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EFFECTIVENESS OF FAMILY PLANNING IN TAIWAN:

A Methodology for Program Evaluation

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EFFECTIVENESS OF FAMILY PLANNING IN TAIWAN:
A Methodology for Program Evaluation

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I. INTRODUCTION

Throughout the world, money and organizational talent are increasingly being applied to the task of reducing human fertility. To evaluate programs in this field, two questions must be answered: (1) For a given level of effort, which of the many alternative programs appears preferable? (2) What level of effort is in fact warranted? This paper proposes a method for answering the first question. A satisfactory answer to the first question, also, provides the necessary framework for rigorous consideration of the second. The approach followed here is to develop a predictive model of human fertility,

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This paper is a progress report related to research being undertaken for the United States Agency for International Development, Department of State, Contract csd-2151. Data analyzed here are from a variety of published Taiwan sources: The Taiwan Population Census of 1956; The Taiwan Demographic Fact Books, published by the Department of Civil Affairs; The Demographic Reference: Taiwan, published by the Taiwan Population Studies Center. Consolidated cost estimates for the Taiwan Program are taken from the preliminary report of Warren C. Robinson, "Some Tentative Results of a Cost-Effectiveness Study of Selected National Planning Programs," a paper presented at the Annual Meetings of the Population Association of America, April 1969. Many other persons helped in the collection and processing of the data considered here; in particular, I appreciate the contribution of Miss Jane Yu Ho and David Weinschrott. The author remains responsible for errors and inaccuracies embodied in this paper.

from which one may statistically infer from cross-sectional associations the effectiveness of family planning programs to reduce birth rates. Although the method for program evaluation advanced here has many weaknesses, not least of which is its voluminous data requirements, it nevertheless avoids many pitfalls and arbitrary assumptions implicit in other evaluation schemes that mar their reliability and reduce their value for the general design of policy.

Programs that distribute welfare services freely to the public are difficult to evaluate, first, because program outputs are not typically subject to comprehensive monetary appraisal or market valuation, and second, because there is some uncertainty as to how exactly program input costs combine to produce desired program outputs. This paper deals with the second subject, i.e., how program inputs are related to program outputs and objectives, but does not address the enormous and important problem of assigning a social value to the program's objectives.[1] The next section discusses briefly what these objectives are, and in this context shows why many methods of evaluating these programs are unsatisfactory since they rely on imperfect proxies for program output.

II. POPULATION PROGRAM OBJECTIVES AND THEIR EVALUATION

What are the objectives or the general criteria by which the success or failure of a population program is judged? An avowed objective of family planning efforts is to provide parents with the knowledge and means to control their own births.[2] If this were the only program objective, evidence on the prevalence of birth control knowledge in the population before and after a program is launched might suffice to judge the program's success given its cost. But this sphere of knowledge and behavior is personally sensitive, and even when carefully probed by a skilled interviewer, the responses elicited on this subject may not be unbiased. Moreover, the justification for an information and subsidized service campaign in family planning also rests on the presumption that many people want the services, and are sufficiently motivated to use these services to enhance their well-being once they are made publicly accessible.

Alternatively, program evaluation may be based on records of services dispensed for a given cost. The attraction of this approach is that it demands information about the number and character of persons accepting family planning guidance, supplies and services--data which are readily generated within the program itself. However, the ease and speed of program evaluation by this route, though useful as a first approximation, eventually entails the formulation of complex models which are sensitive to the assumed values of various population parameters, e.g., the extent to which people substitute one contraceptive method for another. Since little is generally known or can be inferred about the "true"

values of these particular parameters, evaluation based on an analysis of services rendered is subject to an unacceptably wide margin of error.[3] For example, the motivation and understanding of the acceptor of contraceptives may influence the degree of success he has with them. This problem of estimating contraceptive effectiveness is reduced considerably with the Inter-Uterine Contraceptive Device (IUD), which does not need much attention. But it remains a serious problem for evaluating the worth of other birth control methods and their diffusion outside of program channels. Follow-up surveys among IUD acceptors yields information on the frequency over time of expulsion, removal and pregnancy for various devices and populations. With this information it is now possible to estimate satisfactorily the months of pregnancy protection obtained, on average, by each IUD insertion [18].

But what would have happened to the women helped by the program if there has been no program? Would those who accepted an IUD in the program have had one inserted by a private physician, or used a somewhat less satisfactory method of birth control, or resorted to abortion if their efforts to avert a conception had failed, or continued to have children at the rate experienced before the program? The relation between program inputs and months of protection from pregnancy obtained is being refined rapidly. But we do not know what difference the various degrees of pregnancy protection will make in terms of the birth rate.[4] The effect on birth rates of deliverying a particular quantity of services will depend crucially on the extent to which family planning programs

upgrade contraceptive practices, substituting more reliable and more convenient methods of birth control for less satisfactory ones.[5] This is the gist of the evaluation problem. How much difference does the program make in the effectiveness of birth control practiced by the population.

The only way I know of to avoid these thorny problems is to examine birth rates, and judge the program's effectiveness in terms of its independent influence on actual birth rates. Reduction of birth rates is thus judged to be the best (and ultimate) criteria by which to evaluate a family planning program. There are, nevertheless, two possibly important benefits of a family planning program that are neglected here in order to use this simplified definition of program objectives. First, as observed earlier, a family planning program may assist parents in switching from one to another means of birth control, leaving birth rates more or less unchanged. For example, before a family planning program, people may resort to a coitus interruptus, continence, marital dissolution, frigidity and induced abortion to avert unwanted births, whereas a program provides them with modern techniques of birth control such as the IUD, pill (oral steriod), condom and vaginal preparations. The program objective, narrowly defined, may not have been advanced in this case, yet clearly there have been some private and social gains. This benefit is neglected here.

Second, parents may benefit from a program by learning of new methods of birth control without necessarily putting them to use immediately. Since family planning is largely avoiding unwanted births after having achieved the number of children desired (not spacing births), young parents upon learning about the availability of new reliable means of birth control may not seek to reduce their current birth rate. On the

contrary, young parents may seek to concentrate their child rearing in their younger years, as is common in many industrial countries, because they now know how reliably to avoid having additional pregnancies later in their lives. Although a family planning program could contribute to reducing the completed fertility of today's younger woman, improved contraceptive knowledge might also facilitate a shortening of low-parity birth intervals, contributing to a short-run increase in birth rates for this cohort. Without the time to construct and analyze longitudinal data to evaluate the program's "true" long-run impact on completed cohort fertility, cross-sectional reproductive behavior of women of different ages should be carefully distinguished. Evidence of different short-run program effects on different age cohorts should, therefore, be interpreted cautiously, for birth rate changes among younger women may be a result of offsetting changes in the length of birth intervals and the total number of children these women will bear.[6]

Despite these weaknesses, the demonstrated capacity of a family planning program to reduce birth rates appears to be the most satisfactory single criteria of success. But a simple objective does not make evaluation simple. Only by statistical inference can the relationship between program inputs and birth rates be established. Today we have no schemes or formulae that are capable of translating confidently a change in contraceptive supplies or knowledge into an estimate of the number of births averted by this change. The problem of evaluation reduces to one of discovering how to infer from existing data what fertility would probably have been in the absence of the family planning program. The difference between this inferred and the actual birth rates is the estimated effectiveness of the program. The next section develops a

model of fertility and family planning that permits us later to estimate for Taiwan the effectiveness of the family planning program inputs in reducing birth rates.

III. FACTORS INFLUENCING THE BIRTH RATE: A PREDICTIVE MODEL

The birth rate may be a matter of national concern, but it is the result of private behavior. A population policy will be successful or not depending on the extent to which it influences the number of children parents have. The basis of effective policy design and evaluation therefore requires an understanding of the determinants of fertility.

Much study has been addressed to the determinants and concomitants of the decline of fertility in developed countries, as more attention is being given to fertility in less developed countries. The large differences in fertility between developed and less developed countries has often been attributed to the practice of birth control in the former and its absence in the latter. But the conspicuous variation in fertility within and among less developed countries is difficult to explain unless "natural fertility" is affected by demographic, social, and economic, as well as biological, factors. One approach to understanding differences in fertility is to begin, as Dr. Chow has suggested, with the preferences of parents for children and seek the determinants of birth rates among the objective characteristics of their environment and resources that could influence their opportunities and goals.[7] Empirical analyses of differential fertility in Puerto Rico, Colombia, and Egypt based on this working hypothesis show significant statistical associations between regional fertility and the following features of the parents' environment which were thought likely to modify the number of births parents would want [22, 24].

Schooling and Child Labor

Schooling for children imposes opportunity costs on parents. Even i children do not work outside of the home, they provide help in the home tending younger children and performing routine chores, and this help is reduced when they attend school. School attendance also adds as a rule to direct household outlays for better clothes, school materials, transportation and support away from home. Overall, parents' decision and opportunity to send their children to school increases child costs and may be a strong determinant underlying the reduction in their family size goal.[8] For quite different reasons the schooling of parents may also set the stage for a decline in desired family size. Yet to educate children would appear to exert an immediate effect on birth rates, whereas to educate parents requires a much longer time to effect a change in birth rates.

School facilities at the primary and secondary level provide a conflicting demand on the time of children, depressing child labor force participation. Parents are thus compelled to bear the opportunity costs of their children's schooling rather than make use of their unpaid productive services in family employment. This important change in the role of children in the family reduces parents' incentives for large families and stimulates their investment in the children's education and acquisition of skills needed in the modern sectors of developing countries.

Employment of Women

A significant part of the costs of bearing and rearing children is

the value of a mother's time spent attending to her children's needs. When her most productive activities are easily combined with child rearing in the home, the opportunity cost of her time spent caring for them is small and a large family is to this extent no great inconvenience. However, the household activities traditionally performed by women such as weaving, processing family food, caring for livestock, and handicraft cottage manufacturing tend to be displaced gradually in the development process by modern food processing, textile and manufacturing sectors, and their value depreciated by the growing commercial specialization in agricultural production itself. As development proceeds, the woman finds her most renumerative employment opportunities are increasingly outside of the home and even outside of the rural-agricultural sector of the economy [11]. These employment opportunities are increasingly difficult to combine with child rearing. In this more specialized economic environment, a large family extracts from parents an opportunity cost for the mother's time which may foster their acceptance of a smaller family size goal and more concentrated child bearing. One, therefore, expects to find in an environment where women can earn more income (per unit time), higher female participation rates and lower birth rates.[9]

Uncertainty, Child Mortality and Birth Control

Recent developments have also changed the environment in which parents reach their reproductive goals. Three basic sources of uncertainty enter into the process of family formation: (1) death may take the lives of some children; (2) parents may not be able to bear the number (and sex distribution) of children they want; and (3)

parents may bear more children than they want.

It is reasonable to assume that parents first frame their reproductive goals in terms of the attractions of having a certain number of their offspring (or sons) survive. If this is the case, parents try to compensate for the incidence of death among their children by trying to have the number of births that will give them the desired number of surviving children. Uncertainty surrounding the family formation process of births, deaths, and remarriage may also play a subtle and complementary role in the decisionmaking process. For example, all forms of investment in one's children's skills become more attractive as the chances for the children to survive improve. There may be a reinforcing relationship here between the decline in child mortality and the increased demand of parents for their children's schooling, which in turn increases the cost of child rearing, and constrains the number of additional children the parents can afford.

Historical evidence suggests that for birth rates to fall, the chances for child survival must first improve for an extended period. The unanswered question is how long a lag will separate the recent decline in death rates occurring in the low-income regions of the world from the onset of the decline in birth rates.

To some degree, advances in reproductive biology and improved health and medical care have undoubtedly reduced the prevalence of sterility or subfecundity, the second source of uncertainty in the family formation process. But the most important change has taken place in the technology of birth control which has greatly affected the third source of uncertainty.

