046701	0.590
NINC3	-0.2563	0.0883	8.4325	0.0037	-0.027175	0.774
NINC4	-0.2800	0.0809	11.9931	0.0005	-0.035292	0.756
NINC5	0.00586	0.0607	0.0093	0.9231	0.000898	1.006
ED2	0.1172	0.1184	0.9794	0.3224	0.030254	1.124
ED3	0.5432	0.1220	19.8288	0.0001	0.130074	1.721
EMP	-0.3877	0.0577	45.1220	0.0001	-0.066895	0.679

Association of Predicted Probabilities and Observed Responses

Concordant	= 79.7%	Somers' D	= 0.607
Discordant	= 19.0%	Gamma	= 0.615
Tied	= 1.2%	Tau-a	= 0.107
(127955364 pairs)		c	= 0.804

Unmarried

The LOGISTIC Procedure

Data Set: WORK.TEST2
Response Variable: BIRTH
Response Levels: 2
Number of Observations: 58458
Link Function: Logit

Response Profile

Ordered Value	BIRTH	Count
1	1	2839
2	0	55619

WARNING: 5763 observation(s) were deleted due to missing values for the response or explanatory variables.

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	22714.973	18143.946	.
SC	22723.949	18251.659	.
-2 LOGL	22712.973	18119.946	4593.027 with 11 DF (p=0.0001)
Score	.	.	4618.987 with 11 DF (p=0.0001)

The LOGISTIC Procedure
Analysis of Maximum Likelihood Estimates

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	-15.6192	0.5317	862.9448	0.0001	.	.
AGE	0.7743	0.0345	502.2229	0.0001	3.318335	2.169
AGE2	-0.0133	0.000601	487.6146	0.0001	-3.322134	0.987
NINC1	0.7110	0.2483	8.1975	0.0042	0.176836	2.036
NINC2	1.8554	0.2442	57.7420	0.0001	0.378145	6.394
NINC3	1.4536	0.2438	35.5598	0.0001	0.360915	4.279
NINC4	0.5397	0.2500	4.6606	0.0309	0.103935	1.715
NINC5	0.6472	0.2757	5.5087	0.0189	0.070941	1.910
ED2	-0.0536	0.1834	0.0855	0.7700	-0.011493	0.948
ED3	-0.1097	0.1882	0.3394	0.5602	-0.022249	0.896
EMP	-0.3031	0.0736	16.9348	0.0001	-0.072442	0.739
SAMBO	1.9603	0.0505	1507.3617	0.0001	0.495624	7.102

Association of Predicted Probabilities and Observed Responses

Concordant	= 83.9%	Somers' D	= 0.687
Discordant	= 15.1%	Gamma	= 0.694
Tied	= 1.0%	Tau-a	= 0.064
(157902341 pairs)		c	= 0.844

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