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AN ANALYSIS OF FERTILITY DIFFERENTIALS
IN DEVELOPING COUNTRIES

by

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ABSTRACT

This paper analysed fertility differentials of 69 developing countries using a simultaneous equations model and cross-international data. The results supported the hypothesis that fertility rates tended to correspond to underlying socio-economic conditions. Adult literacy rates, secondary school enrolment rates, and female labour force participation rates were negatively related to fertility; percentage of the labour force in agriculture was positively related to fertility; early increases in life expectancy at birth were positively related to fertility, with further increases reducing fertility. Also, the number of years a country had a family planning programme appeared to have a negative effect on fertility after socio-economic factors were accounted for statistically.

1.0 INTRODUCTION

The rapid population growth of less developed countries (LDC's) during the post World War II period is of common knowledge and of great concern. While there is much discussion, and disagreement, on the reasons for the high birth rates in LDC's, it is widely believed that socio-economic conditions are at least partly responsible. This paper analyses fertility differentials of developing countries in the late 1960's in order to investigate the extent to which socio-economic conditions and government family planning programmes account for these differentials.¹

A number of studies have investigated international fertility differentials.² In most cases, fertility was regressed on a host of explanatory variables which reflected the socio-economic situation of the sample countries. Unfortunately, these studies were handicapped by some or all of the following difficulties:

1. One equation models were used, which might have given biased estimators, since the simultaneously determined relationships between fertility and some of the explanatory variables were not taken into consideration.
2. The measure of fertility was usually crude birth rate, which includes an age distribution component in addition to a pure fertility component.
3. Data were from the early 1960's or before, and often included both developed and developing countries. At this time fertility estimates were not available for many countries, therefore samples were relatively small. In addition, few countries were undergoing demographic transitions at this time so that regression lines mainly explained the variance between developed and developing countries and were assured good fits, although explaining only a small percent of the variance within each cluster.³ Work by Kirk indicates that this may no longer be true.⁴

4. Family planning programmes were not included among the explanatory variables.

In this paper a simultaneous equations model is developed, based on data from 69 LDC's in the 1968-1970 period. A fertility measure which is theoretically independent of age distribution is used, and government family planning programme is included as an exogenous variable.

2.0 SAMPLE

The sample consisted of all countries which met the following criteria:

1. Market economy
2. Population of 500,000 or more in 1969
3. Non-European with a per capital national income below \$1000 US in 1969

After deletions for lack of adequate data, 69 countries remained in the sample. (See Appendix A for the list of countries). Non-market economies were excluded from the sample because some data, for example, income per capita, were not comparable between market and non-market economies. Countries with less than 500,000 people were excluded, since our analysis gives equal weight to each country, and without such a restriction, basic relationships might be determined by many very small countries. An income per capita definition of development was used rather than the United Nations' definition which is based largely on geography⁵, because income per capita is the most widely used measuring rod for economic development. The only differences between criterion three and the United Nations' definition of development is that Libya, Kuwait and Puerto Rico are excluded as developing countries by criterion three.

The data for this paper come from a variety of sources, although United Nations' specialised agency year-books were relied on heavily. Generally, one source was used to obtain most of the information on a given variable, and secondary sources were used to fill in missing values. Appendix B lists definitions and data sources.

3.0 THE MEASUREMENT OF FERTILITY

Ideally, gross reproduction rate (GRR) is the best measure of fertility for a paper such as this, since, unlike the crude birth rate, GRR is unaffected by age distribution.

Unlike age specific fertility rates, the crude birth rate is influenced by the age composition of the population and, therefore, is not a pure measure of fertility.

Like the life expectancy at birth, in the case of mortality, it (gross reproduction rate) is the composite expression, in a single measure, of the combined effect of fertility rates prevailing at each age, in complete independence of the composition of the population in regard to sex and age.

Yet, previous studies of the present type have generally used the crude birth rate (BR) as their fertility measure, because these data were much more widely available. In this section it will be shown that it is possible to estimate GRR by using the BR and a crude measure of the population age distribution (percent of total population ages 15-44).

To begin with, the birth rate (divided by 1000) is definitionally equal to the birth-population 15-44 ratio times the proportion of the population 15-44.

$$BR = \left(\frac{B}{P_{15-44}} \right) \times \left(\frac{P_{15-44}}{P} \right) \quad (1)$$

It is possible to rewrite the above equation for stable populations so as to include a GRR term, since the birth-population 15-44 ratio and GRR are virtually perfect correlates in stable populations (Table 1).

Table 1

Relationship between GRR and Births-Population
15-44 Ratio in Stable Model Populations with
Life Expectancy 50 and Generation Length 29^a

<u>BR</u>	<u>GRR/Births-Pop. 15-44 Ratio</u>
17.8	29.76
22.1	29.41
26.2	29.66
30.0	29.41
33.7	29.61
37.1	29.41
43.4	29.41
49.1	29.41
54.2	29.41

^a Source: Ansley Coale and Paul Demeny,
Regional Model Life Tables and Stable
Population Models (Princeton, 1965).

