

On the Persistence of Low Birthrate in Japan

Reiko Aoki*and Yoko Konishi‡

“Fertility and Public Policy: How to Reverse the Trend of Declining Birth Rates”

CIS-CESifo, Munich, 1-2 February 2008

Abstract

We first present a simple model to explain why we might observe a positive relationship between birth rate and female labor participation. We verify the implications of the model with cross-sectional Japanese regional (by prefecture) for every five years 1980-2005. We show quality adjusted consumption has a negative effect with number of children. Relationship between labor participation and birthrate becomes negative once this is taken into account. We expand quality adjusted consumption approach to a general equilibrium model and show decline in population will result in higher or lower birthrate, depending on maturity of technology. Technology dictates the relationship between quality of consumption good and skilled labor.

*Institute of Economic Research, Hitotsubashi University aokirei@ier.hit-u.ac.jp

†Research Institute of Economy, Trade and Industry konishi-yoko@rieti.go.jp

‡The authors are very much grateful to the financial support from the academic project on Economic Analysis of Intergenerational Issues, funded by the Grant-in-Aid for Specially Promoted Research from Japan’s Ministry of Education (grant number 18002001).

1 Introduction

We start with some observations from time series and cross-country data on fertility and female labor participation. The usual relationship between female labor participation and fertility is negative (Becker (1965)) as the time series of female labor participation rate (FLPR) and total fertility rate (TFR) of selected OECD countries exhibit (Figure 1). Recently the positive relationship between FLPR and TFR cross-country data in 2005 (average of years 1985-1996 as well as year 2000, Sleebos (2003), d'Addio and d'Ercole (2005), Da Rocha and Fuster (2006)) have gained much attention. In Japan also, cross-section among prefectures show positive relationship in 1987 and 2002 (Figure 2).

We also note that countries with high per capita GDP have low birthrates (Figure 3). The usual interpretation would be based on the positive relationship between higher per capita GDP and higher wages. Higher opportunity cost when wages are high means lower fertility when per capita GDP is high. Higher per capita GDP is also associated with higher quality of consumption. We believe that the trade-off between consumption and number of children should be taken into account when understanding childbearing and working decisions.

We first present a model of consumer choice where children and consumption experience require both goods and time. We demonstrate how change in quality of consumption and change in wages have different effects on number of children. Since wage level and consumption quality are related, relationship between fertility and labor participation can be positive or negative. We verify the model implications with cross-sectional Japanese data for every five years 1980 – 2005. We use indicators of consumption quality as well as consumption behavior.

We verify implications of the model with Japanese cross sectional data from 8 different points in time (every five years from 1970 – 2005) in which a positive correlation between TFR and FLPR among prefectures (regions) have been observed since 1980. However, we find that FLPR has a significantly negative effect on TFR after resolving econometric problems from

unobservable heterogeneity, simultaneity or endogeneity and measurement error by Fixed effect IV estimation. The results are consistent with the theoretical predictions as well as traditional economic models of the relation between TFR and FLPR. Furthermore, consumption variables are statistically significant and have negative impact on TFR.

In the second half of this chapter, we endogenize the wages and consumption quality in a general equilibrium model with heterogenous labor and vertically differentiated products. Through comparative statics, we analyze the cause and implications of low birthrate in the long run. We show that the feedback mechanism of the economy may not reverse the declining birthrate, contradicting an implication of the Easterlin Hypothesis cohort effect. This is because the labor market structure and product market adjusts to change in birthrate and thus the cohort effect never materializes.

The approach is in the spirit to papers in growth and trade that take into account the reaction of the economy in the long run (Acemoglu (1998), Flam and Helpman (1987), Thoenig and Verdier (2003)). Acemoglu (1998) showed that while in the short run, labor input is reduced in response to scarcity of skilled labor and high wages, skilled labor supply increase in response triggers technological change that makes skilled labor even more productive, raising skilled labor wage in the long run. Our analysis suggests that a similar long term adjustment of the economy will prevent a natural feedback mechanism from working. That is, smaller population will increase marginal product of labor in the short run but consumption pattern will change in the long run reducing such an advantage.

2 Re-examination of female labor participation - birthrate relationship

Consider a situation where utility of a household depends on number of children, n , consumption of a good x . Both child rearing and consumption of a good requires time. Number of children is determined by amount of

good x_c , and time devoted, ℓ_c ,

$$n = f(x_c, \ell_c), \quad f_x > 0, f_\ell > 0.$$

Subscripts on functions denote partial derivatives. The utility of consumer is actually determined by amount of z , which is consumption experience that depends on amount of the good, x , and time devoted, ℓ ,

$$z = g(x, \ell), \quad g_x > 0, g_\ell > 0.$$

Utility function is,

$$u(n, z), u_n > 0, u_z > 0.$$

Budget constraint depends on price of good and wage, and labor endowment, $\bar{\ell}$,

$$px + px_c + w\ell + w\ell_c = w\bar{\ell}.$$

Figure 4 demonstrates the optimization problem. The opportunity set is defined as,

$$\{(z, n) | n = f(x_c, \ell_c), \quad z = g(x, \ell), \quad p(x + x_c) + w(\ell + \ell_c) = w\bar{\ell}\}.$$

