An Agent-Based Simulation Model of Age-at-Marriage Norms

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Summary. In this Chap. we analyse an agent–based model designed to understand the dynamics of the intergenerational transmission of age–at–marriage norms. A norm in this context is an acceptable age interval to get married. We assume that this age–interval is defined at the individual level and the individuals' age–at–marriage norms are transmitted from parents to their children. We compare four different transmission mechanisms to investigate the long term persistence or disappearance of norms under different regimes of transmission. Our work is an extension of [4] that introduces a one–sex non–overlapping–generations version of an age–at–marriage model. Here we investigate whether their results also hold in a more complex setup. Therefore, we explicitly take into account heterogeneity with respect to age and sex. Moreover, we also include the timing of union formation and fertility into our model. To create a more realistic model of the evolution of age norms the characteristics of the agents are extended, some new parameters are added to the model and the age-at-marriage norms are split into two sex-specific age–at–marriage norms. A comparison of the results with those of the original model gives information about how additional characteristics and new parameters can influence the evolution of age–at–marriage norms.

1 Introduction

In this Chap. we present an agent–based model to simulate the evolution of age–at–marriage norms. While some individual decisions are mostly influenced by economic incentives and other decisions are mostly driven by social norms there can also be decisions depending on both. We postulate that individuals' choices regarding their age at first marriage is at least partially influenced

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by normative guidelines enforced by the society and put the emphasis of our model onto that aspect of age–at–marriage.

Social norms can only be effectively put into practice if there exist sanctions that punish deviant behaviour. In a densely connected society there exists a versatile bundle of sanctions to put norms into effect such as ostracism, physical retaliation, refusal of social approval, gossip etc. Diekmann and Voss [6] show that rational actors are able to enforce social norms with sanctions even in one–shot situations. However, the existence of a social network is a prerequisite for the successful implementation of norms.

Normative guidelines generally are a decision guidance whenever an individual has to decide about something important. Thus certain actions are influenced by social norms, namely social rules that state how individuals ought to behave in certain circumstances. Many papers address the presence of such social norms. For instance [11] shows that the presence of family–size norms can explain diverse experiences in income and population growth.

Although one might think that modernisation processes may have weakened traditional normative pressure, the effect of social norms may have been internalised in western societies rendering obsolete any need for external societal enforcement of social norms [9]. In post–industrial societies there seems to be a trend towards a diminishing normative regulation of schedules. A decreasing impact of social norms in the transition to adulthood may be related to a decreasing dependence from the traditional references to the family and to the church [5]. Nevertheless, according to [3] new types of norms may have substituted the old ones.

The impact of social norms on shaping individuals' lifes has been adressed by [2]. They accomplish a theory–based empirical analysis of cross-sectional survey data on norms and sanctions concerning sexual life and marriage for young Italian university students. The survey shows the existence of lower and upper age limits on sexual debut and first marriage. Moreover, there exist perceived norms and sanctions connected for instance to the experience of some types of sexual behaviour. Social norms are supposed to be enforced by formal and informal sanctions. Their investigation exhibits strong evidence that sexual behaviour is subject to strong sanctions and that sexual behaviour is highly affected by social norms. Consequently, it seems reasonable to assume that there may be a corresponding normative pressure to adhere to the norm.

Our simulation model is motivated by [4] who introduce a more stylized model using a slightly simpler implementation of norms. The age–at–marriage norms serve as guidelines for individuals to take decisions about the right point in time to get married. Agent–based simulations are frequently applied in the social sciences, since they have proved to be a valuable tool to study the complex dynamics evolving from heterogenous populations. Here they are applied to observe the long–term persistence or dissolution of social norms and to investigate their evolution over time. Within the artificial environments which can be seen as small laboratories it is possible to simulate behaviours that are influenced by such social norms.

The remainder of this paper is organized as follows. Sect. 2 provides empirical evidence regarding the past development of age–at–marriage. Sect. 3 briefly summarizes the agent–based model of [4], who studied the evolution of age–at–marriage norms, their long term persistence or disappearance, the long term impact of the initial distribution of norms in a population, and the impact of random mutations. In Sect. 4 we describe our extended model, the details of the implementation are provided in Sect. 5, and Sect. 6 highlights the numerical results obtained. The concluding Sect. 7 draws a summary of the main results and elaborates on the following questions: Do the missing characteristics influence the results in an important way or does the simpler model serve as a description that is close enough to reality to detect the evolution of age–at–marriage norms? Does this extension provide a step forward to a closer approximation to the real world?

2 Empirics

Hajnal [8] describes two basic marriage patterns, a traditional or non-European pattern of early and universal marriage reflecting the typical behaviour in most of the developing regions and a European pattern of late marriage and high proportions of individuals who never get married characterizing Western European Societies.

Dixon [7] investigates timing and nuptiality in 57 countries according to censuses taken around 1960. In particular she looks at the proportions of men and women not being married at age 20–24 and at the corresponding proportions at age 40–44. First marriages after the age of 44 are not taken into consideration since they occur only rarely and are demographically of little impact. The data show that grooms are older than their brides in all societies. The main difference between the European and the traditional marriage pattern, however, is partially due to the fact that in societies where marriage occurs early, more people marry ultimately than in societies where marriage occurs relatively late. Dixon investigates in particular the *availability of mates*, determined by the sex ratio of persons of marriageable age and by the method of mate selection, the *feasibility of marriage*, determined by expectations with respect to financial and residential independence and the available resources, and the *desirability of marriage*, indicating the strength of the motivation to marry and depending on the available social and institutional alternatives to marriage and childbearing. When looking at the desirability, it is important not only to take the availability of alternatives into consideration but also whether these alternatives are considered rewarding. Dixon states that *the pressure toward marriage and the penalties of remaining single vary in kind and degree, and differ for men and women.* Thus, empirical investigation should also assess the penalties associated with marrying late or never and childlessness like social isolation, stigma, and the loss of economic and social opportunities. This qualifies the desirability of marriage to be an indicator for the relevance of social norms on the decision whether and when to get married. The data investigated by Dixon reveal that *delayed marriage and celibacy are most highly correlated with indicators of the desirability of marriage, less so with feasibility, and least with availability.* Moreover, she arrives at the conclusions that *the degree of social isolation and stigma that bachelors and spinsters experience depends on the level of celibacy in each society* and *in those countries where romanticism provides a primary motivation for marriage, the unmarried person still experiences the discomfort of being visibly 'unwanted' in a society that idealizes personal attractiveness and individual happiness.*

Bhrolcháin [1] examines age preference data for measuring recent levels of partner availability in England, Wales, and the USA and for assessing time trends of partner supply in those countries. The data reveal that mean age differences in England and Wales do not exhibit a long–run secular trend driven by social and cultural change but rather fluctuate during the 20th century. During the same time period mean age differences have varied within a relatively narrow range in the USA, where a long–run but modest change resulted in a decline from an average of around four years around 1900 to 2.4 years in 1990.

Current empirical data regarding female first marriage in Europe reveal that there is no monotone trend in age–at–marriage over a long period but rather a turning point between two opposed trends. Figure 1 illustrates the mean age of women at first marriage for five European countries. It shows that from the birth cohorts in the 1930s to the birth cohorts in the 1940s the mean age at first marriage decreased by about one year and after that it started to increase to levels already higher than at the beginning of the observation. Moreover, the time series suggest that this increase has not finished yet.

Figure 2 shows the rate of first marriage per 1000 females in Italy by 5–year age–groups. In compliance with the previous graph it turns out that for younger women (< 20 and $20 - 24$) the rate of first marriage slightly increased between the 1960s and the 1970s while it declined afterwards. Furthermore, the rate of first marriage of the women aged 25 to 34 decreased between 1960 and 1975 and increased later on. This observation motivates that the lower age limit of first marriage underwent an increase from 1960 to the 1970s and a decrease later on. The picture is not so clearcut with respect to the upper age limit since the rate of first marriage simply fades away for higher ages. However, Settersten and Hägestad [12] investigated a survey of individuals belonging to different age groups in Chicago. Their analysis revealed that 82.3% of the respondents perceived an age deadline for marriage, i.e. an upper age after which it would not be appropriate to get married.