Since $\frac{B}{P_{15-44}} \approx \frac{1}{29} \text{ GRR}$, substituting in (1) and taking the logarithm of both sides:

$$\ln BR = \ln \frac{1}{29} + \ln GRR + \ln \frac{P_{15-44}}{P} \quad (2)$$

Because the population in most countries is not "stable", (2) was estimated by ordinary least squares using 1960 data from 50 countries.⁹

$$\ln BR = \underset{(19.72)}{-3.253} + \underset{(38.23)}{.994 \ln GRR} + \underset{(5.76)}{1.089 \ln \frac{P_{15-44}}{P}} \quad (3)$$

$$R^2 = .97$$

All coefficients were highly significant; the over-all level of explanation was very high; and all three coefficients were not significantly different from those of (2).¹⁰ Equation (3) was then used to obtain estimates of GRR for the 1968-1970 period, and these estimates were subsequently used for this paper's empirical analysis of fertility.¹¹

It needs to be pointed out that the further from "stability" a population is the more in error will be the GRR estimated based on (3).¹² Nonetheless, it is felt that using (3) to estimate GRR is preferable to using other, less up-to-date GRR estimates or using the crude birth rate which is affected by the population age distribution.¹³

4.0 THE MODEL AND ITS THEORETICAL FOUNDATION

The theoretical framework for this paper is based on the socio-economic theory of fertility, namely that couples act rationally to maximise their family's welfare.

I shall assume in this enquiry, that reproductive behaviour is largely a response to the underlying preferences of parents for children.¹⁴

The assumption is, that family size norms will tend to correspond to a number which maximises the net utility to be derived from having children in the society or stratum.¹⁵

Fertility behaviour is the result of household choices in which resources are weighted against preferences. In the economic theory of household behaviour, consumers with given tastes are viewed as maximising utility subject to the constraints of income and prices.¹⁶

This theory is used to relate socio-economic conditions at the national level. For this purpose, parents' education is used as the major proxy for the parents' preference function; wife's labour force participation¹⁷ and children's education as the major proxies for the economic costs of children; agricultural employment as the major proxy for the economic benefit of children; life expectancy at birth as the proxy for health and survivorship probabilities.¹⁸

It is hypothesised that couples decide simultaneously wife's labour force participation, the number of children they have, and the education they give each child. For example, many children and high educational attainment for children, may be incompatible for economic reasons - the family is then faced with the choice of a small well educated family, or a large poorly educated one. Similarly the wife's employment may be incompatible with many children.

Because of the simultaneity involved, ordinary least squares (OLS) estimates of the socio-economic determinants of fertility are biased.¹⁹ Therefore, two-stage least squares (TSLS) is used to purge the coefficients of the simultaneous equations bias. For this purpose the following set of equations is proposed:²⁰

$$\begin{aligned} \text{GRR} = & a_1 + b_1 \text{LFPR} + c_1 \text{Illit} + d_1 \text{Ch Ed} + e_1 \text{LE} \\ & + f_1 (\text{LE})^2 + g_1 \text{Ag} \end{aligned} \quad (4)$$

$$\text{Ch Ed} = a_2 + b_2 \text{Y/N} + c_2 \text{GRR} + d_2 \text{Illit} + e_2 \text{Ag} \quad (5)$$

$$\text{LFPR} = a_3 + b_3 \text{GRR} + c_3 \% \text{Ag} + d_3 \text{Ag}^2 + e_3 \text{M} \quad (6)$$

GRR	Gross reproduction rate
LFPR	Labour force participation rate for women age 15 to 44
Illit	Percentage of adult population which is illiterate
ChEd	Secondary school enrolment rate
LE	Life expectancy at birth in years
Y/N	National income per capita in US dollars
Ag	Percentage of labour force in agriculture
M	Percentage of population which is Muslim

5.0 FEMALE EMPLOYMENT AND CHILD'S EDUCATION (OLS RESULTS)

This section presents the OLS results for the two endogenous variables which are simultaneously determined with fertility, namely ChEd and LFPR. These OLS formulations are then used in the next section to estimate coefficients in the GRR equation using TSLS.

The proposed formulation for ChEd gave the following results ("t" values in brackets):

$$\begin{aligned} \text{ChEd} = & 48.0612 - 2.6100 \text{GRR} + .0094 \text{Y/N} - .1625 \text{Illit} \\ & (6.10) \quad (1.12) \quad (1.18) \quad (3.44) \\ & - .2502 \text{Ag} \\ & (3.37) \quad R^2 = .74 \quad (7) \end{aligned}$$

All of the coefficients had the expected sign. The results implied that increases in fertility levels competed with child's education; that children's education was a normal good; that higher levels of adult education encouraged child's education, and that rural communities (ones with a high percent agriculture) probably found children's education more costly than urban ones, due to the higher opportunity cost of work foregone and the higher costs involved in providing and taking advantage of schooling in less densely populated areas.

