Dynamic Attitudes about Motherhood: Modeling Family Planning Policies in Japan

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Abstract. As concerns about overpopulation begin to grow worldwide, policymakers in Japan struggle to find workable solutions for the opposite problem: encouraging population growth. While many studies have suggested that fertility rates are related to education and income, few models have incorporated methods for capturing the individual women's choices. Using an agent-based model (ABM), this study explores how changes in attitude might be transmitted through a population of women to affect the overall perception of motherhood. Perceptions of motherhood are adjusted dynamically through input from women within a social network. This model serves as an argument for the benefits of adding gender sensitivity into the family planning policies enacted by government officials distantly removed from the individual behavior.

Keywords: Agent Based Modeling, attitudes, Japan, fertility, population crisis.

1 Introduction

Many developed countries have undergone some sort of decline in population growth. For the majority of countries that have experienced reduction in fertility levels, even those that dip below sustainable rates, recent studies have shown that this decline is temporary and will eventually reverse itself [1-3]. Japan and Korea, however, have not experienced a turn-around of their respective post-industrialization fertility decline. In population forecasting studies, Japan appears to be a relatively unique case of uncontrolled population decline [4], suggesting that some aspect of its population crisis is culturally rooted [5].

Japan's population growth has been slowing since post-WWII to the point of reaching unsustainable rates in recent years [6]. Being home to some of the longest human lifespans on the planet, policymakers are deeply concerned that if higher fertility rates cannot be achieved, there will no longer be enough youth to economically support the large population of retirees [7]. By 2005, Japan had already reached zero population growth and begun to move in a negative direction [8]. By 2009, there were 7.64 births compared with 9.54 deaths per 1,000 people [9]. This population decline has resulted mainly from fertility rates dropping to 1.21 children born per woman [9] compared with the sustainable rate of 2.08 [8].

In order to head-off future problems, particularly anticipated economic problems, that will arise if the population continues to decline, policy makers and corporations alike have begun making changes to incentivize larger family sizes [9-10]. While important strides have been made, it is apparent that they have been largely unsuccessful. Contrary to the opinion of most policymakers, it is not a logical conclusion that enforcing macro-level policies will have any effect on micro-level behaviors related to fertility choices. Rather than exploring macro level policies and then looking at the effects on the population as a whole, this model explores micro-level, individual behaviors in order to determine factors that influence fertility change in the Japanese population. By incorporating micro level choices, this approach allows one to more carefully consider the missing factor in many macro-level policies, namely, what is important to the women who make choices about their own fertility.

2 Capturing Fertility Choices

2.1 Why Agent Based Modeling?

While exploration of topics regarding population dynamics have been traditionally left to demographers, observing population decline through a feminist lens provides good reason to approach the problem using the tools of Agent Based Modeling (ABM). Feminism encourages the researcher to consider the individual experiences and agency, or ability to affect one's circumstances, in order to examine larger social phenomena. While feminists often achieve this through examination of personal narratives, ABM allows one to program heterogeneous decision criteria of individual agents and grow the population from the bottom up. Attempting to explain macro-level fertility rates by generating a simulated population that considers individual women's choices allows for a dynamic exploration of population decline.

When considering population dynamics, it is difficult to deny that women's agency plays an enormous role in determining macro-level outcomes. In ABM, this is captured by designing female agents in the model to be both heterogeneous in their opinions about whether to have children or not, as well as autonomous in their decision calculus about marriage and when to have children. Agents interact with others in a bounded space and make decisions based on their own individual preferences. Nonlinear behavior, such as women's fertility choices, cannot be effectively captured using traditional statistical methods [11]. The problem of addressing Japan's declining fertility rate is not simply a matter of predicting *that* the population is getting smaller, but addressing *why*, which inherently rests on individual choices that cause macro-level consequences. Only by addressing the actual agency of women involved in Japan's population crisis can one begin to experiment with policies that might help turn the problem around.