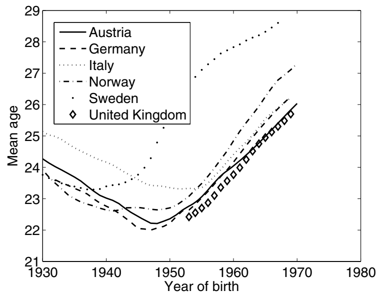

Fig. 1. Mean age of women at first marriage (below age 50), Source: Council of Europe, Demographic Year Book, 2004 Edition

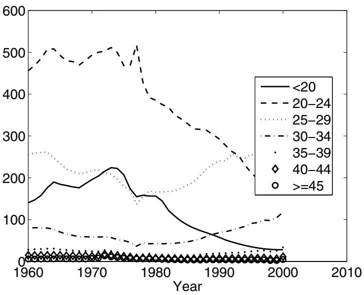

Fig. 2. Sum, by five-year age-groups, of first marriage rates per 1000 females in Italy, Source: Council of Europe, Demographic Year Book, 2004 Edition

3 The One–Sex Model

To show the long term persistence of norms, a population of fixed size is generated, where several individuals are characterized by their age–at–marriage norm. This norm is an age interval, which describes the age at which an individual can marry. The agent's age at a certain time is not a relevant characterization in this setup and is therefore ignored. The absence of additional characterizations is one of the properties to be modified in the following Sect.

Starting with an initial generation with randomly generated age–at–marriage norms, the evolution of the experimental population is simulated. Within this model, the agents do not grow older — they are born, can marry each other, can reproduce if they find a partner, and they die — in the course of one generation. Thus, each time step represents one generation. Individuals can only marry another individual with compatible norms. The norms of two individuals are compatible if they overlap — i.e. if their intersection is nonempty. Other criteria, like age and sex do not matter. Only married individuals are allowed to reproduce, but the reproduction isn't connected with any other criteria like the current age or the duration of the marriage. The independence between age at marriage and the number of children a couple can have is another restriction of this model which will be relaxed in the following Sect. While searching for a partner each individual tries to find someone whose age interval overlaps with the own one. If an agent can't find an acceptable partner it remains single and isn't taken into consideration any longer. Otherwise both partners marry. Married individuals are removed from the list of marriage candidates.

The population within this model is stationary. This is achieved by assigning $\min(\lfloor s/c \rfloor, k)$ children to each married couple, where the parameter s means the size of the starting generation, c is the number of couples and $k \geq 0$ is a numerical parameter determining the minimal number of children a couple could have. After that replenishment of the population is achieved by assigning further children to the couples until the original population size is attained. The case k equal to zero means there is no minimum number of children and therefore it is possible that some couples remain childless.

If a couple has children, their children inherit their age-at-marriage norms by means of a special transmission mechanism. Four different transmission mechanisms are applied,

- Intersection,
- Union,
- Random, and
- Uniform.

These mechanisms are also adopted in the extended model and are described in detail in the following Sect. Combinations of these mechanisms are also allowed. This is achieved by assigning to each individual one out of four mechanisms with the same probability. In this case children inherit both, the age norms and the transmission procedure, from their parents. In addition to the transmission of norms, two alternative forms of mutations are allowed. Thus, with a certain user–defined probability a child does not necessarily inherit the transmission mechanism or the age norm from its parents. In the former case the children are initialised randomly with the same method applied for the initial generation, in the latter case the lower and upper bounds of the child's age norm are calculated as the average of the lower and upper bounds of the parent generation. These two mutation techniques are not adopted to the new model in an attempt to keep the number of degrees of freedom at a tractable level.

4 The Extended Model

This Model is an extension of [4] which is described in brief in Sect. 3. It is designed to study the cultural evolution of age-at-marriage norms. The model is a system in which agents interact in a dynamic and evolving way. The agents search for a partner, marry, and reproduce. The existence of norms implies that marriage only takes place within a particular age interval. As these age norms prevent marriage outside of the personal age interval, they influence the demographic choices of individuals. The norms serve as a guideline for the timing of marriage and for choosing an acceptable partner. Because these norms restrict the individual life course choices, they are important for investigating the further deployment of the life course. The model was developed for simulating these dynamic age norms. In particular the long term persistence and the disappearance of age norms are examined. Further, the impact of the initial distribution of norms within the population is depicted. The long run persistence — i.e. the survival across several generations — of age norms can be investigated by means of agent–based modelling. Agent–based models allow us to study the evolution of norms within setups determined by co-existence of norms.

The previously described model is now extended by adding the demographic structure characteristics age and sex. For this model a starting population of N agents is produced. The agents obtain a starting age between zero and the maximum age m, which is assigned randomly. The sex of the individuals is also chosen randomly. The sex ratio at birth resp. at initialization, srb, which means the ratio of male to female births, can be chosen arbitrarily.

Besides age and sex the individuals are characterized by two sex-specific age-at-marriage norms. The female age–at–marriage norm determines the acceptable age for a woman to marry. Therefore, a female individual recognizes her own marriage readiness by this interval whereas for a male individual it indicates the age his potential wife should have. The male age–at–marriage norm on the other hand determines the acceptable age for men to marry. Consequently, the male agents consider this norm to determine their own readiness while it determines the age range of an acceptable partner from the viewpoint of a female agent. It seems to be appealing to extend the length of the marriage intervals with age since the tolerance of an individual with respect to age differences may expand with increasing age. However, the age–norms in our model are not intended to determine the age differences within unions but to constitute a regulating mechanism with respect to age–at–marriage. Thus, expanding the marriage interval with age means to mess up two different processes. Therefore, we decided not to include this extension into our model. Moreover, in the simulation experiments this extension did not exhibit a significant impact on the results, it simply delayed some of the observed effects.

Each norm is represented by a lower acceptable age–at–marriage, l, and an upper acceptable age–at–marriage, u. The individual lower bound must be above the global minimum age l_a, which may be interpreted as a legal minimum age to get married. The upper bound of the individuals age–at–marriage intervals is only restricted by the age m at which agents are being removed from the simulation. Thus, the lower limit is situated between l_a (which is the minimum age for marriage) and m, and the according upper age limit is set between the lower limit and m.

The norms for the initial population are drawn from a random distribution. First a random number l_i^f satisfying $l_a \leq l_i^f \leq m$ is selected as the lower bound. Then a random number, u_i^f, which must be between this lower bound and m is chosen as the individual's upper bound. These two values describe the female age–at–marriage norm. After fixing the female norm the male age–at–marriage interval is determined according to the same procedure.[3]

[3] This procedure does not generate a uniform distribution for both lower and upper bound. Only the lower bounds are uniformly distributed while the upper bounds are biased towards higher ages. However, Figs. 7 and 8 indicate that all possible norms occur in the initial population. As long as the population size is sufficiently

On the basis of this starting population, the evolution of this population is simulated, where each individual ages, may marry and get children. Since a simulation sequence now represents one year, the individuals grow one year older within one simulation step. The maximum age which an individual achieves is m years. As soon as an agent gets m years old, it is discarded from the model, since it has no influence on the dissemination of age–at–marriage norms due to age–specific fertility rates. For simplicity we neglect age–specific mortality rates and assume that all agents survive until the age m.

In every time step each individual who is in the marriageable age may search for an acceptable partner. An individual arrives at the marriageable age when its own age is situated within its appropriate sex–specific age interval. A potential partner is a marriageable single individual of the other sex, whose sex–specific age–at–marriage norms overlap with the agent's own norms. An unmarried female at marriageable age would search for any male single individual whose current age is within her male age–at–marriage interval and whose female and male age–at–marriage norm have nonempty intersections with her own female and male age–at–marriage norms (see Fig. 3).

Moreover, the chosen potential partner would only accept a partnership if her current age is also within his female age–at–marriage interval.

