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AN ECONOMIC-DEMOGRAPHIC MODEL OF THE PHILIPPINES

by

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1. Introduction

Most economic-demographic models in the literature that have been estimated from empirical data do not provide feedback from economic variables to demographic variables. While population affects consumption and therefore capital formation, population is not in turn influenced by any economic variable in models of the Enke-TEMPO type. In this paper, we consider a model where the determinants of fertility include family income. Based on cross-section regression results, the marginal effect of family income on fertility is positive at income levels below some threshold but negative (as usually expected) above it. The positive effect at low income levels seems due to better health, nutrition, and medical care permitted by more income. At higher income levels, the opportunity costs (in terms of free time or earnings foregone) of having additional children apparently operate to reduce fertility.

The model consists of three blocks of equations. The estimated equations in the first block were obtained by two-stage least squares using annual macroeconomic data during the period 1950-1969.[2/] Definitional equations pertaining to demographic variables are contained in the second block, and other miscellaneous equations appear in the third. Two of these equations, (64) and (65), are based on cross-section results from the 1968 National Demographic Survey.

The time index t (in fiscal years)[3/] is suppressed where unnecessary, as also the time-index q (in quinquennia). For projection purposes, we take as initial conditions the values at $t = 0$ corresponding to fiscal year 1970 and $q = 0$ for mid 1965 to mid-1970. In the case of demographic stock variables, $q = 0$ at mid-1970. Given the initial conditions, which thus include the results of the mid-1970 population census, the model generates annual projections of the economic variables and quinquennial projections of the demographic variables.

2. The Model

2.1 Notation

AM = woman's age at marriage, in years

CP = private consumption expenditures, in million 1967 pesos

CG = government consumption expenditures, in million 1967 pesos

DM = duration of marriage, in years

FR^- = quinquennial fertility rate of a woman whose $FY < FY^*$

FR^+ = quinquennial fertility rate of a woman whose $FY \geq FY^*$

FY = annual family income, in thousand 1967 pesos

FY* = threshold value of FY, taken as 1.65

FY^- = mean FY of families whose $FY < FY^*$

FY^+ = mean FY of families whose $FY \geq FY^*$

H = population, in thousands

HA = population assumed in the macro-model, in thousands

H_k = number of persons in age-cohort k, in thousands

HF_k = number of females in age-cohort k, in thousands

HM_k = number of males in age-cohort k, in thousands

I = gross investment, in million 1967 pesos

K = capital stock, in million 1967 pesos

k = code number for age-cohorts, where $k = 1$ for age 0-4, 2 for age 5-9, ..., 13 for age 60-64, 14 for age 65 and over.

N = employment, in thousands

NB^- = number of children born to a woman whose $FY < FY^*$

NB^+ = number of children born to a woman whose $FY \geq FY^*$

NBF = number of female births during a 5-year period, in thousands

NBM = number of male births during a 5-year period, in thousands

P = implicit GNP price deflator, with $P = 100$ for 1967

PM_k = proportion of women in cohort k currently married

$r(q)$ = percentage growth rate of population during quinquennium q

SF_k = survival rate of females in cohort k, i.e. the proportion of females in cohort k who will be alive 5 years later

SF_0 = the proportion of NBF that becomes HF_1 at the end of the 5-year period

SM_k = survival rate of males in cohort k

SM_0 = the proportion of NBM that becomes HM_1 at the end of the 5-year period

T = tax revenue, in million 1967 pesos

TFY = 5-year mean of total family incomes, in thousand 1967 pesos

TNB = total number of births during a 5-year period, in thousands

TNB^- = total number of births during a 5-year period from women whose $FY < FY^*$, in thousands

TNB^+ = total number of births during a 5-year period from women whose $FY \geq FY^*$, in thousands

TNF = average number of families during a quinquennium, in thousands

W = money wage rate, in thousand pesos

Y = GNP in million 1967 pesos

α = one plus the percentage growth rate of mean FY from one quinquennium to the next