Further analysis indicated that ChEd was also negatively related to the year of independence as well as to continent (Equation 8).

$$\begin{aligned} \text{ChEd} = & 37.291 - 1.589 \text{ GRR} + .022 \text{ Y/N} - .216 \text{ Illit} \\ & (5.12) \quad (0.75) \quad (3.01) \quad (4.20) \\ & - .197 \text{ Ag} + 1.586 \text{ INDEP45-59} - 6.159 \text{ INDEP60} \\ & (2.95) \quad (0.57) \quad (2.08) \\ & + 10.455 \text{ AFRICA} + 9.337 \text{ ASIA} \\ & (2.46) \quad (3.03) \quad R^2 = .83 \quad (8) \end{aligned}$$

This made intuitive sense. Year of political independence probably proxied for the stock of educational infrastructure which was affected by colonial heritage; Africa and Asia dummies indicated regional differences.

Equation (8) was quite good. The general level of explanation was high; all independent variables had expected signs, and most coefficients were significant (a noted exception was GRR).²¹ This formulation will be retained for the TSLS analysis in the next section.

Fair results were obtained with the proposed LFPR formulation. All independent variables had the hypothesised sign even though the R^2 was fairly low.

$$\begin{aligned} \text{LFPR} = & 54.0155 - 5.1748 \text{ GRR} - .2203 \text{ M} - 1.0018 \text{ Ag} \\ & (3.65) \quad (0.78) \quad (3.61) \quad (1.70) \\ & + .0155 \text{ Ag}^2 \\ & (3.30) \quad R^2 = .53 \quad (9) \end{aligned}$$

Muslim populations discouraged female employment, and female employment was a non-linear function of percentage agriculture, negative up to 32 per cent agriculture and positive thereafter, thus confirming the work of others.²² Equation (8) will be retained for use in estimating GRR using TSLS.

6.0 FERTILITY RESULTS USING TWO STAGE LEAST SQUARES (TSLS)

This section estimates the relationships between socio-economic factors, family planning programmes and fertility using simultaneous estimating procedures (TSLS). The stability of the final formulation is examined by running it separately for each continent.

Before proceeding with the empirical results, however, it is necessary to mention, in advance, that these results should be interpreted with caution. Cross-international analysis is always faced with high multicollinearity as well as problems of data quality and data comparability. In particular the measures of FPP (years of an active government programme) and adult educational level (illiteracy rate) were not optimal, although they were the best measures available for a large number of developing countries.

The proposed fertility formulation (4) confirmed a priori expectations with each of the independent variables related to GRR in the expected direction and the positive effect of LE peaking at a believable 50 years (Equation 10, Table 4).²³ However, because of the high multicollinearity between ChEd, Illit, Ag and LE (see Table 3), significance levels generally were not high with only ChEd and LFPR significant at the 10 per cent level.

Significance levels tended to increase when any one of the highly collinear variables was deleted (Equations 11 - 14, Table 4). ChEd was always significant and Illit was always insignificant. The results shown in Equations 11-14 should be interpreted in a ceteris paribus sense, since even Illit is strongly related with GRR when taken by itself as is demonstrated by the simple correlation coefficient between Illit and GRR of .64. The formulation in Equation (10) was used for further analysis, since each of the independent variables is theoretically important and low "t" values were preferred to an obvious specification error.

Table 3

Simple Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) GRR	1.00													
(2) ChEd	-.65	1.00												
(3) LFPR	.05	-.39	1.00											
(4) Illit	.65	-.77	.21	1.00										
(5) Ag	.64	-.80	.49	.70	1.00									
(6) LE	-.62	.84	-.40	-.87	-.80	1.00								
(7) Y/N	-.59	.74	-.33	-.69	-.80	.74	1.00							
(8) M	.34	-.15	-.34	.51	.13	-.22	-.21	1.00						
(9) FPP	-.33	.32	-.14	-.19	-.32	.38	.12	-.03	1.00					
(10) InFPP	-.38	.36	-.18	-.24	-.35	.45	.16	.00	.94	1.00				
(11) INDEP45-59	.03	.21	-.27	.01	-.06	.14	-.16	.40	.33	.36	1.00			
(12) INDEP60	.16	-.45	.44	.39	.31	-.49	-.27	-.10	-.15	-.17	-.44	1.00		
(13) AFRICA	.29	-.57	.33	.63	.50	-.65	-.46	.12	-.22	-.19	-.24	.79	1.00	
(14) ASIA	.03	.20	-.09	-.00	-.01	.13	-.14	.37	.30	.25	.62	-.44	-.52	1.00

Table 4

Two Stage Least Square Results for Gross
Reproduction Rate (GRR)
 ("t" values in brackets)