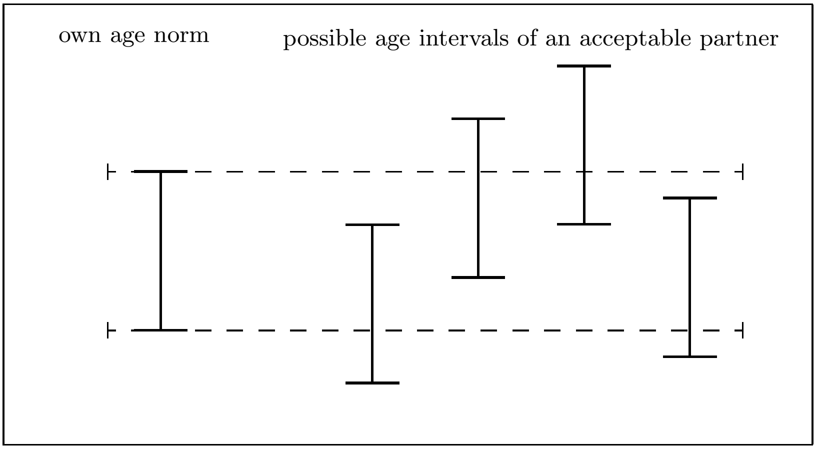

Fig. 3. Age intervals of a potential partner

Additionally, the potential partners must not have the same parents since marriage among siblings is prohibited in our simulation. This restriction is useful to avoid the persistence of a weak norm which is transmitted by only one couple. Given the population is sufficiently large the result of the simulation described so far would be that most individuals find an acceptable partner as

large this bias in the initial population will not have any significant impact on the results.

soon as they enter their individual age–at–marriage interval. Moreover, each agent would marry the very first partner encountered who is acceptable with respect to age–at–marriage norms. This is obviously not the way how dating and marriage happen in the real world. Besides the age of the potential partner there will also be criteria like sympathy, physical attraction, or social and economic status which play a role in mate choice of within human populations. These phenomena are discussed for instance by [13] and [15]. To overcome the problem of a marriage peak just after surpassing the lower age limit [13] and [15] applied a normally distributed courtship time in their model and [14] introduced a variation in the number of dates to be encountered during adolescence. Our solution is in line with these models. Here, every agent who finds an acceptable partner gets married with probability pm given by

$$pm = pm_0 + (1 - pm_0)\frac{a - l}{u - l} \ , \tag{1}$$

where $a - l$ is the number of years since the individual has reached the marriageable age and $u-l$ is the length of the personal age interval. The use of pm allows for an individual to marry as soon as she/he reaches the marriageable age with a certain probability but also to wait after entering the marriageable age–interval (e.g. someone who is sure of having found her/his partner would marry immediately whereas others might rather wait for a "better" partner). An individual who doesn't find an acceptable partner or decides not to marry remains single for that period and continues to search for a partner in the next period if she/he is then still at marriageable age.

However, if female and male age norms of two marriageable individuals match, this couple may eventually get married. In that case these two agents are no longer potential partners for others. Each married couple can have children annually. In our simulation model the probability for a married woman at age a to give birth is

$$\frac{w(a)}{mw(a)} \ af(a) \ tfr \ , \tag{2}$$

where tfr is an adjustable parameter determining the period total fertility rate within the population. This parameter is multiplied by $af(a)$ to replicate empirically observed age–specific fertility patterns. Consequently, $af(a)\ tfr$ would represent the age–specific fertility of all female agents at age a within the population. Moreover, since children are assigned only among the married couples this age–specific fertility rate is multiplied by $w(a)/mw(a)$ where $w(a)$ is the total number of women at age a and $mw(a)$ is the number of married women at that age. Therefore, the fraction $w(a)/mw(a)$ must be greater or equal to one which causes the age–specific fertility of the married women to be greater or equal than the age–specific fertility of the whole female population. Each newborn inherits the conceptions concerning the marriage age of its parents due to a special transmission mechanism. In this model we apply the four transmission techniques introduced in [4].

Intersection: The child's age norms $[l_c^f, u_c^f]$ and $[l_c^m, u_c^m]$ result from the intersection of its parent's intervals, $l_c^f = \max(l_{p1}^f, l_{p2}^f)$, $u_c^f = \min(u_{p1}^f, u_{p2}^f)$, $l_c^m = \max(l_{p1}^m, l_{p2}^m)$, and $u_c^m = \min(u_{p1}^m, u_{p2}^m)$ (see Fig. 4).

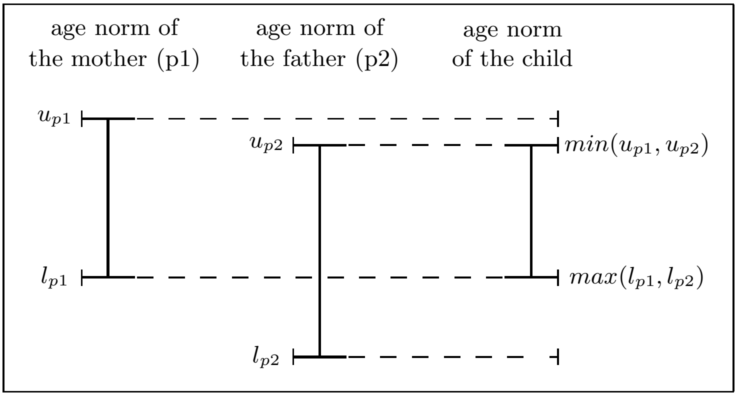

Fig. 4. Intersection of age intervals

Union: The age-at-marriage norms of the child are in each case the unions of the parents' age intervals, $l_c^f = \min(l_{p1}^f, l_{p2}^f)$, $u_c^f = \max(u_{p1}^f, u_{p2}^f)$, $l_c^m = \min(l_{p1}^m, l_{p2}^m)$, and $u_c^m = \max(u_{p1}^m, u_{p2}^m)$ (see Fig. 5).

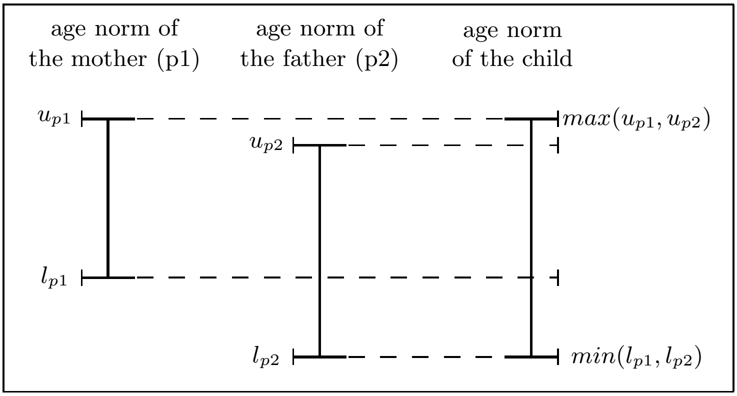

Fig. 5. Union of age intervals

Random: The boundaries of the female norm of the child are selected randomly from the respective boundaries of the parents' female norms. Thus, the lower bound of the child may be either the lower bound of the mother or the lower bound of the father. The upper bound of the female norm as well as the lower and upper bound of the male norm are selected the same way, $l_c^f = \text{random}(l_{p1}^f, l_{p2}^f)$, $u_c^f = \text{random}(u_{p1}^f, u_{p2}^f)$, $l_c^m = \text{random}(l_{p1}^m, l_{p2}^m)$, and $u_c^m = \text{random}(u_{p1}^m, u_{p2}^m)$ where random(x, y) chooses either x or y with the same probability (see Fig. 6).

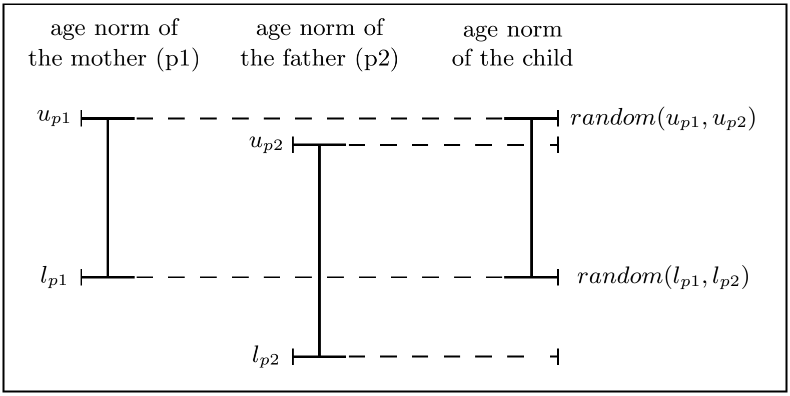

Fig. 6. One possibility for Random combiner. The upper limit is randomly chosen from (u_{p1}, u_{p2}) and the lower limit is chosen from (l_{p1}, l_{p2}).

Uniform: The lower (upper) bound of one of the two norms of the child is a random number between the lower (upper) bound of the respective norm of the mother and the father[4], $l_c^f = \text{uniform}(l_{p1}^f, l_{p2}^f)$, $u_c^f = \text{uniform}(u_{p1}^f, u_{p2}^f)$, $l_c^m = \text{uniform}(l_{p1}^m, l_{p2}^m)$, and $u_c^m = \text{uniform}(u_{p1}^m, u_{p2}^m)$ where uniform(x, y) selects a number between x and y drawn from a uniform distribution (see Fig. 7). Similar mechanisms are used for instance by [10] and [16] to model opinion dynamics within an agent population. While [10] uses a weighted average of an agents current own opinion and the opinions of the other agents to get the agents opinion in the following period, in [16] only two agents communicate with each other and agree to a compromise by adjusting their own opinion slightly towards the opinion of the other agents. Here, the age–at–marriage norm takes over the role of an opinion and the norm of the child is a compromise of the parents norms. Unlike [10] and [16] the particular location of that compromise is not deterministic but results from a random process.