The costs of birth control are much more than the outlays and inconvenience associated with using a method; they also consist of the task of first acquiring and evaluating information about alternative methods. This task may represent an insurmountable obstacle to the natural diffusion of new techniques in a low-income, poorly-educated country. Where the range of alternative birth control methods is limited to traditional ones, relatively large costs are incurred to achieve a high degree of reliability, as in the extreme cases of continence and induced abortion. For the individual living in a "traditional" community, it may be very costly for him to search independently for a more reliable and more convenient (modern) method of birth control, whereas for a society as a whole, informational costs are perhaps more modest per capita because of economies of scale in disseminating information through community health and family planning programs. When contraceptive supplies are once wanted, accessible and understood, their price may still exert a modest influence on their adoption and use, and therefore, public subsidies may to this extent increase their rate of dissemination and use.

Implications of this Model for Policy Choices

From the preceding discussion it appears reasonable to view policy to reduce the rate of population growth as involving two basic elements the distribution of birth control information and services to lessen the number of "unwanted" births, and the promotion of specified changes in man's environment to reduce the number of births he wants. This dichotomy between wanted and unwanted births is in a sense arbitrary, for they are both jointly determined by the costs and inconvenience

associated with avoiding an "unwanted" birth. Nevertheless, the distinction is useful in that the moral, social and economic issues involved in policy that seeks to influence birth rates by the provision of birth control information and services is unambiguously advantageous from a personal welfare viewpoint.[10] But policies that operate directly or indirectly on desired family size require a more complex rationale that marshalls evidence of social diseconomies associated with population growth in a particular setting. Almost certainly, family planning programs influence, to some extent, desired family size through their propaganda and extensive field work, but for the purposes of this study I assume (as shown in Fig. 1) that in Taiwan the program reduces birth rates solely by averting unwanted births through making more reliable and convenient methods of birth control available to all persons regardless of their social or economic advantages.

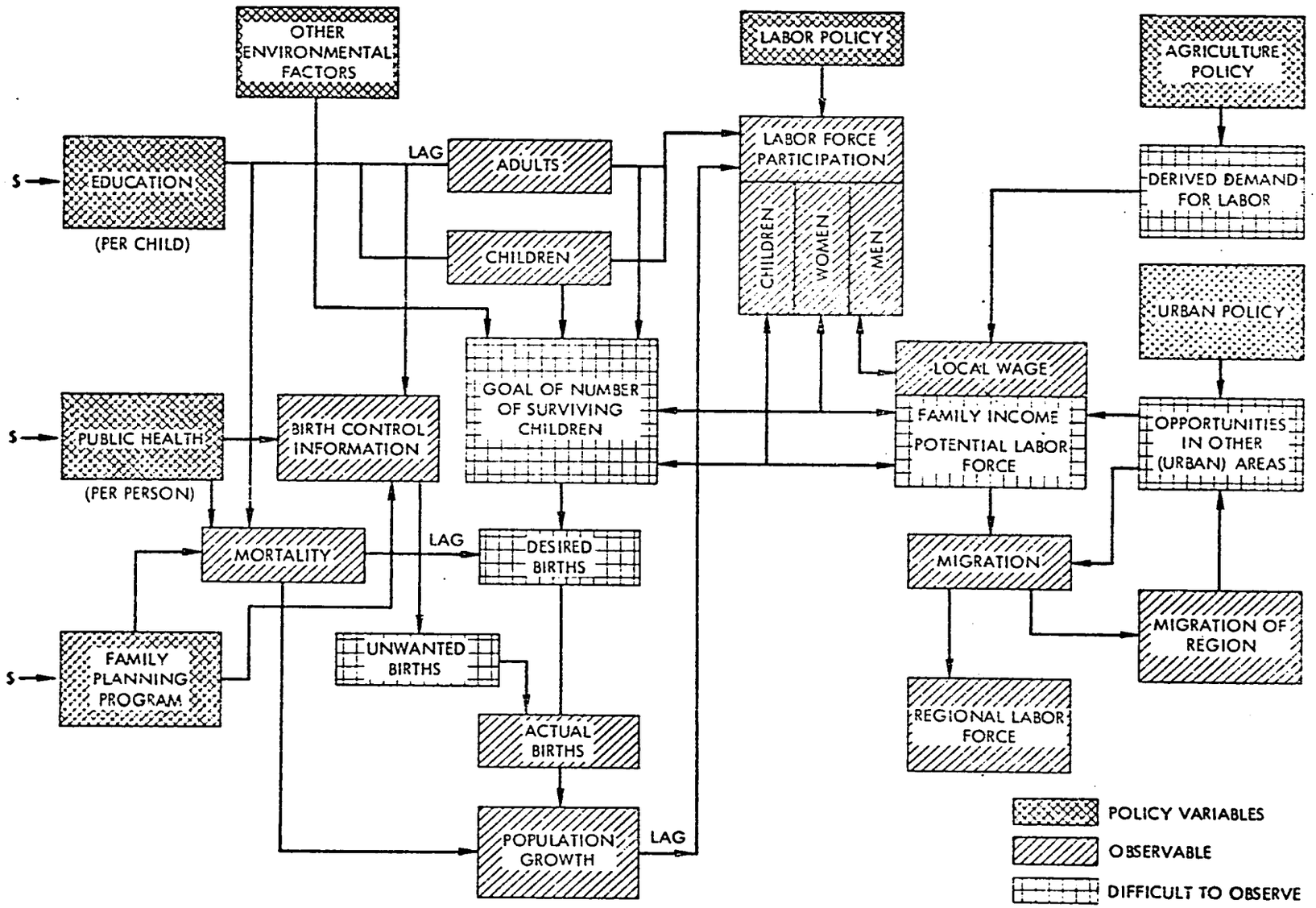

Fig. 1—A possible scheme of interaction among demographic and economic regional variables

IV. MODEL DESIGN

The problem is how to assemble available information on recent occurrences in Taiwan to permit us to infer the independent effect of the family planning program on birth rates. A variety of decisions parents make have a simultaneous bearing on their present and future lives together and desired fertility pattern, but these simultaneous decisionmaking relations are neglected here to simplify this preliminary analysis.[11] Only one relation is analyzed, that between the birth rate and (1) the environmental determinants of the number of surviving children parents want, (2) the child death rate, and (3) the inputs to the family planning program that presumably reduce unwanted births. Assumptions are needed about the nature of this relationship to make inferences from any analysis of these data.[12] First the appropriate functional form of the overall statistical model is discussed, and then the time dimensions of the relations it embodies are examined.

A. FUNCTIONAL SPECIFICATION

In mathematical notation, the relationship we want to characterize is

$$B = f(D)g(X,Y.Z,\ldots)p(M) \qquad (1)$$

where B represents the birth rate, f(D) is a function of the child death rate, g(X,Y,Z,...) is a function of environmental factors, X,Y,Z,... that determines the number of surviving children parents want, and p(M) a function that relates family planning program inputs to the number of averted (unwanted) births.[13] The first function,

that of the child death rate, can be given explicit form if it is assumed that parents adjust systematically for death rates to obtain a particular surviving family size. In this case the death variable enters multiplicatively into the model as 1/S, the inverse of the child survival rate.[14]

$$B = (1/S)^{\alpha}\, g(X,Y,Z,\ldots)p(M) \qquad (2)$$

If parents compensated precisely for the change in child death rates to obtain a constant number of children surviving to a particular age, regardless of the expected incidence of child death, then $\alpha = 1$ in Eq. (2). If $\alpha > 1$, birth rates would diminish as death rates declined by more than enough to hold constant the surviving number of children, and in this case surviving family size would fall. This might occur if parents adjusted not only to the decline in the expected incidence of death, but also reacted plausibly to both the associated reduction in the uncertainty surrounding the child rearing process and to the associated increase in the rate of return to investing in one's children's schooling and vocational skills. Were $\alpha < 1$, and other factors did not change, the number of children reaching maturity would increase as child death rates decline.

Having experimented with various function forms for g and p, I have shown elsewhere the empirical results are relatively insensitive to which of these differing specifications is adopted for the estimating equation [23]. If all variables interact multiplicatively to determine birth rates, or in other words, that the elasticity of each independent variable with respect to the birth rate is constant, the

estimation equation (3) may be conveniently estimated in logarithmic-linear form.

$$B = (1/S)^{\alpha} K X^{\beta_1} Y^{\beta_2} Z^{\beta_3} M^{\beta_4} u \qquad (3)$$

where α and $\beta_i (i=1,\ldots,4)$ are parameters of the model, K is an estimated scale factor, and u a properly behaved lognormal disturbance term.[15]

Because environmental variables, X,Y,Z,..., that enter g are often measured as average characteristics for the communities observed, e.g., schooling rates, proportion in agriculture, the functional form of g may plausibly be linear and additive. If family planning programs work largely to avert unwanted births rather than to change the number of births desired, the production function of family planning services, p, should be independent of the child death rate and the parents desired size of family. These conjectures suggests an estimating equation of the form,

$$B = (1/S)^{\alpha} (C + \beta_1 X + \beta_2 Y + \beta_3 Z) + p(M_1, M_2, \ldots) + v \qquad (4)$$

Where C represents the number of surviving children desired by parents when X,Y,Z, and M_i $(i = 1,\ldots,n)$ are simultaneously zero, and v is a normally distributed random disturbance of zero mean and constant variance. How inputs into the family planning program, M_i, influence the number of unwanted births parents avert raises further issues.

There is little relevant empirical evidence, as yet, on which to base our specification of how program inputs actually have affected birth rates, but some general propositions are plausible.[16] Activities for which at least one input is fixed, in this case the population

demanding family planning services, are likely to experience initially increasing and later decreasing returns to scale -- in other words, additional equal increments of inputs per potential recipient of family planning services will initially contribute to a reduction of an increasing number of births, but eventually as the scale of the program expands beyond a certain point, the same increments to program inputs will contribute to a reduction in a decreasing number of births.[17] For illustrative purposes such a relationship between program scale and marginal effectiveness is shown in Fig. 2a, and is translated into the more familiar average and marginal cost curves for the program's output shown in Fig. 2b. In this hypothetical example, the marginal cost of averting 26 unwanted births per year per 1000 women between the ages of 15 and 49 is about 500 units of effort. But doubling the program effort raises the marginal cost per birth averted about two fold. This expansion only averts an additional 11 births. If society could assign a marginal social value (inclusive of private gains) to averting an unwanted birth, the family planning program may be justifiably expanded until the marginal social cost of averting an additional birth equals this marginal social benefit. One might imagine someday a situation where everyone practiced perfectly reliable birth control and there were no unwanted births. In this utopian case, additional family planning efforts would have no effect on birth rates, and hence no value.