β = ratio of male to female births, taken as 1.05

δ = one plus the percentage growth rate of P, taken as 1.05

σ = standard deviation of the natural logarithms of family incomes

θ = ratio of married women in cohorts $k = 4$ to 9, to TNF

2.2 Macroeconomic equations (annual)

		$\bar{R}^2$/s.e./DW
(1)	$Y = -756.488 + 0.18019\,K + 1.17271\,N$ (5.88) (3.04)	.998/177.8/2.31
(2)	$N = 2319.18 + 0.28372\,Y + 28.63089\,P/W$ (23.68) (1.42)	.987/140.5/2.45
(3)	$W = -0.20021 + 0.85788\,W(-1) + 0.00575\,P(-1)$ (5.50) (2.13)	.956/55.4/1.78
(4)	$P = \delta\,P(-1)$	
(5)	$T = -274.461 + 0.11504\,Y$ (41.65)	.989/66.9/0.82

$$(6)\quad CP/HA = 0.14266 + \underset{(17.04)}{0.68763}\,(Y - T)/HA \qquad .941/14.1/0.47$$

$$(7)\quad CG = -208.219 + \underset{(36.78)}{0.99100}\,T \qquad .986/75.3/1.28$$

$$(8)\quad I = Y - CP - CG$$

$$(9)\quad K = K(-1) + I(-1)$$

$$(10)\quad \bar{Y}(q) = \sum_{t=5(q-1)+1}^{5q} Y(t)/5$$

2.3 Definitional demographic equations (quinquennial)

$$(11)\quad NBF = TNB/(1+\beta)$$

$$(12)\quad NBM = TNB.\beta/(1+\beta)$$

$$(13)\quad HF_1 = SF_0 \cdot NBF$$

$$(14)-(25)\quad HF_k = SF_{k-1} \cdot HF_{k-1}(-1) \qquad (k=2, \ldots, 13)$$

$$(26)\quad HF_{14} = SF_{13} \cdot HF_{13}(-1) + SF_{14} \cdot HF_{14}(-1)$$

$$(27)\quad HM_1 = SM_0 \cdot NBM$$

$$(28)-(39)\quad HM_k = SM_{k-1} \cdot HM_{k-1}(-1) \qquad (k=2, \ldots, 13)$$

$$(40)\quad HM_{14} = SM_{13} \cdot HM_{13}(-1) + SM_{14} \cdot HM_{14}(-1)$$

$$(41)-(54)\quad H_k = HM_k + HF_k \qquad (k=1, \ldots, 14)$$

$$(55)\quad H = \sum_{k=1}^{14} H_k$$

$$(56)\quad TNF = \sum_{k=4}^{14} PM_k(HF_k + HF_k(-1))/2$$

2.4 Other equations

$$(57)\quad \alpha = \frac{\overline{Y}/TNF}{\overline{Y}(-1)/TNF(-1)}$$

$$(58)\quad \overline{FY} = \alpha\, \overline{FY}(-1)$$

$$(59)\quad \overline{\ln FY} = \overline{\ln FY}(-1) + \ln \alpha$$

$$(60)\quad \pi = N\left(\frac{\ln FY^* - \overline{\ln FY}}{\sigma} ; 0, 1\right)$$

$$(61)\quad FY^- = f(\overline{FY})$$

$$(62)\quad FY^+ = \frac{1}{1-\pi}\overline{FY} - \frac{\pi}{1-\pi} FY^-$$

$$(63)\quad \overline{DM} = \frac{\sum_{k=4}^{9} DM_k \cdot PM_k (HF_k + HF_k(-1))/2}{\sum_{k=4}^{9} PM_k (HF_k + HF_k(-1))/2}$$

$$(64)\quad NB^- = 2.391 - .0340\, \overline{AM} + .2709\, \overline{DM} + .27891\, (FY^- - 1.65)$$

$$(65)\quad NB^+ = 2.391 - .0340\, \overline{AM} + .2709\, \overline{DM} - .01736\, (FY^+ - 1.65)$$

$$(66)\quad FR^- = 0.3242\, NB^-$$

$$(67)\quad FR^+ = 0.3049\, NB^+$$

$$(68)\quad \theta = \frac{\sum_{k=4}^{9} PM_k (HF_k + HF_k(-1))/2}{TNF}$$

$$(69)\quad TNB^- = FR^- \cdot \pi \cdot \theta \cdot TNF$$

$$(70)\quad TNB^+ = FR^+ \cdot (1-\pi)\theta \cdot TNF$$

$$(71)\quad TNB = TNB^- + TNB^+$$

$$(72)\quad H(q) = (1 + r(q))^5\, H(q - 1)$$

$$(73)\quad HA(t) = (1 + r(q))^{t-5q}\, H(q)$$

3. Discussion

3.1 The macro-model

In eq. (1) real GNP is taken as a linear function of capital stock K and employment N. (K is actually cumulated gross investment added to an estimate of capital stock in 1950.) N is the average of the two employment figures obtained each year from the May and October surveys. According to (1) the marginal productivity of capital is 0.18 which seems plausible. Technical change could be considered reflected in K, since K is gross.