In Sect. 6 we will present results obtained in simulations with homogenous populations — i.e. populations of agents endowed with the same transmission mechanisms — as well as results gained from heterogenous populations. In the latter case the assignment of combiners to the original population is done randomly with each mechanism being chosen with equal probability. So if the user chooses two mechanisms, these are assigned to the individuals with a

[4] The Uniform transmission is a random transmission with uniform distribution. This notation is consistent with [4].

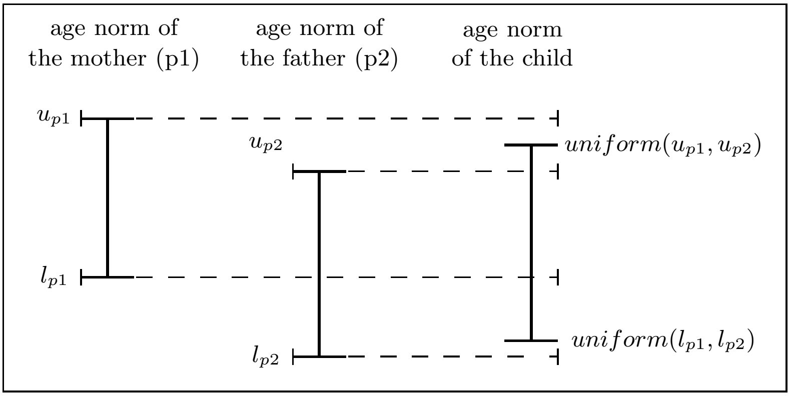

Fig. 7. Uniform combiner

probability of 50 percent. If all four techniques are to be used, these four are divided among the individuals with a probability of 0.25 each. Individuals who are born during the simulation inherit the transmission technique of one parent, where the probability to inherit from the mother is just the same as to inherit from the father. The one mechanism that is inherited to the child is also the one that is used to compute the child's age norms from its parents' male and female norms.

The extensions described above allow us to demonstrate within the simulation that the long term persistence of norms depends not only on the transmission mechanism. Thus other female norms will persist than male norms since the age at marriage of a woman considerably influences the number of children she can give birth and consequently the possibility of passing on her age norms. This natural fact is simulated by the consideration of age specific fertility rates[5] (see Table 1).

Table 1. Age specific fertility rates

	15-19	20-24	25-29	30-34	35-39	40-44	45-49
ASFR [5]	14.8	69.6	98.1	65.6	25.2	5.2	0.4
$af(a)$ [6](%)	1.06	4.97	7.01	4.69	1.80	0.37	0.03

[5] Source: U.S Bureau of the Census, International Database, Table 028: Age specific fertility rates (in Austria in 2002)

[6] The total fertility rate in Austria in 2002 was 1.399. That year a thousand women aged between 15 and 19 years on average gave birth to 14.8 (= 1.48%) children as indicated in the first line of the table. Equation (2) implies that we need a standardized age–specific fertility rate assuming a total fertility rate of 1. This standardized age–specific fertility rate is given in the second line of the table. For a women in the age group [15,19] we get $af(a) = 1.48/1.399 \approx 1.06$.

The implementation of the agents' ages also influences the evolution of norms since the assumption that all couples can get children with the same probability no matter at which age the couple has married does not comply with reality. Thus integration of the age causes a displacement of the lower age at marriage bounds downward.

5 Simulation Details

As already mentioned earlier there are two sex specific age–at–marriage norms. Above all, the introduction of an age–at–marriage minimum is of relevance, as in all countries exists a minimum age before which individuals are not allowed to get married. Although a maximum age for marriage isn't intended legitimately, we restrict the maximum age of the agents to m because the evolution of norms is not effected by agents above that age. Consequently, the upper limit of the agents' age–at–marriage intervals cannot exceed m. The separation of norms shows how age–at–marriage norms of women evolve differently than those of men. Furthermore sex is now a vital selection criteria since marriage between individuals of the same sex is not allowed. Another important extension is the specification of the agents' age. In contrast to the original model the individuals can't marry before they reach their personal marriageable age. This characteristic influences the marriage readiness as well as the reproduction. The probability of having children depends on the age of the female partner.

The inhabitants of our simulation enjoy the pleasure to live in a world in which nobody dies before the age of 60. However, then they are removed from the model. We dare to refrain from modelling mortality in a more accurate way because in highly developed countries the chance to survive until the age of 60 is very high[7] and the dying after the age of 60 does not affect the evolution of age–at–marriage norms, which is the main subject of our study.

The four transmission mechanisms Intersection, Union, Random and Uniform have been retained unchanged but we did not include the two mutation mechanisms (a child does not inherit any information from its parents) into this model. We abandoned the implementation of a mutation operator introducing new age intervals completely randomly because a certain degree of randomness is already being provided by the Random and Uniform operator. Nevertheless, the randomness inserted by these two operators takes place on a well–regulated level.

[7] For instance the period lifetable for Austria for the period 1990/92 indicates that the probability for females to survive until the age of 60 is 91.9% and for males it is 83.6%, (Source: Statistik Austria, Statistisches Jahrbuch 2004, p. 75)

5.1 Numerical Parameters

Some model parameters may be changed to show the effect of their values on the results. The values of other parameters are fixed and cannot be changed. This Sect. gives an overview of all parameters and their values used in the simulation.

N	initial population size, $N = 500 - 5000$. N agents described by randomly chosen characteristics are created. On the basis of this starting population, the evolution of this population is simulated.
m	maximum age an individual can achieve, $m = 60$. As soon as an agent becomes 60 years old it is removed from the model — it dies. Moreover, because agents are removed at age m, this parameter also takes over the role of a global upper bound for age at marriage.
srb	sex ratio at birth. To examine the effects of an imbalanced ratio between sexes, values from 0.5 to 2 are allowed. A srb of 1.05 means that 105 boys are born while 100 girls are born.
l_a	lower bound for age at marriage, $l_a = 15$ years.
pm	probability that an individual who has found an acceptable partner really marries.
pm_0	probability of marriage in the first year after arriving at marriageable age.
tfr	total fertility rate. tfr can take values between 1.0 and 3.0.
$af(a)$	age specific fertility rate of women at age a.
l^f	lower bound of female age at marriage, $l^f \in [15, 59]$.
u^f	upper bound of female age at marriage, $u^f \in [l^f, 59]$.
l^m	lower bound of male age at marriage, $l^m \in [15, 59]$.
u^m	upper bound of male age at marriage, $u^m \in [l^m, 59]$.

5.2 The Agents

Each agent is described by some characteristics determining its behaviour during the simulation. For the age–at–marriage model the following agent characteristics are defined:

Variables	Values	Description
index	0 -	identifier of the agent
age	0 - 59	indicates the agent's age
sex	male / female	shows its sex
married?	true / false	is set true when the agent has married an acceptable partner
mother	index	identifier of the agents mother – for the first generation the value of this variable is undefined.
father	index	identifier of the agents father
brosis[8]	index	lists all agents who have the same mother and father. An agent is not allowed to marry one of these agents
partner	index	if an agent is married this variable shows its partner otherwise the value is nobody
pregnant?	true / false	for male agents and unmarried agents this value is always set false, for married women it is randomly assigned true based on the probability in equation (2)
female-lower-bound	15 - 59	lower bound of the agent's female age norm l^f
female-upper-bound	l^f - 59	upper bound of the agent's female age norm u^f
male-lower-bound	15 - 59	lower bound of the agent's male age norm l^m
male-upper-bound	l^m - 59	upper bound of the agent's male age norm u^m
of-marriageable-age?	true / false	is true as long as the agent's age is situated within its appropriate sex-specific age interval
transmission	intersection/ union/ random/ uniform	indicates the transmission mechanism used to inherit the age norms

[8] abbreviation of brothers and sisters

6 Results

To investigate the effect of the four transmission mechanisms on the persistence or dissolution of age norms, the model was implemented in NetLogo[9]. Our simulations show that the transmission mechanism determines which norms survive and which disappear first. Moreover, we are interested in the impact of a combination of two or more transmission mechanisms on the persistence of age norms. To facilitate the comparison of the different transmission mechanisms, the values of some numerical parameters are kept constant. The following six simulations each are started with an initial population of 5000 agents, whose characteristics like age, sex and age norms are assigned randomly. Male and female agents are generated with the same probability ($srb = 1$). To avoid erratic fluctuations in the size of the agent population we set the total fertility rate tfr equal to two. Consequently, the female agents (about half of the population) give birth to two children on average. Finally the variable pm_0 is set equal to 35%.