From a policymaker standpoint, there are practical reasons for pursuing an ABM in addition to traditional statistical methods. First, there is an aspect of urgency in Japan's population problem in that some speculate it will result in economic crisis. Rather than conducting an entirely new census every year to determine if policies are working, simulated populations provide a timely way to experiment with different policy implications without requiring large and costly sampling. Second, performing experiments on the population, such as allowing some to have government assistance to encourage childbirth and not others leads to ethical dilemmas. Using an ABM, experimenting on a simulated population relieves the ethical burden of unfair treatment of certain portions of the population. Finally, the interactive nature of ABM allows the researcher to dynamically explore solutions to the problem he or she may not have considered before. In Japan's case, due to the urgent nature of the population crisis, experimenting with all possible policy options through ABM could serve a valuable role in determining future plans.

2.2 Model Development

Much of the disconnect between policies aimed at increasing national fertility rates and women's actual preferences is derived from policymakers' reliance on traditional gender roles to mend Japan's future. Often, policymakers have expressed the belief that the best way to increase fertility is to discourage women from working [12]. In general, policies intended to influence fertility rates lack enforceability and have been largely ineffective [13]. Studies have shown, in fact, that culturally enforced glass ceilings have been met with the modern Japanese woman struggling longer and harder to get ahead rather than giving up and going home to have more babies [14]. In the process of battling career limitations, these women instead delay marriage and childbirth leaving a smaller window in which fertility is biologically possible. Despite policymakers' reluctance to appropriately address women's choices in the matter of population growth, a workable solution must involve the possibility of supporting women who wish to work *and* have children [15].

Three separate variables were incorporated into the model to capture women's agency in fertility choices. First, the WorkingMom variable addresses the proportion of women who choose to work even if they have children. The model interface allows the researcher to adjust this variable accordingly from 0 to 100 percent in order to assess the effects of the "working mother" gaining popularity as a lifestyle choice. While this variable does not explicitly lend itself to policy solutions, it allows one to consider how certain trends associated with modernization, such as the financial necessity of mothers pursuing careers, will affect fertility rates. Presently, more and more women are choosing to delay traditional responsibilities such as marriage and childbirth in favor of career mobility and pursuit of hobbies [16]. As more women pursue a life of luxury and financial independence during their youth, it becomes increasingly socially acceptable to leave traditional commitments for later in life [9]. Accordingly, a second variable representing women's desire to get married, again ranging from 0 to 100 percent, reflects this changing trend in Japan regarding traditional lifestyle choices. Likewise, the third variable represents women's opinions about whether she wishes to have children, ranging from never (-1) to definitely (1). As discussed later, the opinion variable adjusts dynamically within the model to reflect women interacting with other women both inside and outside her social network.

Several other aspects were incorporated into the model to reflect real-world decision criteria that women would consider when deciding when and how many children to have. One important limiting factor is the costs of raising children and living in Japan. Ranked among the highest cost of living in the world [17], some researchers point to the need for the Japanese government to drastically increase spending in order to alleviate the costs of raising children, thereby incentivizing parenthood [18]. Within the model, there are three variables that attempt to capture cost of living in the agents' decision calculus. First, there is a specific "cost of living" variable that can be adjusted through the user interface. Second, an adjustable level of government subsidies is incorporated to reflect monetary incentives to have children; these subsidies are granted per child for all children less than 18 years of age. Third, two separate tax rates are coded into the model: one for parents and one for non-parents. This tax incentive can be viewed as a motivator for parents to have children in order to receive the tax break. For this particular model, these three aspects were the only form of financial incentives implemented.

Factors such as women's age and education level have also been indicated in many population studies as important in determining fertility rates [19-20]. Accordingly all agents in the model are seeded with ages to reflect Japan's current age distribution. Fertility choices within the model are restricted based primarily on the woman's age (between 16 and 45), though men do not have children before the age of 18. Reflective of Japan's current demographics where divorce is relatively rare, agents only pursue children if they are married and, once married, agents do not divorce. Based on a study by Shirahase, education level was not incorporated into the model as this was not seen as a major contributing factor to fertility decline in Japan's case [19]. Her study concluded that women's ages at marriage and childbirth are the predominant factors; therefore, only age was utilized in the model. Age factors into this ABM through the women's decision calculus about whether to marry and when to have children.

