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A Quantitative Analysis of Endogenous Target Fertility in Sri Lanka

Keiichiro Matsushita[§] and Noriko Nishimura*

Even though the economic model of fertility seems theoretically plausible, application of the model to empirical data often gives us ambiguous impression about its validity. One source of the ambiguity that is examined by an empirical analysis in this paper comes from simultaneity of demand for and supply of children. Fertility differentials are explained by differences in educational attainment, work experience prior to marriage, possession of durable goods, job categories of the husband and the residual of the age at marriage. Differentials in parity progression are largely explained by the age of marriage or the previous childbirth.. The effect of socio-economic variables is parity dependent in supply of children. Differentials in spacing of childbirths are explained by the expected demand and unexpected additional demand for children and the age difference from the mean age at marriage or the previous childbirth.

Keywords: endogenous target fertility, parity progression, birth spacing, Sri Lanka,

An economic model of fertility introduced by Becker (1960) assumes that the demand for children is supplied as a result of household production. Since the demand for and supply of children is decided by the same family, they are simultaneously revealed in the end of child reproduction.

Thus, we assume the number of children ever born (CEB) as the endogenous target fertility. We assume further that first the family decides the demand for children and then they start having childbirths over a period of time, and that the family may adjust the timing of childbirth according to the demand for additional child and the timing of the preceding childbirth or marriage by optimizing their choice.

This paper consists of three parts: first, the differentials in CEB are explained by a simple regression model with socio-economic variables; second, the differentials in parity progression are explained by applying a logit model; third, the differentials in spacing of childbirth are explained by applying proportional hazard model.

The data for the analysis are taken from the Sri Lanka 1993 Demographic and Health Survey (DHS93), which was made available by the Department of Census and Statistics of Sri Lanka. Samples used in this paper are selected from married females whose ages lie between 30 and 49, who are living with spouse, married once, and bear no multiple childbirths. Selected samples are divided into two age groups, 30's and 40's.

Unfortunately, DHS93 does not include relevant economic variables such as wage rate, working hours, income, educational expenses and living standard for demand analysis. Quantitative analysis is limited by available variables.

1. Demand for Children

We assume here that CEB is the revealed demand for children. Since the data do not permit us to apply a demand analysis, we apply a simple multiple regression model, $\mathbf{CEB} = x\beta + \varepsilon$, to explain fertility differentials.

Independent variables are as follows:

(i) G: possession of TV, refrigerator, motor cycle and car;
(ii) EF: completed years of education by the respondent;
(iii) EH: completed years of education by husband;
(iv) LF: husband's occupation is other than professional and agricultural;
(v) PH: husband's occupation is professional;
(vi) WF: the respondent participates in labor market currently;
(vii) WFB: the respondent participated in labor market prior to marriage;
(viii) DC: the number of children died;
(ix) A40: dummy variable for the respondents aged from 40 to 49;
(x) RMA: residual of the estimated age at marriage, EMA, where

$$\underset{(66.77)}{\text{EMA} = 16.268} + \underset{(17.07)}{.456^*\text{EF}} + \underset{(5.83)}{.182^*\text{EH}} + \underset{(4.10)}{.732^*\text{LH}} + \underset{(3.92)}{1.220^*\text{PH}} - \underset{(0.51)}{.092^*\text{WF}}$$

$$+ \underset{(16.67)}{2.950^*\text{WFB}} + \underset{(3.95)}{.590^*\text{A40}}, \qquad n = 3855, \ \text{adj } r^2 = .25 .$$

Absolute value of the t-statistics is shown in parentheses. The period of education (EF) and work experience before marriage (WFB) are significant positive factors postponing the age of marriage. The completed years of education by husband (EH) has smaller but statistically significant positive effect, the older birth cohort (A40) married on average 0.590 years older than the younger counterparts, and the respondents who married to professionals and employed workers delayed their marriage approximately 1.220 and 0.732 year respectively compared to those married to husbands in agricultural sector. RMA is included to separate an influence of an unexpected choice of the age of marriage on fertility.