Intersection combiner

If the child's norm is the intersection of the age intervals of its parents, its lower bound is the maximum of its parent's lower bounds and its upper bound is the minimum of its parent's upper bounds. Therefore, the child's age intervals are always shorter than, or at most, as long as the intervals of its parents. That implies that the mean length of the age at marriage interval decreases with time. Thus the average mean length converges to a very narrow age interval (see Fig. 8). In reality such a development may not persist in the long run. Nevertheless, in a period of increasing lower age limits and nearly constant upper age limits (see for instance the period from 1980 to 2000 in Fig. 2) a mechanism similar to this intersection combiner may be at work. Figures 1 and 2 suggest the interpretation that there is not one universal mechanism at work in the long run. Therefore, here and in the following we will not only look at the long run equilibria resulting from the transmission mechanisms but also investigate the intermediate dynamics.

The age–at–marriage norms of the initial population were chosen randomly. Hence, Figs. 9 and 10 show that the initial state contains practically every possible norm.

Already after 60 time steps the evolution of age norms exhibits a clear trend towards shorter age intervals. Those norms with the largest interval length become fewer (see Figs. 11 and 12).[10] The female age–at–marriage

[9] Within a short test of different simulation platforms we got the impression that NetLogo provides an easy to use programming environment, which enabled us to quickly implement the simulation model from the scratch. Further details can be found at http://ccl.northwestern.edu/netlogo/

[10] In Figs. 11 and 12 there are more female norms remaining in the upper left corner than male norms which is just a random "accident" of that particular simulation run.

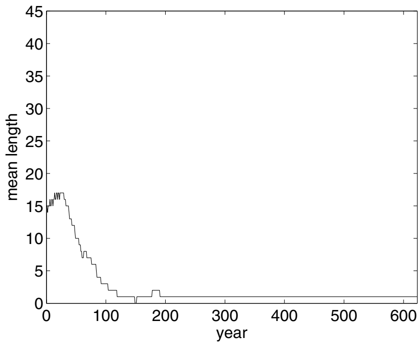

Fig. 8. Mean length of age norms — intersection combiner

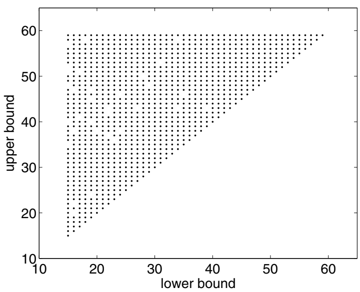

Fig. 9. Female age–at–marriage norms in the initial population

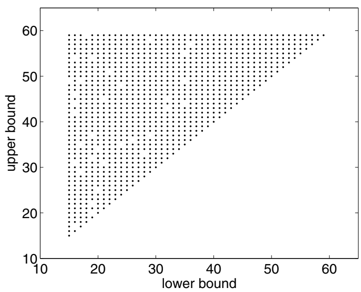

Fig. 10. Male age–at–marriage norms in the initial population

norms with a lower bound of 50 years or above disappear within the first 60 years, until all agents of the first generation with random norms are removed from the model (see Fig. 11). This phenomenon holds for all simulations and can be explained easily. A female agent who marries at the age of 50 or above isn't able to have offsprings because the age specific fertility rate above the age of 50 is zero. Thus, no child can be born who inherits an age norm with a female lower bound above 50.

Because of a very low age specific fertility rate for 45 to 49 year old women, the age norms with lower bounds in this range disappear over the next few years. The persistence of male age norms doesn't show the above behaviour since we did not take into account male (age–specific) fertility rates. For both sexes the norms in the upper left corner of the diagram vanish gradually. These are the norms with the largest length which disappear because of the intersection combiner. Within the next years the female norms keep converging towards the lower half of the diagonal and the male norms converge towards the whole diagonal, but in the long run also the male norms converge towards the lower half of the diagonal, simply because of the fact that younger men

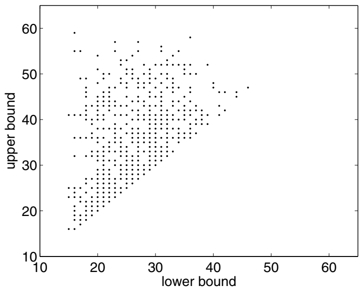

Fig. 11. Female age–at–marriage norms after 60 time steps

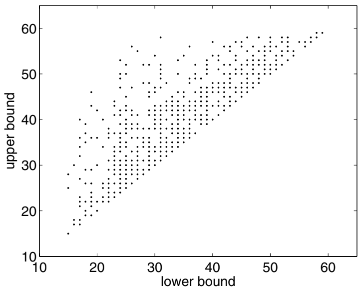

Fig. 12. Male age–at–marriage norms after 60 time steps

have more time to conceive more children to whom they can transmit their norms.

Although those norms along the diagonal have the shortest length of all, and therefore should remain, most of them also disappear. The dissolution of female norms with a higher lower age bound can be traced back to age specific fertility rates. Since in the simulation only married agents can give birth to children, those female agents who get married early have a longer time period for having children and are married during the time in their live with the highest age specific fertility rate. Consequently, these agents have higher chances to have children and pass their norms to the next generation. But there are some norms that died out to which this fact doesn't apply. In addition this phenomenon also occurs in Fig. 12 which shows the male age–at–marriage norms. The disappearance of these norms happens for some other reasons. Individuals who are characterised by such extremely short norms also have very little time to search for a partner. Especially an individual with an age norm at the diagonal is at marriageable age for only one year and his/her partner has to be at a specific age to be able to marry. This reduces the supply of potential partners enormously. Therefore, for those individuals the probability of remaining single is rather high due to the fact that even if there are enough individuals who are characterised by the same norm it is unlikely that they are also at a marriageable age at the same time. On this account also many of these short norms along the diagonal vanish. Finally there are just a handful of norms surviving which each account for a group of agents who are only allowed to marry among themselves (see Figs. 13 and 14). In [4] where the agent's age isn't included the norms converge toward the whole diagonal within a few generations.

Figure 15 illustrates the time development of the mean age at marriage. The dotted line represents one particular simulation run and the solid line shows the average over 10 simulations with the same set of numerical parameters. The mean age at marriage decreases to 18 years due to the fact that the norms surviving in the long run are clustered at the lower end of the diagonal.

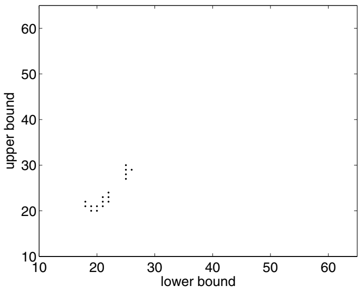

Fig. 13. Female age–at–marriage norms after 250 time steps

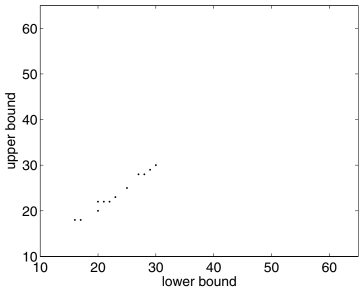

Fig. 14. Male age–at–marriage norms after 250 time steps

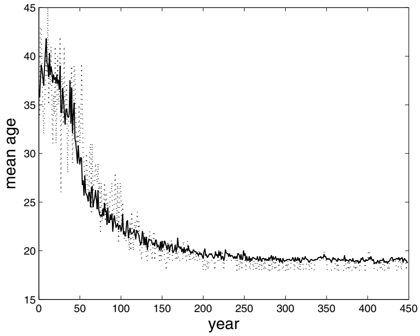

Fig. 15. Mean age–at–marriage within 450 time steps — intersection combiner

Union combiner

Using the parents' union as the children's age norm causes the converse effect of the intersection combiner. Creating a new age norm by using the union combiner sets the lower bound to the minimum of the parents' lower bounds and its upper bound to the maximum of its parent's upper bound. Compared to the intersection, the interval lengths have to be longer than, or at least as long as the parents' intervals. Therefore, the mean length of age–at–marriage norms increases quickly until it reaches the maximum possible length of 44 years (Fig. 16).

