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Evaluation of Population Policies: A Framework for Analysis and its Application to Taiwan's Family Planning Program

T. Paul Schultz

A Report prepared for

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Rand
SANTA MONICA, CA. 90406

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PREFACE

The research on which this study is based was supported by the Agency for International Development, Department of State, under contract csd-2151. This is the last of four "country studies" undertaken at Rand under AID sponsorship which investigate particular aspects of fertility patterns in low-income societies.[1]

The initial focus of this work was on developing and refining quantitative tools of analysis with which inferences could be confidently drawn concerning interactions between man's environment and his reproductive behavior. With these tools the primary objective was to account for differences in fertility among individuals and among groups in low-income societies in order to isolate and evaluate policy options that might reduce birth rates, slow population growth, and enhance development prospects. In the majority of studies, multivariate regression and other forms of statistical analysis were applied to carefully selected cross-sectional data, both to regional population aggregates and to individual family survey records. Guided by simple economic and demographic logic in the selection of probable determinants of desired family size and other family economic behavior, the author found in each country statistical evidence of anticipated relationships linking fertility to observed features of the parents' environment.

In most of these investigations there have been insufficient data to evaluate the influence on fertility of recently initiated family planning programs. One of the most successful and carefully evaluated family programs is in Taiwan. This report relies upon this well documented program and the reliable regional base of vital statistics

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[1] The others are Marc Nerlove and T. Paul Schultz, Love and Life Between the Censuses: A Model of Family Decisionmaking in Puerto Rico, 1950-1960, RM-6322-AID, September 1970; T. Paul Schultz and Julie DaVanzo, Analysis of Demographic Change in East Pakistan: A Study of Retrospective Survey Data, R-564-AID, September 1970; and Alvin J. Harman, Fertility and Economic Behavior of Families in the Philippines, RM-6385-AID, October 1970.

for Taiwan to test the approach to program evaluation. Incorporating the available determinants of desired fertility into a family planning program evaluation methodology provides insights into how the Taiwan Family Planning Program has affected fertility in recent years. Ongoing research at Rand aims at developing a more comprehensive "theory of fertility" as part of a general understanding of family choice processes that are influenced by social and economic development. Progress in this direction should assist both in the selection of overall development policies that will mitigate population problems and in the evaluation of family planning programs.

For many years social scientists have been challenged to develop a satisfactory conceptual and statistical framework within which to evaluate social welfare programs comprehensively; indeed, the approach to this problem adopted here has evolved considerably in the course of this study, and still remains, with regard to specific details, in a state of flux.[1] Thus, this report is intended only as a tentative statement of initial progress in the longer term task of developing improved methods for population program evaluation.

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[1] See earlier progress reports by the author, "The Effectiveness of Family Planning in Taiwan: A proposal for a new evaluation methodology," P-4069, April 1969, and "Effectiveness of Family Planning in Taiwan: A methodology for program evaluation," P-4253, November 1969.

SUMMARY

The problems of evaluating population programs are not easily resolved; indirect inferences or arbitrary assumptions cannot be avoided at one stage or another, for there are unobserved links in the complex chain of events that relate policy instruments to ultimate policy objectives. The tenuous link between the intermediate goals of distributing family planning services and the resultant decline in births must be verified if the evaluation of population programs is to be improved.

The approach developed here is to observe births directly and develop a conceptual and statistical framework within which it should be possible to obtain unbiased estimates of the average, and more important, marginal effects of program activities on birth rates. The policy conclusions drawn from this methodology in the case of the family planning program in Taiwan differ systematically from those derived from other approaches. The program's initial impact on the birth rate in 1966 and 1967 appears to have been larger than previously estimated, but the program has also been subject to sharply diminishing returns as increased personnel were applied to reducing the birth rate. Although this analysis does not indicate why the program's impact has been so substantial or transitory, it may be caused by the initial innovative effect of birth control information disseminated by the program's field staff; it is clearly not entirely a consequence of the acceptance of the particular contraceptive (IUD) emphasized by the program.

Strong evidence is found for the importance of the constraints and opportunities of the parent's environment (schooling rates and child mortality) in explaining parents' diminished birth rates. Without changes in the family environment it is doubtful whether the program would have reduced the birth rate as substantially as it did. In some countries, promoting the changes that bring about the increased demand for family planning can be as important as answering this demand with a well structured, carefully evaluated supply of

family planning services. Priorities in the public sector among health, child nutrition, education, and family planning programs may, therefore, appropriately differ from country to country.