2.3 Attitude Adjustments

Based on the work of Wander Jager and Frederic Amblard, consideration for women's opinions was added to this model in order to better address women's agency [21]. Much like the agents in Jager and Amblard's model, female agents in this ABM have opinions ranging from -1, never want to have children, to 1, definitely want to have children. Each female agent is randomly coded with her individual threshold of acceptance, whereby, if she encounters another agent whose opinion is within this threshold, she will adjust her opinion to move closer to that acquaintance. Each female agent also has a randomly selected individual threshold at which she would reject the opinion of an acquaintance and move her own opinion in the opposite direction. Each time a female agent encounters another female agent within the model, each will update their opinions based on these thresholds for rejection and acceptance. As demonstrated by Jager and Amblard, groups of likeminded women begin to emerge in this model, namely those at each end of the spectrum regarding whether to have a child or not.

In order to reflect social networks that might serve to mitigate how a woman adjusts her opinions based on acquaintances, each female agent has a link to at most five other female agents within the model. These women represent those in her life on whose opinion she might base her own. During each interaction with an acquaintance, the female agent "considers" the opinions of those in her network by weighting her adjustment based her network's average opinion. At present, this is a simplified method of incorporating women's decision criteria into the model and will be further developed in future models.

3 The Model

As can be expected of any forecasts of the future, there is an ongoing debate as to whether Japan's population decline will actually lead to economic collapse [22]. If it is indeed leading in that direction, it is also debatable whether Japan has already passed the point of no return and no amount of family planning policies can turn it around [7]. For the purposes of this study, it is assumed that the fertility decline will have a negative impact and therefore needs to be urgently addressed, but that the tipping point has not been passed and some combination of family planning policies could possibly change this collision course to economic disaster.

This model was implemented using the NetLogo software both because of its simple, natural coding style as well as its user-friendly interface [23]. Coded into the model were both male and female agents at equal proportions and seeded with ages and salaries based on sex [24]. An initial set of agents are selected to be "married" before the simulation begins, as well as seeded with a certain number of (hypothetical) children. Additionally, women are randomly assigned a value to determine if they will be working mothers or not. Agents wander around the bounded space, perhaps representing a small geographic area, and look for suitable mates based on very simple decision criteria. Each tick in the model represents a year for the agents. The simulation automatically stops if the population reaches zero or if 300 years have passed. In the case of this model, unfortunately, the population always crashes.

Corresponding to each tick, the agents age one year in the simulation. Based on their status, such as marital status, woman's age, and combined income, females determine whether or not to have a child. To find a suitable mate, female agents, after reaching the age of 16, consider men within a certain radius and "marry" based on a random probability. Only after marriage will a female agent begin to have children and, as mentioned earlier, once married agents do not divorce. In the event that a female agent's "husband" dies, she becomes a widow and can marry again.

After marriage, couples determine if they want to have children first based on the female agent's age. If she is within her biological fertility range (in this case between 16 and 45), and her opinion about whether to have children is above the "opinion-threshold" (set in the user-interface), the couple then calculates their combined disposable income (after deducting taxes, cost of living, and cost of raising existing children) in order to determine if there is enough left over to financially support another child. If this is the case, then the female agent will "give birth" to another agent with equal probabilities male and female. This calculation does rest on the assumption that, given sufficient disposable income and a tolerable threshold for opinions about fertility choices, that females would have more children. After having a child, a "biological clock" timer is automatically set that will not allow the woman

