Simulation Models of Partnership Choice and the Examination of Marital Homogamy

Walker, L.K. [1]

[1] Department of Statistics and Department of Sociology, The University of Auckland, Auckland
Email: lk.walker@auckland.ac.nz

Keywords: *Agent based simulation, partnership matching models, homogamy, intermarriage*

EXTENDED ABSTRACT

Simulation provides an effective means of observing the effects of complex social interactions and decision models. This paper examines an abstract simulation model of partnership choice and then extends the ideas into a proposed empirical simulation using New Zealand Census data.

The motivation behind these simulation models is to examine the impact of various decision rules and factors such as social norms on the homogamy (like with like) of the partnerships. In particular, the focus of the empirical simulation is on inter-ethnic cohabitation and the potential micro-macro linkages which may affect it.

Netlogo is used to examine how different decision rules affect the degree of marital homogamy for a randomly allocated hierarchical trait in an artificially generated population. The simulation programme allows the user to vary the distribution of the trait and add spatially constrained neighbourhoods in addition to testing the different decision rules for the level of attraction between the agents. The null model of random choice is compared to other decision models to see how the degree of homogamy varies. The effects of the different population distributions and constrained neighbourhoods are also examined.

The partnership models are coded in Netlogo to examine differences between "random", "most similar" and "highest level" choice models based on a randomly allocated hierarchical trait. In addition, the effect of the distribution of the trait amongst the population and the effect of limited agent sight are examined.

The agents examine the potential partners around them and allocate an attraction score based on one of the three choice models. At teach iteration the couple with the highest mutual attraction scores are partnered and then the process is repeated.

Two-way tables showing the frequencies of each combination of scores for the male trait and scores for the female trait are produced. The degree of homogamy of the partnerships can be observed by the number of couples seen on the diagonal of the table. The measure of homogamy is then formalised through the use of the Social Homogamy Index (Robbins, 1981).

Treating the random attraction as a baseline, the choice models where agents are attracted to the agent of the opposite sex with the most similar trait score and the choice model of being attracted to the agent of the opposite sex with the highest trait score both generated tables with a higher degree of homogamy.

These differences are further emphasised by constraining the sight of the agents to limited "neighbourhoods". This means that agents get to evaluate a more limited pool of potential partners and are more likely to be constrained into what would have formerly been a sub-optimal partner choice.

Varying the distribution of the trait in the population altered the marginal distribution of scores for the agents but did not have a strong effect on the homogamy of the tables.

Having observed the operation of a simple abstract model, a model of partnership choice using the New Zealand Census is discussed. The implications of the behaviour of the abstract simulation models are discussed with respect to the proposed empirical application.

The key findings of the simulations, with regards to the proposed Census based simulation are the importance of the decision rules and the strong effect of regional variation on partnering patterns and in particular the observed proclivity of agents to partner in a homogamous manner.

1. INTRODUCTION

Social simulation is a different paradigm from many other forms of simulation. Although it can be used for prediction, the main focus of the technique is to capture the underlying social processes by which social phenomena are occurring rather than simply reflecting the transition probabilities of the various states of the model (Gilbert & Troitzsch, 2005).

The aim of this paper is to take the initial steps to integrate the relevant social theory of intermarriage and partnership choice into abstract simulation models of partnering, with the ultimate goal of transferring the ideas into an empirical simulation based on New Zealand Census data. The focus of the work will be on partnership homogamy (like partnering with like) and how this changes over time, with attention paid to relevant social theory, rather than just relying simply on tables of probabilities.

Early work in the area saw Merton (1941) state that social norms affect the degree and type of social contact one has with other groups, whether it be race, religion or class and "non-normative conditions" will affect the proportions of intermarriage. In simplistic terms, the concept is that one is more likely to marry/cohabit with those who are similar since their social network is more likely to be made up of people such as themselves.

This idea was echoed by Parsons (1954) who discussed the idea of "occupational hierarchy" and affluence as factors that influenced the structure of an individuals social network and their subsequent partnership choices.

The release of Inequality and Heterogeneity: A primitive theory of social structure (Blau, 1977), reignited interest in the area of homogamy and partnership choice. In particular, Blau introduced a new macro-sociological theory of social structure which discussed how the demographic make up of an individual's social network would place constraints on who they were actually able to choose as a partner, irrelevant of what their personal preferences were. These social constraints of the decision marking process in partnership choice form an important part of how partnership formations could be modelled and provide a crucial link between the micro and macro effects that take place.

Despite the flexibility of simulation, partnership matching tends only form a small part of larger demographic simulations (van Imhoff & Post, 1998). The choice of partner is often determined from a fixed set of life table probabilities with little contemplation for the processes underlying the matching of partners or for the various sociological theories regarding the area.