In the past, studies have documented the number of persons helped (that is, acceptors) in various family planning programs, but it is difficult to confidently translate these measures of services supplied into the more concrete objectives of births averted by a family planning program. Analysis of the interregional variation in birth rates is proposed in this report as an approach to program evaluation that takes account of both the environmental changes thought to alter parents' desired fertility and the activities of the family planning program thought to help avert unwanted births. Multiple linear regression and non-linear estimation techniques are used to analyze variation in birth rates across 361 small administrative regions of Taiwan from 1964 to 1968. This analysis supports several conclusions that have a bearing on development and population policies.

In the parents' environment, there exists a pronounced relationship between the level of child mortality and the subsequent level of age-specific birth rates. This statistical association is strongest when two to four years are allowed to elapse between the measurements of child mortality and fertility, the average time required by a woman to conceive and bear a child. According to the behavioral model developed here, this association is a reflection that parents adapt their reproductive goals and behavior to the loss of existing children. Evidence indicates that lower child mortality in Taiwan in this period is not associated with larger sizes of surviving family; on the contrary, lower child mortality in one region is associated within three years with a fully offsetting lower level of fertility, leaving surviving family size in the region similar to that observed elsewhere.

Child school enrollment rates, which reflect higher costs to parents of rearing offspring and having a large family, are strongly negatively associated with the interregional pattern of birth rates in Taiwan.

The weak inverse association between the level of adult education and fertility vacillates during the period 1964 to 1968. The predominance of agricultural employment in a community is positively associated with birth rates before 1965, but this association has reversed by 1968. The change in the importance of adult education and particularly agricultural activity in accounting for patterns of fertility may not be unrelated to the effects of the family planning program; the program's impact on fertility may have been greater among less advantaged, poorly educated, rural-agricultural classes than among better educated, urban cosmopolitan classes who had access to reliable birth control before the program began. The distributional consequences of family planning activity warrant much further study.

The directly assessed association between the allocation of personnel in the family planning program and the reduction in birth rates implies that the program's activities contributed to a substantial reduction in 1966 and 1967 crude birth rates. Most of this impact can be traced to personnel employed in the local field program, but not solely to the acceptance of IUDs, the principal contraceptive distributed by the program. The marginal effectiveness of program personnel diminishes from 1965 to 1968 as the program expanded, and in each single year the marginal effectiveness of personnel is relatively lower in regions where program activity has been relatively greater. Both independent pieces of evidence confirm that more intensive efforts of field workers are subject to diminishing returns: doubling personnel for a given population will not double the number of births averted by the program. For example, the program cost of averting an additional birth in 1966 appears to be about U.S.$10, but this estimate of marginal cost doubles by 1967 and doubles again by 1968.

Part of the decline in program effectiveness is due to the emerging pattern of higher birth rates among women 20 to 29 in regions intensively covered by the Taiwan program which counterbalances in the aggregate the program's impact of reducing birth rates among women over the age of 30. An optimistic explanation of this

recent phenomenon views this pattern of increased fertility among younger women as only a sign of change in the timing of births and not as an indication of any increase in wanted or probable completed fertility. Nonetheless, evidence even among older groups of women is unambiguous -- the effectiveness of program personnel to reduce births has diminished over time.

Another implication of this analysis is that one class of field worker — the Village Health Education Nurse -- is more cost effective in reducing the birth rate than another class of field worker -- the Pre Pregnancy Health Worker. This inefficient disparity in the program's mix of field workers has not been corrected; on the contrary, the more productive class of personnel has been gradually eliminated from the program.

It should be clear to everyone that we know relatively little as yet about how to organize, operate, and evaluate a family planning program. This investigation underscores the need to carefully evaluate the amount and mix of resources employed in such a program in order to secure an efficient allocation of funds in this high priority field. Nonlinear statistical techniques may be essential for the marginal analysis of some aspects of this allocation problem, and a disaggregated treatment of fertility by age is crucial for separating the effects of the program on both the timing of births and the completed size of families.