Once again we start with an initial population of 5000 agents with random parameters. Compared to the previous simulation, those with the largest interval length do not become fewer, but those norms with the smallest interval length do become fewer. The norms along the diagonal are barely represented by now, whereas the norms amass at the upper left corner representing the norms with the highest possible interval lengths. After 100 time steps there is clear evidence that the norms converge toward the maximum (Figs. 17 and 18). Age norms with very short interval lengths completely disappear. Al-

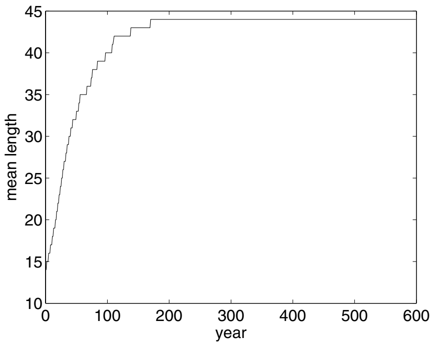

Fig. 16. Mean length of age norms — union combiner

though the female and male age–norms converge toward the same point their evolution is slightly different. The female norms are soon dominated by the lowest possible lower bound 15, whereas the male norms are dominated by the highest possible upper bound 59 (Figs. 19 and 20). This artefact is caused by the fact that male fertility rates are neglected. After 350 years only the norm with a lower bound of 15 years and an upper bound of 59 has survived, all other norms have disappeared completely. Each individual is characterised by the two age norms with the maximum interval length. This implies that every individual of marriageable age easily finds an acceptable partner. Because of an annual probability to get married above 35% an agent remains single on average for only two years. Therefore the mean age–at–marriage becomes 17 years (Fig. 21).

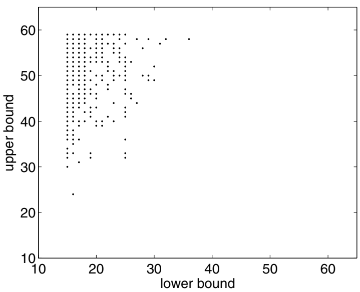

Fig. 17. Female age–at–marriage norms after 100 time steps

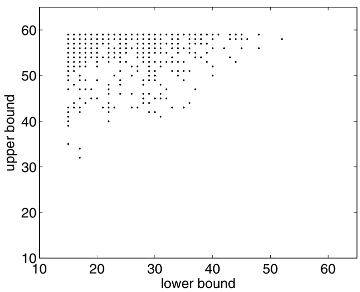

Fig. 18. Male age–at–marriage norms after 100 time steps

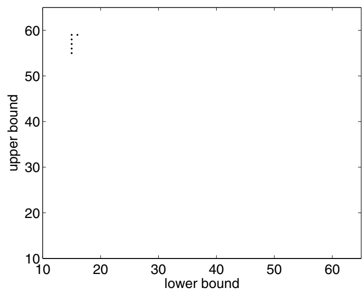

Fig. 19. Female age–at–marriage norms after 250 time steps

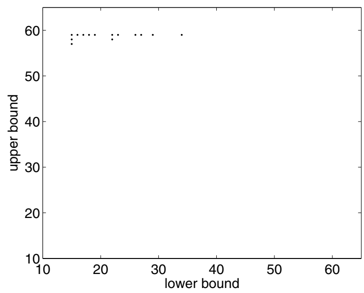

Fig. 20. Male age–at–marriage norms after 250 time steps

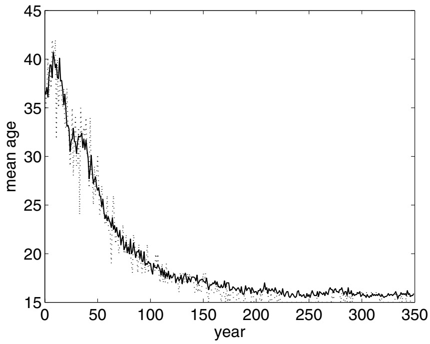

Fig. 21. Mean age–at–marriage within 350 years — union combiner

Random combiner

After investigating the effect of children inheriting their norms as an intersection or as a union of their parents' norms, we demonstrate the consequences of a norm consisting of age bounds applied by chance. Using what we call the random combiner each new born inherits one of its parents' lower bounds with the same probability. The upper bound is chosen the same way. This assignment of bounds doesn't offer the appearance of new bounds but it allows for new combinations of already existing boundaries. Thus age bounds that already got lost during the evolution of norms cannot reappear. Compared to the intersection and union combiner the random combiner allows for more possibilities regarding the norms of the children but not as many as the uniform combiner described in the next Sect. Therefore, the random combiner can be seen as in intermediate mechanism bridging the gap between the two very deterministic combiners and the very undeterministic uniform combiner. This transmission mechanism does not predetermine the change of the mean length. The interval length may increase, decrease, or remain constant as well.

At the beginning the interval length increases which is due to the disappearance of some female norms during the first few years. During the following years there are short term increases as well as short term decreases which is due to the extinction of several bounds but the mean length always levels off at average values since the remaining lower bounds are combined with several upper bounds. Therefore nearly as many norms with a large interval (e.g. persisting male norm with largest length: $(15, 59) \Rightarrow \text{length} = 44$) as norms with a short interval (e.g. shortest remaining male norm with a lower bound of 15: $(15, 21) \Rightarrow \text{length} = 6$) remain. Within this simulation the mean length of the age intervals converges towards 25 years (Fig. 22). Since the random combiner possesses the ability to behave in the same way as the intersection or the union combiner but may also create norms by any other combination of the parents norms, the dynamics of the mean length of age–norms is also somewhere between the results obtained from the two extreme transmission mechanisms.

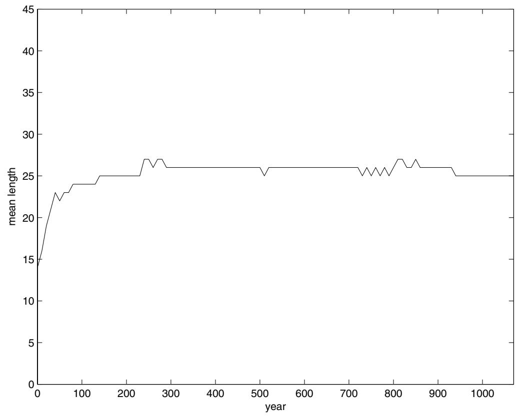

Fig. 22. Mean length of age–norms — random combiner

Already after a few simulation steps it can be seen that only the female norms in the left half of the diagram remain. It is obvious that norms consisting of a small lower age bound have a high chance to survive. But there are no upper bounds that are obviously superior to others. When looking at male norms there is also a clear trend to the left half of the diagram. However, the convergence happens much slower because the age–at–marriage of men does not have an immediate impact on the number of births. After 1050 time steps (more than twice the simulation time we used for intersection and union combiner) there is still no stable structure (Figs. 23 and 24). There are still numerous variations of possible age–at–marriage norms. Since the structure of norms within the population is not stable yet, the mean length of the age intervals can still change as well. Comparing Figs. 23 and 24 with the results obtained from the union combiner we can conclude that the variety in lower age limits gets reduced in both cases but the random combiner sustains a higher variety of upper age bounds than the union combiner.

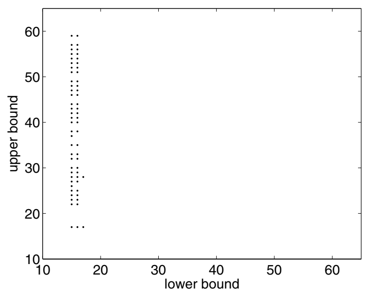

Fig. 23. Female age–at–marriage norms after 1050 time steps

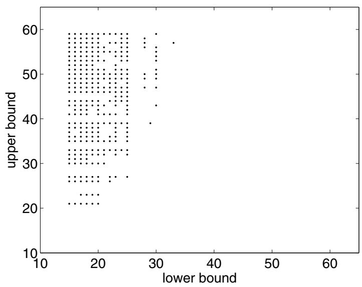

Fig. 24. Male age–at–marriage norms after 1050 time steps

Since the norms do not converge toward an equilibrium, the average value for the age–at–marriage does not converge either but fluctuates between 19 and 23 years in the long run (Fig. 25). The reason for these values is the mean lower bound of female norms of 17 years and the mean lower bound of male norms of 22 years. Due to the mean interval length of 25 years it follows from (1) with $pm_0 = 0.35$, $a - l = 1$ (annual step), and $u - l = 25$ that the probability for individuals to marry increases by $(1 - 0.35) * 1/25 = 2.6$ percentage points per year. Because of this increase most agents who find an appropriate partner do not remain single for more than one year.[11]

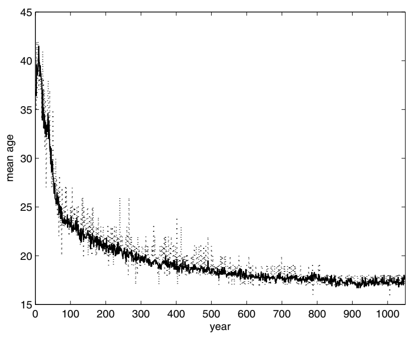

Fig. 25. Mean age–at–marriage within 1050 time steps — random combiner

[11] This does not mean that agents who find an appropriate partner but do not marry remain connected to that partner for future periods of the simulation.