Independent variables	(10)	(11)	(12)	(13)	(14)
Constant	1.3955 (0.97)	1.7026 (1.10)	1.5076 (1.22)	.8945 (0.64)	3.1005 ^a (6.14)
ChEd	-.0238 ^b (2.07)	X	-.0242 ^b (2.18)	-.0320 ^a (3.27)	-.0236 ^a (2.40)
LFPR	-.0086 ^b (2.28)	-.0106 ^a (2.45)	-.0088 ^a (2.60)	-.0056 ^c (1.82)	-.0117 ^a (4.07)
Illit	.0005 (0.16)	.0015 (0.45)	X	.0009 (0.27)	.0000 (0.01)
Ag	.0070 (1.36)	.0139 ^a (2.95)	.0071 (1.39)	X	.0104 ^b (2.31)
LE	.0744 (1.36)	.0431 (0.74)	.0727 (1.37)	.1117 ^b (2.35)	X
(LE) ²	-.00075 (1.39)	-.00059 (1.02)	-.00074 (1.40)	-.00111 ^b (2.33)	X
LE turn- ing point	50	37	49	50	X
R ² (based on instruments)	.62	.60	.62	.61	.61

c Significant at 10 per cent level

b Significant at the 5 per cent level

a Significant at 1 per cent level

Table 4 (cont'd.)

	AFRICA (15)	ASIA (16)	AMERICA (17)
Constant	1.0077 (0.48)	-2.2254 (0.73)	2.2636 (0.22)
ChEd	-.0220 (0.91)	.0110 (0.61)	-.0521 ^c (2.01)
LFPR	.0006 (0.10)	-.0032 (0.63)	-.0231 (1.45)
Illit	.0018 (0.26)	.0077 (1.13)	.0069 (0.73)
Ag	-.0009 (0.13)	.0026 (0.27)	.0033 (0.20)
LE	.1001 (1.07)	.2031 ^c (1.82)	.0327 (0.10)
(LE) ²	-.00114 (0.98)	-.00224 ^c (2.16)	.00001 (0.00)
LE turning point	44	45	X
R ² (based on instruments)	.39	.73	.81

c Significant at 10 per cent level

b Significant at the 5 per cent level

a Significant at 1 per cent level

The relative "stability" of Equation (10) was investigated by running it separately for each of the three developing continents. Expectations were that, while the strength of the various relationships would vary by continent, their direction would not. Considering the relatively small degrees of freedom in each continent, the results were fairly convincing (15-17 in Table 4), since there were only four sign reversals and these coefficients had very low "t" values.

The results implied that fertility levels in LDC's tended to respond consistently to a number of underlying socio-economic factors. Higher levels of female employment, children's education, and adult literacy tended to reduce fertility; higher levels of agricultural employment tended to increase fertility; and increases in life expectancy at birth tended to increase fertility at first (up to a life expectancy of approximately 49 years) and then decrease it.

A government family planning programme variable (FPP) was added to (10) in order to see whether FPP had a significant effect on fertility rates after the underlying socio-economic conditions in each country were taken into consideration. Both number of years of family planning programme and its logarithm were used as FPP measures.²⁴ A priori it was expected that $\ln$ FPP would perform better than FPP, because if FPP affects fertility, the marginal decrease in fertility due to each additional year of FPP should approach zero after the programme has been in existence a large number of years. As expected, both FPP measures were negatively related to GRR, and $\ln$ FPP was more strongly related to GRR than was FPP with $\ln$ FPP significant at the 10 per cent level and FPP insignificant (Equation 18, 19, Table 5). A long standing FPP (e.g. 15 years) reduced GRR by approximately one-third of a birth according to Equation (19).

The relative "stability" of the relationship between FPP and GRR was investigated by running Equation (19) separately for each continent. In all three continents $\ln$ FPP was negative; in addition the specification of FPP for Africa caused the coefficients of two variables to revert to the hypothesised sign (Equations 20-22), Table 5). These results tended to confirm the negative relationship between FPP and GRR in Equation (19).²⁵

Table 5

Two Stage Least Squares Results for Gross
Reproduction Rate with Years of Family
Planning Programme as an Independent Variable

("t" values in brackets)

Independent variables	All developing countries		AFRICA	ASIA	AMERICA
	(18)	(19)	(20)	(21)	(22)
Constant	.9372 (0.64)	.7928 (0.55)	1.1924 (0.59)	-2.5086 (0.82)	1.2458 (0.12)
ChEd	-.0228 ^c (1.98)	-.0218 ^c (1.92)	-.0132 (0.49)	.0036 (0.21)	-.0509 (1.59)
LFPR	-.0073 ^c (1.92)	-.0073 ^c (1.95)	-.0017 (0.28)	-.0036 (0.70)	-.0216 (1.31)
Illit	.0023 (0.64)	.0033 (0.90)	.0033 (0.47)	.0092 (1.27)	.0076 (0.74)
Ag	.0063 (1.22)	.0068 (1.33)	.0011 (0.14)	.0038 (0.40)	.0031 (0.14)
LE	.0829 (1.52)	.0815 (1.51)	.0787 (0.86)	.1942 (1.70)	.0657 (0.20)
(LE) ²	-.00078 (1.44)	-.00073 (1.36)	-.00085 (0.74)	-.00194 (1.71)	-.00027 (0.09)
FPP	-.0179 (1.16)	X	X	X	X
Ln FPP	X	-.1233 ^c (1.78)	-.2354 (1.16)	-.1070 (0.96)	-.0365 (0.17)
LE turning point	53	56	46	50	122
R ² (based on instruments)	.62	.63	.45	.74	.81

c Significant at 10 per cent level

b Significant at 5 per cent level

a Significant at 1 per cent level

It is necessary to interpret the relationship between FPP and GRR very cautiously for a number of reasons. First, FPP was measured by the number of years a government had actively supported family planning with government facilities, and this was not necessarily indicative of the programme's size (but there should be a reasonably good correlation between number of years and size if only because no FPP programme is zero). Second, most countries did not have an FPP in 1968. Third, a relationship between FPP and GRR did not necessarily imply causation; it may have been that countries with lower fertility rates tended to adopt FPPs because the population was more favourably disposed toward such programmes.

