Chapter I

GUIDELINES FOR APPLICATION OF SELECTED EVALUATION METHODS

*United Nations Secretariat**

The guidelines given in this chapter pertain specifically to three of the evaluation procedures described in *Manual IX* (United Nations, 1979): the standardization approach; component projection approach I; and path analysis. It is thus in the context of the application of each respective technique that the clarifications presented below become meaningful.

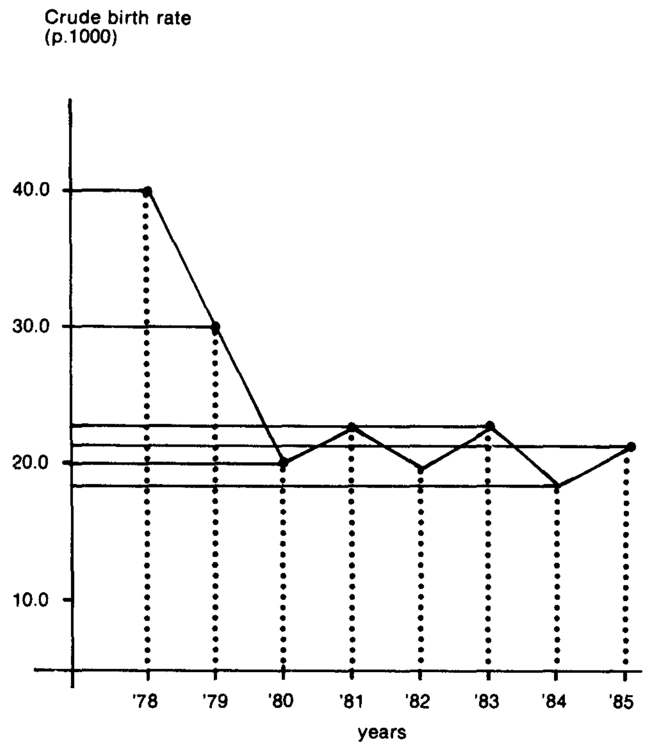
A. Standardization approach

It should first be borne in mind that, although the methodology and application of the standardization approach presented in *Manual IX* (United Nations, 1979, pp. 7-33) utilize the initial year and the last year of the period under study as the basis for decomposition, this was done only to underscore that the use of different years (and data) as the basis for standardization yields slightly different results. In practice, it is sufficient to use only one calendar year as the basis for the decomposition.

Attention is drawn again to the importance of two aspects of the analysis that are likely to affect the results inadvertently if they are not explicitly taken into consideration:

(*a*) Great caution must be exercised in selecting the length and limits of the period during which fertility change is observed. It is fundamental to bear in mind that the slope of the fertility observations can vary greatly not only as a result of true fertility changes but as a result of annual random fluctuations. When only the latter change occurs, the difference in fertility indices do not reflect a genuine change. As can be seen from the hypothetical illustration in figure I, the decomposition of a crude birth rate decline between 1981 and 1984 could be undertaken, but it would be of little interest because the overall fertility trend suggests that between 1980 and 1985 the observed variations in crude birth rates are mere fluctuations. On the other hand, the period from 1978 or 1979 to 1984 displays a genuine rate of decline and could be analysed using a decomposition;

Figure I. Hypothetical decline in crude birth rates



(*b*) A consistency test must always be applied. This step is crucial, and its importance has been strongly underscored in *Manual IX* (United Nations, 1979, p. 19). This test should always be performed when analysing crude birth rates and general fertility rates in order to ensure consistency among the various fertility indicators utilized and to minimize the magnitude of the interaction terms if a decomposition is undertaken. Inconsistencies are almost always encountered in this type of analysis, especially when general rates and specific rates are estimated from different sources[1] and adjustments have thus to be made.

B. Component projection approach I: computerized model

An analysis of previous applications of component projection approach I reveals that the major problem with its application relates to the definition of the inputs (Nortman, 1979). Table 1 displays the input data utilized with the case study of Sri Lanka, which serves to illustrate various points relevant to the proper definition of input data for the CONVERSE method. Comments are made below with respect to only those input numbers where past experience with the method has shown the existence of interpretational difficulties.