Estimated coefficients and related statistics are shown in Table 1 for (i) CEB, (ii) CEB with RMA included in independent variables, and (iii) the number of children alive at the survey (CEB – DC). Those coefficients show similar results in their value and significance.

Table 1 Regression analysis of the number of children ever born

	CEB1		CEB2		CEB-DC	
	β	t	β	t	β	t
C	4.078	49.24	4.128	56.11	4.122	57.60
G	−0.070	−3.23	−0.082	−4.27	−0.082	−4.27
EF	−0.093	−10.45	−0.096	−12.07	−0.095	−12.13
EH	−0.032	−3.04	−0.032	−3.47	−0.032	−3.45
LH	−0.397	−6.82	−0.396	−7.67	−0.396	−7.67
PH	−0.490	−4.71	−0.477	−5.17	−0.477	−5.17
WF	−0.061	−1.04	−0.054	−1.04	−0.055	−1.05
WFB	−0.534	−9.37	−0.537	−10.60	−0.536	−10.60
DC	1.147	21.65	0.983	20.77		
A40	0.705	14.52	0.725	16.82	0.723	16.91
RMA			−0.149	−32.13	−0.149	−32.28
adj r^2	0.320		0.463		0.376	
n	3855		3855		3855	

Most significant variables in common are the period of education by the respondent (EF), work experience prior to marriage (WFB) and the older birth cohort (A40). Higher educational level of respondents may reflect the higher opportunity cost of children and the demand for higher quality of children. Work experience prior to marriage, which reduces CEB by approximately 0.53, may reflect higher opportunity cost of children. The older birth cohort have approximately 0.7 child more than the younger counterparts, which is not explained by socio-economic factors but possibly by the time trend of fertility decline.

Possession of more number of durable goods (G), which may reflect higher standard of living, reduces CEB. The estimated coefficient of the husband's occupation implies that those employed have approximately 0.40 child and professionals 0.48 child less than those in agricultural sector. This may reflect occupations differentials and lower cost of living. The estimated coefficient of the completed years of education by husband is negative. Quantity-quality trade off may well negate the positive income effect on demand for children. Current labor force participation of respondents (WF) does not significantly affect CEB.

It should be noted that the same variables are effective on the age at marriage. Although the time sequence of demographic events implies that the childbirth follows after marriage, the economic interpretation of the demand for marriage implies that the demand for children is an endogenous variable to determine the demand for marriage. In other words, if the demand for children is one of the deciding factors of the age at marriage, simultaneity between two variables prevent us to include the age at marriage as an independent variable to explain fertility differentials by a simple manner.

Instead of the age at marriage, its residual is included CEB2. The result shows an improvement in the adjusted coefficient of determination by 0.143. The estimated coefficient implied that an unexpected 7 years of early marriage results in one additional childbirth.

In regression 3, the number of children alive at the survey (CEB – DC) is regressed on the same variables except DC. We found the similar result again for estimated coefficients. The adjusted coefficient of determination is as high as 0.376.

2. Parity Progressions in Supply of Children

While the demand for children may be given as a particular number, the supply of children is discrete and takes a period of time to satisfy the demand. Thus, the supply of children can be partly seen as a process of parity progression.

For each parity $i-1 (i=1, 2, 3, 4)$, we assume that $B_i=1$ if $B_i^* > 0$ and $B_i=0$ otherwise, where $B_i^* = \beta_0 + \Sigma\beta_j x_{ij} + u_i$. The probability of parity progression, P_i, can be shown as $P_i = Pr(B_i=1) = Pr(u_i > -(\beta_0 + \Sigma\beta_j x_{ij}))$. Assuming that the cumulative distribution of u_i follows logistic distribution, we obtain the following logit model, $\log(P_i/(1-P_i)) = \beta_0 + \Sigma\beta_j x_{ij}$.