7.0 CONCLUSION

This study analysed fertility differentials using cross-international data from the 1968-1970 period. Results confirmed the main hypothesis underlying the socio-economic theory of fertility. Increases in adult literacy rates, levels of children's education, and female labour force participation rates tended to reduce fertility; increases in percentage of the labour force in agriculture tended to increase fertility. Increases in life expectancy at birth tended to increase fertility at first (up to approximately 49 years) and then decrease fertility with further increases in life expectancy. The number of years a country had a family planning programme tended to decrease fertility levels below that implied by the underlying socio-economic conditions.

There were a number of factors which lent credence to the results contained in this paper. One, the results met a priori expectations. Two, only developing countries were analysed thereby reducing the likelihood that a good fit would be assured. Three, the sample size (69) was fairly large. Four, an approximation of gross reproduction rate (a fertility measure which is independent of the population age distribution) was used, and this caused some differences. Fifth, relationships were estimated in the context of a simultaneous equations

model thereby eliminating some of the simultaneous equations bias which is inherent in ordinary least squares estimates. Sixth, by continent, the basic relationships between socio-economic variables and fertility were fairly consistent in terms of sign.

However, as with all cross-international analysis, empirical results must be interpreted cautiously. Data comparability is not always as high as one would like; measurement error is sometimes fairly large; data does not always correspond to the same year for all countries; multicollinearity is high. In addition, various lag structures were not investigated, and the results may not be representative of time series changes in a specific country. In particular, the preliminary work with the family planning programme should be interpreted cautiously awaiting confirmation with more up-to-date analysis and a better measure of the programme's size.

APPENDIX A

List of Countries in Sample

Africa: Algeria, Angola, Burundi, Cameroon, Central African Republic, Chad, Congo, Dahomey, Egypt, Ethiopia, Ghana, Ivory Coast, Kenya, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Somalia, Tunisia, Uganda, Tanzania, Upper Volta, Zambia. Central America and Caribbean: Costa Rica, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago. South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezeula. Asia: Afghanistan, Burma, Hong Kong, India, Indonesia, Iran, Iraq, Jordon, Korea (S), Laos, Nepal, Pakistan, Saudi Arabia, Sri Lanka, Syria, Philippines, Thailand, Turkey, Yemen Democratic People's Republic.

APPENDIX B

Data Sources and Definitions

1. Gross reproduction rate (GRR) is the average number of female births to all women of childbearing age during one year. Data were the latest estimate for the 1968 to 1970 period. Source: vital registration data in Office of Population Research, Princeton University, Population Index (Princeton, April 1974) for Mauritius, Panama, Trinidad and Tobago, Venezuela, and Hong Kong. For other countries GRR was estimated using the latest estimates of crude birth rate and percentage of the population 15-44 years in 1970 (see Section 3 for the procedure).

2. Crude birth rate (BR) is the number of births per 1000 population. Data was the latest estimate for the 1968 to 1970 period. A check on data quality was made by comparing BR estimates from Office of Population Research, Princeton University, Population Index (Princeton, July 1973), and UN Demographic Yearbook, 1971 (New York, 1972), Tables 3 and 23 (considered to be of good quality by the UN). When any of these estimates for comparable years differed by more than 5.0, and there was no explanation for these differences, the country in question was deleted from the sample (Liberia, Togo and South Viet Nam). Source: UN, Demographic Yearbook, 1971 (New York, 1972), Table 23, for all countries except Algeria and Yemen, Democratic People's Republic which were from Table 3 of the same volume.

3. Percentage of the population 15-44 (%15-44) is the percentage of the total population which is age 15 to 44 years. Data were for 1970. Source: ILO, Labour Force Projections 1965-1985 (Geneva, 1971) which used country specific information generated by, but not contained in, UN, World Population Prospects as Assessed in 1968, Population Studies No.53 (New York, 1973). When the fertility

assumption underlying the estimate of $\%15-44$ was incorrect (generally where the United Nations had not expected a decline in the birth rate), $\%15-44$ was adjusted upward to take into consideration the fact that fewer births had occurred than were assumed. This adjustment affected: Egypt, Mauritius, Tunisia, Costa Rica, El Salvador, Guatemala, Panama, Trinidad and Tobago, Argentina, Chile, Hong Kong, and Sri Lanka.