Considering Eq. (3) and (4), we first estimate a linear approximation for the relationship between program inputs and births averted, and then a third degree polynomial is fitted to the input variables to distinguish

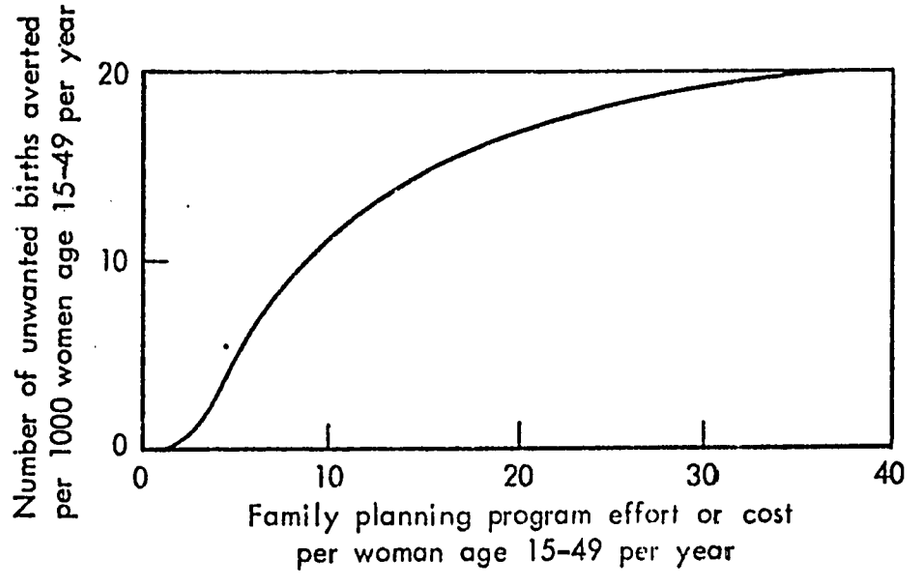
Number of unwanted births averted per 1000 women age 15-49 per year
20
10
0
0
10
20
30
40
Family planning program effort or cost per woman age 15-49 per year

Fig. 2a

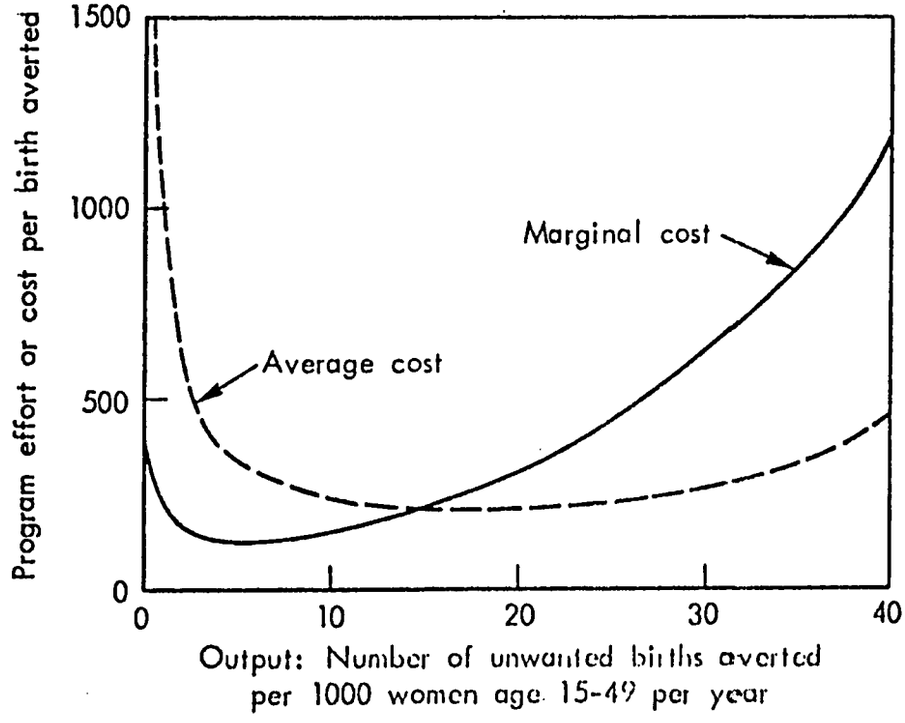
Program effort or cost per birth averted
1500
1000
500
0
Marginal cost
Average cost
0
10
20
30
40
Output: Number of unwanted births averted per 1000 women age 15-49 per year

Fig. 2b

whether there is statistical evidence of changes in the returns to scale as argued above. In both the linear and the cubic production functions for family planning services, estimates should be interpreted with caution and only over the mid-range of the observed levels of program activity.

Thus far we have discussed the approximate functional form in specifying the relationship between a single program input and the number of unwanted births averted. Where feasible the relative effectiveness of a variety of different program inputs should be considered. It is possible that when more than one input exists, the productivity of any one may not be independent of the mix of others currently employed. It is assumed in Eq. (3) that the elasticity of substitution between all pairs of inputs is equal to one, and in Eq. (4) it is equal to zero.

B. TEMPORAL AND VARIABLE SPECIFICATION

Children represent a long-term irreversible commitment, and they tend to play a central role in the organization of their parent's lives. Thus parents are likely to decide on the number of children they want and their timing of births simultaneously with a number of other decisions bearing on their present and future lives. We are concerned here only with the relation between birth rates and parents' environment including local family planning efforts.

Because anticipations about the future are often not fulfilled, and it takes an uncertain amount of time to have a child, and they die unpredictably, lags and adjustments of a biological and behavioral nature interpose themselves between the observed environment characterized

in our model and the observed birth rate which our model seeks to predict. Most environmental conditions that modify parents' preferences for children change slowly, at least at the regional level considered here. But death rates, on the other hand, are subject to substantial year-to-year variation and cannot be predicted accurately for a small community, to say nothing of the family unit. Deaths may result, therefore, in a short-run reaction to replace losses. Our model implies a mechanism by which the death of a child to a still fertile mother may influence her to have a somewhat higher birth rate than she would otherwise have had. Although the death of a child may motivate its mother to seek additional offspring, the effect on her reproductive behavior is difficult to distinguish in the short run if she is young, for her age cohort will probably continue having additional children for some time at about the maximal rate, regardless of the incidence of child mortality. If on the other hand, the mother is older, say in her late 30s, and a sizable proportion of her cohort intends to avoid further births, her behavioral response to the child's death, that of seeking another birth, will distinguish her sharply from others in her cohort within a relatively short time.[18] Though it is not possible from published data to trace the frequency of child death to mothers of a specific age, it is possible in each region of Taiwan to estimate the age specific death rate for children for several years prior to observed birth rates and examine the strength of the statistical association for evidence on the length of this behavioral-biological lag [22, 24].

Experimentation with various discrete lags for Taiwan is constrained to the few years for which the appropriate data are collected

and published.[19] The association between regional child death rates and subsequent 1966 age-standardized birth rates is statistically strongest and very significant after three years, although the two-year lag is also strong, and indeed marginally more powerful than the three-year lag in accounting for interregional variation in the birth rate among young women between the ages of 20 and 29.[20] A three-year lag between death and subsequent 1964 birth rates is also found to be highly significant. These quantitative findings are generally consistent with other direct evidence on the mean length of closed birth intervals for women not practicing contraception [7, 16, 27].

With this evidence of a two- or three-year behavioral-biological lag in the determination of birth rates, it is appropriate to lag other environmental and program input variables by the same number of years. Family planning program inputs, however, represent a still more complex problem. Not only should these inputs be lagged by two or three years, but also since the program is likely to have a persisting effect on contraceptive knowledge in the community, which only slowly "depreciates" as people forget and new generations grow up, all past values of program inputs should be introduced with some scheme of diminishing weights.[21] Time series of data are today too short to explore empirically the time dimension of program input effectiveness. A satisfactory approximation in the short run is to ignore the depreciation effect and simply consider the total stock of past program inputs as the relevant determinant of current knowledge in the locality.[22] At the simpler level, empirical confirmation is again evident for the two or three year lag; the negative association

between birth rates in 1966 and family planning program inputs for 1965 is weak, but much stronger for program input data for 1964.

Because the remaining environmental characteristics change gradually and are observed less frequently, variables derived from them are lagged as nearly to three years as data sources permit. Data limitations for Taiwan seriously constrain refinement in the specification of this environmental dimension of our model.[23]

V. THE PREDICTIVE MODEL: EMPIRICAL FINDINGS

This section summarizes a statistical analysis of interregional variation in birth rates in Taiwan, with the objective of isolating and quantifying the effectiveness of the family planning program to reduce birth rates. First the environmental model designed to predict birth rates in the absence of the program is examined for birth rates in 1964 and 1966. Then the simple and more complex variants of the model are estimated for 1966 and 1967 birth rates.

The Taiwan system of household registrations provides a rich and reliable source of certain types of demographic and economic data which have been compiled and published in the last few years for 361 administrative units of Taiwan -- precincts, townships and hsiangs.[24] From these data it is possible to estimate school attendance for children, educational attainment for adults and also derive the occupational attachment of men.[25] The earlier discussion of the family planning hypothesis identified several features of the local environment that may influence the number of surviving children parents might want. The effect of the educational process is measured in two ways: school attendance among children, and educational attainment of adults.[26] Agricultural activity of men is analyzed both as a proxy for the traditional rural-urban dichotomy and as a reflection of parent's opportunity to utilize the productive labors of their children within family enterprises. Regrettably, no direct and reliable measure of child labor force participation or that of women and their opportunity wage is currently available by region in Taiwan.

As fertility secularly declines, it is common for the relative decline in birth rates to older women to exceed the decline to younger women, as is evidenced for Taiwan in Table 1. The proportion married in Taiwan has fallen of late for women aged 15 to 19, but has not changed appreciably since 1959 for older women, though for older cohorts the slow secular trend has been toward an increasing proportion married due to the decline in adult mortality. The postponement or early consummation of marriage is one form of family planning, and may, like others, adapt to environmental opportunities and constraints, such as a change in child mortality or an increase in returns to, and opportunities for, extended education. Consequently, our model is designed to predict age specific birth rates and not age specific birth rates of married women. The extent to which the model accounts for regional differences in birth rates to women 15 to 19, two instruments of family planning are likely to be in operation: birth control within marriage, and postponement of marriage itself. More generally, however, the model has greatest relevance to the age specific reproductive behavior of women over the age of 30, for whom birth control is likely to become increasingly common as demographic transition progresses.

Estimates of the association implied by the family planning model between birth rates in 1964 and 1966 and appropriately lagged environmental variables are shown in Tables 2 and 3. This formulation of the model accounts for 23 percent of the interregional relative variation in the age standardized birth rate in 1964 and 57 percent in 1966.[27]

Table 1

PERCENTAGE DECLINE IN TAIWAN BIRTH RATES FROM 1955 TO 1967

Age of Women	Birth Rate per 1000 Women
15-19	-24
20-24	- 9
25-29	-13
30-34	-47
35-39	-68
40-44	-73
45-49	-84
Total Fertility Rate[a]	-33
Crude Birth Rate	-38

Note:

[a]Sum of age specific fertility rates times five, that is the number of years in each cohort.

Source: 1955 birth rates from Demographic Reference Taiwan, Republic of China, 1966, Vol. VI, and 1967 birth rates from tabulations prepared by the Taiwan Population Studies Center to be published by the Department of Civil Affairs in the Taiwan Demographic Fact Book 1967.

Table 2

REGRESSIONS ON REGISTERED FERTILITY IN ADMINISTRATIVE REGIONS OF TAIWAN, 1964[a]
(In parentheses beneath regression coefficients are their t statistics, or the ratios of the coefficients to their standard errors)

Regression Number	Dependent Variable	Constant Term	Percent of Children Age 12 to 19 in School 1961	Percent of Adults with Primary School Certificate 1961[c]	Percent of Male Labor Force in Agriculture 1965	Reciprocal of Child Survival probability 1961[d]	R^2
1	Birth Rate Normalized for Age and Sex Composition[b]	112	-.100 (-4.2)**	-.005 (-.12)	.017 (1.75)	1.218 (5.74)**	225
	Age Specific Birth Rate per 1000 Women of age:						
2	15-19	1.246	-.094 (-1.08)	.273 (1.76)	-.086 (-2.37)*	4.050 (5.16)**	.107
3	20-24	2.418	-.056 (-1.85)	.025 (.47)	.008 (.60)	.953 (3.47)**	.074
4	25-29	2.689	-.047 (-2.05)*	-.070 (-1.70)	.023 (2.36)*	-.186 (-.89)	.055
5	30-34	2.545	-.144 (4.82)**	-.027 (-.51)	.017 (1.39)	1.238 (4.50)**	.202
6	35-39	2.441	-.224 (-5.01)**	-.109 (-1.37)	.052 (2.80)*	2.801 (6.96)**	.310
7	40-44	1.931	-.256 (-4.29)**	-.028 (-.27)	.077 (3.10)*	3.351 (6.22)**	.271

Table 2 continued.

*Coefficient significantly different from zero at 1% level of confidence.

**Coefficient significantly different from zero at .1% level of confidence.

NOTES:

[a]All variables expressed as logarithms (to base 10). Sample size is 361.

[b]Actual Crude Birth Rate divided by Normalized Crude Birth Rate derived by attributing the national age specific birth rates to the seven age cohorts of women in each region. Deviations from one (or zero in the log form), therefore represent deviations in local crude birth rate from that expected nationally from the regions age/sex population composition.

[c]Adults considered to be all persons over the age of 12, and out of school.