Eq. (2) can be thought of as an employment demand function, N depending negatively on the real wage W/P. The money wage rate W used is the average wage of unskilled industrial workers in the metropolitan Manila area. In (3), W is seen to adjust itself to the price level with a one-year lag.

A constant percentage rate of increase is assumed in (4) for the price level P. For projection purposes this seems the better procedure compared to using

$$(4') \quad P = 53.598 - \underset{(-5.63)}{0.00162}\, Y + \underset{(14.37)}{0.02622}\, Z \qquad .992/1.27/1.83$$

in place of (4) in the model. Z is the money supply in million pesos. Eqs. (4) and (3) imply that the real wage will tend to some value with time, and the higher the growth rate of P, the lower the limiting value of W/P.[4/]

Eqs. (5)-(7) give tax revenue, private consumption expenditures per capita, and government consumption expenditures in terms of single explanatory variables. These are over-simple specifications and the Durbin-Watson values show autocorrelation. Multiplying both sides of (6) by HA, the implied consumption due to population is 143 pesos a year per person which seems plausible, as also the implied marginal propensity to consume of 0.688. The reason for distinguishing between HA (population as assumed in the macro-model) and H (population) will become apparent after a discussion of the complete model for use in making projections. Eq. (6) is actually a regression of CP/H on (Y - T)/H.

Gross investment and capital stock (at the beginning of the year) are given by (8) and (9). Foreign saving to complement domestic saving in financing investment is ignored in (8). Eq. (10) simply defines the mean Y over the 5-year period composing quinquennium q.

Given the initial conditions W(0), P(0), K(0), I(0), and HA(0) and an annual growth rate of HA, eqs. (1)-(10) suffice to determine the values of the variables appearing on the left-hand side for t = 1, 2, ... Simultaneity exists regarding Y and N in (1) and (2), so we give here their reduced forms:

(1') $Y = 2942.16 + 0.27004\ K + 50.3173\ P.W$

(2') $N = 3153.93 + 0.07662\ K + 42.9069\ P.W$

3.2 The definitional demographic equations

Most of these are self-explanatory and require little comment. In (13), a given fraction SF_0 of NBF, the number of females born during quinquennium q, will survive to form the stock of females age 0 to 4 at time q. In (26), the females in age-cohort 14 (age 65 and over) at time q consist of those surviving from age-cohort 14 at time q - 1 five years earlier in addition to those surviving from age-cohort 13.

In (56), the mean number of families TNF during a quinquennium is defined as the average of the numbers of women currently married at the beginning and at the end of that quinquennium. This definition understates the number of families because of non-inclusion of women and men widowed. But if the proportions of these categories do not change relative to TNF, the understatement has little consequence, as will be seen shortly in connection with calculating the growth of family income.

We take the sex-ratio at birth, age-specific survival rates and proportions married as given parameters. We also have the initial conditions $HF_k(0)$, $HM_k(0)$, $k = 1, \ldots, 14$. Once TNB(1), the number of births during quinquennium 1, has been determined, eqs. (11)-(56) determine all the values of the variables on the left-hand side for $q = 1$. TNB(1) need not be known, however, to get $HF_k(1)$ for $k = 2, \ldots, 14$.

3.3 The other equations I

Eq. (57) gives the growth of GNP per family from one quinquennium to the next. We note that if TNF is always understated by the same proportion, this does not affect the value of α. Assuming that the share of total family income in GNP is constant, the growth of mean family income $\overline{FY}$ is also given by α; hence (58).

Given the initial conditions $\overline{Y}(0)$ and TNF(0), $\overline{Y}(1)$ from (10) and TNF(1) from (56), (57) determines $\alpha(1)$. Given also $\overline{FY}(0)$, (58) then gives $\overline{FY}(1)$.