4. Children's education (ChEd) is the secondary school enrolment rate per 100 children of secondary school age. Data were the latest estimate for 1965 to 1969 period. Source: UNESCO, Statistical Yearbook, 1971 (Louvain, Belgium, 1972), Table 27, for all countries except Ghana which was from Central Bureau of Statistics, Statistical Handbook of Ghana, 1969 (Accra, 1970), and Tunisia which was from Institut Nationale de la Statistique, L'Economie de la Tunisie en Chiffres, 1971 (Tunis, 1972).

5. Female labour force participation rate (LFPR) is the percentage of women aged 15-44 who are in the labour force. Data were for 1970. Source: ILO, Labour Force Projections 1965-1985 (Geneva, 1971).

6. Agriculture (Ag) is the percentage of the total force which is engaged in agriculture. Data were for 1970. Source: FAO, Production Yearbook, 1971 (Rome, 1972), Table 5D.

7. Life expectancy at birth (LE) is the average number of years lived by a person just born if the person had the age specific mortality rates of the current population. Where there were separate LEs for males and females, an arithmetic average of the two was taken. Data was the latest estimate for the 1960 to 1970 period. Source: UN, Demographic Yearbook, 1971 (New York, 1972), Table 19; Haiti, Bolivia and Columbia which were from Centro Latinoamericano de Demografia, Buletin Demografico, no.10 (Santiago, 1972); Philippines which was from ILO, Sharing in Development (Geneva, 1974); and India which was from Department of Statistics, Statistical Handbook of India, 1972 (New Delhi, 1973).

8. Illiteracy (Illit) was the percentage of adults age 15 or more who were illiterate. Data were the latest estimate for the 1960 to 1966 period. Source: World Congress of Ministers of Education on the Eradication of Illiteracy, Tehran, 8-19 September 1965, Statistics of Illiteracy (Paris, 1965) for all countries except for Chad, Argentina, Dominican Republic and Indonesia which were from UN Demographic Yearbook, 1970 (New York, 1971). Table II.

9. Family planning programme (FPP) is the number of years a government had family planning programme which used government facilities, including countries which supported family planning through maternal and child health programmes. When the birth rate data was an estimate for the 1965 to 1970 period, 1968 was used as the reference year from which to judge the number of years a country had an FPP.

Source: International Planned Parenthood Federation, Family Planning in Five Continents (Hertford, July 1971) for all countries except for Madagascar, Mauritius, Nigeria, Ecuador and Hong Kong where the year the FPP began was from Dorothy Nortman, "Population and Family Planning: A Factbook", Reports on Population/Family Planning (July 1971).

10. Income per capita (Y/N) is the average national income per person in US dollars. Data was the latest estimate for the 1963 to 1969 period. Source: UN, National Accounts of Statistics Yearbook 1971 (New York, 1973); Vol. 3, Table 1B.

11. Percentage Muslim (M) is the percentage of the total population which adheres to the Muslim religion. Data was for the 1940 to 1970 period. Source: Russett, et al, World Handbook of Political and Social Indicators (New Haven, 1964) for all countries except Angola, Malawi, Mauritius, Zambia, Costa Rica, El Salvador, Haiti, Jamaica, Paraguay, Uruguay, and Venezuela, which were from Europa Publications, Europa Yearbook, 1971 (London, 1971), Uganda which was from Statistics Division, Uganda Census, 1969 (Entebbe, 1973), Vol. III, and Mozambique which was from Direcção dos Serviços de Economia e de Estatística Geral, Recensamento Geral da População Civilizada, 1955 (Lourenço Marques, 1958).

12. Year of independence (INDEP 45-59 and INDEP 60+) were dummy variables which took on the value of one when a country became politically independent in the specified period and zero otherwise. INDEP 45-59 was one when independence occurred between 1945 and 1959 and zero otherwise. INDEP 60 was one when independence occurred during the 1960's or a country was still a colony. The excluded class was countries which were independent before 1945. Source: Europa Publications, Europa Yearbook, 1971 (London, 1971).

APPENDIX C

Means and Standard Deviations

	<u>Mean</u>	<u>Standard Deviation</u>
GRR	2.91	0.51
BR	43.15	7.81
% 15-44	41.96	1.35
Ch Ed	17.00	13.44
LFPR	36.62	25.96
Ag	61.39	21.11
IE	48.98	9.95
Illit	64.24	28.20
FPP	1.43	3.07
Ln FPP	0.37	0.07
Y/N	247.77	189.93
M	28.28	38.93
INDEP45-59	0.22	0.42
INDEP60	0.41	0.49
AFRICA	0.42	0.50
ASIA	0.28	0.45

NOTES

1. An important use for such analysis is in long-run simulation models where fertility is endogenously determined, since empirical analysis of point in time household surveys often provide unreasonable coefficients for long-run simulations. An example of this use appears in a preliminary version of the ILO's BACHUE-Philippines economic-demographic simulation model. Analysis of Philippine household survey data (1968 Philippine National Demographic Survey) showed reasonable relationships between socio-economic variables and fertility in terms of sign, but the coefficients were as such as to imply only a small change in the birth rate even when spectacular economic growth was assumed (Wéry, Rodgers and Hopkins, "BACHUE-2: Version - I, A Population and Employment Model for the Philippines", ILO Population and Employment Working Paper No.5 (Geneva, 1974)).