The frontier is downward sloping (see Appendix). It reflects the budget constraint as well as the technologies, g and f . We can show that

Claim 1. *When wage increases, the opportunity set expand. (Dotted line in Figure 5.) Under regularity conditions, hours worked increases and number of children increase or consumption increases or both when wage increases. That is, denoting equilibrium quantities as ℓ_c^* , x_c^* , ℓ^* , and x^* , if $u(n, z)$, $f(x, l)$ and $g(x, c)$ are concave, then*

$$\frac{\partial \ell_c^*}{\partial w} < 0, \frac{\partial \ell^*}{\partial w} < 0, \text{ and } \frac{df(x_c^*, \ell_c^*)}{dw} > 0 \text{ or } \frac{dg(x^*, \ell^*)}{dw} > 0 \text{ or both.}$$

Proof is in the Appendix. The result is intuitive. When wage increases, there is substitution away from labor to goods, which increases hours worked. Higher wage expands the budget set and will increase x_c . This may off set

the decline in ℓ_c which increases number of children despite lower ℓ_c , i.e., more hours worked. A positive relationship between labor participation and child birth is observed.

We further index consumption (consumption experience) by quality, Q . Utility function is

$$u(Qz, n)$$

where z measures quantity of consumption. First-order condition for utility maximization are,

$$\frac{f_x}{f_\ell} = \frac{g_x}{g_\ell} = \frac{p}{w}, \quad (1)$$

$$\frac{u_n}{u_z} = Q \frac{g_x}{f_x}. \quad (2)$$

Equation (1) implies less labor intensive consumption and child rearing method will be used when wage increase. The time series of female wage has been rising in Japan would lead to less labor intensive methods which means greater labor participation. Equation (2) implies better quality of consumption leads to more consumption and less children.

Higher wage but not significantly higher quality means positive relationship. However with the same higher relative wage and higher quality consumption means negative relationship between labor participation and fertility. Availability of consumption goods, such as entertainment and restaurants, is much greater in larger cities. This means higher Q , meaning less children and more consumption in cities.

2.1 Empirical Evidence with Japanese Regional Data

In this section we examine the empirical evidence to support the theoretical implications of the previous sections. In Section 2.2, we present the data with descriptive statistics and confirm the positive relationship between total fertility rate (TFR) and female labor participation rate (FLPR) among regions (prefectures) in Japan, as seen in other OECD countries. We present the estimation results in Section 2.3. We estimate the equations that as-

sume that regional TFR is affected by regional variables that reflect quality of consumption goods. Specifically we consider household leisure and entertainment expenditures, automobile ownership, and number of department stores as explanatory variables, in addition to the traditional marriage and other family variables. Child bearing and female labor market participation are determined simultaneously which implies there is a simultaneous or endogenous relationship between TFR and consumption behavior variables. Furthermore, because the quality of consumption goods are the latent variables, we employ some proxy variables. To address the simultaneity, endogeneity and measurement error problems, we apply the fixed effects instrumental variables(FE-IV) method to our panel data. The unobserved heterogeneity among regions is also taken into account by this approach.

2.2 Data and Descriptive Statistics

We use data from 47 prefectures for years 1970, 75, 80, 85, 90, 95, 2000, and 2005 (Okinawa prefecture is not included in 1970). Figure 4 plots correlation coefficients between regional TFR and FLRP for every five years from 1970 to 2005. The coefficient is negative for 1970 but is positive thereafter. For the last few years, the correlation is not only positive but close to 0.5, a very clear positive relationship between TFR and FLRP. The positive relationship has also been observed in cross=section of other OECD countries in recent years. We will be controlling for consumption variables implied by the proceeding theoretical model to understand the relationship.

The labels and sources of the variables for the regression in the next section are summarized in Table 1. We introduce some new variables as determinants of TFR in addition to the traditional marriage and household variables. Specifically we consider household leisure and entertainment expenditures and automobile ownership as the consumer behavior variables that capture optimal choice, i.e., consumer behavior. In order to reflect quality of consumption, we use the number of department stores, which specialize in high end or high quality products. Leisure and Automobile Ownership can be considered to be high quality goods and Department Store to be a proxy

variable for high quality of consumption goods. They both should have negative impacts on TFR.

Table 2 summarizes the changes through time by depicting mean, standard deviation, minimum and maximum values for each variable for each year. The steady decline of TFR is striking and TFR in 2005 has decreased to almost one-half of that in 1970. The number of married couples has been declining as well. FLPR declines slightly in the period, but the standard deviation has changed from 6.313 (in 1975) to 2.467 (in 2005), implying that prefectures have become more homogeneous as far as FLPR is concerned. There is a similar phenomenon in Marriage standard deviation. On the other hand, we also observe that some variables have had rising means (proportion of one-person households, proportion of leisure and entertainment expenditure, automobile ownership rate and number of department stores), and in particular the means of Automobile Ownership and the number of department store have risen substantially. And their standard deviations have increased, suggesting they could be better explanatory variables for heterogeneity of prefectures. In Section 2.3 we regress TFR on FLPR and other variables, and apply the fixed effect instrumental variable model to our panel data to address the econometric problems and unobservable heterogeneity among prefectures.