In this important area for social policy, it is disconcerting that different approaches to evaluation yield different conclusions with regard to (1) the overall impact of the program, (2) changes in returns to the scale of program activity, and (3) the relative effectiveness of various classes of field workers. More research will be needed to determine the reasons for these differences in policy conclusions, but probable explanations for these inconsistencies imply a number of guidelines for policy formulation and evaluation.

First, analysis of intermediate outcomes in a family planning program, such as the number of IUD acceptors served, may not accurately reflect the final impact of the program on birth rates, especially when various field workers receive different incentives for disseminating intermediate products. There is a need to focus more analytical study on what social and economic forces account for existing patterns of fertility in order to isolate more precisely the contribution of population programs to the reduction in birth rates. It must be recognized, however, that this approach requires more lead time than may be available for some policy decisions.

Second, day-to-day information on the functioning of the program should be drawn from unbiased sources to improve short-run policy making and to assure that these operational guidelines approximately coincide with those derived from long-term studies of the program's impact on birth rates. Incentives built into the organizational structure of the population program must be aligned to motivate individuals to accomplish the objective of the program or, in this case, to increase the effectiveness of contraceptive practices of the population and convince them of the value and safety of modern birth control methods. The emphasis initially placed in Taiwan on a single contraceptive method, the IUD, as the principal basis for record keeping, program evaluation, and field staff remuneration may have excessively discounted the role of other birth control methods. If demands for all forms of birth control had been monitored, whether they were satisfied within or outside of the program, a different image of program success might have emerged at an earlier date.

Third, a potential problem with analysis of nonexperimental data is that statistical associations between treatments (levels and mixes of program activity) and outcomes (levels of birth rates) may not denote cause-and-effect relationships. This does not appear to be the case in Taiwan, but it may complicate policy evaluation efforts in other countries and warrant the consideration of countermeasures

To apply cost effectiveness evaluation techniques to alternative policies that seek to change birth rates, whether by direct provision

of birth control information and services in a family planning program or by indirect emphasis of policies that promote the adoption of a smaller family size goal, one needs a comprehensive theory of the principal determinants of fertility. Although such a theory is in its early stages of development, it is far enough along to see that it is very much worth pursuing both conceptually and empirically. If agreement can be reached on how to measure the independent effect of family planning programs and other indirect population programs on slowing population growth, much improved information and management techniques could be applied to increase the effectiveness of these population policies. The notion that fertility and population growth obey Malthusian laws and are not amenable to the self-interested behavior of parents is a counterproductive myth that denies the need for a supporting theory of fertility and impedes our better understanding of the motivations for reproduction and their important implications for policy.

ACKNOWLEDGMENTS

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I. INTRODUCTION: PROGRAM OBJECTIVES AND EVALUATION

Evaluating the social contribution of population programs is a difficult task. As more resources are spent in many parts of the world to facilitate and foster a reduction in fertility, evaluation of these efforts must receive priority if one is to learn from experience. A variety of evaluation methods has developed, but this report presents disconcerting evidence that different approaches can yield starkly different implications for improving policy. Research is urgently needed to ferret out the sources of error built into our information systems and to identify the weaknesses embodied in our methods of statistical inference that must be responsible for these inconsistent conclusions for policy. This investigation of the Taiwan family planning program explores these issues and develops guidelines for the organization and evaluation of population programs.

This first section reviews alternative approaches to population policy evaluation. In the context of Taiwan, the remainder of this report develops an analytical approach to evaluation and applies it to confirm the effectiveness of field personnel in the Taiwan family planning program and to challenge early evidence on this program's optimal size and structure.

KNOWLEDGE OF BIRTH CONTROL

Initially, family planning advocates assumed that if information about modern means of birth control were made available throughout a society, the program should be regarded a success. While increased knowledge of birth control within a population may be one partial measure of success, certainly one should consider as well the important issues of how useful this knowledge is, how much people benefit from it, and what welfare implications follow from the patterns of behavior that occur as a consequence of this new disseminated information.[1]

---

[1] To demonstrate the expressed need for family planning programs, sample surveys were designed to inquire into contraceptive Knowledge,