The results of logit analysis are shown in Table 2. The same variables

Table 2 Logit analysis of the parity progressions

	P_1 (Parity 0)				P_2 (Parity 1)			
	LA1		LA2		LA1		LA2	
	β	t	β	t	β	t	β	t
C	4.40	13.75	9.79	18.50	3.67	16.08	9.62	22.76
G	0.02	0.29	−0.01	−0.14	−0.02	−0.48	−0.07	−1.27
EF	−0.01	−0.17	0.12	3.48	−0.13	−5.35	−0.03	−1.01
EH	−0.13	−3.24	−0.09	−2.19	−0.05	−1.77	0.00	0.11
LH	−0.35	−1.54	−0.22	−0.88	−0.27	−1.76	−0.16	−0.90
PH	−0.42	−1.35	−0.23	−0.67	−0.43	−1.95	−0.21	−0.86
WF	−0.27	−1.54	−0.38	−1.92	0.17	1.28	0.21	1.38
WFB	−0.65	−3.79	0.12	0.60	−0.61	−4.95	0.16	1.11
A40	0.61	3.72	1.22	6.40	0.61	5.26	1.29	9.20
A_{i-1}			−0.28	−16.22			−0.29	−19.85
McFadden r^2	0.06		0.26		0.08		0.28	
Obs with Dep=0	192		192		407		407	
Obs with Dep=1	3663		3663		3256		3256	
n	3855		3855		3663		3663	

	P_3 (Parity 2)				P_4 (Parity 3)			
	LA1		LA2		LA1		LA2	
	β	t	β	t	β	t	β	t
C	2.68	16.49	8.11	24.27	1.38	9.42	6.81	19.08
G	−0.16	−4.18	−0.20	−4.67	−0.13	−2.99	−0.19	−4.01
EF	−0.14	−8.11	−0.06	−3.36	−0.11	−7.07	−0.05	−3.00
EH	−0.05	−2.70	−0.02	−1.00	−0.03	−1.47	0.00	−0.24
LH	−0.32	−2.92	−0.21	−1.76	−0.39	−3.81	−0.30	−2.63
PH	−0.60	−3.30	−0.34	−1.66	−0.14	−0.63	0.27	1.05
WF	−0.12	−1.16	−0.12	−1.05	−0.04	−0.38	−0.10	−0.80
WFB	−0.47	−4.66	0.12	1.03	−0.55	−4.87	−0.07	−0.55
A40	0.88	9.91	1.40	13.29	0.73	8.16	1.17	11.34
A_{i-1}			−0.25	−20.58			−0.23	−17.59
McFadden r^2	0.13		0.27		0.08		0.20	
Obs with Dep=0	908		908		988		988	
Obs with Dep=1	2348		2348		1360		1360	
n	3256		3256		2348		2348	

used in regression analysis of CEB are included in LA1 as independent variables. In LA2, MA is added to P_1 and the age at $i-1$'th childbirth, A_{i-1}, is added to P_2, P_3, and P_4 to show that the timing of marriage and previous childbirth is affecting the parity progression to a great extent. Note that in LA2, since MA and A_{i-1} are dependent on socio-economic variables, the estimated coefficients may be considered to indicate adjusting effect of those variables on parity progression.

(i) P_1: LA1 shows negative effect of EH and WFB and positive effect of A40. Higher educational level of husband and work experience of respondents lowered the probability of first childbirth after marriage while older birth cohort has higher probability. It should be noted that educational level of respondents and possession of durable goods do not show significant effect. On the contrary, EF shows positive effect and WFB shows no significant effect on parity progression in LA2. The age at marriage has negative effect on parity progression while A40 keeps positive effect on it even after MA is included in independent variables.

(ii) P_2: While EH shows no significant effect, EF shows negative effect on parity progression in LA1. WFB shows negative effect and A40 shows positive effect again. Surprisingly, if we add A_1 in LA2, none of socio-economic variables shows significant effect. A_1 shows negative effect and A40 positive again. This implies that if the timing of the first childbirth is decided by the respondents, it could be only its timing and the birth cohort of mothers that determine the parity progression from parity 1 to parity 2.