2. Irma Adelman, "An Econometric Analysis of Population Growth", American Economic Review, vol.52, no.3; Gregory, Campbell and Chang, "A Cost Inclusive Simultaneous Equations Model", Econometrica, vol. 40, no.4; Barbara Janowitz, "An Empirical Study of the Effects of Socio-Economic Development on Fertility Rates", Demography, vol. 8, no.3.

3. UN, "World Population Prospects as Assessed in 1963", Population Studies, no.41 (New York, 1967), pp. 3-4.

4. Dudley Kirk, "A New Demographic Transition", in Rapid Population Growth (Baltimore, 1971).

5. UNESCO includes as developing countries every country except USSR, USA, Canada, Japan, Israel, Australia, New Zealand, South Africa and all of Europe (UNESCO, Statistical Yearbook, 1971 (Louvain, Belgium, 1972)).

6. Barbara Janowitz, "An Empirical Study of the Effects of Socio-Economic Development on Fertility Rates", Demography, vol. 8, no.3, p.323.

7. United Nations, Population Division, Population Newsletter, no.7 (New York, 1969), p.11.

8. This ratio is a slight function of the generation length (Table 2).

Table 2

Relationship between GRR and Birth-Population 15-44 Ratio Holding Average Life Expectancy at Birth Constant at 50, Population Growth Rate Constant at 2.0, and Varying Generation Length in West Model Stable Population^a

<u>Generation Length</u>	<u>GRR/Birth Population 15-44 Ratio</u>
27	27.93
29	29.40
31	31.00
33	32.78

^a Source: Ansley Coale and Paul Demeny, Regional Model Life Tables and Stable Population Models (Princeton, 1965).

9. The GRR and BR data were taken from the UN, Demographic Yearbook, 1971. Countries with estimates of GRR around 1960 were used if the GRR was within the 1959 to 1962 period, and it was considered to be of good quality by the United Nations. The percentage distribution for 1960 (i.e. percentage of the population which is 15-44, the main childbearing years) was from UN Population Division, Population Estimates by Regions and Countries, 1950-1960 (New York, 1970). Birth rates were centred in the 1959 to 1962 period - the same as for the GRR.

10. Ln age at marriage was added to Equation (3) (see footnote 8 on previous page); it was not significant nor did it significantly reduce the residual sum of squares. Data sources were: Ruth Dixon, "Explaining Cross-Cultural Variations in Age at Marriage and Proportions Never Marrying", Population Studies, vol. 25, no.2; Daniel Bogue, Principles in Demography (New York, 1969).
11. GRR estimates for the 1968-70 period based on what were believed to be complete vital registration statistics were used if they were available in the Office of Population Research, Princeton University, Population Index (Princeton, April 1973).
12. Some other factors are completely neglected in this procedure (e.g. sex composition, age pattern within the 15-44 year age group, and the age specific fertility pattern).
13. In the subsequent empirical analysis of fertility in Section 6.0 an attempt was made to circumvent the need for the work in Section 3.0 by using crude birth rate as the fertility measure and percentage 15-44 as one of the independent variables. However, this did not provide satisfactory results. Percentage 15-44 had a very high "t" value but an unexpected negative sign. (Obviously causation was running from the birth rate to the age distribution, with high birth rates causing a low percentage 15-44). In addition, percentage 15-44 acted like a dominant variable greatly altering the signs of the socio-economic variables.
14. T. Paul Schultz, "An Economic Perspective on Population Growth", Rapid Population Growth, p.149.
15. Ronald Freedman, "The Sociology of Human Fertility", Current Sociology, Vol.X-XI (1961-62), p.49.
16. Richard Easterlin, "Towards a Socio-Economic Theory of Fertility", Fertility and Family Planning: A World View, ed. S.J. Behrman, et al, (Ann Arbor, 1969), p.128.

17. It has been argued by some that only certain types of female employment (basically non-agricultural wage and salary employment) conflicts with fertility and child-rearing, since unpaid family work or employment near home, are not believed to conflict with fertility (Robert Weller, "The Employment of Wives, Role Incompatibility, and Fertility", Milbank Memorial Quarterly Fund, vol. 4, no.3; J.M. Stycos and R.H. Weller, "Female Working Roles and Fertility", Demography, vol. 4, no.1.). If so, the appropriate measure of female employment would be the percentage of women 15-49 in non-agricultural wage and salary jobs. The author earlier attempted to construct such a measure, but the results were not encouraging (R. Anker, "An Analysis of International Variations in Birth Rates: Preliminary Results", ILO, Population and Employment Working Paper No.3 (Geneva, 1974).

18. One should not take too literally the division of factors into costs and tastes, since many factors fall in more than one category. For example, parents' education increases the opportunity cost of work foregone as well as changing the preference function.