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TABLE 1. INPUT DATA FOR CONVERSE MODEL, SRI LANKA

Input No. 1. Parameters

Number of methods	5
Years of projection period	10
Initial year	1971
Code for changes in method over time	2
Code for presence of initial users	1
Code for absence of abortion	0
Programme name	Sri Lanka

Input No. 2. Methods[a]

Sterilization
Intra-uterine device
Pills
Injection
Condoms

Input No. 3. Overlap of use, in years, with post-partum amenorrhoea

Sterilization	0.167
Intra-uterine device	0.200
Pills	0.167
Injection	0.167
Condoms	0.175

Input No. 4. Proportion of acceptors who initiate use of method

	Age group					
	15-19	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*
Sterilization	0.979	0.977	0.971	0.963	0.952	0.935
Intra-uterine device	0.890	0.890	0.890	0.890	0.890	0.890
Pills	0.560	0.560	0.560	0.560	0.560	0.560
Injection	0.810	0.810	0.810	0.810	0.810	0.810
Condoms	0.560	0.560	0.560	0.560	0.560	0.560

Input No. 5. Annual rate of discontinuation

	Age group					
	15-19	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*
Sterilization	0.080	0.080	0.080	0.080	0.080	0.080
Intra-uterine device	0.100	0.100	0.100	0.100	0.100	0.100
Pills	0.200	0.200	0.200	0.200	0.200	0.200
Injection	0.200	0.200	0.200	0.200	0.200	0.200
Condoms	0.200	0.200	0.200	0.200	0.200	0.200

Input No. 6. Proportion of acceptors by method each year

	Year									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Sterilization	8.79	13.48	21.11	33.56	30.62	34.57	24.05	23.75	33.14	60.72
Intra-uterine device	23.21	26.18	28.70	23.59	25.60	26.26	26.92	24.94	18.77	10.34
Pills	52.36	45.46	35.66	28.55	29.48	24.87	34.73	33.69	28.27	15.75
Injection	00.00	00.00	00.00	00.00	00.00	00.00	00.00	3.29	5.52	5.22
Condoms	15.64	18.88	14.53	14.30	14.30	14.30	14.30	14.30	14.30	7.97

Input No. 7. Marital fertility rates[b]

Age group	*Year 1*	*Year 11*
15-19	0.383	0.383
20-24	0.404	0.404
25-29	0.318	0.318
30-34	0.233	0.233
35-39	0.148	0.148
40-44	0.046	0.046

Input No. 8. Proportions married

Age group	*Year 1*	*Year 11*
15-19	0.104	0.102
20-24	0.459	0.438
25-29	0.734	0.682
30-34	0.858	0.811
35-39	0.889	0.857
40-44	0.869	0.858

Input No. 9 Proportions sterile[c]

Age group	
15-19	0.005
20-24	0.020
25-29	0.025
30-34	0.035
35-39	0.100
40-44	0.200

Input No. 10. Mortality schedule and age structure

Mortality—empirical : 2
Population size—real : 2

Input No. 11. Age-specific death rates

Age group	*Death rate*	*Age group*	*Death rate*	*Age group*	*Death rate*
0-1	0.0449	25-29	0.0024	55-59	0.0099
1-4	0.0060	30-34	0.0025	60-64	0.0153
5-9	0.0017	35-39	0.0032	65-69	0.0263
10-14	0.0010	40-44	0.0034	70-74	0.0471
15-19	0.0014	45-49	0.0047	75-79	0.0680
20-24	0.0018	50-54	0.0063	80-84	0.1263

Input No. 12. Age distribution of females

Age group	Percentage distribution of females	Age group	Percentage distribution of females
0-4	13.3	45-49	4.1
5-9	13.4	50-54	3.1
10-14	12.8	55-59	2.6
15-19	10.9	60-64	1.9
20-24	10.2	65-69	1.3
25-29	7.7	70-74	1.0
30-34	5.7	75-79	1.0
35-39	5.8	80+	1.8
40-44	4.4		

Total female population in initial year: 6,158,536
Crude death rate for females in initial year: 7.7
Sex ratio at birth: 1.05