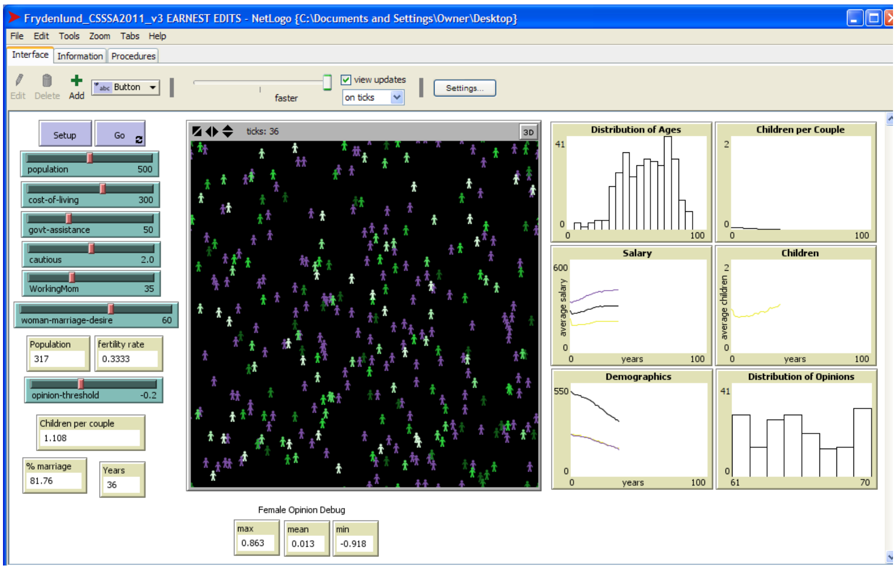

Figure 1: NetLogo Graphical User Interface

to have another child for an entire year. Though not all actual children are spaced one year apart, this biological clock keeps rich, older agents from overzealously reproducing.

The graphical interface (Figure 1: NetLogo Graphical User Interface) allows for the researcher to control certain aspects of the model's starting conditions. First, population can be adjusted anywhere from 0 to 1,000. In general, the model runs extremely slowly for populations over 500. Cost of living, represented in 10,000 yen can be set anywhere from 0 to 500. In Japan, the average cost of living for a family of two or more people would be the equivalent of 300 in the model [25]. Adjusting this sliding variable might give researchers an idea about what types of assistance would be necessary to evoke increased fertility. In part because tax breaks are given only to those who have already born children, giving some kind of incentive to lower the cost of living might help a couple save money and therefore proactively incentivize higher fertility rates. The government assistance variable, adjustable from 0 to 150, looks at incentives for parents after a child has already been born. The cautious variable allows one to compensate for cultural factors that might influence fertility choices. Cautious marks how much financial cushion a family requires before having another child. If Cautious is set to 2, then parents will not have another child until their disposable income is twice the cost of raising another child. The working mom variable can be adjusted from the interface to determine what percentage of women will choose to work while raising children; the woman-marriage-desire allows one to adjust the percentage of women who will want to marry at all. Note, for future models, this variable may be converted into a randomly seeded attitude variable as well that changes dynamically within the model.