[d]This variable is defined as the reciprocal of one minus the summed death rates for children from birth to age 15 in the region. Thus if d_i is the frequency of death per person age i in a region, the death variable for that region is defined as

$$(1-(\sum_{i=1}^{15} d_i)).$$

Table 3

REGRESSION ON ADJUSTED REGISTERED FERTILITY IN ADMINISTRATIVE REGIONS OF TAIWAN, 1966[a]
(In parentheses beneath regression coefficients are their t statistics, or the ratios of the coefficients to their standard errors)

Regression Number	Dependent Variable	Constant Term	Percent of Children Age 12 to 19 in school 1965	Percent of Adults with Primary School Certificate 1965[c]	Percent of Male Labor Force in Agriculture 1965	Reciprocal of Child Survival Probability 1963[d]	R^2
1	Birth Rate Normalized for Age and Sex Composition[b]	.371	-.185 (-10.3)**	-.075 (-2.18)*	.013 (2.06)*	1.928 (12.46)**	.566
	Age Specific Birth Rate per 1000 Women of age:						
2	15-19	1.756	-.198 (-2.31)*	.035 (.22)	-.054 (-1.73)	5.709 (7.71)**	.211
3	20-24	2.765	-.111 (-4.07)**	-.131 (-2.52)*	.021 (2.14)*	1.130 (4.81)**	.185
4	25-29	2.725	-.109 (-6.08)**	-.048 (-1.41)	.029 (4.46)**	.246 (1.58)	.216
5	30-34	2.695	-.211 (-6.61)**	-.087 (-1.44)	.009 (.76)	2.169 (7.89)**	.338
6	35-39	2.722	-.406 (-7.61)**	-.140 (-1.37)	.027 (1.36)	3.579 (7.74)**	.372
7	40-44	2.349	-.455 (-5.82)**	-.181 (-1.21)	.087 (3.05)*	4.458 (6.58)**	.312

See Notes to Table 2.

For the age specific birth rates from age 30 to 44 the model accounts for 20 to 38 percent of the variation, but for the age 20 to 29 cohort only 6 to 22 percent of the variance can be understood in terms of these environmental variables. These over-all findings are consistent with our expectation that the model pertains primarily to the older age cohorts when birth control is practiced more widely.[28]

As observed in other studies of this type, the child death factor and child school attendance rates are the most powerful explanatory variables in the model [22, 24]. The association in both years betwee birth rates and the child death factor lagged three years is positive and statistically significant at the .1 percent confidence level, except for women in 1964 between the ages 25 and 29. As indicated earlier the reproductive behavior of this group is not as likely to be influenced as strongly by the determinants of the family planning model and particularly death rates. The coefficient estimated for the child death factor, α, in the age-standardized birth rate equation in both years exceeds unity (i.e., 1.2 [$\pm$ .2] in 1964 and 1.9 [$\pm$ .2] in 1966), which implies that a lower regional child death rate is associated significantly with a reduction in the number of children parents in that region are likely to have surviving to the age of 15. The longer the period since the beginning of the decline in child death rates the larger we expect the value of α to be, if it is estimated from cross-sectional data.

Educational opportunities are also associated with lower birth rates. The association is more consistent and statistically significant for child school attendance rates than for adult primary

education rates. The relationship between child schooling and the birth rate is stronger among women over 30, but by 1966 even among the younger women this association is emerging strongly. Adult education plays no noticeable role in 1964, according to these findings, but appears to be statistically more significant among women 20 to 24 in 1966. This may be an indication that better educated women are beginning to space their births or practice birth control even during their 20s.

The proportion of the active population in agriculture is frequently linked to differences in birth rates, and the reasoning is that small-scale agriculture permits parents to utilize, to a great extent, the productive contribution of children's time. Examining this relationship in Taiwan we find it weak. In 1964 it does not satisfy the traditional test for significance (at the 5 percent level) and in 1966 it hardly passes this test, revealing slightly higher age standardized birth rates in areas of heavy agricultural dependence.[29] More interesting than the over-all effect is the age-specific association. It appears there is a tendency in areas where agricultural activity predominates for birth rates to be lower for the 15-19 age cohort, and higher for some later ages. With the scarcity of land in Taiwan, it is not implausible that there would be a systematic tendency for marriage and child bearing to be delayed until land ownership or operation were within reach of the younger generation.[30]

VI. EVALUATING THE IMPACT OF THE FAMILY PLANNING PROGRAM

By 1966 the large-scale unofficial family planning program, pilot tested in 1963 and launched in 1964, may have begun to help parents avert unwanted births.[31] Initially the number of man-months of medical and non-medical personnel employed in a region's family planning program in 1964 or 1965 per 1000 women of childbearing age (15-49) is used as a measure of program inputs. Personnel inputs increased almost threefold from 1964 to 1965, and since the regional distribution of these inputs was not highly correlated the multiplicative model represented by Eq. (3) is first estimated with both years inputs separately distinguished.[32] The regression results reported in Table 4 confirm that program activity is significantly associated with lower regional birth rates than can be accounted for by our other environmental determinants of desired fertility. For the age-standardized birth rates, Regression 1 (Reg. 1) the 1965 program inputs (one-year lag) appear to have only one-third the effect on birth rates as do the 1964 program inputs (two-year lag); that is their regression coefficients are -.0103 and -.0336, respectively. The overall relationship including the family planning inputs accounts for 62 percent of the interregional variation in birth rates, whereas without considering these inputs we could account for only 57 percent of the variation. More important, the inclusion of family planning inputs has reduced the association between agricultural employment, adult schooling and birth rates and increased the estimated value of α, the coefficient for the child death factor, from 1.93 to 2.10.

Table 4

FERTILITY REGRESSIONS WITH 1964 AND 1965 FAMILY PLANNING INPUTS[a]

Dependent Variable: Birth Rate 1966	Constant Term	Percent of Children Age 12 to 19 in School 1965	Percent of Adults with Primary School Certificate[c] 1965	Percent of Male Labor Force in Agriculture 1965	Reciprocal of Child Survival Factor[d] 1963	Man Months of Effort in Family Planning Program[e] 1964	1965	R^2
1. Age standardized and normalized[b]	1.72 (11.0)	-.168 (-8.10)	-.0487 (-1.27)	.0049 (.65)	2.10 (10.9)	-.0336 (-4.68)	-.0103 (-1.49)	.618
2. Age 15-19	3.63 (5.52)	-.126 (-1.43)	.0740 (.46)	-.0605 (-1.91)	5.13 (6.34)	-.103 (-3.40)	-.0245 (.84)	.240
3. Age 20-24	6.27 (30.0)	-.0984 (-3.53)	-.125 (-2.44)	.0219 (2.17)	1.15 (4.47)	-.0283 (-2.93)	.0218 (2.30)	.205
4. Age 25-29	6.25 (44.7)	-.102 (-5.48)	-.0450 (-1.31)	.0287 (4.38)	.125 (.72)	-.0040 (-.60)	-.0066 (-1.07)	.222
5. Age 30-34	6.08 (25.5)	-.173 (5.44)	-.0712 (-1.22)	.0062 (.54)	1.49 (5.07)	-.0147 (-1.34)	-.0429 (-4.05)	.389
6. Age 35-39	5.92 (14.9)	-.326 (-6.15)	-.104 (-1.07)	.0235 (1.22)	2.45 (5.00)	-.0610 (-3.32)	-.0446 (-2.52)	.424
7. Age 40-44	4.81 (8.40)	-.317 (-4.16)	-.115 (-.81)	.0787 (2.85)	2.46 (3.49)	-.105 (-3.99)	-.0817 (-3.21)	.395
8. Age 45-49	1.55 (1.26)	.166 (1.00)	-.360 (-1.19)	-.0348 (-.59)	5.86 (3.85)	-.107 (-1.87)	.034 (.62)	.069

Notes:

[a]In parentheses beneath regression coefficients are their t statistics, of the ratio of the coefficient to their standard errors. All variables expressed as natural logarithms. Sample size is 361.

[b]Actual Births divided by Normalized Births derived by attributing the national age specific birth rates to the seven age cohorts of women in each region. Deviations from one (or zero in the log form), therefore

Table 4 continued:

represent deviations in local crude birth rate from that expected nationally from the regions age/sex population composition.

[c]Adults considered to be all persons over the age of 12, and out of school.

[d]This variable is defined as the reciprocal of one minus the summed death rates for children in the region from birth to age 15. Thus if d_i is the frequency of death per person age i in a region, the death variable for that region is defined as

$$1/(1-[\sum_{i=1}^{15} d_i])$$

[e]This represents the number of man months of village-health-education nurses (VHEN), prepregancy-health-workers (PPHW), and doctors (MD), allocated to each region in a particular year per 1000 women between the ages of 15 and 49 in that region. Since the equation is fitted in logarithmic form, and many regions received no manpower inputs in this initial year of the program, .1 man months per 1000 women in childbearing ages is arbitrarily added to the input for all regions; there being no logarithm for zero. The program input measured thus for the entire country increased from 1.47 in 1964 to 3.26 in 1965 and to 3.63 man months per 1000 women in 1966. The 1964 inputs should have an effect on birth rates in later years as well as 1966, and thus the effect estimated in this regression is <u>not</u> a long run estimate of the effect of the program inputs in this initial year.

Focusing only on 1964 program inputs (two-year lag) Table 5 presents regression estimates for the three components of the manpower employed in the family planning program.[33] This evidence suggests that the employment of a Village Health Education Nurse (VHEM) is associated with a somewhat greater reduction in birth rates than is the employment of a Pre-Pregnancy Health Worker (PPHW) or Doctor (MD), i.e., their coefficients are respectively -.0234, versus -.0192 and 0.0193. But doctors are not a close substitute for the other two types of field workers; hence, our analysis focuses on a comparison between the effectiveness of VHEN and PPHW for whom the training and employment costs are comparable.[34]

The impact of family planning activity is distinctively different among different age groups of women; overall the program inputs are most noticeably linked to lower birth rates among the very young (15-19) and older (30 or over) women (See Table 4). No strong association emerges (in the expected direction) between 1965 program inputs and birth rates among women less than 30, but beyond that age the 1965 inputs appear to have a significant impact. Initial program inputs in 1964 may have "skimmed off the cream" of those most in need of birth control at all ages, whereas the second year of the program penetrated to the women 30 to 34 who were only beginning to feel the need for birth control in 1964.

The apparent age-specific impact of the various types of personnel is more complex, and must be regarded at this stage in our analysis as tentative (Table 5). Among the young (15-19) the VHEN is more strongly associated with lower birth rates than is the PPHW (-.104 versus -.059), but among older women (30-39) the PPHW appears to be the

Table 5

FERTILITY REGRESSIONS WITH DISAGGREGATED 1964 FAMILY PLANNING INPUTS[a]

Dependent Variable: Birth Rate 1966	Constant Term	Percent of Children Age 12 to 19 in School 1965	Percent of Adults with Primary School Certificate[c] 1965	Percent of Male Labor Force in Agriculture 1965	Reciprocal of Child Survival Factor[d] 1963	Man Months of Effort in Family Planning[e] 1964			R^2
						VHEN (A)	PPHW (B)	MD (C)	
1. Age Standardized and Normalized[b]	.605 (4.39)	-.153 (-8.49)	-.0610 (-1.85)	.0139 (2.03)	1.70 (11.08)	-.0234 (-2.71)	-.0192 (-3.20)	-.0193 (-3.29)	.607
2. Age 15-19	3.38 (4.98)	-.118 (-1.33)	.0562 (.34)	-.0475 (-1.41)	5.06 (6.68)	-.104 (-2.44)	-.0588 (-1.98)	-.0339 (-1.17)	.240
3. Age 20-24	6.22 (28.6)	-.0898 (-3.14)	-.123 (-2.35)	.0192 (1.78)	1.04 (4.28)	-.0170 (-1.24)	.0011 (.11)	-.0157 (-1.70)	.195
4. Age 25-29	6.18 (43.0)	-.0944 (-5.09)	-.0362 (-1.05)	.0245 (3.51)	.198 (1.24)	.0034 (.38)	.0008 (.12)	-.0163 (-2.65)	.233
5. Age 30-34	5.99 (23.8)	-.184 (-5.56)	-.0756 (-1.25)	.0182 (.86)	1.93 (6.88)	-.0128 (-.81)	-.0303 (-2.75)	-.0140 (-1.31)	.361
6. Age 35-39	5.70 (13.8)	-.336 (-1.13)	-.112 (-1.13)	.0337 (1.64)	2.96 (6.42)	-.0442 (-1.71)	-.0724 (-4.01)	-.0349 (-1.98)	.420
7. Age 40-44	4.41 (7.31)	-.331 (-4.18)	-.129 (-.89)	.0931 (3.04)	3.50 (5.19)	-.0978 (-2.58)	-.0901 (-3.41)	-.0697 (-2.71)	.370
8. Age 45-49	1.18 (.94)	.179 (1.08)	-.418 (-1.38)	.0024 (.04)	5.50 (3.90)	-.238 (-3.01)	-.0601 (-1.09)	.0041 (.08)	.085