Simulation models that aim to extend themselves beyond the life table styled models often use regression based methods instead. Bouffard *et.al.* (2001) compared the standard life table method with an alternative stochastic algorithm which was based on a logistic regression using the age differences of the potential partners and economic factors to find better matches. Validation testing demonstrated that the stochastic algorithm provided better predictions against American census data than the fixed probability method, although they also note that further improvements could be made, particularly with regards to dividing the broader marriage market into sub-markets to improve the accuracy of the matches.

Similar findings were seen by Perese (2002), who also applied logistic regression to marriage matching within a microsimulation model and was able to replicate similar joint distributions of spousal age differences, education and earnings to collected survey data using the American Congressional Office's Long Term (CBOLT) microsimulation model.

An alternative paradigm using abstract simulation rather than regressed census data is examined by Chen (2005), where agents use various search algorithms to find a partner. The methods were considered in terms of the proportion of couples who were successfully matched and the cost of the searching. These included choice models based on potential partners being "the best only", "well-rounded" or "compensatory".

This paper aims to build on the ideas introduced by Chen (2005) and the with an abstract simulation of partnership choice, comparing the effect of choice algorithms, population distributions and constraining the sight of the agents. In addition to presenting and discussing the results of these simulations, it will discuss their relevance to a proposed empirical simulation using Census data.

2. METHOD

The Netlogo simulation programme (see http://ccl.northwestern.edu/netlogo) is used to examine partnership homogamy. It builds on a marriage simulation model demonstrated at the Stanford University Workshop in Formal Demography 2006 (see http://cgi.stanford.edu/dept/anthsci/cgi-bin/rlab/doku.php?id=lab:exercises).

2.1. Partnership Simulation Model

The partnership simulation examines a randomly assigned generic hierarchical trait. This trait could represent any hierarchical trait, for example education level or income. A score for this trait is assigned to every agent in the simulation based on the distribution shape specified in the parameters. For the purpose of this simulation, the trait is assigned as a score between 0 and 4.

The simulation programme is detailed in Figure 1.

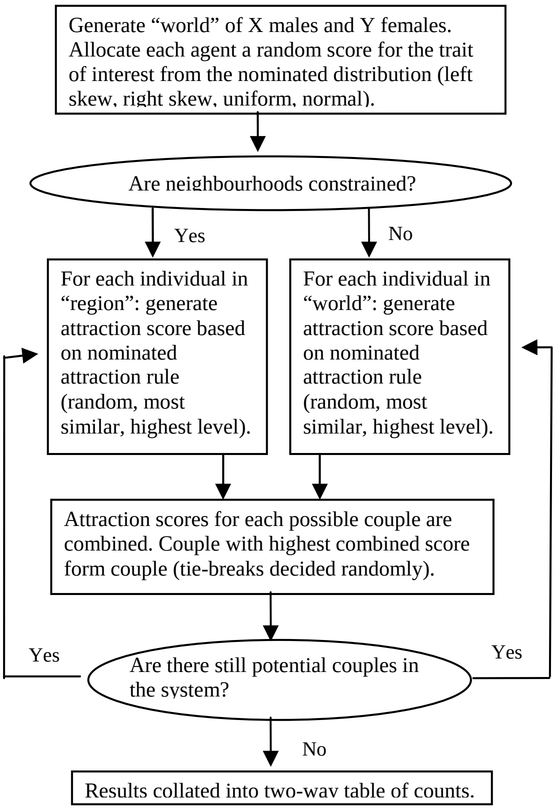

Figure 1. Partnership simulation algorithm.

At each iteration, each individual in the population examines the trait score of each potential partner in their field of vision (neighbourhood or world) and then allocates them an attraction score based on the attraction method which has been selected.

For this exercise, the method of attraction and the scoring were done identically for each individual. The pair with the highest mutual attraction is then partnered (with tie-breaks allocated randomly) and the simulation repeats, continuing until there are no possible pairs remaining. For a simulation with no constraining neighbourhoods, this will mean that every individual is partnered. If the agents only have a limited range of sight then some may remain single due to the inability to see a single potential mate.

2.2. Simulation Parameters

Table 1. Adjustable simulation parameters.

Parameter	Options
Neighbourhood (agents can see all or only near neighbours)	On/Off
Attraction	Random Most Similar Highest Level
Distribution of trait scores	Uniform Left skew Right skew Normal
Size of neighbourhood	1-10 units

Table 1 shows the adjustable parameters of the simulation model.

The main parameters of interest are the effects of constrained neighbourhoods, choice mechanisms for attraction and distribution of the trait scores.

The neighbourhood variable controls whether the agents in the model can see the levels of all other agents or only the agents that are within a certain distance (i.e. within their neighbourhood). The size of the neighbourhood can also be adjusted although this will tend to amplify any effect of neighbourhood rather than have an effect of its own.