Table 2: Descriptive Statistics

Variables	Year	Mean	S.D.	Min.	Max.
TFR	1970	2.092	0.115	1.88	2.35
	1975	2.006	0.165	1.63	2.88
	1980	1.829	0.135	1.44	2.38
	1985	1.825	0.125	1.44	2.31
	1990	1.616	0.125	1.23	1.95
	1995	1.525	0.134	1.11	1.87
	2000	1.473	0.133	1.07	1.82
	2005	1.307	0.122	0.98	1.71
FLPR	1970	54.483	6.313	40.2	65.5

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Variables	Year	Mean	S.D.	Min.	Max.
	1975	48.545	5.73	35.7	58.8
	1980	49.057	5.26	36.3	59.4
	1985	49.264	4.398	37.6	57.5
	1990	49.385	3.744	38.7	56.3
	1995	49.868	3.178	40.7	56.1
	2000	48.909	2.849	40.8	54.0
	2005	48.572	2.467	41.9	53.1
Marriages	1970	8.980	1.458	6.4	12.5
	1975	7.987	0.695	6.5	9.6
	1980	6.383	0.497	5.3	7.7
	1985	5.853	0.430	5.1	7.3
	1990	5.453	0.570	4.5	7.0
	1995	5.885	0.658	4.8	7.6
	2000	5.936	0.590	4.8	7.4
	2005	5.272	0.554	4.3	6.9
One-person Household	1970	N/A	N/A	N/A	N/A
	1975	0.113	0.033	0.068	0.256
	1980	0.13	0.033	0.083	0.267
	1985	0.18	0.039	0.121	0.339
	1990	0.201	0.039	0.143	0.359
	1995	0.229	0.039	0.176	0.381
	2000	0.249	0.04	0.191	0.409
	2005	0.267	0.04	0.209	0.425
Automobile Ownership	1970	0.12	0.027	0.068	0.184
	1975	0.238	0.038	0.164	0.333
	1980	0.319	0.048	0.212	0.443
	1985	0.354	0.051	0.246	0.478
	1990	0.428	0.057	0.304	0.560
	1995	0.561	0.078	0.342	0.718
	2000	0.681	0.105	0.358	0.852

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Variables	Year	Mean	S.D.	Min.	Max.
	2005	0.773	0.127	0.365	0.957
Leisure & Entertainment	1970	N/A	N/A	N/A	N/A
	1975	0.083	0.008	0.063	0.106
	1980	0.085	0.009	0.068	0.111
	1985	0.088	0.009	0.07	0.115
	1990	0.095	0.008	0.08	0.113
	1995	0.096	0.01	0.076	0.121
	2000	0.101	0.009	0.08	0.12
	2005	0.102	0.01	0.076	0.127
Department Store	1969	17.196	20.722	3	123
	1975	29.213	37.56	4	203
	1978	35.532	41.937	2	231
	1981	51.617	59.258	7	300
	1986	57.106	59.045	5	242
	1991	44.596	45.377	3	235
	1996	65.085	63.898	11	322
	2001	63.447	60.699	12	295

2.3 Estimation Results

Table 3 is from cross section regression of TFR on all variables in Table 2. The regression equation is,

$$\begin{aligned} TFR_i = c + \beta_1 FLPR_i + \beta_2 Marriage_i + \beta_3 Oneperson_i \\ + \beta_4 Leisure_i + \beta_5 Automobile_i + \beta_6 Dpt.Store_i + \epsilon_i, \end{aligned} \quad (3)$$

where $i = 1, \dots, 47$, c is the constant term, $\beta_j, j = 1, \dots, 6$ are unknown parameters and ϵ is the error term.

Table 3 only shows the estimated coefficient ($\hat{\beta}_1$) of FLRP and ** indicates the null hypothesis $\beta_1 = 0$ can be rejected at 5% significance level. Although we observed a positive correlation between FRP and FLRP by the Pearson's Correlation Coefficient (See Figure 4), after adding to the consumption variables, the FLPR coefficient is no longer significant at the 5% level. However, the coefficient is significantly positive when cross sections are pooled for 1975 – 2005 with $\beta_{FLRP} = 0.066$.