ISTRIBUTION OF SERVICES

The most common approach to evaluation of family planning programs is to measure services rendered by these programs and their complementary activities -- the number of pills dispensed, IUDs inserted, traditional contraceptives given away or sold at concessionary prices within the program. More sophisticated measures are possible -- calculations may be made with a great deal of precision on how long the IUD is likely to remain in place for the average woman served by some programs, and how effective it will be during this period in preventing births [6, 10]. These effectiveness models estimated from follow-up survey data leave much to be desired, however, when they are used to translate a program's supply of contraceptives into an effect on the birth rate. As these studies are careful to point out, no one knows what women who accepted a form of contraception in the program would have done without the program. To what extent do family planning programs transfer the demands for birth control from the private marketplace to the lower-cost sources of government-subsidized supply? Similarly, if women adopting modern techniques of birth control had been employing traditional schemes of limited, but positive, effectiveness, the impact of the program on the birth rate would be only a fraction of that implied by the contraceptive potential of the birth control devices distributed by the program.

The second serious problem with this method of program evaluation is its inability to cope with the influence of information flows that alter reproductive behavior but do not necessarily influence the program's distribution of birth control supplies. For example, the spread of the idea of family planning may stimulate interest in

---

Attitudes and Practices (KAP). By recent count, 400 KAP surveys have been conducted in 67 countries [7]. Aside from the controversial problem of eliciting meaningful and accurate responses to questions on these personally sensitive and complex matters, the subsequent use of KAP surveys to evaluate family planning programs has raised another issue. Is one primarily interested in announced intentions and admissions of knowledge or actual reproductive behavior? A shift in the content of KAP surveys from contraceptive knowledge and use toward actual fertility behavior may facilitate the application of new evaluation methods such as those proposed in this report.

traditional and modern forms of birth control which may be partially satisfied in the private marketplace and not through the program itself, or may shift the timing of births and other life-cycle activities.

MATCHING STUDIES

In an effort to control for the "substitution effect," mat studies have been designed. Their objective is to compare the subsequent fertility of a group of women accepting some form of contraception in the program with a control group who have not entered the program, matched by such characteristics as age, education, number of births, and time since their last birth. Evidence of higher fertility in the control group than in the program group can be translated into an estimate of the program's effectiveness in reducing the birth rate [1].

Although the matching approach is an improvement over program evaluation methods that rely only on the supply of contraceptives dispensed, it is costly, time consuming, and still subject to biases If the program contributes to the general diffusion of information about family planning, as it certainly must, and thereby influences some people in the control group to obtain improved methods of birth control from private sources, the matching study understates the impact of the family planning program on the birth rate. On the other hand, the matching procedure may also overstate the role of contraceptives dispensed by the program, because women who adopt contraception in the program are self-selected (unrandomly) and are presumably more highly motivated than those in the control group to limit their subsequent fertility. How these two biases balance out is not known.

II. THE CASE OF TAIWAN

The complex problems of population policy evaluation are brought into clearer focus if a concrete case is considered; therefore, the remainder of this study deals with Taiwan. In 1967 Kingsley Davis challenged the advocates of family planning to demonstrate that their programs had influenced birth rates. With reference to Taiwan, he argued that since birth rates were declining before the program began, the contribution of the program was not evident [4]. A typical response to Davis is portrayed in Fig. 1: The family planning program pilot operations began in 1963, and the subsequent rate of decline of the birth rate exceeded the past downward trend.

This interpretation of the program's impact has numerous shortcomings. First, the program began on a country-wide scale only in 1964. The gradually improved effectiveness of contraceptive practices that is attributed to the program could not have influenced birth rates substantially until 1965. Since the average interval between births for a population not practicing contraception is about two years, the full impact of the program is not likely to emerge from data on birth rates until 1966.

In addition, this interpretation of the evidence suffers from more than the merely mechanical defect of selecting the wrong turning point; there are fundamental problems with any single factor analysis of complex national time trends. During the 1960s Taiwan was not standing still. For example, the proportion of children between the ages of 12 and 19 going to school increased from about 41 percent in 1960 to 50 percent by 1967. This increase in enrollment rates occurred despite a 50 percent increase in the number of children in these age groups. Though Taiwan's economic progress since the Second World War has been notable, the rate of growth in per capita real income shown in Fig. 2 is accentuated in the period since 1962. Behind such changes in schooling and income levels many other social and economic changes are probably taking place that could be responsible for changing desired and actual levels of fertility.

