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Structural Changes in the Patterns of Japanese Fertility

Shoko Suzuki Sophia University

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KIOICHO, CHIYODA-KU, TOKYO 102-8554, JAPAN

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Shoko Suzuki[a]

Abstract

Butz and Ward developed a model of fertility behavior by maximizing utility subject to household budgetary constraints. They concluded that in the United States, the 1950s baby boom occurred in response to increasing male income; in contrast, the 1960s baby bust was a response to increasing female wages, which reflect the opportunity cost of female time. The Butz-Ward model has since been applied in other industrialized countries. In Japan, the Total Fertility Rate (TFR), which is defined as the average number of children by women aged 15-49 assuming that current age-specific birth rates remained constant, has sharply decreased since the beginning of the 1950s, when the first baby boom occurred in 1947-1949. Thereafter, the fertility rate remained constant at 2.0, including during the years of the second baby boom, 1971-1974. The fertility rate began gradually decreasing in 1975, while female wages have increased. Another contributing factor could be that the female marriage rate has decreased since 1975. Therefore, we apply the Butz-Ward model to Japanese prefecture-level data for 1965-2015 and extend the Butz-Ward model by adding a variable for female marriage rate. We also test structural changes in fertility patterns from 1965 to 2015 using the Chow test, which indicates that a structural change occurred between 1975 and 1980. Based on these results, we split the period from 1965-2015 into two subperiods, I (1965-1975) and II (1980-2015). Next, we estimate fertility using a fixed-effect model and a random-effect model. The estimation results show that the Butz-Ward model explains subperiod I (1965-1975) well. In contrast, the estimation results for subperiod II (1980-2015) are not consistent with the Butz-Ward model. For 1965-2015, both female wages and male income negatively impact fertility. In addition, the coefficient for female marriage rate is positive and statistically significant for all periods, including 1965-2015 and both subperiods I and II. This result indicates that the increase in the number of unmarried females may be one of the dominant factors controlling the decrease in Japanese fertility rate. In addition, the results suggest that couples may be choosing to invest more money in human capital for a smaller number of children.

Keywords: Fertility rate, Structural changes, Female wages, Female married rate, Japan
Classification Codes: J11, J12, J13

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[a] Sophia University, 7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-8554, Japan.
E-mail: shoko.suzuki@eagle.sophia.ac.jp
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1 Introduction

In recent years, the relationship between fertility and male and female earnings has drawn considerable interest. Most developed countries can be classified into one of two types based on the relationship between fertility and the female labor force, either having a positive or a negative correlation between the two. Japan is one of the countries that has experienced lower fertility as the female labor force has increased.

Behind this phenomenon lies an increase in highly educated females and correspondingly greater female entry into the labor market, thus decreasing the wage differential between males and females. This circumstance has caused females to remain unmarried and to delay marriage, which could be one of the dominant factors causing the decrease in Japanese fertility.

The most developed and well-used model of fertility behavior is based on standard microeconomic demand theory, which was developed by Becker (1960, 1965). The model maximizes utility subject to household budget constraints. In this model, the demand for children depends on the price (cost) of children, including the costs of education and daycare, household income, personal preferences, and birth control.

The objective of this paper is two-fold. First, we employ the Butz and Ward methodology using time-series data to analyze the longitudinal fertility trend for 1965-2015. Moreover, we test for structural change during this period using a Chow test. The test results suggest a shift between 1975 and 1980, so we divide the time-series data into two subperiods, from 1965-1975 and 1980-2015 (subperiods I and II, respectively). In brief, our results are as follows: subperiod I supports the hypothesis of countercyclical fertility but subperiod II does not.

Second, we attempts to expand the Butz-Ward model by adding another variable, female marriage rate, and examining its effects on fertility. Because women are remaining unmarried and delaying marriage, the female unmarried rate has increased. Figure 1 shows the female (aged 15-49) married rate[1] for 1965-2015. The peak occurs between 1975 and 1980, after which the female marriage rate decreases. Delaying marriage means females are older (middle-aged) when they become pregnant. As females age, fecundity decreases, and the number of children a couple may have decreases. In addition, an important aspect of fertility behavior is the fact that couples tend to have children after marriage; this behavior is traditional in Japan. Therefore, female marriage behavior is one of the dominant factors affecting recent Japanese fertility behavior. Briefly, our results are as follows: the estimated effect of female marriage rate is positive and highly significant over the entire period from 1965-2015, including both subperiods I and II. This result suggests that female marriage rate is one of the dominant factors in reducing Japanese fertility.

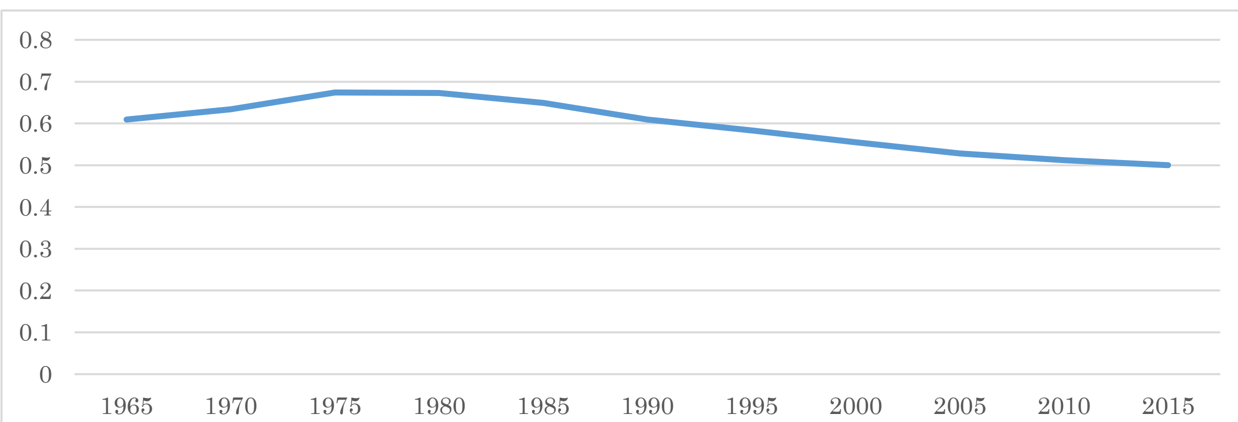

Figure1. Female marriage rate (1965-2015)
Data source: the Census (Ministry of Internal Affairs and Communications)
Okinawan data for 1960-1970 was not available.

