AGENT-BASED MODELING TO ANALYZE THE IMPACT OF WORK STATUS ON CHILDBIRTH: A CASE STUDY OF KOREA

Mazhar Sajjad[1, 2], Chang Won Ahn[1, 2]

[1]University of Science and Technology (UST), Korea
[2]Electronics and Telecommunication Research Institute (ETRI), Korea)
[1]sajjad@etri.re.kr, [2]ahn@etri.re.kr

ABSTRACT

To maintain a desirable fertility level for each country population is the top priority. It is very well known that fertility has been steadily declined to a remarkably lower level in Korea. This study explores the relationship between women's work status patterns and fertility in the women's socio-economic context of South Korea. In this paper, our model applying combined micro-simulation and agent-based model (ABM) to investigate the economic influence by using agent's work status i.e. employment and education and its feedback on childbirth decision. This model appears to be a good approximation in describing the childbirth decision based on women's work status. The result shows that women without employment have more probability to go for childbirth than women having part or full time employment. Among employment women having full-time employment are more likely to become mothers than the part-time. Our study suggests that work status play an important role in childbirth transition in Korea.

Keywords: Total fertility rate, work status, trend and agent-based model, micro-simulation, macro-simulation

1. INTRODUCTION

Many developed countries are facing decline in population growth. Fertility has been steadily declined to a remarkably lower level in Korea. Young generations in recent years are intending to have one or two children at most. Korean government have major concerns about what kind of the economic forces should play a role in child birth decisions and what kind of policy could be effective. Korea completed fertility transition under the replacement level in the middle of the 1980s. The TFR (total fertility rate) continued to decline, reaching the lowest level of 1.076 in 2005, but has rebounded to 1.297 in 2012 [1].

The work status and fertility relationship is complex. The direction can be from work status to fertility or the other way around; the direction can be mutual; and there can be some common external factors affecting both behaviors [2]. The purpose of the paper is to analyze the relationship of women's work status patterns and childbirth in the socio-economic and institutional context of South Korea. The issue of the work status is put into perspective in the context of family childbirth decisions and to study the mechanism that create inter-dependencies among various social characteristics. Our model is trying to identify those features that may affect the relationship between work status and childbirth. In our research, we will concentrate on how work status dynamically affects the women childbirth. The model allows us to study demographic dynamics and interpret empirical data in terms of a formal theoretical structure.

Using agent-based modeling of population dynamics, it is possible to design women agent to be both autonomous and heterogeneous in their decision making about when and how many childbirth they would have or not [3]. This study will focus on one direction of the relationship: the role of woman work status in the childbirth decision. 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 [8-9]. 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.

2. SOCIO-ECONOMIC CONTEXT OF SOUTH KOREA

Dating back to the 1950s and the 1960s, Korea was a country with rapid population growth, high population density, high fertility levels and little developed industrial economy [4]. In 1962, the Korean government implemented family planning program to control population growth [5]. Figure 1 shows that Korea's TFRs experienced a sharp decline from above 4 in the 1960s and the 1970s to below the replacement level in 1983. The period 1984-2000 witnessed a stagnated fertility decline, with TFRs lingering between 1.8 and 1.4. In sharp contrast with the fertility decline is the steady increase in women employment rates.

The Equal Employment Act in 1988, prohibited discrimination against women in employment, wages, and working conditions. It also prohibited discrimination against employed women due to

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marriage, pregnancy or child delivery. Meanwhile, a women public employee target system was established to enhance the recruitment of women in the public sector [6]. The Korean government has also made efforts to promote child care services to help women reduce the burden of childrearing and to facilitate for women to reconcile work and family life [7].

Figure 2, shows Korean women's labor force participation rate by ages and years. M-shaped curves appear for all calendar year periods. For decades, Korean women have followed a similar strategy to arrange their work-family life career: labor market entry – leaving labor market for family life – labor market re-entry when their children need less concern. The patterns indicate that for Korean women, temporarily sacrificing their career at a certain stage of life for the sake of family formation and expansion is entrenched with tradition. If we take a closer look, we can see that labor market exits have gradually shifted from ages 25-29 to ages 30-34. Besides, fewer women drop out of the labor market for family life in most recent years. Women aged 20-44 are more economically active in the latter periods.

3. MODEL DEVELOPMENT

3.1. Agent Based Modeling

Agent-based modeling is a bottom-up approach computational framework for simulating dynamic-processes that involves autonomous and heterogeneous agents having their own decision criteria and growing the population. The ABM offers a new approach to the problem of social phenomena in order to analyze the dynamic mutual-independent relationship among individual behaviors that could lead to emerging evolution. Agent based computational demography includes also micro-simulation that has been used to derive macro-level outcomes from empirical models of micro-level demographic processes, but also formal models of demographic behavior that describe micro-level decision with macro-level outcomes [10].