Eq. (59) assumes implicitly that family income is always lognormally distributed with constant σ^2. On this assumption, the Lorenz measure of income concentration does not change through time and (Aitchison and Brown 1957, pp. 112-13 and p. 8)

$$\overline{FY}(-1) = \exp(\overline{\ln FY}(-1) + \sigma^2/2)$$

$$\overline{FY} = \exp(\overline{\ln FY} + \sigma^2/2)$$

From (58),

$$\ln \overline{FY} = \ln \overline{FY}(-1) + \ln \alpha$$

Eq. (59) then follows from these three equations, and we can calculate $\overline{\ln FY}$.

On the same assumption of lognormality of FY, we have (60) which gives the proportion π of families whose incomes fall short of the threshold value. $N(z^*|0, 1)$ is the distribution function of $\ln FY$ after normalization to mean 0 and standard deviation 1, so that $N(z^*|0, 1) = \text{Prob}(z \leq z^*)$ where $z = (\ln FY - \overline{\ln FY})/\sigma$.

Eq. (61) says that FY^-, the mean of incomes below FY^*, is a function of $\overline{FY}$ under lognormality and constant σ^2. For $\overline{FY}$ determines $\overline{\ln FY}$ and, using (60), π fixes the values of FY whose mean is FY^-. FY^+ then obtains from the identity

$$\overline{FY} = \pi FY^- + (1 - \pi)FY^+$$

Eq. (63) gives the average duration of marriage, $\overline{DM}$, as a weighted average of the DM_k of married women age 15 to 44. We take the DM_k as given parameters, but the age distribution may be expected to change through time as a result of changing survival rates (and fertility rates, after a 15-year lag).

3.4 The other equations II - fertility equations

The hypothesis underlying the specifications of (64) and (65) is that there is a threshold level of income FY^* such that the marginal effect of FY on NB is qualitatively different when one crosses the threshold. Although the general view seems to be that, whatever the mechanism or motivation, rising family income tends to bring about lower fertility (Simon 1969), one could also argue that at the low income levels of the LDCs, one major effect of the rising incomes is to enable women to acquire better health and have greater access to medical facilities and prenatal care, resulting in their greater capacity to bear more children. At a subsistence level of family income FY*, below which the health of the mother would be substandard almost by definition, an income lower than FY* would mean a higher probability of still-births and miscarriages. Accordingly we would expect that a woman's fertility NB (defined as the number of live children she has borne) would rise with FY up to the point FY*. Beyond FY*, however, we may have the usually expected relationship of a higher FY reducing fertility.

We could therefore consider the specification

$$NB = a_0 + a_1 AM + a_2 DM + a_3 \min(0, FY - FY^*) + a_4 \max(0, FY - FY^*)$$

where a_3 would be the marginal effect of FY on NB if FY < FY* and a_4 would be the relevant coefficient if $FY \geq FY^*$. For the numerical value of FY* we would choose 1.5 (thousand pesos), which would be the annual income of a worker earning the minimum daily wage in 1968 and working 250 days in the year.

From a previous paper (Encarnación 1973a) we have the following regression equation

$$(64') \quad NB = \underset{}{2.061} - \underset{(-3.86)}{0.0340}\,AM + \underset{(50.61)}{0.2709}\,DM + \underset{(4.24)}{0.3068}\min(0, FY - 1.5) - \underset{(-2.09)}{0.0191}\max(0, FY - 1.5) \qquad \bar{R}^2 = .456$$

obtained from a subsample of 3,629 married women in the 1968 National Demographic Survey (which covered about 7,000 households).[5/]

Data comparisons made by M. Mangahas and V. Paqueo of the 1968 NDS and the 1957, 1961 and 1965 Bureau of the Census and Statistics surveys of family income and expenditures suggest, however, that the NDS income data might have been understated by perhaps 10-12 percent. Assuming that FY data in the NDS should be 10 percent higher, this involves merely a change in the units in which FY is expressed so that corrected FY are 1.1 times the FY data. Accordingly, we increase the value of FY* from 1.5 to 1.65 and deflate the coefficients of the min and max terms correspondingly by dividing them by 1.1, without any essential change in (64').