Input No. 13. OPTS table printing option

	Table No.																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
OPTS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Input No. 14. Year 1 age distribution of acceptors, by method

	Age group					
Method	15-19	20-24	25-29	30-34	35-39	40-44
Sterilization	0.00	9.06	31.99	32.36	21.00	5.59
Intra-uterine device	5.22	35.83	31.78	16.34	8.36	2.47
Pills	4.89	33.72	33.70	17.42	8.17	2.10
Injection	4.84	35.74	33.10	17.06	7.49	1.77
Condoms	4.89	33.72	33.70	17.42	8.17	2.10

Input No. 15. Total annual acceptors aged 15-44

Year	Total acceptors
1	49 323
2	71 044
3	95 931
4	125 847
5	127 933
6	102 934
7	79 218
8	92 445
9	107 533
10	185 981

Input No. 17. Number of initial users, 1971[d]

Sterilization	3 500
Intra-uterine device	44 687
Pills	21 888
Injection	000
Condoms	6 321
TOTAL	76 396

Input No. 18. Proportion of married women of each age group using all methods combined

Age group	Proportion
15-19	0.0440
20-24	0.0796
25-29	0.0739
30-34	0.0506
35-39	0.0231
40-44	0.0091

Source: Devendra (1985), pp. 206-209.

[a] Subsequent input variables involving method must maintain the order of methods prescribed in input No. 2.

[b] Year 11 rates incorporate changes from year 1 for reasons other than contraceptive use: a change in duration of breast-feeding is one such possible reason. The effect of contraception on age-specific fertility rates is achieved by the CONVERSE model itself.

[c] It is advisable to utilize survey findings for this parameter, not estimates of natural secondary sterility.

[d] It is advisable to perform a consistency test between input Nos. 17 and 18.

Input No. 1

The maximum number of contraceptive methods allowed is six. The methods should appear on input No. 2.

The period of projection can be either five or 10 years.

A code is provided to make allowance for changes in contraceptive methods over time: code 1 for no change; code 2 for change.

Initial users

Allowance is made for the presence of users at the beginning of the evaluation period: code 0 for no initial users; code 1 for initial users. These initial users may or may not be programme users. If they are not, the births averted by these users should not be considered prevented by the programme. The output tables provide separate estimates for the births averted by initial users.

Abortion

An attempt is made to take abortions into account: if there are no abortions, code 0; if there are abortions, code 1. In the latter case, data on abortions should be included wherever data on contraception are required in the inputs. Although they do not prevent conception, abortions are treated by the programme as a contraceptive method, but with complete discontinuation during the second month so that women are users only during the calendar year the abortion is performed.

Input No. 2

Input No. 2 provides for a maximum of six birth regulation methods. They do not have to be necessarily the same methods as those given in table 1.

Input No. 3

Overlap of use, input No. 3, may vary, especially with the type of delivery system. In a post-partum programme, overlap would, of course, be maximized. Data on overlap of use are not readily obtained, and in the absence of available data appropriate to the country under study, the estimates from the illustration could be used.

Input Nos. 4 and 5

Input Nos. 4 and 5 pertain to the decay formula:[2]

$$R_t = ae^{-rt}$$

where R_t = retention rate at time t;

a = proportion of acceptors not immediately discontinuing (input No. 4);

e = natural logarithm;

r = annual rate of discontinuation (input No. 5);

t = unit of time (months or years).

If these data are not already available, they can be readily estimated from continuation surveys by the CONVERSE program, which includes two subroutines, CONTINUE and CONTINUE 2. All that is needed are proportions of users in a cohort of acceptors at successive regular time intervals (every six months or every 12 months) for at least two points in time. The first subroutine is to be used when proportions of a cohort of acceptors who are using the contraceptive method are available for only two points in time since acceptance; the second is to be used when three or more such observations are available. A distinction should be made for first-method and multi-method use, if possible. If no data are available, standard rates taken from the input table provided in *Manual IX* could be used (United Nations, 1979, p. 52).

Input No. 6

Input No. 6 provides the proportions of acceptors by method for each year of programme evaluation. The total number of acceptors is given in input No. 16.

