MARRIAGE AGE MODEL

Model formulated and implemented by S. F. Railsback.

This model is loosely based on the marriage age model of:

> Billari, F. C., A. Prskawetz, B. Aparicio Diaz, and T. Fent. 2007. The “wedding-ring”: an agent-based marriage model based on social interactions. *Demographic Research* 17:59-82.
> Available on-line at: www.demographic-research.org/Volumes/Vol17/3/

However, this model is different from the model of Billari et al. in many important ways and should not be compared to, or treated as equivalent to, their model. This file was updated 7 October 2014.

MODEL DESCRIPTION (ODD FORMAT)

PURPOSE

This model addresses social norms in the age at which people marry. These norms can be described by a graph showing what percent of people are married at each age. The model specifically explores the role of social networks (peer groups) in influencing marriage age. If we assume people are more likely to get married when more members of their social network are married, does that explain the typical distribution of age-at-marriage?

The model could also be modified to investigate the effect of alternative social networks on marriage ages. If people are more affected by their younger, older, or closer peers, how does that affect when they marry? If people know of more or fewer potential marriage partners, how does it affect the age-at-marriage distribution?

ENTITIES, STATE VARIABLES, AND SCALES

The objects in this model represent people. People have two state variables to describe their location within a social network (described in the following paragraph). People also have variables for their age, sex, and marriage status.

This model does not use geographic space, but instead represents a social network as a two-dimensional space, wrapped in one dimension so it acts like a cylinder. A person's social location (where they are in a circle of individuals, with people closer on the circle being more closely linked socially) is described via their angle (real numbers between 0 and 360 degrees) on the cylinder's surface. The NetLogo implementation represents this "social angle" as the Y coordinate of a world with max-ycor set to 360, so turtle Y coordinates range from -0.5 to 359.5. The X axis represents age, so an individual's X coordinate is equal to their age (0-60, in years). A person's close social network (people close in both social connection and age) is therefore its neighborhood on the social space.

The model runs at a one-year time step. Simulations run for 200 years.

PROCESS OVERVIEW AND SCHEDULING

The model includes the following actions executed each time step.

Aging and death: The age of all individuals is incremented. Individuals exceeding age 60 die.

Childbirth: Married females with age less than 40 may have children, which are placed randomly in the social neighborhood between their parents. Childbirth happens at a rate that keeps the population stable in the long term. Childbirth is scheduled before marriage so women do not have children the same year they marry.

Marriage: Marriagable individuals (those still single and age 16 or higher) decide whether to try to marry, which depends on "social pressure". Social pressure is a non-linear function of the fraction of the social network that is married. If they decide to marry, they randomly identify a partner (if there is one) within their social network. If a partner is found, the two marry (their marriage status changes from false to true).

Output: The marriage-at-age distribution is represented via a histogram showing the number of people married at each age, for the current population.

DESIGN CONCEPTS

Emergence: The model's primary output is the "age-at-marriage" distribution, which emerges from marriage decisions by individuals. These decisions are determined by (a) the social network and (b) the shape of the social pressure function.

Adaptive behavior: The key individual decision is whether to marry each year. This decision is a deterministic function of (a) the fraction of the individual's social network who are already married, and (b) the availability of potential mates in the individual's social region. Individuals adapt their behavior in response to the fraction of peers who are married: as this fraction increases, they are more likely to marry. However, individuals do not adapt their social network in any way (e.g., by expanding the network with age or by being more linked to people of their own marital status).

Fitness: Conformity with the marital status of social peers is an implicit fitness measure: the adaptive behavior acts to give individuals a marriage status more like that of their social peers.

Learning, *Prediction*: The individual behaviors are not based on expected future state and do not change; no learning or prediction are represented.

Interaction: Direct interaction occurs when an individual identifies a marriage partner. The individual "marries" the partner, converting the partner's status from single to married. Indirect interaction occurs as competition for partners: for examples, more males in a social region would decrease the availability of females for each other, affecting the behavior and marital status of the other males.

Sensing: Individuals are assumed simply to know the marital status of all individuals in their social network, and to know the sex and marital status of all potential marriage partners.