We are using ABM methodology to explore the economic influence of work status of an agent and its feedback on the childbirth decision. In population dynamics, it is obvious that women play a remarkable role in determining macro-level indexes. In ABM of population dynamics, it is possible to design women agent to be both autonomous and heterogeneous in their decision making about when and how many childbirth they would have or not [4]. Individual micro behavior results in a macro outcome which is could feedback to the individual decisions. Likewise, micro-macro independency could be obtained, which can't be modeled in a traditional micro-simulation [11].

The problem of addressing Korea'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 ratio of women involved in Korean's population crisis can one begin to experiment with policies that might help turn the problem around.
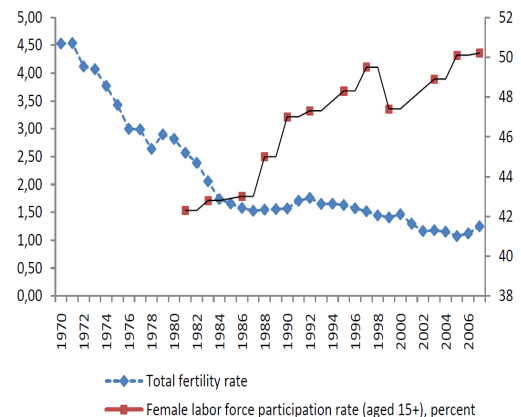

Figure.1. Development of total fertility rate and women labor force participation rate, Korea
Source: Korea Statistical Information System (KOSIS) & LABORSTA Labor Statistics Database, International Labor Organization.
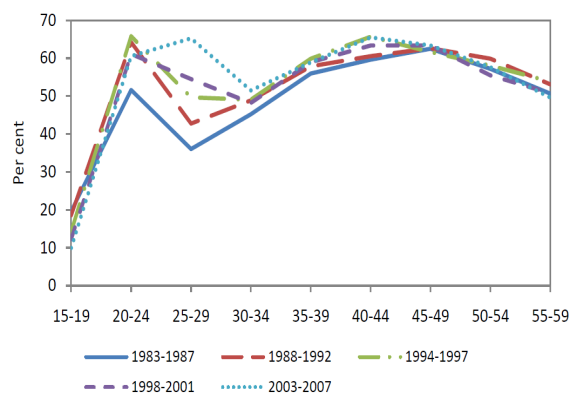

Figure.2. Women labor force participation rate of Korea by age since the early 1980s

Source: LABORSTA Labor Statistics Database, International Labor Organization (data unavailable for 1993 and 2002).

3.2. Model Specification

We setup a single sex model, limited our model to consider only 'woman agent' the most influential partner regarding childbirth decision, although both partners play a major role while deciding about childbirth. In our ABM, we can observe the aggregate effects of decentralized decision making without very strong assumptions to limit agent's behaviors to the scope of the current work. In our model the fertile period of an agent is from 16 to 45 years. In our model, We assume that only married women can give birth to child mean there is no cohabiting state in the context of Korea, every married woman is fertile, all mothers are real, the time spent between the childbirth and actual conception is ignored, the minimum childbirth space is one year, childbirth could be either single or twin and each woman agent has an expecting number of desired

childbirth, but may not have as many children as expected due to the family economic outcome or other social factors.

We apply our model to analyze the causes and effects of woman work status on childbirth with the bottom-up approach using Korean census data from 1990 to 2010, since 1990, the Korea TFR (total fertility rate) declined rapidly as the country struggled through the financial crises in 1997, below 1.2 in 2000 and 1.08 in 2005, the lowest in the world [6]. Each individual agent has a household-member-id and three characteristics. The first and foremost time varying dependent variable 'agent work status' with job characteristics like full time, part time and never employed. Factors such as age and education level have also been indicated in many population studies as important in determining fertility rate [12], [13].

Therefore, our two time varying control variables are 'agent age' grouped into 16~20, 21~25, 26~30, 31~35, 36~40 and 40~45 years in order to analyze the relation of work status on various age groups. The 'agent education' status categorized into elementary, high, university in which woman are still enrolled. We are in the process to build agent-based simulation model that incorporates both historical census data on population characteristics that allow us to study the influence of work status on fertility decision by the interaction of various agent characteristics and behavior assumptions at different stages.