See Notes to Table 4.

more effective worker. Since the PPHW is trained in the family planning program to systematically contact and recruit mothers in their 30s with a recently recorded birth, whereas the VHEN is taught to disseminate the principles and practice of public heath, sanitation, hygiene, home economics and family planning to the entire village population, the observed pattern of differing age-specific effectiveness of these two types of program personnel is plausible.[35]

Without discarding the log-linear form of the model, the functio relating family planning program inputs to births averted can be varied to determine whether the constant elasticity assumption should be changed to a more sophisticated formulation. A third degree polynomial is fitted to the program inputs in Table 6. All three terms of the polynomial are statistically significant at the 5 percent leve for the age standardized regression, and in each of the age-specific regressions between age 35 and 44. These estimates imply program inputs are subject to diminishing returns to scale throughout the range of observed program activity. But, the negative sign on the third degree term suggests that returns to scale may begin to increase after a plateau is reached of approximately 4 to 5 man months of inputs per 1000 women aged 15 to 49 per year. Program inputs began to reach these levels in later years and analyses of 1967 and 1968 birth rates may be able to determine whether this turning point is a statis tical artifact of the first year's low level of activity or a persisting and significant characteristic of efficiency in the large-scale Taiwan program.

The second varient of the estimation equation represented by Eq. (4) presumes that program inputs affect birth rates only through

Table 6

FERTILITY REGRESSIONS WITH POLYNOMIAL ESTIMATES FOR FAMILY PLANNING PROGRAM INPUTS IN 1964[a]

	Constant Term	Percent of Children Age 12 to 19 in School 1965	Percent of Adults with Primary School Certificate[c] 1965	Percent of Male Labor Force in Agriculture 1965	Reciprocal of Child Survival Factor[d] 1963	Family Planning Program Total Manpower 1964[e]			R^2
						M	M^2	M^3	
Age Standardized Birth Rate 1966[b]	.762 (.12)	.160 (-.912)	-.0542 (-1.65)	.0094 (1.48)	1.70 (11.0)	-.0735 (-3.39)	.0193 (2.16)	-.0019 (-2.07)	.609
Age Specific Birth Rate									
15-19	3.80 (5.82)	-.128 (-1.47)	.0864 (.53)	-.0641 (-2.03)	5.09 (6.66)	-.2218 (-2.06)	.0627 (1.42)	-.0062 (1.36)	.237
20-24	6.32 (30.3)	-.0956 (-3.44)	-.120 (-2.31)	.0186 (1.84)	.993 (4.06)	-.0489 (-1.42)	.0150 (1.06)	-.0016 (-1.10)	.199
25-29	6.25 (44.9)	-.103 (-5.54)	-.0413 (-1.20)	.0277 (4.12)	.191 (1.18)	-.0137 (-.60)	.0025 (.27)	-.0003 (-.30)	.229
30-39	6.05 (15.2)	-.343 (-6.47)	-.0915 (-.92)	.0168 (.87)	3.00 (6.44)	-.194 (-2.96)	.053 (1.98)	-.0053 (-1.89)	.417
40-44	4.95 (8.83)	-.344 (-4.60)	-.0654 (-.47)	.0553 (2.03)	3.48 (5.30)	-.324 (-3.51)	.0998 (2.64)	-.0121 (-3.08)	.410
45-49	1.87 (.87)	.472 (1.65)	-.828 (-1.55)	-.114 (-1.09)	7.68 (3.05)	.0550 (.16)	-.0676 (-.46)	.0061 (.41)	.040

See notes to Table 4.

their reduction in the number of unwanted births, and that environmental determinants of the parents' desired surviving number of children have a linear effect. This form of model is no longer linear in its parameters, and non-linear estimates of the equation are sought to minimize the unexplained variation in the birth rate. The results for this preferred estimating equation are reported in Table 7.[36] When the number of averted births is assumed to be a linear function of personnel effort (Reg. 1, Table 7) the average program activity through 1965 is associated with a 4.8 percent reduction in age-standardized birth rates in 1966. The distribution of VHEN activity is more closely and strongly associated with the reduction in births in 1966 than is the distribution of PPHW activity. Estimating the production function as a third degree polynomial (Reg. 2), there is again evidence in each type of personnel class of diminishing returns to scale over the levels of activity frequently reported in 1964 and 1965, but in the case of the PPHW and the Doctors (MD) returns are lower than for VHEN, but diminish more slowly. The non-linear estimating equation has appreciably lowered the estimated value of α from the vicinity of 1.7 to 1.1, and restored a weak inverse association between adult education and the birth rate.

Estimates of the effectiveness of the family planning program were also prepared on the basis of a preliminary analysis of 1967 age-specific birth rates. The linear approximation for the relationship between program personnel and births averted performs poorly (Reg. 3, Table 7), except for doctors (MD) where their effectiveness is low but nearly constant (linear). The third degree polynomial

Table 7

REGRESSIONS ON AGE-STANDARDIZED BIRTH RATE (EQUATION 4)[a]

Regression Number and Year of Birth Rate	Determinants of Desired Birth Rate					Accumulated Family Planning Program Effort in Man Months to					
	Death Adjustment (3 Year Lag) α	Constant C	Child Schooling 1965 β_1	Adult Education 1965 β_2	Agricultural Labor Force 1965 β_3	1965 VHEN	1965 PPHW	1965 MD	1966 VHEN	1966 PPHW	1966 MD
1. 1966 (linear) $R^2 = .675$	1.30 (11.7)	1.38 (34.2)	-.00433 (-10.1)	-.00195 (-2.68)	-.000145 (-.50)	-.0663 (-3.66)	-.00563 (-1.48)	-.0218 (-5.16)			
2. 1966 (cubic) $R^2 = .691$	1.14 (10.0)	1.43 (34.0)	-.00408 (-9.45)	-.00226 (-3.12)	-.000104 (-.35)	-.169 (-2.02)	-.0537 (-3.30)	-.0225 (-2.79)			
					(squared)	.0391 (.28)	.0112 (2.27)	.00146 (1.25)			
					(cubed)	.0147 (.27)	-.000494 (-1.41)	-.0000370 (-1.05)			
3. 1967 (linear) $R^2 = .373$	1.11 (10.3)	1.23 (19.4)	-.00398 (-6.27)	.00100 (.88)	-.000708 (-1.65)				-.0141 (-.79)	-.00001 (-.03)	-.00888 (-4.18)
4. 1967 (cubic) $R^2 = .406$	.997 (9.17)	1.34 (20.2)	-.00334 (-5.25)	.00011 (.09)	-.000951 (-2.19)				-.1272 (-1.85)	-.0596 (-3.73)	-.0217 (-3.27)
								(squared)	.0608 (1.01)	.0106 (3.46)	.00101 (1.74)
								(cubed)	-.00772 (-.62)	-.000420 (-2.89)	-.0000147 (-1.36)

Note:

[a] Beneath each coefficient in parentheses is its "t" statistic or the ratio of the coefficient to its asymptotic standard error.

fit to the same data (Reg. 4, Table 7) reveals the strongly non-linear effectiveness of PPHW and VHEN as postulated in our analysis. All three types of personnel are again found to be subject to diminishing returns within observed ranges of program activity. The environmental determinants of desired birth rates continue to be associated with actual birth rates: The estimate of α falls toward unity, the association between adult education and low birth rates vanishes when program inputs are included in the regression, and the initial (1964) positive association between agriculture and fertility reverses sign and gains statistical significance in 1967 when program inputs are accounted for.[37]

To both extend our time series and consider another, more commonly used, indirect criteria of family planning program success - the rate of IUD acceptances in the population of married women - we consider the relationship between this measure of services delivered and program inputs and environmental characteristics of the population served. In addition to the personnel variables analyzed earlier, a dummy variable for Taichung is included; Taichung city was the focus of an intensive pilot family planning program in 1963 for which we do not have regional personnel records.[38]

Studies of a number of family planning programs have noted that acceptance rates for the IUD tend to be higher among better educated women than among less well educated women. Thus, a measure of educational attainment of the adult population is included in the predictive model for acceptance rates to distinguish the potential receptivity of the region's population.

Preliminary regression findings are reported in Table 8. As anticipated, the acceptor rate from 1963 to 1965 is strongly associated

Table 8

REGRESSIONS ON IUD ACCEPTOR RATES 1963 TO 1966

Dependent Variable: Acceptors as Percent of Married Women Age 20 to 44	Constant Term	Percent Adults with Primary School Certificate[c] 1965	Taichung Dummy (1963)	Family Planning Program Manpower in Man Months															R^2
				1964				1965				1966				1964-1966			
				Total	VHEN	FPHW	MD	Total	VHEN	FPHW	MD	Total	VHEN	FPHW	MD	VHEN	FPHW	MD	
1. 1963-1965	5.72 (6.22)	.0437 (2.13)	5.19 (4.11)	1.24 (6.88)				.032 (.34)											.272
2. 1963-1965	4.56 (5.13)	.0542 (2.80)	4.68 (3.88)		2.66 (4.01)	2.67 (9.45)	.322 (1.46)	.179 (1.94)											.356
3. 1963-1965	4.08 (4.64)	.0565 (2.98)	4.55 (3.86)		2.29 (3.51)	2.71 (9.51)	.829 (3.04)		2.91 (4.41)	.362 (3.09)	-.091 (-.67)								.391
4. 1963-1966	8.69 (6.32)	.0807 (2.74)	5.84 (1.79)													1.15 (2.50)	.892 (9.86)	.210 (4.15)	.282
5. 1966	4.44 (6.42)	.0263 (1.73)	-.886 (-.96)	.145 (1.09)				-.0145 (-.13)				.367 (3.89)							.148
6. 1966	3.98 (6.22)	.0289 (2.07)	-.811 (-.96)	.387 (3.09)				-.285 (2.59)					.523 (1.47)	1.30 (9.10)	.288 (3.21)				.282

with the number of persons employed locally during that period in the family planning program. The education and Taichung variables are also associated with higher acceptor rates. Substantially greater predictive power is obtained when the personnel variable is disaggregated. The regression coefficients for VHEN and PPHW personnel are approximately equal for 1964 alone (i.e., 2.66 and 2.67 in Reg. 3), but for 1965 the VHEN coefficient is eight times larger than that for the PPHW (Reg. 3). This suggests that the increased number of PPHW employed in the program in 1965 is not associated with a commensurate increase in acceptances.[39] Doctors in 1964 are associated with acceptor rates, but this association vanishes in 1965. Turning to acceptor rates only in 1966, for a hint as to what the future holds as the program expands, the picture reverses, and the current PPHW employment variable is more strongly associated with acceptor rates than is that of VHEN employment (Reg. 6). This reversal in the relationship between PPHW employment in 1965 and 1966 may suggest the fully-staffed program by 1966 was performing its function more effectively than in 1965, when anomalous results were found both in our analysis of birth rates and acceptor rates.