[1] We calculate the female marriage rate as follows: $\text{Female marriage rate} = \frac{\text{Population of married females}}{\text{Population of females}}$.
We obtained data on the population of married females and the population of females from the census conducted by the Ministry of Internal Affairs and Communications.

This paper is organized as follows. Section 2 reviews previous literature. Section 3 introduces the Butz-Ward model. Section 4 describes the dataset used. Section 5 reports the estimation results, and section 6 discusses them. Finally, section 7 presents the conclusions.

2 Literature

2.1 The Butz-Ward Model

Butz and Ward (1979) developed a model to explain both the baby boom of the 1950s and the baby bust of the 1960s in the U.S. Two important features of the Butz-Ward model are the inclusion of both male and female earnings and the assumption of two types of households: a household with an employed wife and a household with a non-employed wife. Using time-series data from the end of World War II to 1975, Butz and Ward concluded that fertility had moved countercyclically.

Since Butz and Ward demonstrated the countercyclical pattern of fertility in the U.S., numerous studies have examined the relevance of the Butz-Ward model in other industrialized countries using time-series data.

2.2 Literature from Western Countries

For western countries, a number of studies have been conducted based on the Butz-Ward model. While Ermisch (1979, 1988) and Hyatt and Milne (1991) found results consistent with the Butz-Ward model, Macunovich (1995) found the opposite. Ermisch (1980) and Abeysingke (1993) found partial support for the Butz-Ward model.

Ermisch (1979), using British data for 1951-1975, found that in the linear specification, the effect of the interaction term for female employment rate and female wages was negative and statistically significant, the effect of male wages was positive and statistically significant, and the effect of the interaction term for female employment rate and male wages was negative and statistically significant. The results were similar for the log-linear specification, but the effect of the interaction term for female employment rate and male wages was positive and statistically significant.

Ermisch (1988) analyzed the pattern of British fertility for 1952-1983. He added economic variables to the model such as children's allowance and women's cohort size and used male and female net (after tax) wages rather than gross wages. He found that the net hourly earnings of females relative to the net weekly earnings of males influenced fertility. For almost every age and birth order, higher net female wages were more likely to reduce the likelihood of a birth, while higher male net earnings increased it.

Hyatt and Milne (1991) fitted the Butz-Ward model to Canadian data for 1948-1975 and for 1948-1984, demonstrating a countercyclical pattern in fertility movement. The effect of the interaction term for female employment rate and female wages on fertility was negative and significant, and the effect of male income was positive and significant.

In contrast, Macunovich (1995) reexamined the Butz-Ward model using micro-level U.S. data for 1964-1987. Her estimation results showed that the coefficient for the interaction between the female employment rate and female wages was positive and not significant, the coefficient for female employment rate and male income was negative and statistically significant, and the coefficient for male income was negative and highly significant.

Ermisch (1980) examined Western German fertility with the Butz-Ward model using data for 1957-1977 and found that the effect of female wages on fertility was positive and insignificant, although the effect of male income with a female who participated in labor force was negative and significant, and the effect of male income with a female who did not participate in labor force was positive and significant.

Abeysinghe (1993) constructed an estimation model by adding the variable of male parental income to the Butz-Ward model using Canadian data for 1951-1986. In the fully modified estimation procedure for cointegrated regression, which was unrestricted, he found that the effect of female wages on fertility was positive and significant, the effect of male income was positive and significant, and the effect of male parental income was negative and significant. However, in the fully modified estimation procedure for cointegrated regression, which was restricted, the effect of female wages was negative and significant, and the effect of male income relative to parental income was negative and insignificant.

In general, earlier Western literature found that the Butz-Ward model was able to explain fertility patterns. As estimation techniques have developed and recent data has been utilized, however, the Butz-Ward model no longer offers a sufficient explanation for fertility patterns.

2.3 Literature from Japan

Several studies of the fertility movement have applied the Butz-Ward model to Japanese data. Ohbuchi (1982, 1988), Imai (1996, 2001), and Kato (1997) found that the Butz-Ward model could not adequately explain

Japanese fertility patterns. However, Ogawa and Mason (1986), Osawa (1988), Lee and Gan (1989), and Shimizu (2002) concluded that the Butz-Ward model was applicable.

Ohbuchi (1982) tested the Chicago model, which is the Butz-Ward model using Japanese data for 1948-1980. The coefficient for male wages was positive and statistically significant. The coefficient for the interaction term for female employment rate and male wages was negative and statistically significant, and the coefficient for the interaction term for female employment rate and female wages was positive and statistically significant. The signs of these parameters were unexpected, particularly the results of the interaction term.

Ohbuchi (1988) expanded the Butz-Ward model by adding a dummy variable for the year 'hi-no-e uma'[2] and using Japanese data for 1950-1983. Female wages positively affected fertility, indicating a lack of support for the theory. Male wages in a household with a female that was not employed positively affected fertility, and male wages in a household with an employed female negatively affected fertility. The dummy variable for the year 'hi-no-e uma' negatively affected fertility.

Imai (1996) reported that the Butz-Ward model did not fit Japanese data for 1968-1994. Imai used two variations of the Butz-Ward model: the original model and the original model written in elasticity form. In the original model, the effect of the interaction between female employment rate and male income was positive and insignificant, the effect of male income was negative and insignificant, and the effect of the interaction between female employment rate and female wages was negative and insignificant. However, for the model written in

[2] 1966 was a year with many fires, according to the old Chinese calendar. In addition, there is a superstition that females who were born in 1966 have tempers so sharp that they kill their husbands. Therefore, the number of babies born in 1966 was much lower than babies born in other years.

elasticity form, the effect of the interaction between female employment rate and male income was negative and insignificant, the effect of male income was positive and significant, and the effect of the interaction between female employment rate and female wages was negative and significant. Based on these results, Imai concluded that the Butz-Ward model is not applicable to Japanese data.

Imai (2001) found that the Butz-Ward model did not fit Japanese prefecture-level data for 1968-2000. Imai also estimated fertility by using the average number of children for females aged 35-39 in 1995. The results showed that the coefficient for female wages was negative and statistically significant; in contrast, the coefficient for male income was positive and not statistically significant.

Kato (1997) analyzed the structural change in patterns of Japanese fertility by testing a unit root and using a stepwise Chow test. In addition, Kato utilized the Butz-Ward model with Japanese data for 1968-1995. Kato confirmed that the patterns of Japanese fertility movement followed a probability trend. The results showed that the coefficient signs were not consistent with the Butz-Ward model. However, in the model without the variable for female employment rate, the coefficients for female wages and male income were consistent with the Butz-Ward model; that is, the effect of female wages on fertility was negative and the effect of male income was positive.