A further adjustment of (64') called for stems from the fact that the age distribution of married women in our NDS subsample is different from that of the 1970 census. Our sample selected relatively fewer women from the younger age-cohorts, apparently because of our single-family households criterion and the fact that some younger couples live with their in-laws until they save enough to set up their own households. Let

$$DM_c = \frac{\sum_{k=4}^{9} DM_k \cdot PM_k \cdot HF_k}{\sum_{k=4}^{9} PM_k \cdot HF_k}$$

where the HF_k are 1970 census data. While $DM_c = 11.195$, the mean DM in our sample is 12.413 because the latter is more heavily weighted towards older age-cohorts with their higher DM_k. In order to use (64') for projection purposes, we simply assign the discrepancy to the constant term in (64'), i.e. we add .2709(12.413 - 11.195) to the constant term. With this adjustment and the earlier ones regarding FY, we have (64) and (65) where $\overline{DM}$ is given by (63) and $\overline{AM}$ is a parameter.

It should be mentioned that from another paper (Encarnación 1973b), it is clear that (64') is deficient in several respects, and therefore also (64) and (65). As may be expected because of nonlinearity, the addition of DM^2 as an explanatory variable on the right-hand side of (64') improves its explanatory power. (In addition, with DM^2 included, trying alternative values for FY*, the t-value of the coefficient of the max term is highest when the value chosen for FY* is 1.5. Considering the understatement of the FY data, this suggests, from the viewpoint of our hypothesis, that the minimum wage was below subsistence level.) Further, location of residence (urban or rural), labor force participation and education level of the woman are significant determinants of NB. Indeed, the explanatory role of the education level of the wife is much like that of FY, and when the woman's education level is included as an explanatory variable, the max term loses its significance (the t-value of its coefficient drops to less than 1.) Apparently, FY at higher levels is largely a proxy for the education level of the wife in explaining fertility, and fertility reduction gets attributed to FY because of the correlation between FY and level of education. One further point about (64') is that it is an unweighted regression and takes no account of the different sampling fractions for urban and rural households -- the latter fraction being 1/3 that of the former.

Despite all these, we include (64) and (65) in the present version since the objective at this stage is simply a model that at least shows some economic-demographic inter-action and is internally consistent. Later work is planned to reduce over-simplications.

With (64) and (65) in hand, we can use (66) and (67) to approximate 5-year fertility rates of lower and upper income women. The constants appearing there derive from NDS data. Specifically, in the case of (66), 0.3242 is the ratio of: (a) the mean number of children born to the lower income women in the sample during the 5 years preceding the survey, to (b) the mean NB among those women. Similarly in (67) for upper income women.

3.5 The other equations III

The remaining equations are straightforward, θ, the proportion of child-bearing women in the total, is given by (68), a convenience merely for use in (69) and (70) which give the total numbers of children born during a quinquennium to lower and upper income women. Their sum is the total number born TNB, (71). TNB then becomes an input for (11) and (12), so that population H at the end of the quinquennium is determined.

Eq. (72) defines implicitly the annual growth rate r(q) of population during quinquennium q. Finally, in (73) we assume that during a quinquennium, the population variable HA in the macro-model (specifically eq. (6)) takes on the growth rate of H during the preceding quinquennium. This simplifying assumption avoids the necessity of an iterative procedure to make HA identical to H, and since the growth rate of population should change little from one period to the next, it creates no great distortion. In substance we are assuming a 5-year lag in the effect of the population growth rate on consumption.

This completes the description of the model. It is clear that given the initial conditions and parameter values, the model will generate projected values through time.

4. Initial conditions and parameter values

4.1 Initial conditions

To start up the macro-model we need the following values for $t = 0$ (i.e. fiscal year 1970): $P(0) = 126.2$, $W(0) = 2303.8$, $K(0) = 95249$, $I(0) = 6729$. Assuming a constant growth rate of the price level similar to the historical experience, $\delta = 1.05$. The annual growth rate of population between the census years 1960 and 1970 being 3.01 percent, we take $r(0) = 0.0301$, which then applies to $HA(0) = 36520$. Given all this information, the macro-model generates projected values annually during $q = 1$ (mid-1970 to mid-1975).