The choice mechanisms by which attraction is scored can be allocated randomly, based on attraction to another agent with the most similar level or based on attraction to the agent with the highest level. The random attraction can be considered a baseline to compare the other two methods against.

Finally, various possible distributions of the trait: left skew, right skew, uniform, normal; are each trialled to examine any differences that these may have to the way in which the couples are matched and whether there is an impact on the degree of homogamy.

2.3. Simulation Runs

One thousand iterations of the simulation were run for each combination of the parameters using a population of fifty males and fifty females and the data collected into cross-tabulations of the frequencies for the male trait scores and the female scores of all of the matched couples. Although the differences in homogamy can generally be seen by examining the tables and observing the proportion of frequencies on the diagonal, the social homogamy index provides a more formal way of measuring the homogamy of the tables.

2.4. Social Homogamy Index

Romney (1971) introduced the idea of trying to measure the degree of subgroup endogamy in a population of finite size, with a focus cross tabulations of marriage data. He examined hypothetical cases of intermarriage and examined the ratios of the row and column totals to the cell counts.

Romney's model was adapted by Robbins (1981) to incorporate distance into the measure of homogamy. Robbins' measure of social homogamy provides an index number (*H*) between 0 (minimum homogamy) and 1 (maximum homogamy) by computing the ratio of the current level of homogamy to the possible extremes given the marginal totals for each category. It is calculated as:

$$H = 1 - \frac{H_{\max} - H_0}{H_{\max} - H_{\min}}, \tag{1}$$

3. RESULTS

With three attraction mechanisms, four different trait distributions and the option of constrained neighbourhoods, there are twenty four different combinations of the parameters of interest. Due to space constraints, only the more significant comparisons are provided in table form.

3.1. Constrained Neighbourhoods

The initial comparison is between limited and unlimited neighbourhood simulations. Table 2 shows the results from two simulations where all of the agents were created from a population where the levels were uniformly distributed and the same method of attraction but in one the agents were constrained by having a "neighbourhood" that they cannot see beyond.

Visually, the degree of homogamy can be seen by the relative size of the frequencies on or near the diagonal. This is reinforced by the Social Homogamy Index value. Comparing the limited and unlimited neighbourhoods, it is clear that the constraint of a limited neighbourhood forces agents into sub-optimal choices. This pattern is most noticeable with the "highest level" method of attraction. The other key element of this comparison is that when the agents face constrained neighbourhoods some are left without a partner as they are not able to see a potential partner within their limited neighbourhood.

Table 2. Partnership frequencies to compare partnerships taking place with and without constrained neighbourhoods.

Limited Neighbourhood: Homogamy Index 0.635

Male Partner Scores	Female Partner Scores: 0	1	2	3	4	Total
0	2512	2071	1145	481	115	6324
1	2132	2574	2159	1041	384	8290
2	1150	2144	2706	2283	986	9269
3	451	1137	2149	3208	2678	9623
4	104	335	1013	2709	5855	10016
	6349	8261	9172	9722	10018	43522

Unlimited Neighbourhood: Homogamy Index 0.887

Male Partner Scores	Female Partner Scores: 0	1	2	3	4	Total
0	8260	1538	22			9820
1	1711	6417	1779	24		9931
2	15	1984	6172	1816	10	9997
3		28	1938	6675	1510	10151
4			14	1564	8523	10101
Total	9986	9967	9925	10079	10043	50000

Decreasing the size of the neighbourhood that agents could see amplified the effect of the having a neighbourhood, creating less homogamy as agents had less suitable partnering options from the reduced space.

In terms of future simulations and also for further comparisons in this paper, the inclusion of constrained neighbourhoods seems like an intuitive decision. As a result, further comparisons are made based only on models with constrained neighbourhoods.

3.2. Comparison of Attraction Mechanisms

Table 3 shows the comparisons between each of the attraction mechanisms using constrained neighbourhoods and a uniform distribution of trait scores. Random attraction, where each level of the trait is equally desirable, can be considered a baseline. As expected, the random attraction method resulted in an even distribution of frequencies across every combination of trait levels.

The marginal totals for the attracted to the "highest level" show how this method generated a push

Table 3. Partnership frequencies to compare partnerships under each of the attraction mechanisms.