Input No. 7

Marital age-specific fertility rates in year 1 (first year of evaluation) are the observed rates at the beginning of the evaluation period. The input pertaining to year 11 (in the case of a 10-year projection) or to year 6 (in the case of a five-year projection) is expected to be the same as in year 1, unless the rates are assumed to have changed for reasons other than voluntary contraceptive use, such as lactation or abstinence practice. It would be erroneous to state for year 11 the expected marital fertility at the end of the evaluation period since the point of the exercise is to produce as an output the marital fertility rates with the programme in operation.

Input No. 10

For input No. 10, mortality, the model life table is code 1; and empirical data are code 2. For population size and distribution, stable population is code 1; real population is code 2.

Input No. 13

For printing tables, use code 1 in input No. 13. When not printing tables, use code 0.

Input Nos. 14-18

Input Nos. 14-18 are straightforward and do not require comments.

Two consistency tests are recommended. First, input Nos. 17 and 18[3] should be tested for consistency with each other. An illustration of such a test is given below in table 2.

Column (3) in table 2 is derived from the total female population and the data from column (2), both obtained from input No. 12. Column (4), taken from input No. 8, and the corresponding figures by age group in column (3) yield the estimates of column (5) which, multiplied by the proportions in column (6) (taken from input No. 18), provide the number of initial users by age group given in column (7). The total of column (7) should be very close to the total shown in input No. 17. If the discrepancy is more than 2 or 3 per cent, the figure should be checked and corrected.

Secondly, a consistency test should be performed with input Nos. 7, 8 and 12 to ascertain the consistency and the order of magnitude of the implied crude birth rate in year 1. The crude birth rate, as estimated from the input data for year 1, should then be compared with the observed crude birth rate for the same calendar year. A simple test is illustrated in table 3. The procedure is as follows: the marital fertility rates are obtained from input No. 7; the number of married women is obtained as shown in the preceding consistency test (see table 2, column (5)); the number of births is obtained as the product of the number of married women by age group and the age-specific fertility rates; the crude birth rate is

TABLE 2. CONVERSE: CONSISTENCY TEST FOR INITIAL USERS IN YEAR 1, ILLUSTRATION WITH SRI LANKA DATA

Age group *(1)*	*Percentage distribution of females* *(2)*	*Number of women in age group* *(3) = Total × (2)*	*Proportion of married women* *(4)*	*Number of married women* *(5) = (3) × (4)*	*Proportion of initial users among married women* *(6)*	*Number of initial users among married women* *(7) = (5) × (6)*
15-19	10.9	671 280	10.4	69 813	4.40	3 072
20-24	10.2	628 171	45.9	288 330	7.96	22 951
25-29	7.7	474 207	73.4	348 068	7.39	25 722
30-34	5.7	351 037	85.8	301 190	5.06	15 240
35-39	5.8	357 195	88.9	317 546	2.31	7 335
40-44	4.4	270 976	86.9	235 478	0.91	2 143
45-49	4.1	252 500	..	..	.	..
TOTAL	-	6 158 536	-	1 560 425	-	76 463

Number of initial users = 76 396
Total of column (7) = 76 463

Sources: For column (2), table 1, input No. 12; for column (3) total, table 1, input No. 12; for column (4), table 1, input No. 8; for column (6), table 1, input No. 18; for total initial users, table 1, input No. 17.

TABLE 3. CONVERSE: CONSISTENCY TEST FOR CRUDE BIRTH RATE IN YEAR 1, ILLUSTRATION WITH SRI LANKA DATA

Age group *(1)*	*Number of married women* *(2)*	*Marital age-specific fertility rate (per 1,000)* *(3)*	*Number of births* *(4) = (2) × (3)*
15-19	69 813	383	26 738
20-24	288 330	404	116 485
25-29	348 068	318	110 686
30-34	301 190	233	70 177
35-39	317 546	148	46 997
40-44	235 478	046	10 832
TOTAL	1 560 425		381 915

Total female population reported 6 158 536
Total male population (sex ratio, 1.05) 6 466 463
Total population 12 624 999
Crude birth rate (estimated) = 381 915/12 624 999 = 30.25 per 1 000

Sources: For column (2), table 2, column (5); for column (3), table 1, input No. 7; for total female population and sex ratio, table 1, input No. 12.

computed as the ratio of the number of births to the total population; the total population is obtained from input No. 12, total female population and sex ratio.