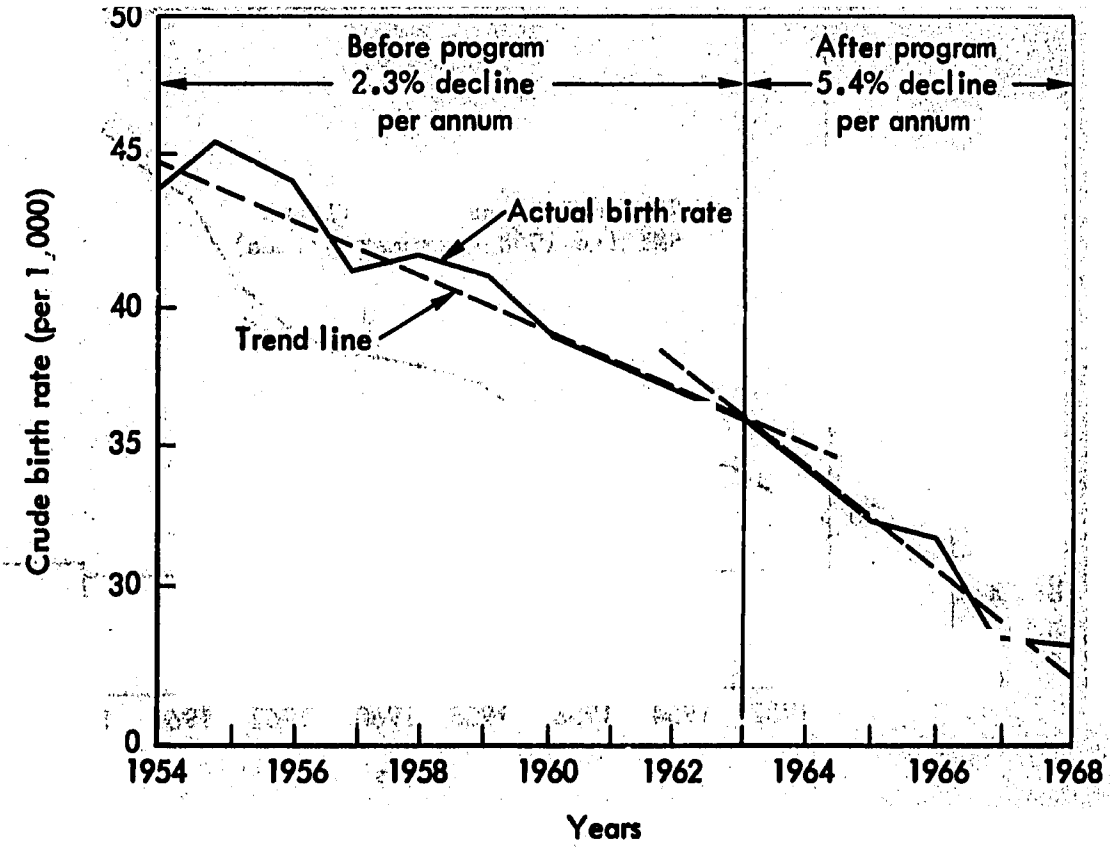

Fig. 1 -- Fertility decline before and after establishment of family planning program in 1963: Taiwan

Source: Joint Monthly Report, Family Planning and Population Studies Program, May and June 1968, Series P-7 (68-3).