Random Attraction: Homogamy Index 0.335

Male Partner Scores	Female Partner Scores 0	1	2	3	4	Total
0	1791	1705	1730	1791	1770	8787
1	1726	1670	1826	1792	1740	8754
2	1679	1674	1732	1687	1780	8552
3	1665	1697	1670	1669	1694	8395
4	1727	1739	1765	1785	1724	8740
Total	8588	8485	8723	8724	8708	43228

Attracted To Highest Level: Homogamy Index 0.635

Male Partner Scores	Female Partner Scores 0	1	2	3	4	Total
0	2512	2071	1145	481	115	6324
1	2132	2574	2159	1041	384	8290
2	1150	2144	2706	2283	986	9269
3	451	1137	2149	3208	2678	9623
4	104	335	1013	2709	5855	10016
Total	6349	8261	9172	9722	10018	43522

Attracted To Most Similar Level: Homogamy Index 0.796

Male Partner Scores	Female Partner Scores 0	1	2	3	4	Total
0	5744	1143	429	301	354	7971
1	1221	5826	1021	352	331	8751
2	470	1054	5891	1033	445	8893
3	350	358	1020	5649	1181	8558
4	333	333	453	1171	5966	8256
Total	8118	8714	8814	8506	8277	42429

towards the higher trait scores, resulting in more of the agents who remained single at the end of the simulation to be in the lower groups.

The “most similar” and “attracted to highest level” methods of attraction both generated considerably more homogamy than random attraction. This can be observed by a greater proportion of the frequencies on or near the diagonal of the table. The social homogamy index scores reinforce this, with the “most similar” method (0.796) having a higher homogamy index value than the “attracted to highest level” method (0.635).

Within each method of attraction, the different population distributions of trait level resulted in only small changes in the homogamy index.

3.3. Comparison of Trait Distributions

Four different distributions were trialled for generating the trait scores: left skewed, right skewed, uniform and normal.

The cross-tabulations for each of these distributions created marginal distributions for the frequencies of the male trait scores and the female trait scores which resembled the original distributions. For example, the right skewed distribution generated a greater number of low trait scores for the males and females and fewer high trait scores.

The homogamy index values for each tended to be fairly consistent (see Table 4 for the homogamy index scores using the “most similar” attraction mechanism) across each of the methods of scoring attraction. In part, this could be due to fact that same distribution was used for the male scores and female scores for each simulation.

Table 4. Comparison of trait distributions for the "most similar" attraction method.

Attraction method	Neighbourhood	Population	Homogamy Index
Most Similar	Limited	Right Skew	0.831
Most Similar	Limited	Left Skew	0.796
Most Similar	Limited	Uniform	0.796
Most Similar	Limited	Normal	0.730

4. DISCUSSION

Given the simplicity of the Netlogo models, the findings from them are generally as one would expect. They do provide a good starting point for an empirical simulation using unit level data from the New Zealand Census.

This proposed simulation will focus on inter-ethnic homogamy rather than a generic trait; examining the rate of homogamy of ethnicity for cohabiting (married or living together in a de-facto partnership) couples over the period 1981 to 2001 and trying to simulate the underlying social processes that were driving these rates. Although the decision rules will in part be empirically based, consideration of the findings of the Netlogo simulation will also be incorporated and expanded upon.

The simulations with constrained neighbourhoods found that when agents had limited sight, a great amount of satisficing behaviour took place since agents had access to few possible partners. This also resulted in some agents remaining single due to a lack of possible partners in their field of vision. The key implication of this to the proposed empirical simulation is the need to capture regional variations and constraints within the model. For example, simulated agents living at one end of the country would be very unlikely to partner with agents living at the other end of the country.

The Netlogo simulations showed that the way in which attraction and choice mechanisms are modelled can have a considerable impact on the proportion of homogamous partnerships. A form of the random attraction model will remain the baseline model. It will contain some non-ethnicity based variables to see whether the patterns in inter-ethnic partnership can be captured without the use of ethnicity variables. Ethnicity variables based on the "most similar" and "highest ranked" attraction methods will then be tested.

The distribution of traits did not have a strong effect on the levels of homogamy. In an empirical simulation this becomes less relevant as the distributions become observed variables rather than controllable ones.

The key extension of the empirical simulation model, beyond what is seen in the Netlogo simulation is the inclusion of a feedback loop, where agent behaviour at a given time step will be based on the actions of the agents in the previous time step. This will model the sociological aspect of the micro-macro link on top of the decision models demonstrated in this paper.

5. CONCLUSION

Abstract simulation models of partnership choice were run in Netlogo and cross-tabulations of male and female partnership choice were produced with respect to a generic hierarchical trait. The effect of three attraction methods: random attraction, "attracted to most similar" and "attracted to highest" were compared, together with the effect of constrained neighbourhoods and the distribution of the trait in question.

The "attracted to most similar" method generated tables with the greatest degree of homogamy, as measured by the Social Homogamy Index, followed by the "attracted to highest level". The distribution of the trait altered the marginal distributions across the trait scores but had little impact on the homogamy of the table. Reducing the sight of the agents into "constrained neighbourhoods" generated tables with less homogamy as agents were restricted to fewer options.

Applying these findings to a proposed Census based simulation indicates the importance of the decision rules and the strong effect of regional variation on partnering patterns.

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