Table 1. Summary of agent variable and parameters

Agent Variable	Variable Values
Work Status	• Full Time • Part Time • Unemployed
Childbirth Age	• 16~20 • 21~25 • 26~30 • 31~35 • 36~40 • 41~45
Education Level	• School (elementary, middle, high) • College • University

3.3. Model Implementation

The model is implementing using Anylogic 7.0 professional software, both because of its simple, natural programming style as well as its user-friendly interface [14]. Before using empirical data in in micro-simulation, first we set behavior criteria for childbirth. After marriage, couples determine if they want to have children first based on the woman agent age, in our model the agent age must be within biological fertility range i.e. 15 to 45 years. The agent must be married, because regarding Korean population there is no custom

of cohabitating fertility. After marriage the agent decide the desired family size and the minimum fertility gape based on the employment condition. The woman agent age and fertility gape can be tested again in the model after a period of one year in the simulation environment.

To examine the relationship of women employment and childbirth, we apply event history analysis using micro-simulation empirical data. Our model considering those women that follows the above set behavior criteria for childbirth. The observation starts when a woman reaches the age of sixteen till the age of forty-five. We apply Cox proportional hazard model depicted below.

$$h(t|X) = h(t)\exp(X_1\beta_1 + \cdots + X_p\beta_p).$$

Where h(t/X) is the hazard at time 't', the h(t) is the baseline hazard. The $X_{1,\ldots,}$ Xp are the covariates and 'βs' are the hazard ratios (HR) of the covariates. In our model, the covariates $X_{1,\ldots,}$ X4 are women age, year, work-status and education level of the women respectively and β1,…… β4 are the respective hazard ratio of our four covariates (variables).

Considering the conventional social practice of Korea women leaving the job market for family life, we subtract nine months from the date of any first childbirth to capture the effect of pre-pregnancy work status and job characteristics on first childbirth. In our model, the woman can give maximum two kids at one time as normal fertility outcome. There are several variables that affect the outcome of childbirth, but here we are interesting to analyze the relationship of work status and fertility as shown in table-1. We are in the process to use various empirical models about initial demographic setup and transition from one state to another. Apart from these empirical methods, we are building the interactions model based on these agent characteristics at various stages that affecting the fertility over time.

Table 2, 3 and 4 shows the detail statistics of our sample data regarding the agent's variables. We are analyzing the Korean census data from 1990 to 2010 with five years interval and see the trends of childbirth event under various conditions. Our sample data includes the effect of 1997 Asian financial crises that disturbed the economy of Korea badly and 2005-2010 years data that was the time of economy recovery period after crises. Table-2 indicates the amount of time in months of the number of the women in a specific year and the number of childbirth event occurred in those women.

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Table-2 Distributions of women time and childbirth event by main variables

Variables	Variables Categories	Women Time (Months)	Childbirth Event (First Birth)
Year	1990	27672	134
	1995	27290	120
	2000	26625	110
	2005	26245	102
	2010	25890	93
Work Status	Full Time	72052	242
	Part Time	33698	135
	Not Working	27972	182
Education Level	School	63214	268
	College	38243	114
	University	32265	177

Our main variable explanatory variable is the time varying employment status of Korean women. Here we are considering the three main categories: the full-time employment indicates that the women staying in the labor force, the part-time indicates that women is partially participating in the labor force and the un-employment indicates periods when the women have left the labor market.

Another time-varying variable is women education level. It is categorized into three broad groups: School level education combined elementary, middle and high school level. The college and university level indicates the college and university level education respectively.

4. EXPERIMENTAL RESULTS

Our result shows the relative childbirth event by main work status and other control covariates. Using the Cox proportional hazard model, we calculated the hazard ratio of our all four variables. Results shown in table-3 indicate the hazard ratios based on women's age, year, work status and education levels of the women. The hazard ratio-1 include only women's age and colander year to find the calendar year effect on women likelihood to become mother. The hazard ratio-2 and 3 include the work status and education levels to investigate the effects on childbirth.

The hazard ratio-2 indicates that women from age 26 to 30 have more than double intensity to become a mother than other age group. The overall reduction of first childbirth has been event detected. The involvement of work status, education level does not change this decline trend. The hazard ratio-2 includes work status for analysis. Women who have left the employment have more than 100% chances to become a mother than women who are full or part time employed. This discovery indicates that women who leave the work status usually go for childbirth, unemployment extent the family.

The hazard ratio-3 discovered the effects of education levels on childbirth. Women who completed their education or have college level education are most

likely to become mothers than the low educated women. It shows that the highly educated women once get married then they are more committed toward childbirth. The agent based simulation interface in Anylogic is shown in figure-3.