C. PATH ANALYSIS

The presentation of the multivariate areal analysis in *Manual IX* describes the basic principles and underlying assumptions of path analysis, including the nature and purpose of the path diagram and the "basic theorem of path analysis" for decomposing the correlation coefficients into direct and indirect effects (Hermalin, 1979, pp. 102-103).

The purpose of this additional section on path analysis is to describe how the direct and indirect effects of the independent variables on the dependent variables are derived from the basic theorem and how the total effect is computed as a sum of these direct and indirect effects. These notes thus represent a complementary exposition of the methodology previously described and do not constitute an updating of path analysis research.

1. *Path analysis decomposition of effects*

A structural regression equation provides only measures of the direct effects of specified independent variables on dependent variables. Path analysis,[4] by expanding the causal model, has the ability under specific assumptions to provide estimates of both direct and indirect effects of the explanatory factors on the dependent variable, assuming that the direction of the influences has been determined through a theoretical model.

The regression coefficients p, called path coefficients, are similar to beta coefficients β (standardized regression coefficient):

$$\beta_{ij} = p_{ij}$$

where i identifies the dependent variable and j the direct effect of a given independent variable.

2. *Decomposition of the measure of association* r

Path analysis yields a decomposition of the total association between two variables. The total association is estimated by the linear correlation coefficient between the relevant variables. The direct effect describes the effect of one variable on another when its influence is exercised without any intermediate variables; the indirect effect describes the effect of one variable on another when the influence passes through an intermediate variable. The total effect is the sum of the direct and indirect effects (Kendall and O'Muircheartaigh, 1977, pp. 10 and 16), although the total effect may but does not necessarily equal the total association. This is so because there are also portions of the total association due to common causes (often called "spurious effects") and unanalysed correlations. In other words, while the total effect consists of the sum of direct plus indirect effects, the total association consists of the total effect plus other components of association.

The relationship between the coefficient of correlation (i.e., the total association) and its path coefficient components is expressed by the "basic theorem of path analysis" (Hermalin, 1979, p. 103):

$$r_{ij} = \sum_q p_{iq} r_{jq} \tag{1}$$

where r is the correlation coefficient;

p is the path coefficient;

i and j denote a dependent and an independent variable, respectively;

q denotes successively all variables from which a path leads to the dependent variable.

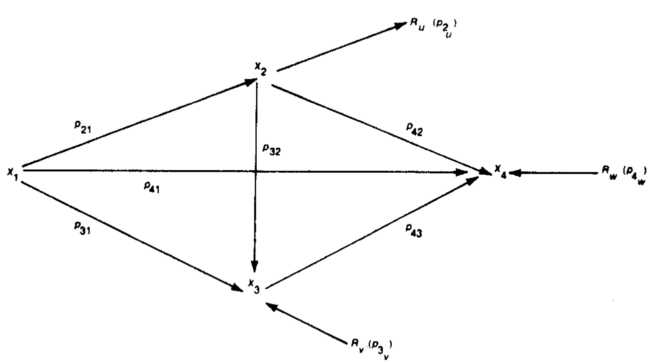
A hypothetical model is presented (for illustrative purpose) in figure II.

The variables are defined as follows:

X_1 = social structure;
X_2 = family planning facilities;
X_3 = family planning personnel;
X_4 = new programme acceptors.

The R terms represent the residuals that account for all unmeasured variables that may cause variations in the dependent (endogenous) variables, and p_{2u}, p_{4w} and p_{3v} are the corresponding path coefficients which measure the effect of these residuals.

Figure II. Hypothetical four-variable path analysis diagram



Source: Derived from Kendall and O'Muircheartaigh (1977), p. 13.