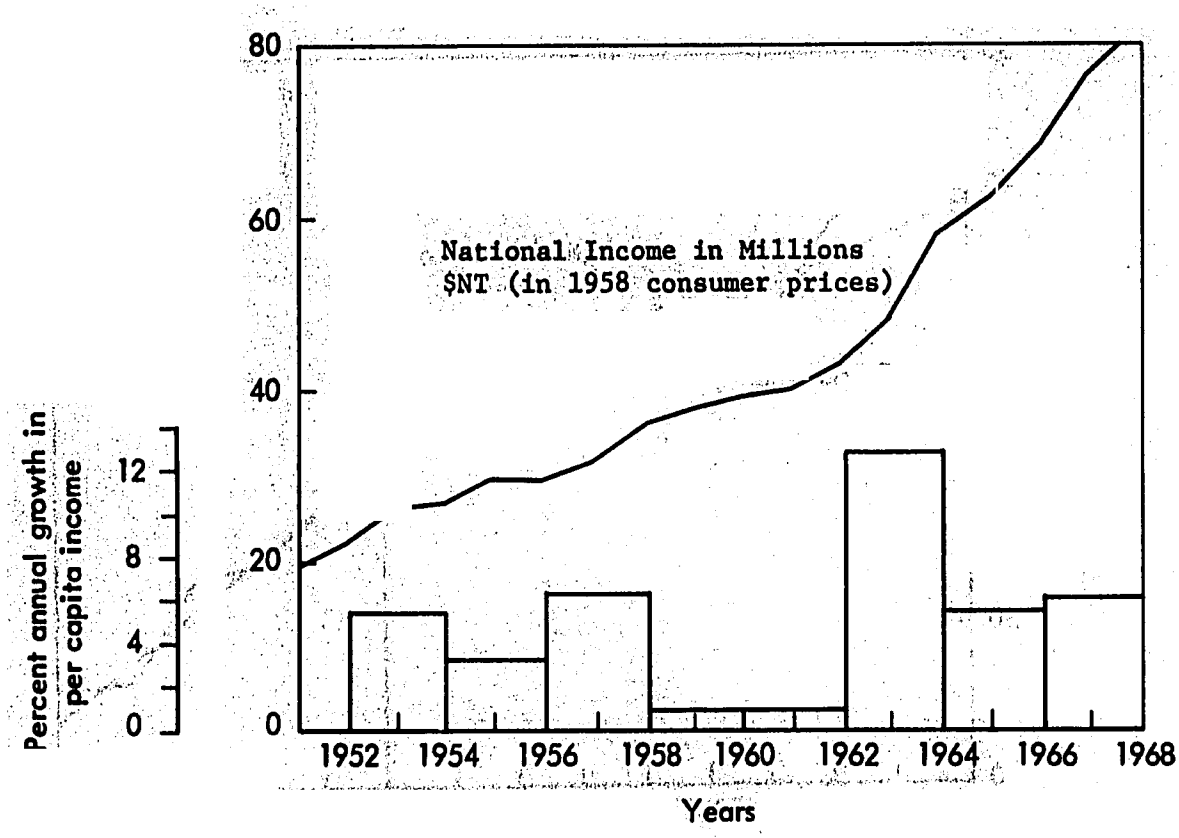

Fig. 2 -- Growth of real national income in Taiwan

Sources: Derived from International Monetary Fund's Financial Statistics, and Taiwan Demographic Factbooks.

The problem of interpretation posed by Fig. 1 is common to the social sciences which must depend largely on nonexperimental data -- causality cannot be confidently inferred from the concurrence of a short time series (on vital rates) and the initiation of a program (family planning). First, more information is needed, such as is often obtained from a cross section of smaller units (families or communities) over time, for which program activity differs. Second, a satisfactory analysis of the partial effect of a program on the birth rate requires a general framework for understanding variation in reproductive behavior. In other words, there is need for a more comprehensive and realistic portrayal of the determinants of reproductive behavior that will isolate the effects of particular dimensions of social and economic change on fertility as well as estimate the influence of the family planning program.

Since the many social and economic constraints and opportunities that might reasonably influence desired reproductive behavior are not necessarily uncorrelated, all relevant exogenous factors should be considered together to appraise, without bias, their joint and individual influence on the birth rate. The complexity of this problem precludes the convention of partitioning the population until groups are derived that are homogeneous with regard to all influential factors except program inputs. As a practical matter of multivariate statistical analysis, a functional form must then be adopted to relate the various factors to each other and to the birth rate. The parameters of this functional relationship are then typically estimated by regression procedures.