Stochasticity: Stochastic functions are used to initialize individual locations, age, sex, and marital status, and to set the location and sex of children born during the simulation. Whether a single individual marries is a stochastic function of its social pressure.

Collectives: Collectives are not represented. Each individual has a social network of other individuals that it treats as social peers and potential partners, but these networks have no behaviors or characteristics of their own.

Observation: The key model output used by Bellari et al. for comparison to data is the "age-at-marriage" curve. This curve cannot be produced via the simple summary statistical reporters in NetLogo, so instead we use a histogram of number married vs. age.

INITIALIZATION

The population of 1000 individuals is initialized with age selected randomly with equal probability of ages 0 to 60. Initial marriage status (for individuals of marriagable age) is assigned randomly with a probability of being married equal to 0.1. (This unrealistic assumption helps determine the extent to which patterns of marriage age produced by the model are an artifact of initial conditions.)

Initial social angle is set randomly to a value between 0.0 and 360.0.

INPUT DATA

No time-series inputs are used.

SUBMODELS

Partner search and marriage

The fundamental behavioral assumption of this model is that people's efforts to marry increase as the fraction of their social network that is married increases. This assumption is implemented through the following steps. (Note that for young people of marriageable age, the social network and potential spouses may actually include people with age less than 16.)

a. Identify the social network. An individual's social network is defined as the other individuals within a rectangular area on the social space (the NetLogo world). The social network's size is defined by two parameters, which are (in this version) the same for all individuals. In the x (age) dimension, the social network ranges +/- social-network-age-range from the individual's age. In the Y (social angle) dimension, the social network ranges +/- social-network-angle-range from the individual's angle. Default values of social-network-age-range and social-network-angle-range are 3 years and 20 degrees. Hence the social network of an individual with age 21 and social angle 280 deg. includes any individuals with ages between 18 and 24 and social anges 260 and 300.

b. Evaluate the married fraction in the social network. This is simply the fraction of all people in the social network who are already married (including people married within the current time step).

c. Evaluate "social pressure". Social pressure is a variable describing the effect of the married fraction of the social network on a single person's effort to marry. The relationship between the married fraction of the social network and "social pressure" is represented as a logistic curve. Logistic curves are useful for representing many nonlinear relations that are common in natural and human systems: at both low and high levels of the independent (X) variable, there is little change in the dependent (Y) variable, but the relationship can be steep at intermediate levels. The value of the dependent variable Y ranges between 0 and 1.0.

An equation for the logistic function is: $Y = \exp(Z)/(1 + \exp(Z))$

where: $Z = a + bX$

and a and b are parameters defining how wide and steep the relationship is.

One way to define a and b is to think about X values at which the value of Y is 0.1 and 0.9; call these *x01* and *x09*. Now:

$$b = -4.394 / (x01 - x09)$$

$$a = -2.197 - [(b)(x01)]$$

Here we use the assumption of Bellari et al. that social pressure (Y) has a value of 0.1 when the married fraction (X) is 0.3, and has a value of 0.9 when the married fraction is 0.7. Hence:

x01 = 0.3 and *x09* is 0.7

$a = -5.4925$

$b = 10.985$

To explore shapes of this relationship, we recommend users implement these equations in a spreadsheet and play with values of *x01* and *x09*.

d. Decide whether to marry. This is simply a stochastic function of social pressure. A uniform random number between zero and one is drawn, and if it is less than the social pressure the individual looks for a marriage partner.

e. Identify a partner. Partners are selected by randomly identifying a single individual of the opposite sex within the social network. If no such partners exist, the individual remains unmarried. If a partner is found, then both individuals are immediate assumed married and no longer available for selection by other single individuals.

Childbirth

Childbirth rates are imposed to maintain a stable population size. Potential mothers are all females that are married (because of how actions are scheduled, newlyweds married in the current time step are excluded) and have age less than 40.

Each yearly time step, 16 potential mothers are randomly chosen to each produce one child. If there are fewer than 16 potential mothers in the population, then they all produce a child.

New children are given an age of 0 and a randomly selected sex. The social angle of new children is set to a random location uniformly distributed between those of the two parents.