Table 3. Childbirth event estimation from the main effect model

Variables	Category	Hazard Ratio-1	Hazard Ratio-2	Hazard Ratio-3
Women's Age	16 ~ 20	0.12 ***	0.27 ***	0.34 ***
	21 ~ 25	0.98 ***	1.00 ***	1.10 ***
	26 ~ 30	2.11 ***	2.06 ***	2.11 ***
	31 ~ 35	0.75 ***	0.67 ***	0.72 ***
	36 ~ 40	0.53 ***	0.46 ***	0.49 ***
	41 ~ 45	0.25 ***	0.18 ***	0.20 ***
Year	1990	1.70 ***	1.74 ***	1.71 ***
	1995	1.53 ***	1.58 ***	1.61 ***
	2000	1.12 ***	1.15 ***	1.14 ***
	2005	0.65 ***	0.68 ***	0.62 ***
	2010	0.58 ***	0.63 ***	0.60 ***
Work Status	Full-Time		1.23 ***	1.25 ***
	Part-Time		0.79 ***	0.92 ***
	Unemployment		1.95 ***	2.10 ***
Education	School		0.89 ***	1.05 ***
	College		1.15 ***	1.18***
	University		1.17 **	1.28 ***

Note: Statistical significance: ***: $p<=0.01$; **: $p<=0.05$; *: $p<=0.10$
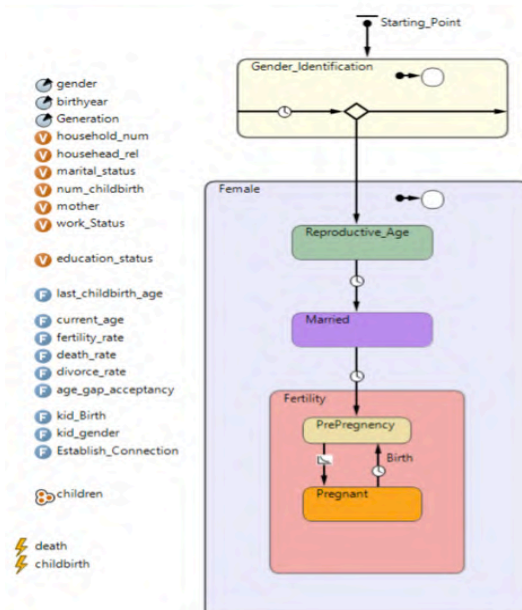

Figure-3 Agent Based Model Interface in Anylogic

4.1 Work Status Characteristics over Time

Our model composed of agent based simulation to find the relationship between work status and fertility. Various work status characteristics of each woman agent changes over time. Figure 3 shows how the

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hazard ratio by work status changes over time. The agent behavior shows a general decline of childbirth occurs in all types of women since 1990 irrespective of their work status. The result shows that in 1990 the women with part-time employment and with no employment had a high probability of becoming a mother than women in the labor force with full time employment. The Korean economic downturn in 1997 reflects more declines in unemployment and part-time employment than the full time employment. This decline reflects these women intensions to re-adjust their life career under the bad financial condition. When the country economy starts its survival after 2000, again we see positive feedback about childbirth.
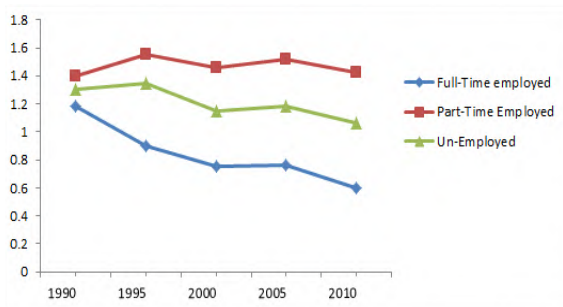

Figure 4 Relation of work status with year during childbirth

5. CONCLUSION

This study investigates the relation between the work status and fertility in the context of South Korea. The model develop in this paper appears to be a good first approximation in describing the fertility based on work status using agent-based simulation technique. We applied agent-based model to study the role of different characteristics interaction for explaining the observed demographic patterns on the transition to motherhood. I have applied event history analysis to the Korean census data to estimate how work status status and job characteristics are related to motherhood entry. Main effects models along with work status characteristics were specified to address our research questions.

The results showed that women who had left the labor market were more likely to become a mother than women continue as full-time or part time in the labor force. Another finding of the study relates to the effect of women education characteristics on motherhood entry. The results reveals that among women who completed their education and women at college level or above are most likely to become mothers. The higher educated women once gets married then those women are more committed to become mother than the lower educated women. Our results reveal that the structure of a society represented by parameters specifying work status patterns has the potential to alter the role of family policies, because the working women who become mothers are faced with the decision on whether to return to the labor force or when to return. Upon

return, they have to face challenges with career opportunities for mothers.

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