Ogawa and Mason (1986) showed that the Butz-Ward model could explain Japanese data for 1963-1984 and 1966-1984. The effect of female wages on fertility was negative and statistically significant and the effect of male wages on fertility was positive and statistically significant. These results also supported the utility of the Butz-Ward model for explaining patterns of Japanese fertility.

Osawa (1988) also reported that Japanese fertility patterns for 1960-1980 supported the Butz-Ward model. The coefficient for the interaction term for female employment rate and female wages was negative and statistically significant. The coefficient for the interaction term for female employment rate and male income was positive and statistically significant. However, for most of the results, the effect of male income was negative and insignificant, and the effect of female wages was positive and insignificant.

Lee and Gan (1989) analyzed Japanese fertility patterns for 1960-1984 by extending the Butz-Ward model and constructing a simultaneous equation system. The system contained a function for fertility behavior, a function for female labor supply, and a function for married females living with their husbands. Lee and Gan found that the coefficient for the interaction term for females married and living with their husbands and the male wage rate was positive and statistically significant, and the coefficient for the interaction between female employment rate and female wage rate was negative and statistically significant.

Shimizu (2002) showed that the original Butz-Ward model did not explain Japanese data for 1971-2002. However, Shimizu also calculated the estimate lifelong female wages, male income, the number of children, and the female employment rate using Japanese data for 2001, and then applied the Butz-Ward model to the data. The results showed that the coefficient signs were consistent with the Butz-Ward model; the effect of the interaction between female employment rate and female wages on fertility was negative and statistically significant, the effect of male income on fertility was positive and statistically significant, and the effect of the interaction between female employment rate and male income was positive and statistically significant.

These applications of the Butz-Ward model have made important contributions to determining the mechanisms behind variations in Japanese fertility trends. However, we suggest that other factors also influence fertility. Female marriage behavior has changed over time; as females achieve higher levels of education, the wage differential between males and females decreases. Increases in female earnings have also given females less incentive to marry, instead remaining unmarried or delaying marriage. This female marriage behavior could play an important role in Japanese fertility patterns.

3 Model

The Butz-Ward model has demonstrated the effect of both the husband's income and the wife's wages on fertility behavior. When the husband's income increases, the household income increases, and this often induces the couple to have more children. The effects of an increase in the wife's wages on fertility behavior are two-fold; first, an increase in the wife's wages also increases household income and may cause the couple to have more children. In addition, when the wife's wages increase, the opportunity cost of her bearing and rearing children also increases, thus decreasing the couple's incentive to have children.

As noted by Butz and Ward (1979), the probability of a couple having a child in a given year should be different for households with employed wives and households with non-employed wives. The probability of having a child in a household with a non-employed wife should be a function of the husband's income, the wife's opportunity cost, and other factors. The wife's opportunity cost depends on the husband's income. Thus, the probability of having a child in a household with an employed wife should be a function of the husband's income, the wife's market wage (that is, the opportunity cost associated with her time), and other factors.

We use the following model derived by Imai (1996) from the original Butz-Ward model:

$$\ln B = \beta_0 + \beta_1 k \ln Y_m + \beta_2 (1-k) \ln Y_m + \beta_3 k \ln W_f$$

$$= \gamma_0 + \gamma_1 k \ln Y_m + \gamma_2 \ln Y_m + \gamma_3 k \ln W_f \qquad (1)$$

where B is the probability that a couple will have a child in a given year, k is the proportion of households in which the wife is employed, Y_m is the husband's income, and W_f is the market wage rate of an employed wife.

The model also hypothesizes that $\beta_1 = \gamma_1 + \gamma_2 > 0$, $\beta_2 = \gamma_2 > 0$ and $\beta_3 = \gamma_3 < 0$: when β_1 and β_2 are positive, this indicates an income effect, and when β_3 is negative, this indicates a substitution effect.

Since the Butz-Ward model has not been successfully applied to Japanese data, we followed the modified Butz-Ward model as constructed by Imai (2001). The estimation model is as follows:

$$B = \alpha_0 + \alpha_1 Y_m + \alpha_2 W_f \qquad (2)$$

where B is the average number of children whose mothers are married and aged 35-39, Y_m is the husband's income, and W_f is the market wage rate of an employed wife. In our model, we utilized the Total Fertility Rate (TFR)[3] as a proxy for B.

As Figure 1 shows, female marriage rate can significantly affect fertility, so we added a variable for the female marriage rate to the model (eq.(2)) to control for this effect.

The Butz-Ward model is a useful methodology for analyzing longitudinal fertility behavior using time-series data. Additionally, time-series data are compiled at both the national and the prefecture level. We used time-series data from 46 prefectures for the model in this paper[4]. The other important feature of the Butz-Ward

[3] The Total Fertility Rate is obtained from Vital Statistics compiled by Ministry of Health, Labour and Welfare.
[4] We excluded Okinawan data primarily because the Okinawan TFR is far higher than in other prefectures. In

model is to provide a tractable form for empirical implementation.

4 Data

In this section, we discuss the prefecture-level data used in our model and its sources. The following tables show descriptive statistics for every 5 years within the period 1965-2015.

1965 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	2.174	0.135	1.94	2.54
Female Wages (monthly)(1,000yen)	46	0.402	0.0412	0.342	0.536
Male Income (monthly)(1,000yen)	46	158.451	13.701	136.627	195.579
Female Married Rate	46	0.609	0.0247	0.535	0.651
Female Income (monthly)(1,000yen)	46	79.102	7.624	67.626	103.464
Female Contractural Cash Earnings (monthly)(1,000yen)	46	66.758	6.113	57.150	85.057
Male Contractural Cash Earnings (monthly) (1,000yen)	46	128.152	10.807	112.296	153.678
Female Special Cash Earnings (monthly) (1,000yen)	46	12.344	1.953	9.538	18.407
Male Special Cash Earnings (monthly) (1,000yen)	46	30.299	3.700	23.327	41.901
Female Actual Working Hours (monthly)	46	197.022	2.603	192	202
Population of Married Females	46	361603.4	318203.5	97852	1812391
Population of Females	46	607452.2	577563.1	155630	3387810

1970 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	2.092	0.115	1.88	2.35
Female Wages (monthly)(1,000yen)	46	0.610	0.075	0.493	0.824

addition, Okinawan data was not compiled for 1965 and 1970 because Okinawa was occupied by the U.S. from 1965 to 1972. These factors are explained in detail in the next section.