Some changes are necessary, however, because of recently published revisions of the national income accounts back to calendar year 1967 and fiscal year 1968. These revisions have mostly to do with changes in the figures for consumption expenditures which are now being directly estimated. If in the macro-model projections for fiscal 1971 we multiply Y, CP and CG by the factors 1.00393, 0.94441 and 0.80997 respectively, we find the results identical to the actual 1971 figures. The simplest adjustment, though of course alternative procedures are possible, is thus to augment the model by adding

$$(1A) \quad YA = 1.00393\ (1730.285 + 0.21471\ K + 0.72095\ N)$$

$$(6A) \quad CPA = 0.94441\ (0.11886\ HA + 0.72523\ (Y - T))$$

$$(7A) \quad CGA = 0.80997\ (-128.394 + 0.95478\ T)$$

and replacing eq. (8) by

(8A) $I = YA - CPA - CGA$

The new variables YA, CPA and CGA are adjusted figures for Y, CP and CG respectively.

The demographic part of the model requires $\overline{Y}(0)$, the mean GNP during $q = 0$. Since the published national income accounts have been revised backward only to calendar year 1967 and fiscal 1968, we take $\overline{Y}(0) = 28118$, the value of GNP for fiscal 1968 (at 1967 prices).

Given the female age-distribution at 1970 and the age-specific survival rates for $q = 1$, plus the PM_k (proportions married), the number of families for $q = 1$ is known. Assuming that this would have increased at 3.01 percent annually like population, $TNF(0) = 5826$. Using an estimate from the NDS of the proportion of total family income to GNP (0.5516), we calculate initial mean family income $\overline{FY}(0) = 2.662$.

On the assumption of lognormality, $\overline{FY} = \exp(\overline{\ln FY} + \sigma^2/2)$, so that with $\sigma = 1.1255$ from NDS data, $\overline{\ln FY}(0) = 0.3457$. (This implies, taking the antilog, that the median income at $q = 0$ was 1.413.) Then, $\pi(0) = 0.5547$ from

$$z^*(0) = \frac{\ln FY^* - \overline{\ln FY}(0)}{\sigma}$$

and the normal probability table. Numerical methods then determine $FY^-(0) = 0.7782$, and appendix 1 shows how future values of FY^- are calculated.

4.2 Parameter values and other initial conditions

Table 1 gives the age-sex distribution at 1970 as calculated by Dr. Peter C. Smith of the U.P. Population Institute. The figures for proportions currently married (PM_k) are simple means of the 1960 census and the 1968 NDS figures, as the published 1970 census results do not as yet include this information and the 1968 NDS figures appear to be too much on the low side for the younger age-cohorts. The DM_k obtain from NDS data, and table 2 giving survival ratios by sex for each quinquennium was produced by the U.P. Population Institute.

Finally, with $\overline{AM}$ from NDS data, this completes all information needed for the model to generate projections.

4.3 The constant term in the fertility equations

As it turns out, the model as described above gives a population growth rate for 1970-75 of only 2.49 percent a year, which seems rather low in view of the 3.01 figure of the immediate past. The model is clearly wrong in any number of ways, considering all the simplifications that have had to be made. We now make the assumption that the <u>only</u> thing wrong in the model (including parameter values and initial conditions) is the value of the constant term in the fertility equations (64) and (65). In order to find the correct value, we also assume that $r(1)$, the growth rate of population during 1970-75, will come out to be 3.01 percent. As appendix 2 shows, this enables calculation of a revised value for the constant term so that if

Table 1. Age-sex distribution at q = 0, proportions married and duration of marriage

Age	k	Male $HM_k(0)$	Female $HF_k(0)$	Proportion married PM_k	Duration of marriage DM_k
0-4	1	3109	2949		
5-9	2	2766	2589		
10-14	3	2196	2142		
15-19	4	1749	1933	.0925	2.47
20-24	5	1564	1770	.4670	3.95
25-29	6	1404	1453	.7590	7.41
30-34	7	1168	1134	.8305	11.51
35-39	8	953	915	.8580	15.97
40-44	9	723	743	.8385	20.83
45-49	10	596	660	.8180	
50-54	11	506	573	.7465	
55-59	12	438	482	.6840	
60-64	13	352	373	.5905	
65+	14	630	651	.4035	