Uniform combiner

In the following we will discuss the results obtained from simulation experiments based on the uniform transmission mechanism. Now the children may get any bound between the respective bounds of the parents. Therefore the mean length does not converge toward an extreme, but rather toward an intermediate value. In this case the value for the interval length is nine years as it can be seen in Fig. 26. During the first few decades, the mean length increases which is comparable to the increase of the intersections mean length in the beginning. Like in the previous simulations, some short female norms (those with a lower bound of 50 and above) disappear within the first 60 years, which causes the short increase of mean length at the beginning. From that moment the mean length decreases until it arrives at approximately 9 years. This shrinkage of interval lengths is due to the fact that children inherit bounds somewhere between the respective bounds of their parents, which results in a modest tendency towards shorter age intervals.

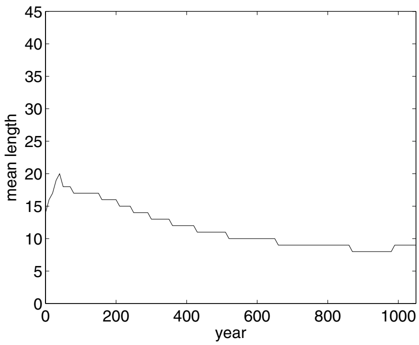

Fig. 26. Mean length of age norms — uniform combiner

The norm's evolution can be anticipated soon. It can be seen that the first norms to disappear are those that have survived in two of the previous experiments (Figs. 27 and 28): The norms which prove to be the strongest in the experiment with the union transmission mechanism are those in the upper left corner. The norms that survived in the intersection experiment are those with the shortest length, which are those along the diagonal. These two groups of norms are the first to die out.

Norms that are nearby a maximum value or a minimum value vanish. These boundary values disappear because they are likely to be paired with a partner with a value that is further away from that bound. Consequently their children are likely to inherit a shorter age interval. Female norms with higher lower limits disappear like in the other tests. However, it takes more than 1000 time steps until only three female norms and tree male norms remain. All

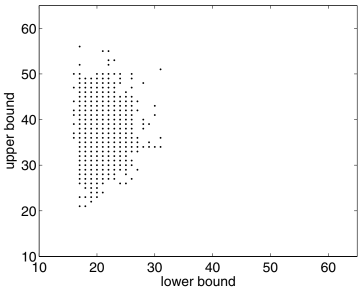

Fig. 27. Female age–at–marriage norms after 150 time steps

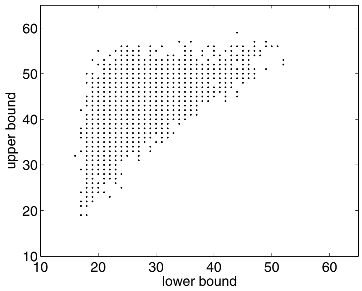

Fig. 28. Male age–at–marriage norms after 150 time steps

remaining female norms already have the same upper bound namely 28 years. The female lower bound varies from 19 years to 21 years (Fig. 29). The male lower bound is for all agents 28 years (like the female upper bound). The male upper bounds still varies from 38 years to 40 years (Fig. 30). These bounds are explained by the fact that 21 (female lower bound) is the mean value for the lower bound weighted by the age specific fertility rate and 28 (female upper bound) is the weighted mean value between 21 and 59. The bounds of the male norms are weighted with the remaining time for conceiving children. The according weighted averages for the male lower and upper bound are thus 28 and 38 years, respectively.

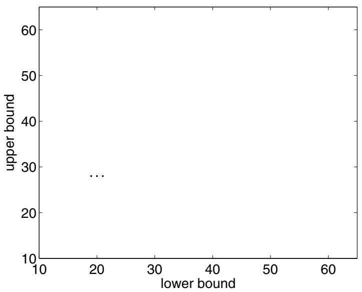

Fig. 29. Female age–at–marriage norms after 1050 time steps

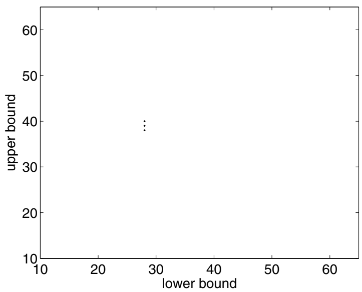

Fig. 30. Male age–at–marriage norms after 1050 time steps

Sooner or later there will be only one point left in each diagram representing the strongest norm. Women achieve their marriageable age between 19 years and 21 years while all men reach the marriageable age at 28. Thus the mean age at marriage among the whole population fluctuates between 23 and 25 years in the long run (Fig. 31).

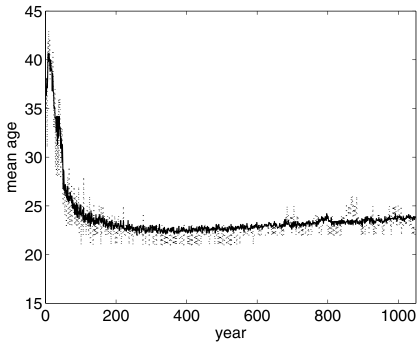

Fig. 31. Mean age–at–marriage within 1050 time steps — uniform combiner

Intersection and union

Now we will investigate a mixed population containing agents with the intersection combiner as well as agents with the union combiner. These are those two transmission mechanisms which result in extreme age norms when they are used in a homogenous population of agents. The union combiner, which results in the age norm in the upper left corner having a maximum mean length of 44 years is combined with the intersection combiner that results in an age norm along the diagonal with short interval lengths. The aim of this experiment is to investigate how the dynamics differ within a heterogenous population compared to the homogenous populations. Each initial agent is randomly assigned one transmission mechanism with the same probability (0.5 each). Newborn agents inherit the transmission mechanism from one of their parents.

At the beginning the mean length increases nonmonotonically. A little bit later it becomes monotonically increasing until it reaches the maximum possible value of 44 after only 200 years (see Fig. 32). The reason for the increasing length is that the union combiner (causing an increasing length) dominates the intersection combiner which causes a decreasing interval length. The union combiner is the stronger of the two because it allows for more acceptable partners for marriage, which results in a bigger number of couples who can hand down the union transmission mechanism. Only relatively few agents with the intersection combiner get married, and consequently fewer children with an inherited intersection transmission mechanism are born.

The union's predominance against the intersection is very strong. After only 100 years already more than 80 percent of all individuals are characterised by the union transmission and after 450 years the weaker combiner does not occur anymore in the population (Fig. 33).

Therefore the only norm that remains until the end of the simulation is the one with the lower bound at age 15 and the upper bound at age 59, which is the same that survived in case of a homogenous population of agents applying

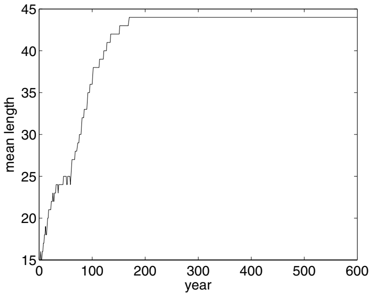

Fig. 32. Mean length of age norms — intersection and union combiner

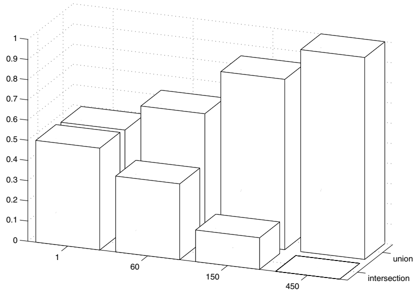

Fig. 33. Proportion of intersection and union combiner

the union combiner. Since the union transmission mechanism dominates the intersection mechanism, the mean age at marriage levels off at 17 years, which was the mean age at marriage in the simulation applying the union combiner.