Reproductive behavior is not adequately described by the crude birth rate because of differences in the age and sex composition of the population over time and across regions. Also, under similar circumstances, birth rates for women of one age group may respond differently from those of another age group. The decline in birth rates that emerged in Taiwan after the mid-1950s, as shown in Fig. 3 did not occur evenly across age groups; it is accentuated among women over 30 years of age, and is not yet substantial among women

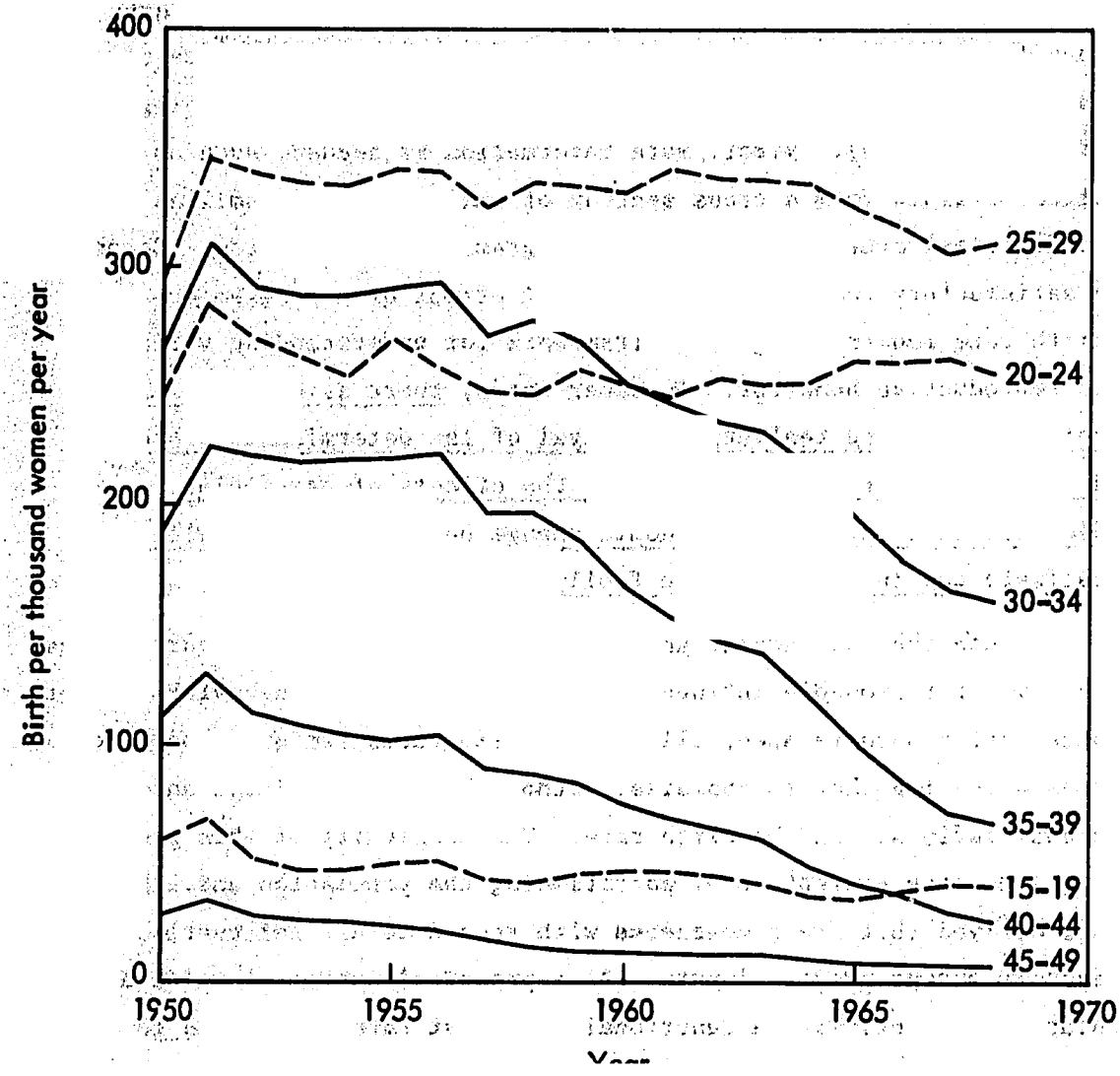

Fig. 3 -- Age-specific birth rates: Taiwan

Sources: 1950-1961 from 1961 Taiwan Demographic Fact Book, Table 9; 1962-1965 from 1967 Taiwan Demographic Fact Book, Table 8; 1966-1968 from Quarterly Report on Taiwan's Family Planning and Population Studies, April-June 1969, Appendix C, Table 1.

under 30. It is anticipated, therefore, that the family planning program will have made its major contribution to the reduction in fertility by facilitating this marked decline in birth rates among older women. The program may also have influenced the reproductive behavior of younger women, possibly by balancing other social and economic forces that have fostered higher desired birth rates. Although in the evaluation of population programs age-specific and age-standardized birth rates[1] are more appropriate for analysis than crude birth rates, it is still not possible to disentangle from cross-sectional data on birth rates, changes both in the timing of births and in the size of completed family. For example, young parents may now be having their children closer together because they can reliably stop bearing children at an earlier age than their parents. Thus, evidence of different short-run program effects on different age cohorts should be interpreted cautiously.