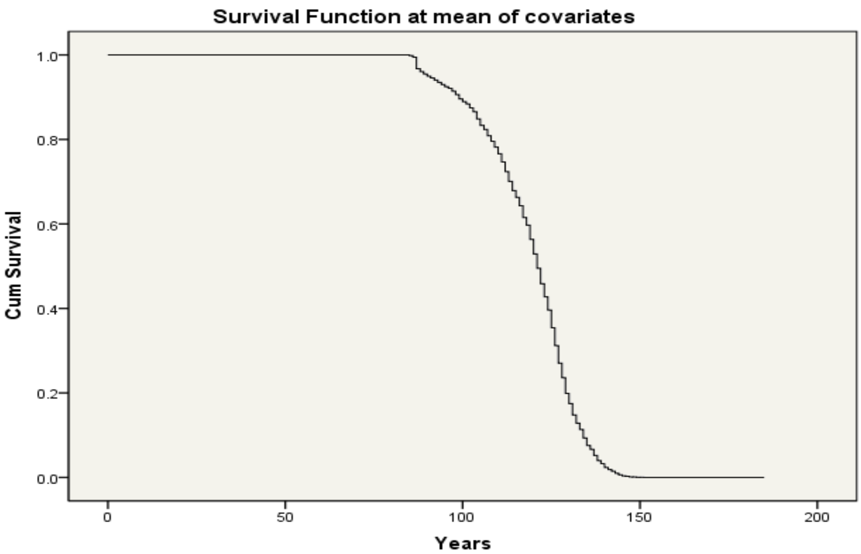

Figure 2: Survival Function for Final Model

4 Analysis

Various levels of each variable were explored using the BehaviorSpace feature of NetLogo, which implements a factorial design. It is important to note that in the best case scenario, the population lasted only 185 years before crashing; in the worst case, the population crashed after just 85 years. On average, the model ran without extinction for about 120 years. In general, after about 90 years, the probability of the population surviving begins to drop precipitously (see Figure 2). Due to computational time constraints, the model was fixed at a population of 500 and only two repetitions were run for each combination of values for each variable. The following levels of each variable were explored:

- Cautious [1, 2, 3]
- Opinion-Threshold [-.75, -.25, 0, .25, -.75]
- WorkingMom [30, 60, 90]
- Govt-Assistance [75, 100, 125]
- Cost-of-Living [100, 300, 500]
- Woman-marriage-desire [10, 50, 90]

At two runs per combination, the model was run 1,944 times and required 19 hours of simulation time.

Because the model always led to extinction, a Cox Proportional Hazard Model was utilized through the statistical package SPSS to evaluate the time to reach the population crash. Only first order effects were explored as second order effects become difficult to interpret into policy decisions. A backward stepwise procedure was used to first assess all factors in the model and eliminate variables at each step

Table 1: Final Step of Model Selection Procedure

	B	SE	Wald	Df	Sig.	Exp(B)
OpinionThreshold	2.658	0.063	1761.44	1	0.00	14.268
WomanMarriageDesire	-0.008	0.001	117.21	1	0.00	0.992

based on statistical significance. Table 1 represents the fifth and final step of the model selection process in which only the variables representing the threshold at which a woman will evaluate her opinion and decide to have children and the probability that a woman will desire to marry remain. It should be noted that the variable representing the proportion of women wanting to work while raising children was the final factor eliminated in the previous step. All three variables representing feminist perspectives within the model, i.e. those that address women's agency, were the final factors remaining in the model until the very last step. The woman-marriage-desire variable has an exponential B coefficient very close to zero, indicating that for increase in the proportion of women wishing to marry, the hazard of population extinction is reduced only by about 0.8%. Likewise, for each increase in the opinion threshold, the hazard of population extinction increases by a factor of around 14.3. This may seem counterintuitive; however, this variable reflects the threshold at which women may decide to have children. If the threshold is set very low, women who might *say* they never want to have children will indeed have them. If the threshold is very high, only those whose opinion reflects "definitely have children" (or similarly above the threshold) will actually have them. As is clear in Figure 3, the lower the opinion threshold and the higher the desire to get married, the longer the population tends to last before crashing, as in case number 66 in the top right corner.