A recursive system of equations represents the model as follows:[5]

$$X_2 = p_{21}X_1 + p_{2u}R_u; \tag{2}$$
$$X_3 = p_{31}X_1 + p_{32}X_2 + p_{3v}R_v; \tag{3}$$
$$X_4 = p_{41}X_1 + p_{42}X_2 + p_{43}X_3 + p_{4w}R_w. \tag{4}$$

Applying the path analysis theorem of equation (1), the following decompositions are obtained:

(*a*) For association between X_1 and X_2,

$$r_{21} = p_{21}r_{11},$$
$$r_{21} = p_{21} \tag{5}$$

The total association (correlation coefficient) between variables X_1 and X_2 equals exactly the path coefficient between X_1 and X_2. The direct effect is here a total effect equivalent to the total association;

(*b*) For association between X_1 and X_3,

$$r_{31} = p_{31}r_{11} + p_{32}r_{12}. \tag{6}$$

But since $$r_{12} = p_{21}, \tag{7}$$

one has $$r_{31} = p_{31} + p_{32}p_{21}. \tag{8}$$

The total association between variable X_1 and X_3 results from p_{31}, which is the direct influence of X_1 on X_3 and from $p_{32}p_{21}$, the indirect influence of X_1 on X_3 through X_2. The indirect plus the direct effect equals the total effect, which also equals the total association. The numerical value of $p_{32}p_{21}$ is obtained from the product of p_{32} and p_{21};

(*c*) For association between X_3 and X_2,

$$r_{32} = p_{31}r_{21} + p_{32}r_{22}; \tag{9}$$
$$r_{32} = p_{32} + p_{31}p_{21}. \tag{10}$$

The total association between variables X_2 and X_3 is accounted for only by the direct effect of X_2 on X_3 (first right-hand side term of equation (10)) since, as can be seen from the model, no path leads indirectly from X_2 to X_3. The second term on the right-hand side of the equation reflects the common dependence of X_3 and X_2 upon X_1 and does not actually represent an "effect" of X_2 on X_3;

(*d*) For association between X_4 and X_1,

$$r_{41} = p_{41}r_{11} + p_{42}r_{12} + p_{43}r_{13}; \tag{11}$$
$$r_{41} = p_{41} + p_{42}p_{21} + p_{43}(p_{31} + p_{32}p_{21}); \tag{12}$$
$$r_{41} = p_{41} + p_{42}p_{21} + p_{43}p_{31} + p_{43}p_{32}p_{21}. \tag{13}$$

The effect of variable X_1 on X_4 is described as resulting from the direct effect of X_1 on X_4 (first term of equation (13)), plus the indirect effect of X_1 on X_4 through X_2 (second term), plus the indirect effect of X_1 on X_4 through X_3 (third term), plus the indirect effect of X_1 on X_4 through both X_2 and X_3 (fourth term). The sum of these terms equals the total effect as well as the total correlation so that the total association as given by r_{41} is accounted for;

(*e*) For association between X_4 and X_2,

$$r_{42} = p_{41}r_{21} + p_{42}r_{22} + p_{43}r_{23}; \tag{14}$$
$$r_{42} = p_{41}p_{21} + p_{42} + p_{43}(p_{31}p_{21} + p_{32}); \tag{15}$$
$$r_{42} = p_{42} + p_{43}p_{32} + p_{41}p_{21} + p_{43}p_{31}p_{21}. \tag{16}$$

The total effect of variable X_2 on X_4 results from the direct effect of X_2 on X_4 (first term of equation (16)), plus the indirect effect of X_2 on X_4 through X_3 (second term). The third and fourth terms account for the influences originated in X_1 (as shown by the subscripts) and do not describe effects originating in X_2. The total effect is thus constituted by the sum of the first two right-hand side terms only;

(*f*) For the association between X_4 and X_3,

$$r_{43} = p_{41}r_{31} + p_{42}r_{32} + p_{43}r_{33}; \tag{17}$$
$$r_{43} = p_{41}(p_{31} + p_{32}p_{21}) + p_{42}(p_{32} + p_{31}p_{21}) + p_{43}; \tag{18}$$
$$r_{43} = p_{43} + p_{41}p_{31} + p_{41}p_{32}p_{21} + p_{42}p_{32} + p_{42}p_{31}p_{21}. \tag{19}$$

The role of variable X_3 on X_4 is described by the direct path only (first term of equation (19)) because no other path leads from X_3 to X_4. The other four terms describe the role of other variables whose influences are reflected in the correlation coefficient between X_3 and X_4. The direct effect p_{43} constitutes here the total effect, although not accounting for the total association, because of the common dependence of X_3 and X_4 upon X_1 and X_2. The effects of variables X_1, X_2 and X_3 on X_4 are summarized in table 4.