Male Income (monthly)(1,000yen)	46	236.300	24.208	195.288	290.307
Female Married Rate	46	0.634	0.022	0.566	0.674
Female Income (monthly)(1,000yen)	46	119.584	13.760	96.638	156.040
Female Contractural Cash Earnings (monthly) (1,000yen)	46	99.390	10.512	82.199	125.276
Male Contractural Cash Earnings (monthly) (1,000yen)	46	190.807	19.124	157.945	228.996
Female Special Cash Earnings (monthly) (1,000yen)	46	20.194	3.468	13.767	30.764
Male Special Cash Earnings (monthly) (1,000yen)	46	45.494	5.717	36.156	63.735
Female Actual Working Hours (monthly)	46	196.249	2.570	188.051	200.294
Population of Married Females	46	402348.4	369401.9	99041	1961755
Population of Females	46	642609.3	621041.5	154518	3466307

1975 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.987	0.102	1.63	2.14
Female Wages (monthly)(1,000yen)	46	1.002	0.114	0.834	1.295
Male Income (monthly)(1,000yen)	46	321.136	27.362	274.064	385.782
Female Married Rate	46	0.674	0.025	0.601	0.719
Female Income (monthly)(1,000yen)	46	187.49	17.852	159.038	229.988
Female Contractural Cash Earnings (monthly) (1,000yen)	46	147.929	12.956	128.113	178.835
Male Contractural Cash Earnings (monthly) (1,000yen)	46	246.658	19.670	211.960	288.996
Female Special Cash Earnings (monthly) (1,000yen)	46	39.561	5.041	30.690	51.348
Male Special Cash Earnings (monthly) (1,000yen)	46	74.479	8.141	62.104	96.786
Female Actual Working Hours (monthly)	46	187.520	3.757	177.584	194.103
Population of Married Females	46	438977.4	408074.6	100854	2018700
Population of Females	46	655539.5	632729.9	149647	3360253

1980 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.817	0.108	1.44	2.01
Female Wages (monthly)(1,000yen)	46	0.970	0.124	0.785	1.340
Male Income (monthly)(1,000yen)	46	333.134	36.602	271.535	418.722
Female Married Rate	46	0.673	0.025	0.588	0.715
Female Income (monthly)(1,000yen)	46	183.952	19.356	152.594	236.358
Female Contractural Cash Earnings (monthly) (1,000yen)	46	148.195	14.014	125.997	184.436
Male Contractural Cash Earnings (monthly) (1,000yen)	46	263.111	26.218	220.623	319.362
Female Special Cash Earnings (monthly) (1,000yen)	46	35.758	5.476	25.354	51.923
Male Special Cash Earnings (monthly) (1,000yen)	46	70.023	10.635	50.912	99.360
Female Actual Working Hours (monthly)	46	190.072	4.149	176.407	195.416
Population of Married Females	46	439128.9	404793.9	98742	1904653
Population of Females	46	659580.8	635599.4	145893	3240337

1985 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.815	0.104	1.44	2.01
Female Wages (monthly)(1,000yen)	46	1.084	0.146	0.840	1.491
Male Income (monthly)(1,000yen)	46	360.856	42.698	294.417	461.191
Female Married Rate	46	0.649	0.025	0.553	0.687
Female Income (monthly)(1,000yen)	46	204.012	22.963	161.485	262.53
Female Contractural Cash Earnings (monthly) (1,000yen)	46	163.830	16.636	135.283	205.493
Male Contractural Cash Earnings (monthly) (1,000yen)	46	284.584	30.276	236.474	350.101
Female Special Cash Earnings (monthly) (1,000yen)	46	40.182	6.464	26.202	57.037
Male Special Cash Earnings (monthly) (1,000yen)	46	76.271	12.701	54.547	111.090
Female Actual Working Hours (monthly)	46	188.618	4.157	176.118	194.231

Population of Married Females	46	422858.1	390460.7	93198	1785841
Population of Females	46	664353	650942.8	140399	3231731

1990 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.609	0.116	1.23	1.85
Female Wages (monthly)(1,000yen)	46	1.248	0.155	0.983	1.698
Male Income (monthly)(1,000yen)	46	401.811	45.512	322.129	519.117
Female Married Rate	46	0.609	0.027	0.506	0.650
Female Income (monthly)(1,000yen)	46	232.696	24.686	189.189	298.139
Female Contractural Cash Earnings (monthly) (1,000yen)	46	186.334	18.300	154.053	232.708
Male Contractural Cash Earnings (monthly) (1,000yen)	46	314.858	32.046	258.175	390.622
Female Special Cash Earnings (monthly) (1,000yen)	46	46.362	6.651	33.526	65.432
Male Special Cash Earnings (monthly) (1,000yen)	46	86.953	13.797	61.186	128.495
Female Actual Working Hours (monthly)	46	186.803	3.602	175.544	192.469
Population of Married Females	46	399973.4	367599.2	87363	1611715
Population of Females	46	675908	666947	138078	3185374

1995 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.517	0.125	1.11	1.73
Female Wages (monthly)(1,000yen)	46	1.487	0.164	1.157	1.976
Male Income (monthly)(1,000yen)	46	421.617	38.619	347.424	534.169
Female Married Rate	46	0.583	0.028	0.479	0.626
Female Income (monthly)(1,000yen)	46	263.235	25.900	210.172	337.257
Female Contractural Cash Earnings (monthly) (1,000yen)	46	209.327	18.814	175.229	260.464
Male Contractural Cash Earnings (monthly) (1,000yen)	46	330.928	26.868	282.686	404.363
Female Special Cash Earnings	46	53.908	7.383	34.943	76.793

(monthly) (1,000yen)					
Male Special Cash Earnings (monthly) (1,000yen)	46	90.689	12.025	64.737	129.807
Female Actual Working Hours (monthly)	46	177.269	2.465	170.672	181.686
Population of Married Females	46	376617.1	341009.5	82631	1461292
Population of Females	46	667363.7	650415	136190	3049225