We believe that the variables we employ do not completely explain the heterogeneity of TFR. We suspect that there must be a correlation with the error term, which causes a bias in the OLS estimators, as is often the case. To address this problem, we assume the heterogeneity among the prefectures is time invariant and apply the fixed effect model to our panel data. This will guarantee a consistent estimation even with unobservable heterogeneity. We show the estimation results in Table 4, Column 1 of Table 4 is the pooled OLS regression result of equation 3, where $t = 1975, \dots, 2005$ and c is the constant term. We show the same result in Table 3, the FLPR coefficient is significantly positive with 0.066. Column 2 is result of equation 4 where α is the constant term and $t = 1970, \dots, 2005$. This is a fixed effects model that takes into account of heterogeneity(α) and FLRP and Marriages are the only dependent variables, as in the previous studies. The FLPR coefficient is not significant at the 5% level, even the sign is negative.

$$TFR_{i,t} = \alpha_i + \beta_1 FLPR_{i,t} + \beta_2 Marriages_{i,t} + \epsilon_{i,t} \quad (4)$$

Column 3 shows a regression results of equation 5, where $t = 1975, \dots, 2005$ and we obtain the negative coefficient of FLPR and it is significant.

$$\begin{aligned}
TFR_{i,t} = & \alpha_i + \beta_1 FLPR_{i,t} + \beta_2 Marriage_{i,t} + \beta_3 Oneperson_{i,t} \\
& + \beta_4 Leisure_{i,t} + \beta_5 Automobile_{i,t} + \beta_6 Dpt.Store_{i,t} + \epsilon_{i,t} \quad (5)
\end{aligned}$$

Comparison of Column 2-4 allows us to understand the effects of consumption variables more clearly. As we pointed out previously, we must address the simultaneity and endogeneity between TFR, FLPR, and consumer behavior variables as well as the latency of proxy variables for the quality of consumption goods. To this end, we employ the fixed effects instrumental variables model (FE-IV model), which will guarantee a consistent estimator even unobservable heterogeneity, simultaneous problem or measurement error problem. We employ the lagged variables of FLPR, Marriages, and the other consumption expenditures (e.g. expenses for food, lighting and heating, furniture, transportation expenses and so on) as instrumental variables, and Marriages is the exogenous variable. Column 4 shows a Fixed effect IV estimation results of equation 5. We conclude that this result is our final result in the analysis.

We focus the analyze on the impact of FLPR on TFR, the coefficient of FLPR is significantly negative after controlling the effect of consumption and dealing with the econometric problems. We emphasize that the magnitude of FLPR's coefficient is larger than Column 3 in absolute value, it suggests that OLS estimator has a downward bias. The coefficient of Marriages is significantly positive, the region which has large number of married couples rather than other region achieve at higher TFR. There is a same phenomenon in the proportion of one-person households. We observe the significantly negative effects of Automobile Ownership and Leisure and Entertainment on TFR. Department Store is not significant in this estimation. Isolating the the effect of high-quality goods on TFR is left for future research.

3 General Equilibrium with high quality product and heterogenous labor

In this section we analyze a general equilibrium model in which consumers have a utility function that reflect the previous analysis, although somewhat simplified. Consumers differ by two attributes, their preference and quality of labor. Consumers choose either to consumer high quality product or standard (low quality) product. Child bearing choice differ according to which product they choose, as well as if they are skilled or not. Skilled workers produce the high quality product and the labor supply level determine the level of quality.

3.1 Approach

Consumers

We simplify the consumer's problem so that she chooses between consumption (x) and childbearing (n). Her preference is represented by the following utility function which also depends on the quality of the good consumed, Q ,

$$U_\rho(n, x) = (Qx^\rho + n^\rho)^{\frac{1}{\rho}}, \quad 0 < \rho < 1. \quad (6)$$

Consumers preference, ρ , is distributed uniformly over $[0,1]$. Consumption good is either the standard (low quality) $Q = 1$ or high quality $Q > 1$. Consumer's labor endowment is $\bar{\ell}$ and wage is w which is also the opportunity cost of children. Denoting price of the good by p , consumer chooses consumption and number of children to maximize (6) with respect to the budget constraint,

$$px + wn = w\bar{\ell}.$$

Each consumer's consumption and number of children given quality Q is determined by the utility maximization given the budget constraint,

$$x_\sigma^*(p, w; Q) = \frac{Q^\sigma \bar{\ell}}{\left(\frac{p}{w}\right)^\sigma \left(Q^\sigma \left(\frac{p}{w}\right)^{1-\sigma} + 1\right)}, \quad n_\sigma^*(p, w; Q) = \frac{\bar{\ell}}{Q^\sigma \left(\frac{p}{w}\right)^{1-\sigma} + 1}, \quad (7)$$

where $\sigma \equiv \frac{1}{1-\rho} > 1$.

Consumption is increasing and number of children is decreasing in quality, as in the previous section. The indirect utility is,

$$v_\sigma(p, w; Q) = \bar{\ell} \left(Q^\sigma \left(\frac{w}{p}\right)^{\sigma-1} + 1 \right)^{\frac{1}{\sigma-1}}.$$

The consumer must choose which quality to consume. If her marginal utility from more consumption is relatively large, she devotes less resources to children and has fewer children. If the quality is low and not as beneficial, she derives utility by having many children. She compares the utility levels from consuming each quality and buys whichever yields higher utility. We denote the prices of the goods with different qualities by p_H and p_L . Consumer will buy the high quality good when

$$v_\sigma(p_H, w; Q) > v_\sigma(p_L, w; 1).$$

This condition is equivalent to,

$$\sigma < \hat{\sigma} \equiv \frac{\ln \frac{p_H}{p_L}}{\ln \frac{p_H}{p_L} - \ln Q}. \quad (8)$$

Since $\sigma > 1$, there will be no demand for the low quality good if $\ln \frac{p_H}{p_L} < \ln Q$. This occurs if low quality product is more expensive ($p_L \geq p_H$) since $Q > 1$ and $p_H > p_L$ but the price premium for the high quality is small relative to difference in quality. It does not depend on the level of income.