An alternative to this decomposition approach is based on the systematic use of reduced-form equations. Beginning first with equations containing only predetermined (exogenous) variables and then adding successive intermediate variables in sequence from cause to effect, it is possible to generate directly all the information needed to decompose the total effect of a variable into its direct and indirect effects. The reduced equations yield

TABLE 4. PATH ANALYSIS RESULTS

Effects	X_1 *on* X_2	X_1 *on* X_3	X_2 *on* X_3	X_1 *on* X_4	X_2 *on* X_4	X_3 *on* X_4
Total association ...	r_{21}	r_{31}	r_{32}	r_{41}	r_{42}	r_{43}
Total effect	p_{21}	$p_{31}+p_{32}\,p_{21}$	p_{32}	$p_{41}+p_{42}p_{21}+p_{43}p_{31}+p_{43}p_{32}p_{21}$	$p_{42}+p_{43}p_{32}$	p_{43}
Direct effect	p_{21}	p_{31}	p_{32}	p_{41}	p_{42}	p_{43}
Indirect effects	None	$p_{32}p_{21}$	None	$p_{42}p_{21}+p_{43}p_{31}+p_{43}p_{32}p_{21}$	$p_{43}p_{32}$	None

Source: Equations (5)-(19).

the various estimates of effect directly and as such may be less cumbersome than the structural equation approach which requires many additional steps. This method applies to both standardized and unstandardized variables and provides an exact accounting of effects if all standard structural equation assumptions are met and provided the model is fully recursive (Alwin and Hauser, 1975).

3. *Estimation of path coefficients* p

Since the path coefficients, p, are similar to regression coefficients in standard form, the easiest means of estimating their value is to undertake regressions by the ordinary least-squares method for each equation in the model. If all assumptions are met, the standardized regression coefficients obtained are the same as the path coefficients included in the model. The residual path coefficients, which account for the unobserved and omitted variables, are estimated as follows:

$$p_{2u} = \sqrt{1-R_2^2} \tag{20}$$

where p_{2u} is the path coefficient of the residual term R_u, and R_2^2 is the coefficient of determination of the equation that has X_2 as dependent variable.

The estimating procedure through the ordinary least-squares technique is straightforward if the model is fully recursive.[6] If path analysis is adopted for the selection of the most important program input variables, it is recommended that the analysis be started with a fully recursive model; statistical tests can be applied to assess the significance of the coefficients. If certain coefficients appear non-significant and if conditions warrant a credible significance test, the corresponding variables may be eliminated from the model.[7]

According to one source, testing the significance of path coefficients raises a particular issue, namely, that the F-test has a built-in bias against the measurement of direct effect. In other words, if two models are compared and tested, the model where a given relationship is described with a direct effect only might show a non-significant path coefficient for that relationship whereas if the same relationship were described with the pertinent intermediate variable, the corresponding path coefficients would appear significant, at the same level of significance (Kim and Kohout, 1975, p. 393).

4. *Problems in path analysis*

The question whether standardized coefficients β_{ij} (or p_{ij} for path coefficients) or unstandardized coefficients b_{ij} (path regression coefficients) should be computed raises a number of problems.

Two types of regression coefficients can be computed from multiple regressions, namely, the unstandardized regression coefficient, b, and the standardized regression coefficient, β; and they are both measures of direct effects. The first quantifies the change taking place in the dependent variable for one unit of change in the independent variable, all other variables being held constant. The second quantifies the change taking place in the dependent variable in standard deviation units for one standard deviation change in one independent variable, all other variables being held constant. They are related as follows:

Standardized coefficient (beta)

$$\beta_{ij} = b_{ij}\frac{\sigma_j}{\sigma_i} = \text{path coefficient } (p)$$

where b, p and β are defined as above, and where σ_i and σ_j are the standard deviations of the dependent and the independent variables, respectively (Hermalin, 1975, pp. 287-288; Kim and Mueller, 1976, p. 424; Hargens, 1976).