2000 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.465	0.124	1.07	1.67
Female Wages (monthly)(1,000yen)	46	1.582	0.160	1.275	2.100
Male Income (monthly)(1,000yen)	46	415.672	39.248	345.106	524.806
Female Married Rate	46	0.555	0.029	0.455	0.602
Female Income (monthly)(1,000yen)	46	276.065	25.924	223.615	359.780
Female Contractural Cash Earnings (monthly) (1,000yen)	46	223.363	19.590	186.428	284.749
Male Contractural Cash Earnings (monthly) (1,000yen)	46	334.320	27.952	284.030	407.032
Female Special Cash Earnings (monthly) (1,000yen)	46	52.702	6.748	37.186	75.031
Male Special Cash Earnings (monthly) (1,000yen)	46	81.352	11.961	50.360	117.774
Female Actual Working Hours (monthly)	46	174.617	1.871	170.915	178.332
Population of Married Females	46	338205.6	309479.8	73788	1345235
Population of Females	46	629406.7	619686.3	129498	2953621

2005 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.347	0.110	1.00	1.50
Female Wages (monthly)(1,000yen)	46	1.584	0.163	1.307	2.180
Male Income (monthly)(1,000yen)	46	413.633	47.166	325.997	561.379
Female Married Rate	46	0.528	0.028	0.446	0.572
Female Income (monthly)(1,000yen)	46	275.147	26.139	231.792	370.704
Female Contractural Cash Earnings	46	230.870	20.773	197.869	306.185

(monthly) (1,000yen)					
Male Contractural Cash Earnings (monthly) (1,000yen)	46	339.905	33.728	280.699	443.406
Female Special Cash Earnings (monthly) (1,000yen)	46	44.277	5.739	33.923	64.519
Male Special Cash Earnings (monthly) (1,000yen)	46	73.729	13.797	45.298	117.973
Female Actual Working Hours (monthly)	46	173.794	2.093	168.422	178.027
Population of Married Females	46	308375	296395.3	64829	1330525
Population of Females	46	599525.1	611548.7	121416	2984866

2010 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.463	0.120	1.12	1.68
Female Wages (monthly)(1,000yen)	46	1.618	0.159	1.304	2.188
Male Income (monthly)(1,000yen)	46	398.715	42.940	323.836	527.073
Female Married Rate	46	0.512	0.027	0.443	0.556
Female Income (monthly)(1,000yen)	46	279.609	25.996	226.270	368.391
Female Contractural Cash Earnings (monthly) (1,000yen)	46	237.206	20.802	196.047	308.753
Male Contractural Cash Earnings (monthly) (1,000yen)	46	333.728	31.479	281.567	429.659
Female Special Cash Earnings (monthly) (1,000yen)	46	42.403	5.623	30.223	59.638
Male Special Cash Earnings (monthly) (1,000yen)	46	64.988	12.078	41.285	97.415
Female Actual Working Hours (monthly)	46	172.900	1.716	168.392	176.126
Population of Married Females	46	290960.7	298749.7	56877	1391393
Population of Females	46	580558.3	626638.5	110791	3139059

2015 Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
TFR	46	1.520	0.115	1.24	1.78
Female Wages (monthly)(1,000yen)	46	1.631	0.181	1.389	2.290

Male Income (monthly)(1,000yen)	46	393.455	45.221	320.566	542.011
Female Married Rate	46	0.500	0.022	0.453	0.533
Female Income (monthly)(1,000yen)	46	281.292	28.962	238.216	384.649
Female Contractural Cash Earnings (monthly) (1,000yen)	46	237.139	22.369	203.741	314.777
Male Contractural Cash Earnings (monthly) (1,000yen)	46	324.698	32.494	272.004	429.407
Female Special Cash Earnings (monthly) (1,000yen)	46	44.153	7.039	34.475	69.873
Male Special Cash Earnings (monthly) (1,000yen)	46	68.757	13.298	48.562	112.604
Female Actual Working Hours (monthly)	46	172.603	2.008	167.346	175.516
Population of Married Females	46	274021.8	295458.3	52074	1425767
Population of Females	46	555106.3	619077.1	104211	3139710

One of the primary sources of data for our analysis is the Basic Survey on Wage Structure[5] conducted by the Ministry of Health, Labour and Welfare. Male income and female wages are calculated as follows:

$$\text{Male income} = \text{Contractual cash earnings(monthly)} + \text{Special cash earnings(monthly)}^{6}$$

$$\text{Female wages} = \frac{\text{Contractual cash earnings(monthly)} + \text{Special cash earnings(monthly)}}{\text{Actual working hours (monthly)}^{7}}$$

More specifically, contractual cash earnings and annual special cash earnings are the weighted average for males and females aged 15-49. These values are measured in real terms using the 2015 Consumer Price Index published by the Ministry of Internal Affairs and Communications (2015 is the base year). To obtain female wages, we divided female income (which is calculated by adding special cash earnings (monthly) to

[5] In the 1965 Basic Survey on Wage Structure, data for the monthly actual number of hours worked and annual special cash earnings were not compiled by age group, so we used total data for all sizes of enterprise.

[6] The Basic Survey on Wage Structure contains special cash earnings on an annual basis, so we divided it by 12 (months) to determine the monthly base for both males and females.

[7] Actual working hours (monthly) were calculated by adding the actual number of scheduled hours worked (monthly) to the actual number of overtime hours worked (monthly). This calculation was applied from 1980 to present; for 1965, 1970, and 1975, actual working hours (monthly) were compiled in the Basic Survey on Wage Structure by the Ministry of Health, Labour and Welfare, so we used those data.

contractual cash earnings (monthly)) by actual working hours (monthly). The actual working hours are also calculated as the weighted average for females aged 15-49.

For estimation purposes, we divided male income by 1,000. We performed this calculation because we received the following message from the STATA data analysis and statistical software: "the rank of the differenced variance matrix does not equal the number of coefficients being tested, so there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale." Therefore, we scaled male income to be closer to female wages by dividing it by 1,000.

We used data from the Basic Survey on Wage Structure every 5 years beginning in 1965 because other census data is collected every 5 years by the Ministry of Internal Affairs and Communications.

Another primary data source for the model was the census conducted by the Ministry of Internal Affairs and Communications every 5 years. We used data for females aged 15-49 and the population of married females aged 15-49 to calculate the marriage rate for females aged 15-49 as follows:

$$\text{Female marriage rate} = \frac{\text{Population of married females}}{\text{Population of females}}$$

To determine the TFR, we used the Vital Statistics collected by the Ministry of Health, Labour and Welfare.

As mentioned in the previous section, we excluded Okinawan data because the Okinawan TFR is higher than in the other 46 prefectures (Figure 2). In addition, Okinawan data for 1965 and 1970 was not available because Okinawa was under U.S. control at that time. The prefecture reverted to Japan in 1972.