Consumer's labor supply is the hours not devoted to raising children,

$$\ell_\sigma(p, w; Q) = \bar{\ell} - n_\sigma^*(p, w; Q) = \frac{Q^\sigma}{Q^\sigma + \left(\frac{p}{w}\right)^{\sigma-1}}. \quad (9)$$

Markets

The labor each consumer supplies is either skilled (s) or unskilled (u). There are total of N consumers, and $\theta \in (0, 1)$ of the consumers are skilled. Labor endowment, $\bar{\ell}$, is the same for both types. We denote wages for skilled and unskilled by w_s and w_u . Production technology is constant returns to scale in labor: one unit of skilled labor produces one unit of high quality product and one unit of unskilled labor produces one unit of the standard product. Furthermore we assume both products are supplied competitively. Thus we have $p_H = w_s$ and $p_L = w_u$.

One skilled worker's demand for high quality product is , denoting relative wage by $\xi = \frac{w_s}{w_u} > 1$ and using (7),

$$x_s^H(\xi) = x_\sigma^*(w_s, w_s; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + 1}, \quad \sigma < \hat{\sigma} = \frac{\ln \xi}{\ln \xi - \ln Q},$$

and demand for low quality is,

$$x_s^L(\xi) = x_\sigma^*(w_u, w_s; Q) = \frac{\bar{\ell}}{\xi^{-\sigma}(\xi^{\sigma-1} + 1)}, \quad \sigma > \hat{\sigma}.$$

There will be positive demand for the low quality only if $\xi > 1$ since $\xi = \frac{p_H}{p_L}$. We make the following observation

Claim 2. *High skilled consumers consume more of both quality, $x_s^H(\xi) > x_u^H(\xi)$ and $x_s^L(\xi) > x_u^L(\xi)$.*

Total demands from all the skilled workers for high quality product and low quality product are ,

$$X_s^H(\xi) = \theta N \int_1^{\hat{\sigma}} x_s^H(\xi) d\sigma, \quad X_s^L(\xi) = \theta N \int_{\hat{\sigma}} x_s^L(\xi) d\sigma.$$

Similarly for unskilled workers, we have the individual demands for high quality good,

$$x_u^H(\xi) = x_\sigma^*(w_s, w_u; Q) = \frac{Q^\sigma \bar{\ell}}{\xi^\sigma (Q^\sigma \xi^{1-\sigma} + 1)}, \quad \sigma < \hat{\sigma} = \frac{\ln \xi}{\ln \xi - \ln Q},$$

and demand for low quality good,

$$x_u^L(\xi) = x_\sigma^*(w_u, w_u; Q) = \frac{\bar{\ell}}{2}, \quad \sigma > \hat{\sigma}.$$

Total demands for each quality from all unskilled workers are,

$$X_u^H(\xi) = \int_1^{\hat{\sigma}} x_u^H(\xi) d\sigma, \quad X_u^L(\xi) = \int_{\hat{\sigma}} x_u^L(\xi) d\sigma.$$

Since production of one unit of good requires one unit of labor, demand for skilled and unskilled labor, L_s^D and L_u^D are,

$$L_s^D(\xi) = \theta N X_s^H(\xi) + (1 - \theta) N X_u^H(\xi), \quad (10)$$

$$L_u^D(\xi) = \theta N X_s^L(\xi) + (1 - \theta) N X_u^L(\xi). \quad (11)$$

Labor supply is constructed in a similar manner from individual supplies. Individual labor supply as function of relative wage is , using (9) ,

$$\ell_s^H(\xi) = \ell_\sigma^*(w_s, w_s; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + 1}, \quad \sigma < \hat{\sigma},$$

$$\ell_s^L(\xi) = \ell_\sigma^*(w_u, w_s; 1) = \frac{\bar{\ell}}{\xi^{1-\sigma} + 1}, \quad \sigma > \hat{\sigma}$$

$$\ell_u^H(\xi) = \ell_\sigma^*(w_s, w_u; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + \xi^{\sigma-1}}, \quad \sigma < \hat{\sigma},$$

$$\ell_u^L(\xi) = \ell_\sigma^*(w_u, w_u; 1) = \frac{\bar{\ell}}{2}, \quad \sigma > \hat{\sigma}.$$

Aggregation yields the total labor supply of each type,

$$L_s^S = N \bar{\ell} \int_1^{\hat{\sigma}} \left\{ \theta \frac{Q^\sigma}{Q^\sigma + 1} + (1 - \theta) \frac{Q^\sigma}{Q^\sigma + \xi^{\sigma-1}} \right\} d\sigma, \quad (12)$$

$$L_u^S = N \bar{\ell} \int_{\hat{\sigma}}^\infty \left\{ \theta \frac{Q^\sigma}{Q^\sigma + \xi^{1-\sigma}} + (1 - \theta) \frac{1}{2} \right\} d\sigma. \quad (13)$$

It is easy to show, from (8), that $\hat{\sigma}$ is decreasing in ξ that L_s^D and L_u^S is decreasing in $\xi = \frac{w_s}{w_u}$ and L_s^S and L_u^D are increasing in ξ . Equilibrium relative wage for a given quality level, $\xi^*(Q)$, is determined by the skilled labor market

clearing condition,

$$L_s^D(\xi) = L_s^S(\xi).$$

The unskilled labor market has cleared by Walrus Law.