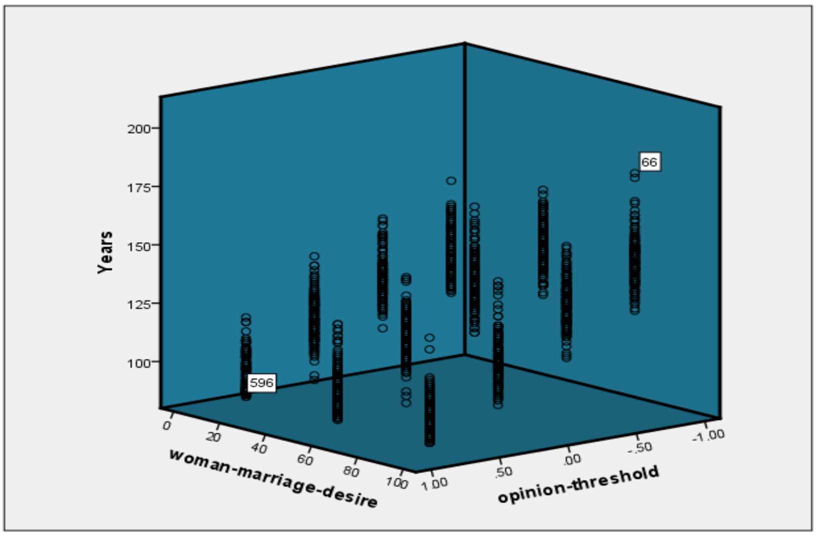

Figure 3: Factors in Final Model

4.1 Verification and Sensitivity Analysis

While this model is still in its development phase, the code has been evaluated by an external ABM researcher to ensure obvious coding mistakes were not made. Additionally, the original metacode (see Appendix) was extensively reviewed by said researcher in order to ensure the model followed a planned, logical map. Due to computational costs, sensitivity analysis was not pursued. An obvious area for sensitivity would be in the initial population size. Original experiments done on this model used a fixed population size of 300 rather than 500 and, in almost all cases, the population began to crash much sooner than in the simulations summarized here, indicating some reliance on starting population size.

4.2 Replication and Empirical Calibration

This model was seeded with the most recent Japanese census data wherever available in order to ensure the closest possible replication of the current fertility circumstances in that country. Certain generalizations were made for simplicity. For example, all agents in an age range make the average salary for that age range based on their sex. Though not based on very old historical data, this model has been able to replicate expectations for population growth and decline consistent with currently used statistical models. This researcher believes this is due in part to the use of actual, current census data to seed the model.

5 Conclusion

Though this model is in its preliminary development stages, it has demonstrated the necessity for incorporating women's agency into the prediction of future population growth, as well as into the future family planning policies of Japan. In future models, this researcher intends to incorporate a factor which accounts for the burden of care often expected of women in Japan. Allowing policymakers to experiment with the ability to reduce or eliminate the burden of care for both elderly family members (i.e. implementation of subsidized elderly care for working women) as well as young children (i.e. widely available subsidized childcare for working women) would provide a way to consider traditional expectations of women that might limit their desire to pursue motherhood. Another possibility might be to reduce the desire of some women to have children beyond a certain family size. At present, as mentioned above, female agents will continue to bear children with a certain probability given sufficient disposable income and within the age constraints. This is a generalization that results in wealthier agents reproducing at higher rates than might be observed in the actual population.

Additionally, future versions of this model might incorporate a way to factor available free time of parents in order to determine whether to have children. Traditionally men in Japan work long hours while women maintain the majority of care work. Creating a variable that allows one to consider available hours might help to determine if implementing more flexible work schedules could restore the fertility rate.

Finally, the concept of immigration as a means of replenishing the population in order to support the increasingly large aged community has, up until now, been purposefully eliminated from the model. As Japanese policymakers are not keen on allowing foreign nationals to become Japanese citizens, this has not traditionally been considered a mainstream solution to the population crisis. As the situation becomes increasingly dire, the urgency with which solutions must be found may require that these options be more carefully considered. For now, the model will continue to be explored assuming that immigration is not the answer and before the tipping point is reached, some combination of policies could be enacted to turn the fertility rates around.

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Appendix: Simplified Metacode

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50% of agents are female
50% are male

Wander: All agents walk around the world until the
population crashes or 300 years have passed

Grow-Old: Agents grow old with each iteration of the
model and adjust salaries according to age

Find-Partner: If female agent is 16 < age < 45, and
encounters a male of suitable age, and neither has a
partner, with some probability, they will “marry”
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Update-Opinion: If female agent encounters another female agent, she will adjust her opinion about motherhood accordingly. If the other female agent's opinion is grossly different, she will adjust away; if it is similar, she will adjust toward. This is weighted by the opinions of other females in her social network.

Grow-Population: If married and not born children within the last year, female agents determine based on age, disposable income (combined couple's salary – tax – cost of living – cost of raising existing children*cautious), and whether her opinion is above the threshold for wanting children (set in user interface as a global value), whether to have children. Boys and girls are born with the same probability.