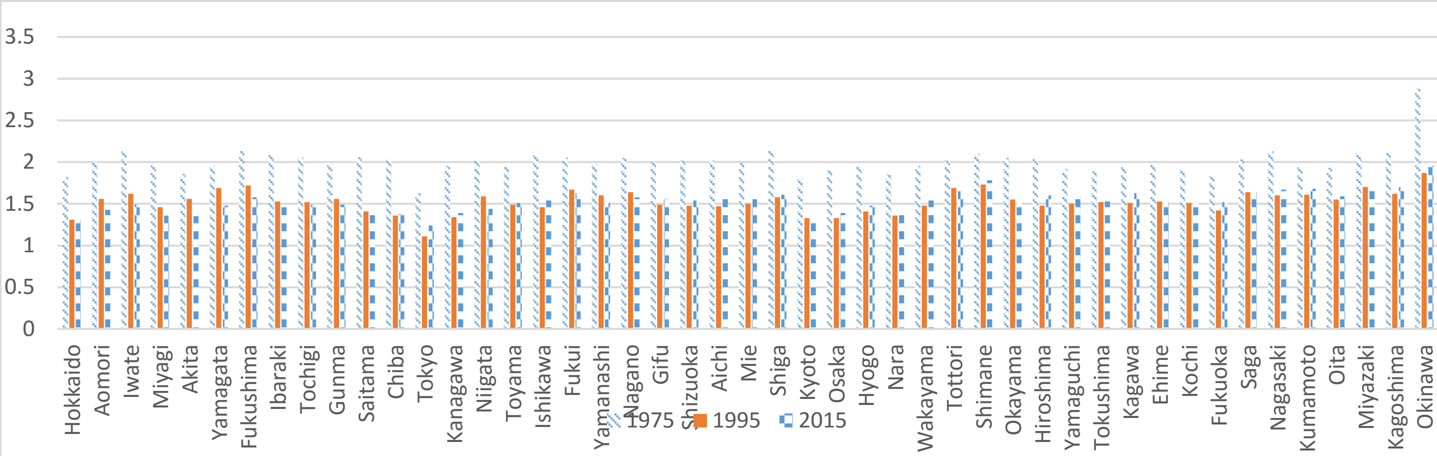

Figure 2. Total Fertility Rate (1975, 1995, 2015)

Data source: Vital Statistics (Ministry of Health, Labour and Welfare)

5 Estimation Results

We determined these subperiods based on the F-value of a Chow test used to assess the presence of a structural change. The results show that the shift in structural break occurred between 1975 and 1980, which is when the largest F-value of 64.61 occurred. Thus, we separated the two subperiods over this interval. Table 1 reports the results of the Chow test. Tables 2-4 show the regression results for 1965-2015, and the subperiods from 1965-1975 and 1980-2015.

Table 1. Results of the Chow test

Time periods	F-value
between 1970 and 1975	30.58
between 1975 and 1980	64.61
between 1980 and 1985	28.54
between 1985 and 1990	44.89
between 1990 and 1995	16.84
between 1995 and 2000	18.62
between 2000 and 2005	27.77
between 2005 and 2010	17.51

The main estimation model we used is the Butz-Ward model as modified by Imai (2001). The TFR is the dependent variable, and the independent variables are female wages and male income. In addition, our model includes a female marriage rate variable and a cross term for female wages and the female marriage rate.

Applying the Butz-Ward model to Japanese data shows that female wages negatively affect fertility for 1965-2015 and for subperiod I (1965-1975). We also find that male income has a positive impact on fertility during subperiod I (1965-1975); in contrast, male income has a negative impact on fertility for 1965-2015. For subperiod II (1980-2015), the impact of female wages on fertility is positive and the impact of male income on fertility is not significant.

5.1 Estimation Results for Fertility for 1965-2015

Table 2 presents estimation results for 1965-2015. The regression model is the Butz-Ward model and the results are reported in Columns A1 and A2. According to the Hausman test, the random-effect model yields better statistical information. The effect of female wages is negative and statistically significant, is consistent with the Butz-Ward model. Female wages are associate opportunity costs with rearing children, so increasing female wages causes a decrease in the fertility rate. The effect of male income is negative and statistically significant; this sign is unexpected and difficult to explain.

In Table 2, Columns B1 and B2 report the results including female marriage rate. Based on the Hausman test, the random-effect model yields a better estimation. The effect of female wages is negative and statistically insignificant. The effect of male income is negative and statistically significant, which is difficult to explain.

Table2. Results of the Butz-Ward Model for 1965-2015: Dependent Variable is the TFR.

	(A1)	(A2)	(B1)	(B2)	(C1)	(C2)
	Fixed	Random	Fixed	Random	Fixed	Random
Female wages	−0.215**	−0.284***	−0.00630	−0.0489	0.0668	−0.111
	(0.0881)	(0.0832)	(0.0829)	(0.0806)	(0.130)	(0.128)
Male income	−0.681*	−0.500*	−1.952***	−1.433***	−1.975***	−1.353***
	(0.334)	(0.312)	(0.331)	(0.305)	(0.332)	(0.304)
Female marriage rate			2.508***	2.079***	2.725***	1.882***
			(0.258)	(0.223)	(0.393)	(0.343)
Female wages×Female marriage rate					−0.157	0.106
					(0.215)	(0.208)
Constant	2.369***	2.368***	0.960***	1.156***	0.841***	1.262***
	(0.0374)	(0.0326)	(0.149)	(0.134)	(0.221)	(0.200)
No.of Obs.	506	506	506	506	506	506
Time dummies	yes	yes	yes	yes	yes	yes
R-sq(within)	0.945	0.945	0.955	0.954	0.955	0.954
R-sq(between)	0.395	0.409	0.443	0.449	0.441	0.453
R-sq(overall)	0.889	0.891	0.886	0.898	0.883	0.890
F-test(u_i=0)	F(45,448)=11.46		F(45,447)=13.27		F(45,446)=12.88	
	Prob>F=0.0000		Prob>F=0.0000		Prob>F=0.0000	
Hausman test	chi2(12)＝7.33		chi2(13)=19.59		chi2(14)=27.00	
	Prob>chi2=0.8350		Prob>chi2=0.1059		Prob>chi2=0.0193	
Breusch-Pagan test	chi2(1)=549.80		chi2(1)=599.69		chi2(1)=550.90	
	Prob>chi2=0.0000		Prob>chi2=0.0000		Prob>chi2=0.0000	

Notes: Standard errors are given in parentheses.