Table C-4

REGRESSIONS ON IUD ACCEPTOR RATES 1963 TO 1966

Dependent Variable: Acceptors as Percent of Married Women Age 20 to 44	Constant Term	Percent Adults with Primary School Certificate[c] 1965	Taichung Dummy (1963)	Family Planning Program Manpower in Man Months															R^2
				1964				1965				1966				1964-1966			
				Total	VHEN	PPHW	MD	Total	VHEN	PPHW	M	Total	VHEN	PPHW	MD	VHEN	PPHW	MD	
1. 1963-1965	5.72 (6.22)	.0437 (2.13)	5.19 (4.11)	1.24 (6.88)				.032 (.34)											.272
2. 1963-1965	4.56 (5.13)	.0542 (2.80)	4.68 (3.88)		2.66 (4.01)	2.67 (9.45)	.322 (1.46)	.179 (1.94)											.356
3. 1963-1965	4.08 (4.64)	.0565 (2.98)	4.55 (3.86)		2.29 (3.51)	2.71 (9.51)	.829 (3.04)		2.91 (4.41)	.362 (3.09)	-.091 (-.67)								.391
4. 1963-1966	8.69 (6.32)	.0807 (2.74)	5.84 (1.79)													1.15 (2.50)	.892 (9.86)	.210 (4.15)	.282
5. 1966	4.44 (6.42)	.0263 (1.73)	-.886 (-.96)	.145 (1.09)				-.0145 (-.13)				.367 (3.89)							.148
6. 1966	3.98 (6.22)	.0289 (2.07)	-.811 (-.96)	.387 (3.09)				-.285 (2.59)					.523 (1.47)	1.30 (9.10)	.288 (3.21)				.282

Table 9

SERVICE, MANPOWER AND EXPENDITURES OF TAIWAN

FAMILY PLANNING PROGRAM: 1963-1968

	1963	1964	1965	1966	1967	1968 (Jan-June)
Service (persons)[a]						
Loop Acceptors	3,650[b]	46,600	99,253	111,242	121,053	58,620
Pill Acceptors	0.	0.	0.	0.	27,552	17,878
Sterilizations	0.	0.	0.	656	573[c]	n.a.
Manpower (months effort)[d]						
Village Health Education Nurse	n.a.	387	296	382	300	93
Pre Pregnancy Health Workers	n.a.	1,094	2,542	2,565	3,275	1,868
Doctors	n.a.	2,308	5,879	7,379	7,872	4,144
Supervisors	n.a.	0.	192	204	264	138
Expenditures (thousand of $NT)[e]						
Training	n.a.	380	1,025	827	460	57
Supplies and Equipment	n.a.	191	663	766	957	425
Salaries	n.a.	327	6,006	6,883	9,097	5,747
Field Expenses	n.a.	507	2,345	2,851	1,390	1,303
Total Direct	n.a.	1,405	10,039	11,327	11,904	7,532
Total Indirect	n.a.	5,415	7,994	7,374	7,212	3,705
Total Expenditures	n.a.	6,820	18,033	18,701	19,116	11,237

Notes for Table

[a]Service statistics refer to new acceptors of loops (intrauterine devices), pills (oral steriods) or sterilization operations (both men and women) serviced through the Taiwan family planning program. Joint Monthly Report, Family Planning and Population Studies Program, May and June 1968, Series P-7 (68-3).

[b]Cases from pilot program in Taichung before December 1963.

[c]Reported for January through April 1967. Demographic Reference: Taiwan, Republic of China, Vol. VIII, July 1968, Table 31, p. 454-455.

[d]Manpower statistics refer to the number of man months of effort employed in the family planning program. Same source of data as in Note (a). Village Health Education Nurses employed jointly by Rural Health-Community Development Authorities and Family Planning Program. Pre-Pregnancy Health Workers employed only by program, as are Supervisors. Doctors are paid for insertion and other services performed, and thus it is not clear whether they should be considered as full-time employees of the program.

[e]All expenditure statistics are from Warren C. Robinson, "Some Tentative Results of a Cost-Effectiveness Study of Selected National Planning Programs." A paper to be presented at the Annual Meetings of the Population Association of America, April 1969.

n.a. = not available or nil.

estimated that a couple-year-of-protection provided by the Taiwan program costs about 60 to 80 NT$ [19]. There is little evidence from these service personnel and expenditure data that the unit cost of an IUD insertion or field worker has increased appreciably or steadily as the program has grown in overall size, and thus from program service statistics alone there is no reason to believe that the program has met with diminishing returns to scale.

To proceed with a program evaluation, unit costs must be converted into estimates of the number of births averted by the program. Pioneering work done by R. G. Potter based on the characteristics of the IUD acceptor population and their retention rates led to estimates that the insertion of one IUD would (in its first segment) contribute to averting between .4 and .9 births [18]. But these estimates depended on a substitution factor which could not be estimated, only guessed. More recently a matching study [4] has provided data on the longitudinal fertility behavior of a group of women within and outside of the program, matched by various demographic characteristics. The results of the matching study suggest that the fertility of the control group has also been falling, and thus the independent effect attributed to the program is less than anticipated. The preliminary estimate of the matching study is that 10 insertions are needed to avert a single additional birth. The matching study also reveals that the births averted due to a program insertion (first-segment) though less than Potter estimated for the first three years, are greater than his estimates thereafter [4]. In other words, the program's fertility reducing effect "persists" even if the IUD method is

rejected because of expulsion or removal. According to these matching study estimates the cost of averting one birth would be five to ten times earlier estimates, or about 1500 NT$ which is equivalent to some US $37 [4].

The previous regression analysis of cross-sectional data for Taiwan may now be translated into comparable estimates of the cost-effectiveness of the family planning program. Because of the exploratory nature of the analysis based on only three years of program activity and two years of birth rates, these estimates should be regarded with utmost caution. Longer time series will be needed to define with confidence the stable patterns of program effectiveness on cohort fertility. The estimates for the preferred statistical model, represented by Eq. (4), are presented in Table 10. Because of the unexplained weakness of the associations between 1965 program inputs and subsequent birth rates, the measure of program effort interpreted here is accumulated program inputs from the beginning of the program in 1964 to the year preceding the observed birth rate.

Program activity was estimated to have reduced birth rates in 1966 by at least 4 percent. On average, the efforts of a field worker in a month in 1964 or 1965 are associated with about five fewer births in 1966. With the average cost per field worker per month 1700 NT$ [19], the cost per averted birth in 1966 was about 340 NT$ or the equivalent of US$8.50. The linear estimates (Reg. 1, Table 7) suggest a 4.8 percent reduction in birth rates may be attributed to all types of program activity in 1964 and 1965, but this appears mainly due to 1964 efforts. Allowing for different personnel mix and significant non-linearities in the

Table 10

REGRESSION ESTIMATES OF PROGRAM EFFECTIVENESS

(In percentage reductions in age-standardized birth rate associated with average regional levels of program activity*)

Source of Estimate		Year of Birth Rate	Total Effect of Program			Average Effect per Man Month Effort per 1000 Women 15-49		
			VHEN	PPHW	MD	VHEN	PPHW	MD
Reg. 1	Table 7	1966	1.61	.80	2.36	5.82	.50	1.12
Reg. 2	Table 7	1966	3.00[b]	2.96[b]	2.89[b]	10.85[b]	1.84[b]	1.38[b]
2'[c]		1966	3.38	2.79	2.47	12.22	1.73	1.17
Reg. 3	Table 7	1967	.57[a]	0[a]	3.45	1.29[a]	0[a]	.82
Reg. 4	Table 7	1967	2.84[b]	3.97	5.38[b]	6.45[b]	1.48	1.28[b]
4'[c]		1967	2.86[b]	4.56	4.91	6.49[b]	1.69	1.17

Notes:

[a]Regression coefficients are not significantly different from zero at 5% level in the linear term.

[b]Regression coefficients are not significantly different from zero at 5% level in the squared or cubed term.

[c]To obtain more reliable estimates of program impact, the regression coefficients in the third degree polynomial form of the production function were eliminated from the estimation equation if they were not significantly different from zero at the 5 percent level as reported in Table 7.

*Mean values of program activity across regional sample used to compute effectiveness were as follows: Through 1965 - VHEN = .2765, squared .2272, cubed .2479; PPHW = 1.6074, squared 5.9971, cubed 29.386; MD = 2.0997, squared 13.581, cubed 149.04. Through 1966 - VHEN = .44033, squared .53241, cubed .91301; PPHW - 2.6868, squared 15.964, cubed 124.02; MD = 4.1998, squared 44.335, cubed 784.07.

production function of family planning services, the 1966 birth rate might have been as much as 8 percent lower due to the program. The non-linear production function is mandatory in the analysis of 1967 birth rates, which appear to be as much as 12 percent lower because of the first three years of program activity. But these relatively large estimates of total program impact are not as necessary for future policy decisions as are the estimates of the marginal effectiveness of personnel in the program shown in fig. 3 for 1967 birth rates (1966 birth rates, Reg. 2, Table 7, yield similar results). According to these estimates, increasing personnel obtains diminishing returns in terms of averted births at all levels of observed program activity. As noted earlier, only doctors are subject to a negligible decline in their scale effectiveness. If there were no underlying constraints on personnel mix, the optimal program personnel policy would drive down the rates of marginal effectiveness over marginal cost for each class of personnel to the same level, equal to the marginal social value of an averted unwanted birth [2].

According to the matching study, the family planning program in 1964 may have contributed directly through its insertion of IUDs to a reduction in the birth rate of perhaps 1.5 percent by 1966. But this reduction is only about one-half to one-third that inferred from our analysis. The remainder of the program associated impact may stem from indirect effects of the program on the diffusion of information regarding traditional contraception. The regression findings of strongly diminishing returns challenges the conclusions drawn only from analysis of IUD insertion rates or services delivered [19]. This

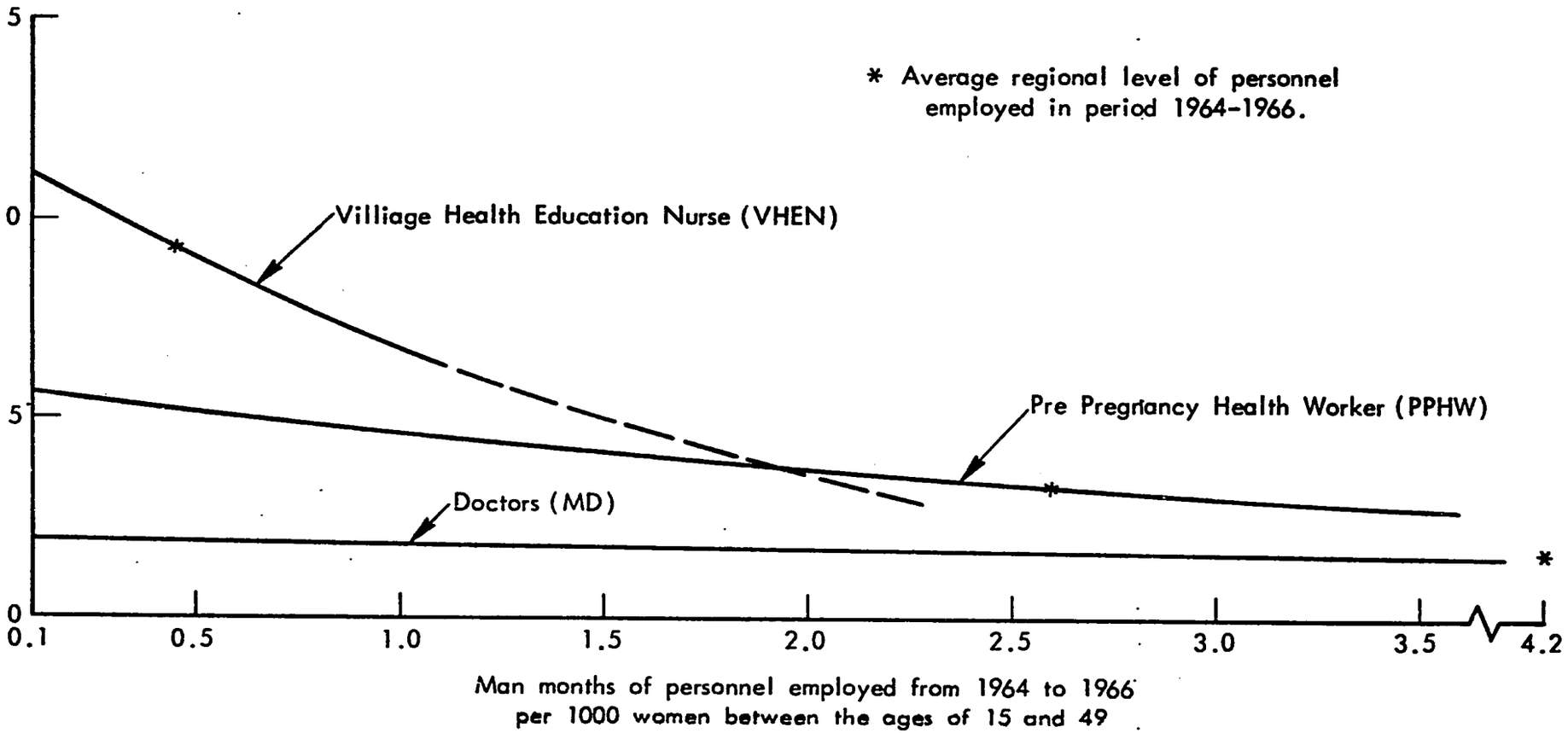

Fig.3—Marginal effectiveness of various personnel in family planning program in reducing the age-standardized birth rate: 1967

Source: Estimates from Reg. 4, Table 7.

paradox may reflect the diminished importance of information dissemination about traditional contraception as the program reaches full scale operation. Confident reconciliation of these differing evaluations of the program will require further analysis.