3.2 Comparative statics

We first see how the equilibrium labor supply and relative wage change with quality.

Claim 3. (i) L_s^S , L_u^S and L_s^D are increasing and L_u^D are decreasing in Q .

(ii) Equilibrium relative wages and level of skilled labor are increasing in quality. That is, $\partial\xi^*(Q)/\partial Q > 0$ and $\partial L_s^*(Q)/\partial Q > 0$.

(See Figures 6 and 7. Proof is in the Appendix.) Higher quality makes consumption attractive for skilled workers and also increase proportion of all workers that consume the high quality product. Thus both demand and supply of skilled labor is increasing in quality. The same effect increases the supply of unskilled workers and reduces demand for low quality good. The latter effect implies demand for unskilled workers decreases when quality improves.

Skilled labor supply is increasing in population, $\partial L_s^S/\partial N > 0$, from (12) and demand is also increasing in population, $\partial L_s^D/\partial N > 0$, from (10). (See proof of Claim 3 in the Appendix.) This implies

Claim 4. Both equilibrium skilled and unskilled labor will increase when population increases, $\partial L_s^*/\partial N > 0$ and $\partial L_u^*/\partial N > 0$.

Again, using the proof of Claim 3 in the Appendix, both demand and supply of skilled labor is also increasing in proportion of skilled consumers, $\partial L_s^S/\partial\theta > 0$, from (12) and $\partial L_s^D/\partial\theta > 0$, from (10).

Claim 5. Equilibrium skilled labor and equilibrium relative wage are increasing in the proportion of skilled consumers, $\partial L_s^*/\partial\theta > 0$ and $\partial\xi^*/\partial\theta > 0$.

Birthrate

Individual number of children are,

$$\begin{aligned} n_s^H(\xi) &= n_\sigma^*(w_s, w_s; Q) = \frac{\bar{\ell}}{Q^\sigma + 1}, \quad \sigma < \hat{\sigma}, \\ n_s^L(\xi) &= n_\sigma^*(w_u, w_s; 1) = \frac{\bar{\ell}}{\xi^{\sigma-1} + 1}, \quad \sigma > \hat{\sigma} \\ n_u^H(\xi) &= n_\sigma^*(w_s, w_u; Q) = \frac{\bar{\ell}}{Q^\sigma \xi^{1-\sigma} + 1}, \quad \sigma < \hat{\sigma}, \\ n_u^L(\xi) &= n_\sigma^*(w_u, w_u; 1) = \frac{\bar{\ell}}{2}, \quad \sigma > \hat{\sigma}. \end{aligned}$$

It is clear that for given wage level, those that consume high quality good devoted even more resources for consumption and thus reduce number of children when quality improves. Since the equilibrium relative wage is increasing in quality, we can say the following,

Claim 6. (i) *Skilled consumers have less children . That is , $n_s^H < n_u^H$ for $\sigma < \hat{\sigma}$ and $n_s^L < n_u^L$ for $\sigma > \hat{\sigma}$.*

(ii) *Skilled consumers have less children when quality of product improves. That is, $dn_s^H/dQ < 0$ for $\sigma < \hat{\sigma}$ and $dn_s^L/dQ < 0$ for $\sigma > \hat{\sigma}$.*

(iii) *Unskilled consumers that consume low quality product have the same number of children when quality improves. That is, $dn_u^L/dQ = 0$ for $\sigma > \hat{\sigma}$.*

Although there is an income effect, the substitution effect dominates and skilled workers that consumer low quality reduce number of children. For unskilled consumers that bought high quality good, improvement makes consumption more attractive (reduce children) but their relative wage becomes lower and the substitution effect works in the opposite direction. The total effect is not clear.

3.3 Endogenous Quality and Easterlin Hypothesis

Assume that level of quality is increasing in the size of the skilled labor. That is, $Q = Q_T(L_s)$ is an increasing function of Q . Subscript T refers to “technology” which is what this relationship reflects. We will denote the inverse relationship between the market equilibrium supply of skilled labor and quality of $L_s^*(Q)$ by $Q = Q_M(L_s)$, which is an increasing function from Claim 3. The equilibrium level of labor L_s^* and equilibrium level of quality, $Q^* = Q_M(L_s^*) = Q_T(L_s^*)$, is the intersection of the two curves.