Table 2. Survival ratios, 1970-75 to 1995-2000

	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
Male						
SM_0	.8870	.9043	.9216	.9315	.9417	.0509
SM_1	.9645	.9700	.9751	.9781	.9812	.9842
SM_2	.9892	.9907	.9920	.9928	.9935	.9943
SM_3	.9883	.9898	.9911	.9918	.9926	.9934
SM_4	.9823	.9845	.9865	.9878	.9890	.9903
SM_5	.9788	.9815	.9840	.9855	.9870	.9886
SM_6	.9780	.9807	.9833	.9848	.9863	.9876
SM_7	.9759	.9788	.9815	.9830	.9846	.9862
SM_8	.9709	.9741	.9771	.9788	.9804	.9822
SM_9	.9615	.9652	.9687	.9706	.9724	.9744
SM_{10}	.9467	.9509	.9548	.9569	.9591	.9614
SM_{11}	.9248	.9298	.9344	.9369	.9395	.9420
SM_{12}	.8916	.8976	.9030	.9060	.9092	.9123
SM_{13}	.8420	.8491	.8556	.8593	.8631	.8670
SM_{14}	.6299	.6361	.6419	.6451	.6485	.6520
Female						
SF_0	.9030	.9184	.9339	.9426	.9516	.9598
SF_1	.9666	.9722	.9777	.9807	.9838	.9868
SF_2	.9894	.9911	.9928	.9937	.9946	.9955
SF_3	.9885	.9903	.9920	.9930	.9939	.9948
SF_4	.9837	.9861	.9885	.9898	.9911	.9924
SF_5	.9806	.9834	.9862	.9877	.9893	.9908
SF_6	.9790	.9821	.9850	.9866	.9881	.9896
SF_7	.9775	.9806	.9834	.9850	.9865	.9880
SF_8	.9747	.9778	.9806	.9822	.9838	.9854
SF_9	.9689	.9722	.9751	.9768	.9784	.9801
SF_{10}	.9587	.9625	.9659	.9678	.9696	.9716
SF_{11}	.9431	.9475	.9518	.9541	.9565	.9590
SF_{12}	.9172	.9229	.9284	.9314	.9345	.9376
SF_{13}	.8739	.8814	.8884	.8923	.8963	.9004
SF_{14}	.6532	.6598	.6660	.6695	.6731	.6868

$$(64A)\quad NB^- = 3.16354 - 0.0340\,\overline{AM} + 0.2709\,\overline{DM} + 0.27891\,(FY^- - 1.65)$$

$$(65A)\quad NB^+ = 3.16354 - 0.0340\,\overline{AM} + 0.2709\,\overline{DM} - 0.01736\,(FY^+ - 1.65)$$

replace (64) and (65) in the model. the resulting projections will give $r(1) = 0.0301$.

If the next census shows that $r(1)$ is some other figure, this information can be used to revise the model so that it will generate the correct $r(1)$. Meanwhile the idea is to have a model that gives a value for $r(1)$ not too different from $r(0)$.

Footnotes

1. This paper is part of a larger study being undertaken with research grant support from the Ford Foundation. A later and more extended version of this paper will be co-authored with my colleagues Mahar Mangahas and Vicente Paqueo. At this stage, sole responsibility rests with me. I have benefited from discussions also with Mercedes B. Concepcion and Peter C. Smith. Porfirio Sazon, Jr. did the programming at the U.P. Computer Center and Ruben de la Paz provided research assistance.

2. In the case of employment data, the time series was 1956-1969 as there were no nation-wide employment surveys before 1956.

3. The macroeconomic equations are based on calendar year data but we are treating the variables involved as if they pertained to fiscal years for convenience in dating both economic and demographic variables.

4. Let $W_{t+1} = a + b\,W_t + c\,P_t$ where $P_t = \delta\,P_{t-1}$. We assume $\delta > 1$ and $0 < b < 1$. Then $W_{t+1} = a + b\,W_t + c\,P_o\,\delta^t$ which has the solution

$$W_t = a\frac{1 - b^t}{1 - b} + W_o b^t + c\,P_o\frac{\delta^t - b^t}{\delta - b}$$

The real wage is then

$$\frac{W_t}{P_t} = \frac{a}{P_o\,\delta^t} \cdot \frac{1 - b^t}{1 - b} + \frac{W_o\,b^t}{P_o\,\delta^t} + \frac{c}{\delta^t} \cdot \frac{\delta^t - b^t}{\delta - b}$$

As t increases, the first two terms on the right hand side tend to zero and the third term tends to $c/(\delta - b)$.

5. The subsample was obtained by including only single-family households with relatively complete records where the family is of the so-called nuclear type, the wife has married only once and was under 45 years of age at the time of the survey, and responses to the following items of information were reported: education levels of both husband and wife, age of wife and duration of marriage, number of children born alive, incomes of wife and of husband, and total family income.