Program Mix of Personnel

The most obvious characteristic of the family planning program is its mix of personnel. Analysis deals here only with the trade-off between Village Health Education Nurses (VHEN) and Pre Pregnancy Health Workers (PPHW) whose training and salaries are roughly comparable.[40] As shown in Table 9 the expansion of the program has not been uniform for all staff members. The number of doctors has increased from 1964 to 1968 more rapidly than has that of all field personnel together, growing from 61 to 66 percent of the total field staff. The PPHW has increased from 29 to 30 percent of the total, and supervisory staff has grown from zero to 2.2 percent. The major change in staff composition has been the virtual elimination of VHEN from 10 percent of the field staff in 1964 to 1.5 percent in the first six months of 1968. One reason given for this policy has been the more frequent mention by IUD acceptors of their contact with the PPHW than with the VHEN.[41] Our regression analysis of acceptor rates also supports the evidence that acceptor rates are more strongly associated with PPHW employment than with that of VHEN, though the margin of superiority is not great (Reg. 3, Table 8). This improved performance of PPHW compared to VHEN with regard to IUD referrals may be related to the fact that PPHW receive bonuses equal to one to six months of salary based on their reaching and exceeding acceptor rate targets. The

literature on the program does not report a similar incentive payment given to VHEN in regions where acceptor rates and referral counts are high [3, 26].

When regression analysis is based on birth rates rather than acceptor rates or other measures of services delivered, the superiority of PPHW to VHEN reverses in 1966. The lower level of employment of VHEN than that of PPHW helps to explain this difference in linear estimates, but the polynomial estimates still imply (Reg. 2 and 4, Table 7) that a more balanced distribution of program staff between VHEN and PPHW would have been more cost-effective. In other words, if it cost about the same to hire either class of field worker, with more VHEN and fewer PPHW the program would appear to have contributed to a greater reduction in birth rates in 1966 and 1967 than actually occurred, lowering the average and marginal program cost per averted birth.

VIII. CONCLUSION

This paper has presented some tentative statistical evidence on the association between regional birth rates and family planning program activity in Taiwan as an illustration of a different approach to evaluation of program effectiveness. Most of our analysis has dealt with the first two years, 1966 and 1967, in which the national program appeared to have a significant effect on birth rates. These estimates of program effectiveness are, of course, subject to refinement and revision as more data are thoroughly reviewed. Some questions about the adequacy of evaluation based solely on program generated service statistics have been raised.

First, the Taiwan program appears to have had an initial effect on birth rates which is substantially greater than can be accounted for by IUD acceptances alone. The greater effect of the program is likely to have occurred through the dissemination of knowledge about traditional forms of contraception. Emphasis on IUD insertion service statistics has also led to the judgment that the PPHW are more effective family planning program field workers than the VHEN. Because personnel appear to be subject to diminishing marginal productivity in the program, heavy reliance on any one type of worker, or for that matter on any one contraceptive strategy may not be optimal. The VHEN and the PPHW perform different duties, seek to reach different populations, disseminate different services and thus are likely to reinforce, not compete, with one another in promoting the program's broader objectives.

Further multivariate analysis of program activity is required to identify firmly the nature of the production function which best characterizes a family planning program. But this study has confirmed the central importance of a behavioral model, even where this model can only take account of a few of the characteristics of the parents' environment which might be responsible for differences in desired birth rates. In this regard, the recent level of child death rates and the prevalence and duration of child schooling in the community appear to exert a strong influence on the subsequent course of fertility in Taiwan.

FOOTNOTES

[1]Much more knowledge is needed on the interactions among economic, social, and demographic developments to translate a statement on program effectiveness (in terms of reducing birth rates), such as is attempted here, into a statement on program benefits (in terms of values that can be compared legitimately with program costs). A rigorous cost-benefit analysis of population programs will thus require a better understanding than is now at hand of the economic and social causes and consequences of changes in fertility, and potential feedback effects of these changes on the dynamic evolution of social systems.

[2]The last several years have witnessed increased interest in programs to extend to all elements of society information on and supplies for family planning. These programs are a response in part to rising concern about the rate of population growth in low-income countries, and in part to growing evidence (e.g. KAP surveys) that a substantial proportion of the populations in these countries favor the adoption of birth control but are now without the knowledge or guidance to obtain, evaluate, and adopt modern means for controlling births [1, 2].

[3]R. G. Potter from Taichung follow-up data concluded that betwewn .43 to .94 births would be averted per first-segment loop inserted, depending on the substitution of family planning methods (discussed below) [17].

[4]Somewhat more satisfactory as a scheme for program evaluation is a matching study. The preliminary results of one are reported later

in this paper, but there is still a serious problem of defining an adequate "control" group since those who accepted an IUD in the program are self-selected by their stronger motivation for family limitation and cannot be matched precisely by women similar in age, parity, education and open birth interval but less motivated [4].

[5]There are also other problems with interpretation of service records for overall program evaluation. In many programs there are reasonable monetary incentives built into the administration scheme to motivate field workers and doctors to help the largest number of persons possible. Though this common procedure is complemented in the Taiwan program by appropriate safeguards to assure records are accurate, it seems nevertheless likely that these incentives will have some bias on service statistics. In other countries this bias may be large, and thus independent sources of information are needed to ascertain both program services rendered and the effectiveness of those services on actual birth rates. See [8] on Taiwan.

[6]In economic terms, we are concerned both with the stock and flow dimensions of fertility. Changes in desired stocks (completed fertility) are translated in complex ways into adjusted flows over time (birth rates of a cohort). Changes in the status and role of women in a society and their employment opportunities outside of the home may induce different patterns of adjustment in birth rates for the same change in desired completed fertility. A perceptive discussion of the changing patterns of fertility and its "tempo" is set forth and analyzed by N. B. Ryder [21].

[7]L. P. Chow states this conclusion forcefully at the end of a recent article on evaluation of the Taiwan Family Planning Program. "The fundamental question 'what would have been the fertility rate if there were no family planning program?' is an extremely difficult one to answer. No matter how primitive he may be, man seems to have the 'rationale' to adjust his numbers in accordance with the resources available, and the environment to which he is subjected. Those who do not want too many children probably would have fewer anyway, regardless of whether there is a large scale organized family planning program or not. This raises a skepticism toward the value of a family planning program. A family planning program, nevertheless, is justified because it should be able to accelerate the fertility decline" [5, p. 305].

[8]To interpret this seemingly general association for the purposes of formulating policy, information is required on what determines interregional differences in school attendance rates. Is it the limited capacity of the school system or, in other words, the <u>supply</u> of schooling that is restricting attendance? Or is it the reluctance of parents to send their children to receive basic education, and thus a lack of <u>demand</u> for schooling that determines the interregional variation in school attendance rates? The more plausible assumption, I believe, is that the capacity of school system, particularly in rural areas, generally constrains the acceptance of students and accounts for much of the interregional variation in attendance rates. If this assumption is correct, and excess demand for schooling exists, a consequence of school expansion is likely to be a reduction in child labor force participation and a reduction in birth rates.

[9]The participation of women in the labor force is jointly determined with fertility, and other life-cycle decisions. Hence, this proxy for the income opportunities women enjoy in the labor force should be treated with caution and preferably as an endogenous variable in the relationship determining fertility. See [22, 24].

[10]To justify a program on social grounds the net private advantages from an information and service program must outweigh the social costs of the program. An important attribute of family planning programs appears to be their redistributive effects (from taxpayers to the less advantaged who otherwise lack birth control information). A social evaluation of this class of redistributional programs may therefore use a very different weighting scheme in aggregating private benefits and costs from the program. Optimization conditions at the margins are discussed in [12].

[11]It is assumed here that the factors determining birth rates are themselves predetermined. Neglecting interactions among family behavioral decisions leads to inconsistent estimates of the effects of environmental and program variables. Most serious in this regard is probably the bias introduced by considering female participation in the labor force as a determinant of birth rates when participation and fertility are jointly determined, in all likelihood, by opportunities for women to obtain an education and secure a rewarding job outside of the home. Other problems with this approach stem from the consideration of a flow, the birth rate, as a function of stock determining variables. The manner in which the flow is adjusted to changes in desired stocks may be very complex and is reconsidered later in the context of age specific birth rates and their analysis.

[12]There are a number of problems to face in any statistical analysis of fertility, if one wants to infer anything about the determinants of reproductive behavior and the effects of a particular factor such as a family planning program on the birth rate. First, what is the appropriate functional form of the overall statistical model; second, what are the time dimensions of the dynamic behavioral relations it embodies; and third, what omitted variables are likely to bias the results, and in what way? Regardless of how simple one's analysis, all of these questions are being implicitly answered in restrictive ways. For example, take the case of presenting a two-way tabulation of birth rates by age, showing that birth rates differ markedly by age. From this "analysis" and additional evidence that the age composition of the population will change in a prescribable fashion, the prediction may be ventured that birth rates will probably respond in a particular way to the change in age composition. This analysis has assumed a linear model relating fertility to age, and that no other factors of importance affect fertility in the population, or that if some important determinants of birth rates are neglected they are uncorrelated with the age composition. Dynamic specification is lacking, but instantaneous adjustment of fertility to changes in age composition is assumed. When, in fact, we find actual birth rates across regions of Taiwan are not directly associated with the age composition in the expected way, are we to conclude that age is unimportant in understanding fertility -- certainly not. Rather we search for a more realistic model that

explicitly incorporates what we know about the additional determinants of birth rates, and we may then anticipate that age composition will be appropriately related in a more realistic multivariate model with observed regional patterns of fertility. The absence of explicit assumptions concerning the form of one's statistical model does not relieve one of the restrictions embodied therein.

[13]In the later estimates based on the log-linear form of the model represented by Eq(3) it is assumed that the program influences both the number of unwanted births and interacts in the determination of the number of births parents desire. Eq(4) implicitly assumes that the family planning program only influences the birth rate by aiding parents in averting unwanted births.

[14]The death factor is defined as the reciprocal of the child survival rate (i.e., one minus the child death rate). For example, if 80 percent of the children survived to age 15, then the child death factor would be 1.25. Parents to have four surviving children would seek five births (4 x 1.25 = 5). It seems probable, however, that uncertainty enters this decisionmaking process and when, say two decades ago, only 50 percent of the children survived to age 15 in the region, parents might still have only wanted four surviving children, but to hedge against the greater uncertainty implicit in such a heavy regime of childhood mortality, they might have sought not 8 births (4 x [1/.5] = 8), but perhaps 9 or 10. In this case the reduction in child death rates would reduce the size of surviving (to age 15) family.