* denotes significance at the 10 % level, ** denotes the 5 % level, and *** denotes the 1 % level.

Table3. Results of the Butz-Ward Model for 1965-1975: Dependent Variable is the TFR.

	(A1)	(A2)	(B1)	(B2)	(C1)	(C2)
	Fixed	Random	Fixed	Random	Fixed	Random
Female wages	−0.733***	−0.604***	−0.794***	−0.620***	−1.088	−1.188*
	(0.226)	(0.206)	(0.224)	(0.202)	(0.718)	(0.667)
Male income	2.891***	1.785**	1.616	1.481*	1.817	1.554*
	(1.030)	(0.841)	(1.177)	(0.840)	(1.271)	(0.850)
Female marriage rate			1.564**	1.024**	1.137	0.328
			(0.740)	(0.444)	(1.241)	(0.855)
Female wages×Female marriage rate					0.436	0.866
					(1.015)	(0.942)
Constant	2.011***	2.134***	1.286***	1.566***	1.525**	1.995***
	(0.117)	(0.0867)	(0.362)	(0.260)	(0.665)	(0.520)
No.of Obs.	138	138	138	138	138	138
Time dummies	yes	yes	yes	yes	yes	yes
R-sq(within)	0.699	0.695	0.714	0.711	0.714	0.711
R-sq(between)	0.0038	0.0018	0.0324	0.0275	0.0326	0.0335
R-sq(overall)	0.270	0.305	0.298	0.322	0.306	0.330
F-test(u_i=0)	F(45,88)＝7.76		F(45,87)=7.95		F(45,86)=7.65	
	Prob>F=0.0000		Prob＞F＝0.0000		Prob＞F＝0.0000	
Hausman test	chi2(4)＝3.61		chi2(5)=3.47		chi2(6)=−478.63	
	Prob>chi2=0.4606		Prob>chi2=0.6273		chi2<0§	
Breusch-Pagan test	chi2(1)=62.99		chi2(1)=64.31		chi(2)=58.96	
	Prob>chi2=0.0000		Prob>chi2=0.0000		Prob>chi2=0.0000	

Notes: Standard errors are given in parentheses.

* denotes significance at the 10 % level, ** denotes the 5 % level, and *** denotes the 1 % level.

§The results of the Hausman test for the regression (Columns C1 and C2) included the following comment: “model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see Suest for a generalized test.”

Table4. Results of the Butz-Ward Model for 1980-2015: Dependent Variable is the TFR.

	(A1)	(A2)	(B1)	(B2)	(C1)	(C2)
	Fixed	Random	Fixed	Random	Fixed	Random
Female wages	0.0673	−0.106	0.139**	0.0496	0.207**	0.148
	(0.0682)	(0.0679)	(0.0631)	(0.0621)	(0.100)	(0.103)
Male income	0.528*	−0.194	−0.244	−0.776***	−0.237	−0.754***
	(0.295)	(0.273)	(0.287)	(0.250)	(0.288)	(0.251)
Female marriage rate			1.826***	2.037***	2.025***	2.327***
			(0.233)	(0.207)	(0.328)	(0.310)
Female wages×Female marriage rate					−0.146	−0.215
					(0.169)	(0.173)
Constant	1.575***	1.984***	0.534***	0.656***	0.427**	0.498**
	(0.0894)	(0.0674)	(0.156)	(0.147)	(0.199)	(0.197)
No.of Obs.	368	368	368	368	368	368
Time dummies	yes	yes	yes	yes	yes	yes
R-sq(within)	0.945	0.941	0.954	0.953	0.954	0.952
R-sq(between)	0.452	0.493	0.169	0.499	0.187	0.506
R-sq(overall)	0.523	0. 736	0.715	0.810	0.721	0.812
F-test(u_i=0)	F(45,313)=28.09		F(45,312)=27.69		F(45,311)=27.65	
	Prob>F=0.0000		Prob>F=0.0000		Prob>F=0.0000	
Hausman test	chi2(9)=41.44		chi2(10)=0.25		chi2(11)=1.99	
	Prob>chi2=0.0000		Prob>chi2=1.0000		Prob>chi2=0.9985	
Breusch-Pagan test	chi2(1)=586.62		chi2(1)=660.27		chi2(1)=650.33	
	Prob>chi2=0.0000		Prob>chi2=0.000		Prob>chi2=0.000	

Notes: Standard errors are given in parentheses.

* denotes significance at the 10 % level, ** denotes the 5 % level, and *** denotes the 1 % level.

The effect of female marriage rate is positive and statistically significant, which reflects the fact that couples tend to have children after getting married.

In Table 2, Columns C1 and C2 report the results including the cross term for female wages and female marriage rate. Based on the Hausman test, the fixed-effect model yields a better estimation. The results show that the effect of female wages is positive and statistically insignificant. The coefficient for male income is negative and statistically significant. The coefficient for female marriage rate is positive and statistically significant. The coefficient for the cross term for female wages and the female marriage rate is negative and statistically insignificant.

5.2 Estimation Results for Fertility for 1965-1975

Table 3 reports the estimation results for subperiod I (1965-1975). The results of the Butz-Ward model are presented in Columns A1 and A2. The Hausman test indicates that the random-effect model gives better statistical results. The effect of female wages on fertility is negative and statistically significant. The effect of male income on fertility is positive and statistically significant. As Butz and Ward noted, female wages have a negative impact on fertility because of the substitution effect, while male income has a positive impact on fertility because of the income effect.

In Table 3, Columns B1 and B2 present results including the female marriage rate variable. According to the Hausman test, the random-effect model yields better information. The effect of female wages on fertility is negative and statistically significant. The effect of male income is positive and statistically significant. These effects are consistent with the Butz-Ward model. The effect of the female marriage rate is positive and statistically significant, which is consistent with the predictions of the Butz-Ward model.

In Table 3, Columns C1 and C2 report the results including the cross term for female wages and female marriage rate. The model fit to these data fails to meet the asymptotic assumptions of the Hausman test. Therefore, we could not determine which model yielded a better estimate. The degrees of freedom decreased because we included the cross term for female wages and female marriage rate; thus, the model did not satisfy the asymptotic assumption.

5.3 Estimation Results for Fertility for 1980-2015

Table 4 reports the estimation results for subperiod II (1980-2015). The results of the Butz-Ward model are presented in Columns A1 and A2. According to the Hausman test, the fixed-effect model yields better statistical information. The effect of female wages on fertility is positive and statistically insignificant, which is inconsistent with the Butz-Ward theoretical framework. The effect of male income positively affects fertility and is statistically significant. As Butz and Ward noted, male income can positively impact fertility because of income effects.