When marginal increase in quality from labor is very large, then the equilibrium is unstable. Graphically, this would mean slope of Q_T is steeper than Q_M ($Q'_T > Q'_M$). This is the case around equilibrium E_1 in Figure 8. A perturbation away from E_1 results in either spiral increase in quality and skilled labor supply or decrease of quality and skilled labor supply. When technology is mature so that marginal quality improvement is very small, then equilibrium is stable ($Q'_T < Q'_M$). This is equilibrium E_2 in Figure 8. There may be multiple equilibria, some stable and others unstable. A slight perturbation from low quality with small skilled labor force will start a spiral of labor and quality improvement until E_2 is reached.

Now using Claim 4, we analyze the effect of declining population. The claim implies that the $Q_M(L_s)$ function will shift upward in the $L_s - Q$ space (Figure 9).

Claim 7. (i) *If the technology is in its infancy, then equilibrium quality and skilled labor supply increase when population declines. That is ,*

$$Q'_T > Q'_M \quad \Rightarrow \quad \frac{\partial Q^*}{\partial N} < 0, \quad \frac{\partial L_s^*}{\partial N} < 0.$$

(ii) *If the technology is mature, then equilibrium quality and skilled labor supply decrease when the population decreases. That is ,*

$$Q'_T < Q'_M \quad \Rightarrow \quad \frac{\partial Q^*}{\partial N} > 0, \quad \frac{\partial L_s^*}{\partial N} > 0.$$

When the technology is mature, then declining population results in “con-

traction” of the economy. That is, quality and supply of skilled labor are reduced. Claim 6 suggests that lower quality will increase the birthrate. Recall that all but unskilled consumers that consumed high quality product will increase birthrate when quality improves. This situation is consistent with a cohort effect.

The situation is different when the technology still has not exhausted increasing marginal returns. The new equilibrium results in more skilled labor and higher quality. Products are more polarized, skilled labor has higher relative wages and work more. Utility is derived from more consumption and there is less children. The cohort effect does not hold because the economy adjusts to the lower level of population according to the available technology.

Now we consider the effect of more skilled workers, using Claim 5. The claim implies that the $Q_M(L_s)$ function will shift downward in the $L_s - Q$ space (Figure 10). Immediately we have the following,

Claim 8. (i) *If the technology is in its infancy, then equilibrium quality and skilled labor supply decrease when the proportion of skilled workers increase. That is ,*

$$Q'_T > Q'_M \quad \Rightarrow \quad \frac{\partial Q^*}{\partial \theta} < 0, \quad \frac{\partial L_s^*}{\partial \theta} < 0.$$

(ii) *If the technology is mature, then equilibrium quality and skilled labor supply increase when the proportion of skilled workers increase. That is ,*

$$Q'_T < Q'_M \quad \Rightarrow \quad \frac{\partial Q^*}{\partial \theta} > 0, \quad \frac{\partial L_s^*}{\partial \theta} > 0.$$

Equilibrium quality will decrease (increase) when technology is in its infancy (maturity). When proportion of skilled consumers increase, each skilled worker needs to supply less labor to maintain the same quality. When marginal quality from labor is very large, quality must be lower to accommodate it. Lower quality (and lower wage) likely to imply higher birthrate. Thus when technology is sufficiently productive, the increasing skilled workers will increase the birthrate. On the other hand when the marginal product of labor is low, then higher labor implies higher quality. This may reduce

the birthrate.

Claims 7 and 8 suggest that increasing the proportion of skilled labor can be effective in reversing decline in birthrate whenever the cohort effect may not hold. This was the case when marginal return from increasing skilled labor is large. On the other hand, when the technology is mature, Esterlin Hypothesis is likely to hold and the same policy will prevent the feedback mechanism that otherwise will function.

4 Concluding Remarks

We have presented an alternative explanation of the positive relationship between total fertility rate (TFR) and female labor participation rate (FLPR) observed in a cross section of OECD countries in recent years.

We first argued that when consumption and childrearing require both time and goods, there will always be a negative relationship between consumption and number of children. However relationship between children and labor participation is not clear. We employed Japanese cross section from eight different points in time (every five years from 1970 – 2005), that have also shown a positive correlation between TFR and FLPR in recent years to test the theory. However, we found that FLPR has a significantly negative effect on TFR after dealing with unobservable heterogeneity, simultaneity or endogeneity problem and the measurement error problem by Fixed effect IV estimation. We note that the use of fixed effects instrumental variables model (FE-IV model) guarantees a consistent estimator. Furthermore, consumption variables are statistically significant and have negative impact on TFR. The results are consistent with our new model as well as traditional economic models of the relation between TFR and FLPR.

We showed how low fertility is associated with consumption of higher quality products using a general equilibrium model with vertical quality differentiation and heterogeneous labor. Higher quality product has two effects: it makes consumption more attractive but also increases wage for skilled workers. The second effect makes working more attractive and the resulting income effect implies having more children or consuming more higher quality

product or both. If the income effect dominates, higher labor participation and higher birthrate will be observed when income effect dominates. If the substitution effect dominates, the relationship will be negative. In both cases, there will be a negative relationship between birthrate and consumption.