19. Johnston, J., Econometric Methods (New York, 1972).

20. A square term on life expectancy at birth is included, because historical evidence indicates that early improvements in health conditions increase fertility rates; (H.J. Habakkuk, Population Growth and Economic Development Since 1950 (Bath, United Kingdom, 1971). Some authors continue to caution about the "possibility of a rise in fertility in the early stages of modernisation" (Roushdi A. Henin, "On the Applicability of the Theory of the Demographic Transition to African Countries", in OECD, The Demographic Transition in Tropical Africa (Paris, 1971), p.22).

21. Two policy variables - percent of government expenditures on education and percent of government expenditures on secondary school - were added separately to (8). Somewhat surprisingly neither variable was even remotely significant having "t" values of 0.03 and 0.18 respectively.

22. J.N. Sinha, "Dynamics of Female Participation in Economic Activity in a Developing Economy", UN World Population Conference 1965, WPC/285 (mimeo).

John Durand, "Economic Development and Dimension of the Labour Force: Some Results of a Comparative International Study", IUSSP, International Population Conference (Liège, 1973).

23. The R^2 from TSLS is not strictly valid as a goodness of fit measure. Consequently, it is not relied on in the discussion.

24. Ln zero was defined to be zero, since it was reasoned that FPP's could not have any impact on fertility during its first year because of the nine month gestation period between conception and birth.

25. Since the crude birth rate (BR) is the most common measure of fertility, Equations (10) and (19) were run with BR in place of GRR in order to see what differences this implied. Although the results were similar there were some interesting differences (Table 6).

1. Ln FPP was more significantly related to BR than to GRR.
2. ChEd was not significantly related to BR yet significantly related to GRR.
3. Ag was significantly related to BR but not to GRR.
4. Illit had an unexpected negative sign in the base formulation when BR was the dependent variable.

Table 6

Two Stage Least Squares Results for Crude Birth
Rate for All Developing Countries

("t" values in brackets)

Independent variables	All countries	
	(23)	(24)
Constant	34.4230 ^c (1.83)	24.6837 (1.33)
ChEd	-.1990 (1.32)	-.1679 (1.14)
LFPR	-.1396 ^a (2.83)	-.1187 ^b (2.46)
Illit	-.0060 (0.13)	.0381 (0.81)
Ag	.1459 ^b (2.16)	.1431 ^b (2.16)
LE	.6284 (0.88)	.7410 (1.06)
(LE) ²	-.00886 (1.25)	-.00845 (1.22)
Ln FPP	X	-2.0108 ^b (2.25)
LE turning point	35	44
R ² (based on instruments)	.72	.73

c Significant at 10 percent level.

b Significant at 5 percent level.

a Significant at 1 percent level.

Population and Employment Project
Working Papers Available

- WEP 2-21/WP.1 Household Savings and Demographic Change in
the Philippines
- by Peter Peek, May 1974.
- WEP 2-21/WP.2 Fertility and Labour Force Participation:
Philippines 1968
- by José Encarnacion, Jr., March 1974.
- WEP 2-21/WP.3 An Analysis of International Variations in
Birth Rates: Preliminary Results
- by Richard Anker, April 1974.
(no longer available, this paper (i.e. WEP 2-21/
WP.16) is a revised version).
- WEP 2-21/WP.4 Migration in the Philippines
- by René Wéry, March 1974.
- WEP 2-21/WP.5 BACHUE-2: Version - I A Population and
Employment Model for the Philippines
- by R. Wéry, G.B. Rodgers and M.D. Hopkins,
July 1974.
- WEP 2-21/WP.6 The Effects of Group Level Variables on
Fertility in a Rural Indian Sample
- by Richard Anker, August 1974.
- WEP 2-21/WP.7 The Economic Analysis of Fertility: A Study
for Brazil
- by Edy Luiz Kogut, September 1974.
- WEP 2-21/WP.8 Patterns of Consumption in the Philippines with
Particular Reference to Demographic Factors
- by Edita Abella Tan and Gwendolyn R. Tecson,
October 1974.

- WEP 2-21/WP.9 Female Participation in Economic Activity
in Colombia
- by Alejandro Angulo and Cecilia L. de
Rodriguez, January 1975.
- WEP 2-21/WP.10 Production, Employment and Wages in Modern
and Traditional Sectors: Argentine Case
(1950-1970)
- by Javier Villanueva, February 1975.
- WEP 2-21/WP.11 Fertility and Desired Fertility: Longitudinal
Evidence from Thailand
- by G.B. Rodgers, February 1975.
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A Decomposition Analysis
- by Mahar Mangahas, February 1975.
- WEP 2-21/WP.13 Family Composition and Female Employment:
The Case of Chile
- by Peter Peek, April 1975.
- WEP 2-21/WP.14 Population Change and Economic Growth:
A Long-Term Econometric Model of the Japanese
Economy
- by Ryoshin Minami and Akira Ono, April 1975.
- WEP 2-21/WP.15 On the Evaluation of Population and Employment
Policy
- by G.B. Rodgers, R. Wéry and M.J.D. Hopkins,
April 1975.