In Table 4, Columns B1 and B2 report the results including the female marriage rate variable. According to the Hausman test, the random-effect model yields better information. The effect of female wages on fertility is positive and statistically insignificant, which is not consistent with the Butz-Ward theoretical framework. The effect of male income affects fertility negatively and is statistically significant, which is again inconsistent with the Butz-Ward model and is difficult to explain. The effect of female marriage rate is positive and statistically significant, as expected.

In Table 4, Columns C1 and C2 report the results including the cross term for female wages and female marriage rate. According to the Hausman test, the random-effect model yields better information. The coefficient for female wages is positive and statistically insignificant. The coefficient for male income is negative and statistically significant. The coefficient for female marriage rate is positive and statistically significant. The coefficient for female wages and female marriage rate is negative and statistically insignificant.

6 Discussion

We estimated Japanese fertility using the original Butz-Ward model and an extension of the model that included a variable for female marriage rate and/or the cross term of female wages and female marriage rate. We used aggregate data for 1965-2015 and separated panel data into the two subperiods, from 1965-1975 and 1980-2015, based on the results of a Chow test.

The Japanese fertility patterns in subperiod I (1965-1975) are consistent with the Butz-Ward model. Female wages have a negative impact on fertility via the substitution effect and male income has a positive impact on fertility via the income effect. This result indicates that the Butz-Ward model is appropriate for the subperiod I (1965-1975). As Butz and Ward noted, female wages, which associate an opportunity cost with child-bearing and rearing, negatively affect fertility because of the substitution effect; in contrast, male income positively affects fertility because of the income effect. These results are consistent with those of Imai (2001), which used the same Butz-Ward model.

However, the results for subperiod II (1980–2015) suggest that the Butz-Ward model cannot explain the pattern of fertility during that period. There are several possible reasons for this result.

First, because we utilized aggregate data, we could not control the heterogeneity, giving rise to larger standard errors.

Second, the Basic Survey on Wage Structure conducted by the Ministry of Health, Labour and Welfare does not compile married female wages and married male income at the prefectural level within age groups. Given that individual wages and income depend on variables such as occupation, employment status, educational level, and tenure, it might be better to utilize data that includes these statistics in future studies, depending on dataset availability.

Third, male income has a negative impact on fertility, similarly indicating a negative effect of income effect on fertility. This result begs the question whether children have shifted in status from normal goods to inferior goods. When children are assumed to be normal goods, the income effect is positive. However, if children are assumed to be inferior goods, the income effect is negative. Another reason for the negative income effect could arise from a couple's preference to have fewer children, allowing them to invest more money in each child's human capital and thus increasing the couple's utility. Thus, there could be a trade-off between quantity and quality in the number of children a couple has.

Fourth, the number of unmarried females has increased. This change in female marriage behavior could partially explain why the Butz-Ward model does not explain recent Japanese data. Originally, the Butz-Ward model determined fertility behavior based on households with a husband and either an employed or a non-employed wife. The increase in the number of unmarried females does not agree with the assumptions of Butz and Ward. Moreover, when there are fewer couples, the fertility rate decreases because couples generally have children after marriage. An increase in the number of unmarried females could decrease fertility more than an increase in the cost of child-rearing. Our results showed that female marriage rate was positively related to fertility from 1965-2015 during both subperiod I (1965-1975) and subperiod II (1980-2015). Further research should examine the determinants of the female marriage rate.

7 Conclusions

We estimated fertility in Japan using aggregate data for 1965-2015. We also tested for structural changes using a Chow test, and the results indicated that there was a structural change from 1975-1980. Based on these results, we separated 1965-2015 into two subperiods from 1965-1975 and 1980-2015. We then estimated Japanese fertility for 1965-2015, subperiod I (1965-1975) and subperiod II (1980-2015) using a fixed-effect model and a random-effect model.

Our results show that the patterns of Japanese fertility in subperiod I (1965-1975) are consistent with the model developed by Butz and Ward: female wages have a negative impact on fertility via the substitution effect and male income has a positive impact on fertility via the income effect. The results for subperiod II (1980-2015) are not consistent with Butz-Ward model. The effect of female wages is positive and the effect of male income is either positive or negative. In addition, for 1965-2015, the effect of female wages tends to negatively affect fertility, but when the cross term for female wages and female marriage rate is included, the effect becomes positive. The effect of male income has a negative impact on fertility.

We suggest that the Butz-Ward model did not fit the data in subperiod II (1980-2015) for the following reasons:

First, because we utilized aggregate data, we could not control for heterogeneity, which caused greater standard errors.

Second, the Basic Survey on Wage Structure conducted by the Ministry of Health, Labour and Welfare does not compile married female wages and married male income at the prefecture level by age groups. In addition, since individual wages and income depend on variables such as occupation, employment status, educational level, and tenure, it would be desirable to including these variables in future research, if datasets are available.

Third, our results show that for subperiod II (1980-2015), male income affects fertility negatively, which suggests two possible conclusions: first, children might be assumed to be inferior goods, and second, couples might choose to spend a greater amount of money on human capital for fewer children.

Finally, as our results show, the decrease in fertility rate could be largely caused by changing female marriage behavior, particularly remaining unmarried or delaying marriage. Since the Butz-Ward model assumes the fertility behavior of a household with a husband and a wife, recent female marriage behavior could be the reason that the Butz-Ward model does not explain recent Japanese data. Moreover, the increase in the number of unmarried females could be an important factor in the decrease in the fertility rate. In our estimation results, the female marriage rate variable was positively related to fertility during all periods: 1965-2015, subperiod I (1965-1975), and subperiod II (1980-2015). Future research should focus on the determinants of female marriage behavior to analyze the patterns of Japanese fertility.

Based on our estimated results, we conclude that the fertility pattern for subperiod I (1965-1975) can be explained by the Butz-Ward model. Compared with subperiod II (1980-2015), the effect of female wages on fertility was negative via the substitution effect, and the effect of male income on fertility was positive via the income effect. For subperiod II (1980-2015), the Butz-Ward model could not explain the fertility pattern. As previously mentioned, the decrease in fertility rate could be caused by the increase in the number of unmarried females rather than an increase in the cost of child-rearing. Thus, understanding the determinants of female marriage behavior is crucial to characterizing recent fertility patterns.

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