The general equilibrium analysis suggests that if the technology is productive enough, the economy will adjust to smaller population and the cohort effect does not reverse the trend of declining population. We also showed that increasing the proportion of skilled consumers (potential workers) can increase birthrate and reverse the trend precisely when the cohort effect does not hold. We note that the same relationship between population size and proportion of skilled consumers means that changing the proportion can prevent the natural feedback mechanism from functioning when it would have functioned.

The two situations are characterized by if the technology has high marginal return from skilled labor (infant) or if this has been exhausted (mature). The economy will correct itself when it is mature, where we also observed the equilibrium to be stable. Therefore, another possible policy is to let the technology mature quickly.¹

¹Immigration is another aspect of globalization. It is interesting to examine the impact of immigration on birthrate. These are tasks for our future research. Case of open economy is explored in Yomogida and Aoki (2005).

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Appendix

Optimization of $u(Qx, n)$

Denoting the Lagrange multiplier by λ , first-order conditions are,

$$u_n f_x = \lambda p, \quad u_n f_\ell = \lambda w, \quad u_n g_x = \lambda p, \quad u_n g_\ell = \lambda w,$$

and the budget constraint. This implies

$$\frac{f_x}{f_\ell} = \frac{g_x}{g_\ell} = \frac{p}{w}.$$

When w increases, ℓ_c and ℓ decrease while x and x_c increase.

Proof of Claim 3

The demand and supply functions, (10), (11), (12), and (13), can be rewritten as,

$$\begin{aligned} L_s^S &= \theta N \bar{\ell} \int_1^\infty \frac{Q^\sigma}{Q^\sigma + \xi^{1-\sigma}} d\sigma + \theta N \bar{\ell} \int_{\hat{\sigma}}^\infty \left\{ \frac{Q^\sigma}{Q^\sigma + \xi^{1-\sigma}} - \frac{Q^\sigma}{Q^\sigma + 1} \right\} d\sigma \\ L_s^D &= \theta N \bar{\ell} \int_1^{\hat{\sigma}} \frac{Q^\sigma}{Q^\sigma + 1} d\sigma + (1 - \theta) N \bar{\ell} \int_1^{\hat{\sigma}} \frac{Q^\sigma}{Q^\sigma \xi + \xi^\sigma} d\sigma \\ L_u^S &= (1 - \theta) N \bar{\ell} \int_1^\infty \left\{ \frac{Q^\sigma \xi^{1-\sigma}}{Q^\sigma \xi^{1-\sigma} + 1} - \frac{1}{2} \right\} d\sigma + (1 - \theta) N \bar{\ell} \int_1^\infty \frac{1}{2} d\sigma, \\ L_u^D &= (1 - \theta) N \bar{\ell} \int_{\hat{\sigma}}^\infty \frac{1}{2} d\sigma + \theta N \bar{\ell} \int_{\hat{\sigma}}^\infty 1 \xi^{-1} + \xi^{-\sigma} d\sigma. \end{aligned}$$

The claim follows from noting that $\hat{\sigma}$ is decreasing in ξ and increasing in Q , and that $Q^\sigma \xi^{1-\sigma} > 1$ for $\sigma < \hat{\sigma}$.

Table 1: Description of Variables

Var. Name	Description	Data
TFR	Total Fertility Rate	the Vital Statistics
FLPR	Female Labor Force Participation Rate	the Labour Force Survey
Marriages	# of married couple at the year per 1000 Pop.	the Vital Statistics
One-person Household	# of one-person households/ # of Private households	the Population Census
Automobile Ownership	# of automobiles / the working population	Automobile Inspection & Registration
Leisure & Entertainment	Reading and recreation / Living expenditure	the Family Income and Expenditure Survey
Department Store	# of department store / 1000	the Unincorporated Enterprise Survey

Table 3: Estimation Coefficients of FLPR

year	1975	1980	1985	1990	1995	2000	2005	1975-2005
Coefficient	-0.002	0.007	0.003	0.007	0.006	0.006	0.007	0.066**
Std. Err.	(0.006)	(0.005)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.002)

Significant Level: ** : 5%

Table 4: Estimation Results

	Pooled OLS Model 1	Fixed Effect Model 2	Fixed Effect Model 3	IV Fixed Effect Model 4
Variables	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)
FLPR	0.007*** (0.00)	-0.005 (0.00)	-0.025*** (0.00)	-0.036*** (0.01)
Marriages	0.053*** (0.01)	0.171*** (0.01)	0.044*** (0.01)	0.076*** (0.02)
One-person households	-1.174*** (0.19)		-0.626** (0.25)	0.867** (0.44)
Automobile ownership	-0.415*** (0.06)		-0.820*** (0.06)	-1.168*** (0.13)
Leisure & Entertainment	-4.162*** (0.74)		-1.597*** (0.51)	-3.133*** (1.18)
Department- store	-1.290*** (0.20)		0.297 (0.27)	0.601 (0.88)
Const.	1.889*** (0.14)	0.861*** (0.17)	3.237*** (0.14)	3.630*** (0.29)
adj. R2	0.806	0.673	0.937	0.901
Hausman Test	N/A	35.6***	51.5***	24.9***
Obs.	329	375	329	282

Significant Level: ** : 5% *** : 1%