[15]The log-linear form of Eq.(3) implies that resources employed to disseminate information about birth control are subject to diminishing returns, but when no resources are employed in the program in some regions, that is, $M_i = o$ for some i, and the logarithm of zero is undefined, it is necessary to add a small constant to all observations which may be interpreted as the latent knowledge of birth control present in the absense of the program. Alternative values of this constant were tried to determine whether the estimates differed substantially. In general, when the constant was fixed at .1 man month per year, the relationship had the maximum predictive power, and this value was used throughout the log-linear estimates reported here. Differences between .01 and 1.0 did not change the ultimate calculated effectiveness measures associated with program activity in 1964 and 1965. [23]

[16]The only empirical evidence I have discovered that sheds some light on the returns to scale in an actual family planning program are those compiled and analyzed by John A. Ross from the carefully designed Taichung experiment. As presented in Studies in Family Planning, his findings do not suggest how program costs and policy choices are related to number of births averted. The incommensurability of IUD insertions and the acceptances of traditional contraceptives leads him to deal with both service supply outputs separately. No single satisfactory measure of program output is devised or related to births averted. With respect to IUD insertions, the lowest (of three) scale effort yielded much the lowest average cost

(including service) per acceptor (4.83 compared with $7.95). But when traditional contraceptive acceptors were considered in the same light, the disadvantage of slightly higher cost per serviced acceptor ($4.22 versus $5.03) may according to some people be offset by the increased rate of acceptors (8.7 versus 13.7)percent of women aged 29-39). Yet even in this somewhat extreme case of equating traditional and IUD acceptors, direct costs appear to double in order to secure an increase in the acceptor rate from 8.7 percent in the small scale program neighborhoods to 13.7 percent in the large scale program neighborhoods. Diminishing returns to scale appears to be evident from the Taichung data Ross has studied, even though the measure of program output is regrettably limited to service statistics [20].

[17]The phrase "returns to scale" is used in this context with the assumption that the size of the recipient population can be appropriately factored out of the production function, and that the aggregated input is homogeneous. In seeking to specify the model along these lines inputs are divided by the recipient population, as the other variables are expressed in terms of population rates.

[18]Most family planning is avoiding unwanted births after having the number of surviving children wanted. As noted before, spacing of births is a subtle and uncommon refinement, for two reasons. First, as fertility declines, birth intervals do not increase, rather child bearing becomes increasingly concentrated in fewer years, usually while the mother is still in her 20's. It therefore appears that woman prefer to have their children close together in their

early years of marriage once reliable means of contraception are available assuming the family environment is relatively stable and predictable. Second, spacing of births relies on foresight, which is difficult to fathom in a rapidly changing environment such as is common in developing countries, whereas avoiding further births when enough children are already living necessitates no forethought and involves obvious reinforcement mechanisms. For example, in Taiwan among women accepting an IUD (Intra-uterine Device) in 1966 about 15 percent reported their objective was spacing as opposed to stopping further births. Among women over the age of 29, the proportion spacing births was only 5 percent. [26] Vol. V, Table 8.

[19]The Taiwan data have various weaknesses and limitations, but nevertheless rank as the best and most reliable demographic and program data base for the purposes of analyzing the operation of a family planning program. A possible source of error in the dependent variable may have been introduced by the adjustment procedure applied to the raw registration data in 1966. To correct for changes in the rate of enumeration at the end of 1966 due to the year-end Census (which penalized households who had failed to register infants) an averaging procedure was applied to the last quarter of 1966. I am informed by Ronald Freedman, that this procedure which was devised at the national level turned out to be unsatisfactory at the regional level, and that an improved adjustment procedure is now being developed. The initial investigation analyzed the adjusted data and has here shifted back to the unadjusted series. The empirical results did not change appreciably, so it is assumed that the

registration and adjustment errors are not a serious problem for our analysis. Data were taken from [25] 1966, table 9.

[20]Using the two-year lag for the age specific birth rates between 20 and 29 did not change appreciably the other regression coefficients, and since the two-year lagged death rates were not available for 1964, comparability was preserved by using the three year lag for regressions in both years. For the rationale and definition of the age standardization and normalization procedure see footnote 27 below.

[21]The analogy with capital formation models or more closely parallel models of advertizing effectiveness is obvious for the main objective of a family planning program is to subsidize the spread of knowledge about birth control. Though the stock of knowledge in the hands of the population may depreciate slowly over time, as people forget what they knew and new generations displace old as parents, the level of activity sustained in Taiwan today is certainly adding to the accumulated body of contraceptive knowledge actively understood and practiced by the population.

[22]In the final estimates for the non-linear model reported in Table 7, the program inputs for personnel type are simply accumulated from the beginning of the program up to the year before the birth rate observation. Since the maximum number of years treated in this way was three -- 1964, 1965 and 1966 aggregated as a predictor of 1967 birth rates -- the actual problem of depreciation of knowledge of birth control disseminated by the program two years earlier is not likely to be substantial. When a longer time series is considered, some explicit scheme of diminishing weights should be estimated.

[23]Still other factors undoubtedly play a role in determining the relative attractiveness to parents of having few or many surviving children, and one might want to identify intervening routes by which parents obtain information about birth control other than through the family planning program. The existence of these additional factors is not necessarily a problem with this evaluation approach, for unless the omitted variables are correlated with the variables included in the statistical analysis, our estimates will not be biased by their omission. For example, critics of this approach may argue that "cinema attendance" is a critical determinant of fertility, just as others have found "long distance telephone calls" correlate highly with low fertility. But a logical behavioral model is required to interpret individual correlations. And it is unclear whether we can prudently endorse the installation of more telephones as a particularly fruitful way of fostering a reduction in fertility.

[24]These unique data for a less developed country are the product of years of concerted effort on the part of the University of Michigan Population Studies Center under the direction of Ronald Freedman and the Taiwan Population Studies Center in Taichung under the direction of L. P. Chow in cooperation with the Department of Civil Affairs. The Taiwan family planning program has become in recent years the prototype of a successful large scale, well run program in a developing country. This reputation is probably closely related to the fact that a large fraction of the program's resources have been used both to improve the design of the program

with the aid of carefully evaluated pilot programs [8] and to collect the basic demographic and program statistics which allow for reliable evaluation of the program's success at each stage in its evolution. For a recent survey of this much-studied program, see [17].

[25]Education and occupation data are available for only a year or two. Women's participation in the labor force was also examined (from unpublished tabulations of the household registry kindly provided by Paul Liu), but were not found to be significantly associated with birth rates. Liu finds from an evaluation check on the accuracy of the registry system that it performs well in measuring births, education and male occupation, but was exceptionally inaccurate when it comes to current work status of women in the community.

[26]The child schooling variable is defined as the number of persons 12 years or over in school as a percentage of the number of persons 12 to 20. In some precincts of Taipei City (perhaps the university locality) this variable exceeds slightly 100, but in most cases ranges from 50 to 85 percent. It has been correctly pointed out by Ronald Freedman that the adult education variable provides information only on the average educational attainment for all persons 12 years or older who are no longer in school. It would be distinctly preferable to have age specific educational attainment data, since the potential parent population's education is germane to the hypothesis we seek to test here. But these age specific educational attainment data are not published from the registry materials. However, the 1966 Census soon to be released may permit one to fashion a more appropriate measure of parent education.

[27]The reason for standardizing and normalizing the overall measure of birth rates is to eliminate the effect of age and sex composition on the measured frequency of births among the regional population and to express the rate in relative terms. The deviations of the region's Total Fertility Rate (sum of age specific rates) from the national rate would provide a normalized age standardized measure of fertility, but attributes equal weight to all age cohorts of women, while in fact older cohorts are smaller than younger cohorts in a rapidly growing population like Taiwan's. Therefore a new variable may be defined with national age-cohort weights, called a size weighted Total Fertility Rate. But this variable does not possess the convenient characteristic of summing to zero for the entire country. The normalized variable examined here sums the local age specific birth rates weighted by the local age cohort weights. This total number of births in the region is divided by the sum of the national age specific birth rates weighted by the <u>local</u> age cohort weights. Symbolically this age standardized birth rate is defined for the ith region as

$$B_i / \sum_{j=1}^{7} \bar{B}_j W_{ij}$$

where B_i is the number of births in the ith region, $\bar{B}_j$ is the national age specific birth rate in the jth age cohort, and W_{ij} is the number of women in the jth cohort in the ith region. For instance, if the age specific birth rates in a region were identical to the national average age specific birth rates, then our age standardized birth rate would be equal to one.

[28]All regressions are significant at the 1 percent level according to the F ratio test of the overall relation. In Table 3 and in later tables all satisfy this test at the .1 percent level. Interpretation of these results should focus on the values of the "t" statistics shown beneath each regression coefficient, and not on the R squared. Values of the "t" statistic greater than 2.3 are significantly different from zero at the 1 percent level and those greater than 3.1 at the .1 percent level. One expects the overall R squared in a cross sectional analysis of this sort to fluctuate substantially from year to year.

[29]It should be noted that the quantitative magnitude of this relationship between agricultural activity and higher birth rates is small indeed. The association suggests if the proportion of active men in agriculture in a region increased 100 percent, the age standardized birth rates would increase 1.3 to 1.7 percent.

[30]A similar tendency was evident in England during the enclosures and industrial revolution, for the age at marriage fell more slowly in the rural setting than in the urban, because land, and support on the land, for a wife and children was generally not within the reach of young men. [15]

[31]See Table 9 for expansion pattern of program in Taiwan from 1963 to the first half of 1968.

[32]The simple correlation between total family planning program inputs in 1964 and 1965 is .67 and the average level of inputs increased from 1.1 to 2.6 man months per 1000 women of childbearing age.

[33]The resources used in the family planning program should be recorded at the regional level of observation, valueing each input comparably at its opportunity value elsewhere in the national economy. For the purposes of program evaluation, aspects or activities of the program that operate through different instruments and can be reasonably combined in different proportions should be treated separately in the program cost accounts. This is particularly useful for human resources where doctors are aided by less skilled paramedical technicians and field workers, whose talents are less scarce than those of the doctor, and may be substituted within certain limits for those of the doctor. Alternative propaganda efforts and promotional expenditure schemes may also be segregated and analyzed to help determine what mix of publicity, direct inducements, and human resources yields a desired effect on the birth rate at least cost.

[34]Training and employment costs were obtained from conversations with Tessie T. Y. Huang of the Population Studies Center and Terry Kao of the Provincial Department of Health. These individuals are responsible for the training and supervision of PPHW and VHEN staff, respectively.

[35]Documentary films and publications on Public Health Administration in Taiwan and the Family Planning Program Administration emphasize the difference in duties between the two types of personnel.

[36]The non-linear estimation procedure used is a gradient method, written by Isenpress, that minimizes the sum of squares of the residuals. Since these programs are still somewhat erratic, an interation technique was also used for a wide range of values for α, in order to

minimize the ordinary sum of squared residuals using a linear regression routine on the transformed data [23]. The results were similar, and are therefore thought to be reliable. The "t" statistics are based on the asymptotic standard errors of the Isenpress regression coefficients.

[37]A variety of evidence has been collected to show that the family planning program in Taiwan accelerated the diffusion of contraceptive knowledge and practice, and equalized the frequency of contraceptive use among diverse social and economic classes. The ability of this program to penetrate all segments of society, regardless of their innovative advantages, is a powerful argument for direct public action in this field rather than indirect public subsidy to private commercial channels of information and distribution. In all likelihood, the decline in importance of adult education and the reversal in association between agricultural activity and fertility is accounted for by the intensive family planning program between 1964 and 1966. See [8, 4].

[38]This Taichung dummy variable has the value of one for the 8 precincts of Taichung City, and the value of zero for the other 353 regions of Taiwan. This dummy variable did not enter significantly into the various birth rate models presented earlier and was therefore omitted.

[39]Experimentation did not uncover evidence of non-linear relations between the manpower inputs and the acceptances rates similar to that found in the birth rate model.

[40]The VHEN is also paid a per diem payment while in the field that may raise her salary payments above those for the PPHW, but there is no indication that she receives bonus payments of a substantial nature related to the local success of the family planning program [11].

[41]For an explanation of the coupon scheme which has been a basic instrument for program evaluation in the Taiwan program, see [3, 5, 8].

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