References

Aitchison, J. and Brown, J.A.C. The Lognormal Distribution. Cambridge University Press, 1957.

Coale, A.J. and Hoover, E.M. Population Growth and Economic Development in Low-Income Countries. Princeton University Press, 1958.

Encarnación, J. "Family Income, Education, Labor Force Participation and Fertility," in A Demographic Path to Modernity: Patterns of Early Transition in the Philippines, ed. W. Flieger and P.C. Smith. University of the Philippines Press, forthcoming in 1973. (a)

Encarnación, J. "Fertility and Labor Force Participation," School of Economics, IEDR Discussion Paper 73-13, University of the Philippines, August 1973. (b)

Enke, S. et al. Description of the Economic Demographic Model. Santa Barbara, California: TEMPO, General Electric Center for Advanced Studies, 1969.

Simon, J.L. "The Effect of Income on Fertility," Population Studies, November 1969, pp. 327-41.

Appendix 1. Calculation of FY^-

In this appendix only, for convenience we write $FY = y$, $FY^* = y^*$, $FY^- = y^-$ and $FY(-1) = y(-1) = x$. By definition,

$$y^- = \frac{1}{\pi}\int_0^{y^*} yf(y)dy$$

$$y^-(-1) = x^- = \frac{1}{\pi(-1)}\int_0^{y^*} xf(x)dx$$

where $f(y)$ is the probability density function of y. With lognormality always and constant σ^2, and since $y = \alpha x$, the graph of $f(y/\alpha)$ is identical to that of $f(x)$. We can therefore use the distribution at time $q-1$ to obtain the needed information, noting that while y^* is a constant, the point y^* at time q corresponds to the point y^*/α on the $q-1$ income axis. Also, y^- at time q corresponds to the point y^-/α on the $q-1$ scale. Hence, on the $q-1$ scale,

$$y^-/\alpha = \frac{1}{\pi}\int_0^{y^*/\alpha} xf(x)dx$$

so that

$$y^- = \frac{\alpha}{\pi}\left[\int_0^{y^*} xf(x)dx - \int_{y^*/\alpha}^{y^*} xf(x)dx\right]$$

$$= \frac{\alpha}{\pi}\left[\pi(-1)y^-(-1) - (\pi(-1) - \pi)w\right]$$

where

$$w = \int_{y^*/\alpha}^{y^*} \frac{xf(x)dx}{\pi(-1)-\pi}$$

i.e. the mean income of families having incomes in the range y^*/α to y^* at time $q-1$, which can be approximated by

$$w = (y^*/\alpha + y^*)/2$$

Accordingly we write

$$y_{*}^{-} = \alpha y^{-}(-1)\pi(-1)/\pi - (\alpha y^{*} + y^{*})(\pi(-1)-\pi)/2\pi$$

whose RHS, not unexpectedly, gives a value for y^{-} not too different from that given by $\alpha y^{-}(-1)$.

The above procedure was suggested by related work of M. Mangahas on calculating the mean of the logarithms of incomes less than y*.

Appendix 2. Calculation of the constant term in the fertility equations

The problem is to adjust the value of the constant term in eqs. (64) and (65) so that the resulting model projections will give r(1) equal to some predetermined number. It is of course easy to calculate what TNB for $q = 1$ must be in order that r(1) be as required. In what follows, an asterisk in front of a variable means that the value of that variable has yet to be determined.

The values of π, θ, TNF, FY^- and FY^+ at $q = 1$ are known from running the original model. We have

(i) $TNB = *TNB^- + *TNB^+$

from (71),

(ii) $*TNB^- = 0.3242 *NB^- \cdot \pi \cdot \theta \cdot TNF$

from (69) and (66), and

(iii) $TNB - *TNB^- = 0.3049 *NB^+ \cdot (1-\pi) \cdot \theta \cdot TNF$

from (70), (67) and (i). Also,

(iv) $*NB^- = *NB^+ + c$

where $c = 0.01736 (FY^+ - 1.65) + 0.27891 (FY^- - 1.65)$, referring to (64) and (65).

The equations (ii)-(iv) can then be solved for $*TNB^-$, $*NB^-$ and $*NB^+$, and a comparison of $*NB^-$ with the value of NB^- as determined by the model gives the necessary information for adjusting the constant term.