It has been recommended that the standardized coefficient should be utilized when the "actual amount of impact" of an independent variable, is to be measured, whereas the unstandardized coefficient may be "more appropriate for describing causal structures" (Hermalin, 1975, p. 288; see also Blalock, 1967; Kim and Mueller, 1976, p. 436). Theoretically, standardized coefficients are different because they express differences in the effect of the variables. If drawn from samples with different variances, however, they may be different because of differences in variance, even if their actual unstandardized effect is similar (Schoenberg, 1972, pp. 4-5; Duncan, 1975, p. 51). There is, however, an absence of consensus on the appropriate use of each type of coefficient.[8] In practice, the choice of the type of regression coefficient depends upon the type of information sought. With the unstandardized regression coefficient, each variable is expressed in different units. This coefficient therefore has the advantage of providing the amount of change in unit values, which is much more straightforward than changes expressed in standard deviation units.[9] On the other hand, the standardized regression coefficient, precisely because it is standardized, is assumed to yield comparable weights of the effects of the various independent variables and, as such, makes it possible at least theoretically to observe the comparative importance of different variables. For the purpose of selecting the most important variables, the standardized coefficients appear to be more appropriate. In order to assess the particular effect of a given input factor, unstandardized coefficients may be preferred.[10]

The treatment of qualitative variables, not examined here, may require some attention;[11] and the use of models that assume unobserved variables may also prove useful for assessing programme impact.[12]

Notes

[1] This is the case notably when crude birth rates are obtained from vital statistics and censuses, and age-specific rates are drawn from sample surveys.

[2] For input Nos. 4 and 5, see more extensive discussions, with illustrations, in Nortman (1970, pp. 133-137; and 1979, p. 56).

[3] Input Nos. 17 and 18 are required only if "initial users" in input No. 1 had code 1.

[4] Description of the procedure can be found notably in Duncan (1966), Land (1969), Hermalin (1975), and Kendall and O'Muircheartaigh (1977). All these references provide appropriate bibliographical sources.

[5] The regression coefficient, *b*, is replaced by the path coefficient, *p*; and the constant term disappears since it is assumed that the variables are standardized.

[6] An equation system is recursive if all "causal" relations run one way and no variables are reciprocally related and if the error term in each equation is uncorrelated with the error term in any other equation.

[7] Discarding a path coefficient is a crucial step. A small sample may lead to deletion of an important relationship; too large a sample may lead to retention of a coefficient that is not too significant. It may be helpful if in cases of rather large samples, a criterion of minimum effect is set on the basis of the particular relationships studied. See Land (1969, p. 35).

[8] For Hargens (1976, p. 250), for example, "that fact that the standardized coefficient is likely to have different values across populations...is not a sufficient reason for prohibiting the use of standardized coefficients in cross-population comparisons". In so far as family planning programme variables are policy variables, the use of "betcoefficients" has been proposed by Cain and Watts (1970, p. 238). See also Aigner (1970), who gives a critical appraisal of this indicator.

[9] For instance, the effect of the family planning programme enrolment on fertility as measured by an unstandardized coefficient of 0.09 means that each woman enrolled in the programme corresponds to a ferility decline of 0.09 or, in other words, a decline of 90 births per 1,000 women enrolled.

[10] See, for example, Wright (1960), Duncan (1966) Blalock (1967, pp. 675-676); Hermalin (1975, pp. 287-288); Hotchkiss (1976); and Kim and Kohout (1975, pp. 394-397).

[11] See, for instance, Boyle (1970).

[12] For more details, see, notably, Hermalin (1975, pp. 290-291), wherein a hypothetical model is presented for studying family planning programme impact using unmeasured variables and multiple indicators. See also Blalock (1963), Hauser and Goldberger (1971); Werts, Jöreskog and Linn (1973), and Alwin and Tessler (1974).

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