(iii) P_3: In LA1, we observe that socio-economic variables affect parity progression significantly in case of P_3 and P_4. G, EF, EH, LH and PH show negative effect. In addition, WFB shows negative effect and A40 shows positive effect again. This implies that while the choice of having the first and second child does not depend on socio-economic variables, it is only after second childbirth when those variables affect parity progression significantly. G and EF even show negative significant effect on parity progression in LA2, while A40 and A_2 show similar effect compared to the results shown in P_2.

(iv) P_4: In LA1, we observe that G and EF have negative significant effect on parity progression. However, EH does not show significant effect on parity progression and LH lowers its probability. WFB and A40 show similar effect again. In LA2, G, EF, A40 and A_3 show similar effect compared to P_3. LH also shows significantly lower probability of parity progression.

We find that in LA1 WFB has negative effect and A40 positive for all parity. Educational level of respondent is effective in P_2, P_3 and P_4 and the standard of living seems to be effective in P_3 and P_4. Negative effect of EH is shown in P_1 and P_3. PH is negative in P_3 and so as LH in P_4.

In LA2, we find that the timing of marriage and preceding childbirth and the birth cohort of respondents are effective for all parity. Effect of socio-economic variables is significant for P_3 and P_4 as expected. Educational level of respondents shows positive effect on P_1 on the contrary. We observe that the effect of socio-economic variables is parity dependent in supply of children.

3. Adjusting Birth Spacing in Supply of Children

In addition to parity progression, the timing of childbirth or the spacing of childbirths can be seen as a process of the supply of children. Proportional hazard models can be applied to the analysis of spacing. Let t_i denote the duration of time between i'th childbirth and i-1'th childbirth. We assume that the hazard rate of i'th childbirth depends on t_i and covariate x such that $h(t_i; x) = h_0(t_i) \exp(x\beta)$, where $h_0(t_i)$ is a base hazard function.

We expect that the duration of spacing is shorter (a higher hazard rate): 1) if the expected demand for children (ECEB) is greater; 2) if the unexpected demand for children is greater (RCEB = CEB − ECEB); 3) if the timing of the previous childbirth is later than its expected timing estimated from the age profile of average cumulative childbirths (DAGE); 4) if the beginning of childbirths is postponed by attaining higher education and; 5) higher demand for additional children is associated with lower educational attainment and with certain job categories.

The result of the proportional hazard analysis is shown in Table 3. The respondents are divided by age group 40-49 and 30-39 years of age and by previous parity from 0 to 3, and the same proportional hazard model was applied.

Estimated coefficients for ECEB, RCEB and DAGE are positive and significant. For parity 0, the effect of ECEB and RCEB is smaller than higher

Table 3 Proportional hazard analysis of the spacing of childbirths

	40 – 49 years of age							
	Parity 0		Parity 1		Parity 2		Parity 3	
	β	χ^2	β	χ^2	β	χ^2	β	χ^2
ECEB	0.232	89.52	0.374	199.29	0.398	219.12	0.623	299.49
RCEB	0.120	47.11	0.257	220.57	0.348	363.45	0.419	407.07
DAGE	0.051	44.28	0.056	50.88	0.050	39.37	0.078	63.73
FH	−0.004	0.00	0.059	0.27	0.297	4.45	−0.114	0.34
LH	0.106	1.33	0.177	3.19	0.394	9.51	−0.115	0.38
EF0-2	−0.331	14.58	−0.284	9.71	0.162	2.52	0.186	2.01
EF3-5	−0.143	3.33	−0.148	3.19	0.262	7.92	0.325	7.04
EF6-9	0.058	0.70	−0.021	0.09	0.265	9.90	0.300	6.71
n	1682		1642		1517		1221	
χ^2	244		572		867		998	