Combination of all four transmission mechanisms

In this Sect. we have a look at the evolution of norms applying a combination of all four transmission mechanisms — intersection, union, random and uniform. Considering the combination of the four transmission mechanisms the changes of the mean length are comparable to those evolving from the combination of the intersection and the union combiner (Fig. 34). During the first 60 years the graph is monotonically increasing since all four transmission mechanisms cause an increasing mean length due to the disappearance of all female norms with a lower bound above 50 (which all have a short mean length). The following decades show a mean interval length that does no longer increase monotonically. The intersection and the uniform combiner cause some decreases in the short term but as their joint proportion constitutes less than 30 percent after 150 years, the influence of these mechanisms is rather small. Therefore the curve soon is monotonically increasing again and reaches the maximum possible length of 44 years after only 350 years when already 65 percent of all agents inherit their age norms as the union of their parents' intervals (Figs. 34 and 35).

It takes more than 1000 years until the union combiner dominates all the other combiners and only the norm with the longest possible interval remains. Because of the persisted age norm (15, 59) individuals are allowed to marry when they are at the age of 15. Most agents stay single for two years and get married at the age of 17.

By influencing the evolution of norms, the choice of the transmission mechanism also influences the mean length of the age interval, the number of married couples and singles of marriageable age and the mean age at marriage.

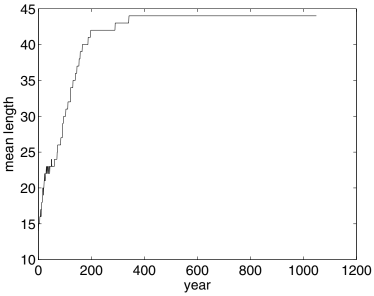

Fig. 34. Mean length applying all four transmission mechanisms

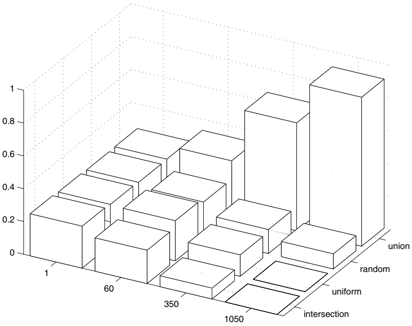

Fig. 35. Proportion of the transmission mechanisms

Table 2 shows the respective values. To make the data comparable, the proportion of married couples of all simulations are taken after 300 years[12].

Table 2. Comparison of the transmission mechanisms

	intersection	union	random	uniform
proportion of married couples (%)	29.6	36.0	30.8	29.9
mean length	1	44	25	9
mean age at marriage	18	17	19–23	23–24

This comparison explains the results of the two investigated combinations of transmission mechanisms. Individuals who are characterised by the union combiner find considerably more potential partners than those who are characterised by the intersection combiner because of the union's large interval length. Therefore, the union combiner dominates the simulations with heterogenous populations. The random transmission mechanism, which has the second largest interval length and thus the second largest proportion of couples, does also persists in a combination of all transmission mechanisms. The execution of different simulations showed that after 1050 years 10% to 25% of the agents are characterised by the random combiner. After the intersection combiner has died out also the uniform combiner disappears because its marriage rate is not that high as well. Since the union transmission technique is the strongest one that dominates all other mechanisms both simulated combinations finally lead to the age norm (15, 59) with an age interval of 44 years and a mean age at marriage of 17.

[12] The proportion of married couples was measured after 300 years since these midterm results illustrate the development of the distribution of the combiners within the population. The mean length of the age interval and the mean age at marriage were taken at the end of the simulation since we are interested in the long–term equilibrium.

Parameter variations

So far we have only been looking at simulations based on a set of numerical parameters which are kept constant over the whole time horizon. The purpose of these simulations is to understand how the different transmission mechanisms work and what is their impact on the appearance or dissolution of norms within the agent population. However, the empirical data discussed in Chap. 2 give evidence that in real societies norms and values are not constant over time (see Figs. 1 and 2). Consequently, we want to investigate whether our model is capable to replicate the observed dynamics. From the previous simulations we conclude that the uniform combiner results in medium size interval lengths which is of course the kind of dynamic behaviour which is most appropriate to approximate real world dynamics. Therefore, we set up a simulation model based on an agent population which is homogenous in terms of the uniform transmission mechanism. At the beginning we fix the parameter pm_0 equal to 35% and simulate 100 time steps to arrive at stable age–at–marriage norms. After that we modify pm_0 in ten year time steps such that $pm_0 = 35, 65, 95, 100, 55, 25, 5, 0$ at $t = 100, 110, \ldots, 170$. Fig. 36 reveals that — neglecting the fluctuations — in this setup the mean age at marriage decreases for some decades from around 24 to about 22 and later on increases to mean ages higher than at the beginning of the simulation. Looking at the age specific rate of marriage we see that the frequency of marriage among young agents increases between $t = 100$ and $t = 120$ but later on decreases to rather low levels (see Fig. 37). Thus, we can conclude that the time dynamics within the agent population are similar to those observed in the real world data discussed in Sect. 2. The pronounced fluctuability in the mean age at marriage in Fig. 36 is due to the rather low size of the agent population, $N = 2000$. Since real populations are much bigger, the curves in Fig. 1 are smoother.

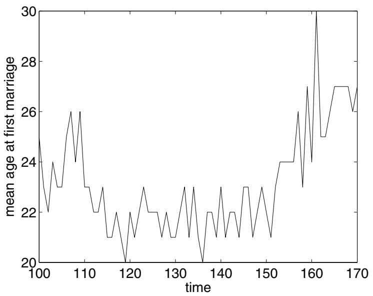

Fig. 36. Mean age at marriage

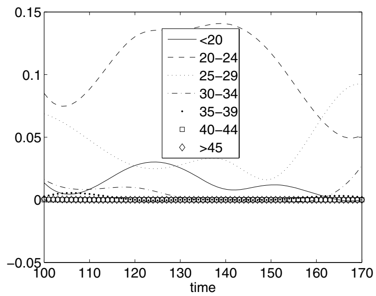

Fig. 37. Rate of marriage

7 Concluding Remarks

In this Chap. we investigated the impact of the design of the transmission mechanism on appearance, shifts, and extinction of social norms within an agent population. Moreover, we looked at the impact of these social norms on the age–at–marriage and on the age specific rates of marriage. In particular we explored the effect of four different transmission mechanisms — intersection, union, random, and uniform — on the dynamic behaviour of the social norms.

The first simulation considered the evolution of norms within a homogenous population of agents endowed with the intersection combiner resulting in a decreasing mean length of the age at marriage interval. The final interval length was 1 year. The age norms converged toward the diagonal and finally only a few age norms with a lower bound between 16 and 20 years and an upper bound of 18 to 20 years survived. Applying the union combiner caused an increasing mean length up to the maximum possible value of 44 years. Regarding age norms a convergence toward the upper left corner could be observed. The random combiner did not cause one isolated norm to survive but the variety of different bounds shrank. Some lower and some upper bounds vanished but the structure of norms within the population was still not stable after more than 1000 years. The interval length of the age norms varied. There was no clear increase or decrease. In case of the uniform combiner, the mean interval length leveled off to a narrow value. The number of age–at–marriage norms reduced until a single point (15,59) survived. But this process lasted considerably longer than it lasted using the intersection or the union combiner. In a heterogenous population of agents equipped with different transmission mechanisms the fraction of the population characterized by the union combiner increased until extinction of all other transmission mechanisms.

A simulation setup based on the uniform transmission alone combined with the variation of the parameter pm_0 determining the initial probability of getting married allowed us to approximate the time development of age–at–marriage and the age specific rate of marriage among birth cohorts observed in empirical data. It turned out that a temporary increase followed by a decrease of the initial probability to get married may be an explanation of the U–shaped curve indicating the mean age at first marriage in some European countries (see Fig. 1). Thus, such shifts in the initial probability of getting married may at least partially explain past trends in age–at–marriage. For instance, it is reasonable to assume that women born in the fourties considered marriage and childbearing as major priorities in their lifes while succeeding cohorts were more interested in getting a proper education and pursuing their professional career before marriage. Compared to the model investigated in [4] the extended model introduced in this Chap. proved to provide a significant step toward reality since the timing of union formation and childbearing is taken explicitely into account. Only with this explicit consideration of time and age it is possible to investigate the impact of social norms and parameter shifts on mean age at marriage and age specific marriage rates. Hence, the increased complexity of the model is needed to replicate the phenomena observed in empirical data.

Of course we are aware that social norms are not the only mechanism influencing individuals on their decision about getting married. There are several forces at work at the same time. For instance, the availability of appropriate mates, economic considerations, and attractiveness may influence the decision. However, the empirical studies summarized in Sect. 2 give evidence for the existence of such social norms and our simulation model shows clearly that the existence of social norms can generate a behaviour similar to empirical data. Taken together, these findings strongly support the assumption that age–at–marriage norms indeed have a major influence on the decision to get married.

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