	30 – 39 years of age							
	Parity 0		Parity 1		Parity 2		Parity 3	
	β	χ^2	β	χ^2	β	χ^2	β	χ^2
ECEB	0.291	109.64	0.521	293.21	0.734	325.00	0.689	192.85
RCEB	0.166	55.72	0.306	192.34	0.501	440.99	0.626	349.16
DAGE	0.077	66.63	0.110	124.06	0.114	102.87	0.100	38.59
FH	0.155	2.56	−0.051	0.23	0.224	1.97	0.143	0.37
LH	0.152	3.27	−0.027	0.08	0.288	3.67	0.081	0.12
EF0-2	−0.463	27.88	0.055	0.35	0.373	10.20	0.199	1.39
EF3-5	−0.306	17.85	0.006	0.01	0.295	8.91	0.102	0.44
EF6-9	−0.107	3.39	0.053	0.70	0.250	7.90	0.168	1.38
n	2141		1994		1703		1159	
χ^2	337		787		1198		911	

parities. Since additional demand for children is naturally a deciding factor of spacing at higher parities, the estimated coefficient is larger for higher parities. The estimated coefficients of ECEB for parity 3 of older cohort and parity 2 of younger cohort indicate that the younger cohort is controlling their fertility in terms of spacing at smaller parity. Estimated coefficients of RCEB show relatively constant increase as parity increases. Unexpected demand for children at higher parity will increase its effect on shorter spacing of the additional birth.

It is also shown that if the timing of the childbirth at any specific parity is later than expected, respondents will shorten the spacing between current and next parity. The estimated coefficients of DAGE are positive and significant. Since the magnitude of estimated coefficients for the younger cohort is greater than the older cohort, the younger cohort may be adjusting birth spacing shorter if the timing of the childbirth delays.

The result shows that husband's job is not so effective on spacing. The estimated coefficients for FH and LH of the parity 3 of the old cohort are positive and significant. Compared to those who married to husbands with professional job, respondents who married to husbands in agriculture or working as employee will significantly reduce spacing between second and third child. For other cases, however, husband's job does not show any significant effect.

Educational attainment of the respondents shows two different directions in its significant effect on spacing. Those who attend the school no more than 2 years show significantly negative effect on hazard rate for parity 0 and parity 1 of the older cohort. Those who attend the school no more than 5 years show significantly negative effect on hazard rate for parity 0 of the younger cohort. This means that those with less schooling show longer spacing in earlier parity progression or that those with higher schooling plan to have children soon after their marriage. On the other hand, those who attend the school more than 3 years and not more than 9 years show significantly positive effect on hazard rate for parity 2 and parity 3 of the older cohort. Those who attend the school not more than 9 years show significantly positive effect on hazard rate for parity 3 of younger cohort. Compared to those with highest educational attainment, the spacing of childbirths in higher parities is shorter for those with less educational attainment. However, its effect is not observed for parity 1 and parity 3 of the younger cohort.

4. Concluding Remarks

Even though the economic model of fertility seems theoretically plausible, application of the model to empirical data often gives us ambiguous impression about its validity. We can easily see its difficulties in identifying measurement of opportunity cost, income transfer and quantity-quality trade off.

One source of this ambiguity that is dealt in the present paper comes from simultaneity of demand for and supply of children. The actual number of children ever born can be considered as the revealed choice of the equilibrium. We assume that the demand for children may be pre-determined and the supply of children follows. For an empirical analysis, data are taken from the Sri Lanka 1993 Demographic and Health Survey.

First, fertility differentials are explained by differences in educational attainment, work experience prior to marriage, possession of durable goods, job categories of the husband and the residual of the age at marriage. Second, differentials in parity progression are largely explained by the age of marriage or the previous childbirth. We also find that the effect of socioeconomic variables is parity dependent in supply of children, *ie.* we find almost no significant effect in parity 0 and parity 1 and significant effect in parity 2 and parity 3. Finally, differentials in spacing of childbirths are explained by the expected demand and unexpected additional demand for children and the age difference from the mean age at marriage or the previous childbirth. We also find that high educational attainment will shorten the spacing between marriage and the first childbirth while it will extend the spacing between second and third childbirths for all samples and between third and fourth childbirths for older cohort.

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