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[1] The standardized crude birth rate is the observed live births divided by the age-standardized estimate of births derived by attributing the national age-specific birth rates to the seven age cohorts of childbearing women in each administrative region. Deviations in this normalized birth rate from one (or zero in the logarithmic form), therefore, represent deviations in local crude birth rates from the level expected nationally from the age/sex composition of the population in the administrative region. The regional age-specific birth rates are also normalized by dividing them by the respective year's age-specific birth rate for all of Taiwan.

III. MODEL DESIGN

To avoid the uncertainties of translating contraceptive adoption or use into births prevented, the approach discussed in this report deals directly with reproductive behavior and attempts through statistical analysis to infer the relations among various sorts of program activities and the level of birth rates.[1]

To infer how program activity influences birth rates, analysis of nonexperimental data must simultaneously evaluate two sets of factors.[2] First, environmental determinants of parents' family size

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[1]This approach does not take account of some of the side-effects of the program that may be beneficial and are perhaps quite important. For example, if women shift from primitive techniques, such as non-medically induced abortions, to more convenient, safe, and modern techniques of birth control, the birth rate may not change. Nonetheless, these women and society are benefiting. There is no easy way to account for this benefit. Furthermore, as in any program that provides services largely to the disadvantaged and poor in a society, income redistribution occurs. Some people are shifting from private market sources of contraceptives to cheaper public market sources. This redistribution of income may not be large, but it nevertheless may be seen as a benefit of the program that is here unavoidably neglected. Of greater potential importance is the effect of the program on the class distribution of per capita income in this and following generations that would occur if the program helped lower-class parents to avert a greater proportion of their unwanted births than upper class parents.

[2]If the allocation of family planning program activities is experimentally designed on a random basis, environmental factors are statistically independent of program factors and each can be evaluated independently of the other without serious bias. The family planning experiment in Taichung City, Taiwan, represents this unusual case where social scientists have undertaken the time consuming task of obtaining truly experimental data from a large scale social action program [5, Chapters 6-12]. This major city was divided into 2400 small neighborhoods (yin) and family planning activity (treatments) were planned and executed in each yin in a randomized manner that permitted the policy analyst to neglect environmental determinants of behavior and to interpret the directly observed relationship between program activity and behavior as an unbiased estimate of the influence of the program on behavior. Freedman and Takeshita pursue this route with respect to the acceptance of contraceptives among the Taichung population. Reproductive behavior in Taichung might also be directly linked to program activity using their methodology. The

goals and desired fertility must be identified and approximated by observed variables. Concurrently, family planning activities that reduce the number of ill-timed and unwanted births must be specified in as much detail and as comparably as possible across different target populations. Complete specification and accurate measurement of both sets of factors allow one to infer the independent contribution of each factor to the level of birth rates.[1]

The problem is how to assemble available information on recent occurrences in Taiwan 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 analysis and presentation. Only one behavioral 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,

---

only problem with the design of the Taichung experiment is the evident importance of interregional diffusion, namely, that intensive program activity in one neighborhood spilled over and appeared to influence contraceptive acceptor rates in adjacent neighborhoods [5, pp. 134-139]. Since no method in the original study is proposed to take account of this indirect diffusion effect of the program, the observed relationship between program activity and behavior is biased toward zero, understating the total (direct and indirect) effect of the program on behavior.

In the study reported here of the nationwide Taiwan family planning program, it cannot be assumed that the program followed a randomized experimental design. It is, therefore, necessary to deal simultaneously with both program and environmental determinants of birth rates (that is, it cannot be assumed that one is wholly independent of the other). Also, the regional unit of observation here is several hundred times larger than that used in the Taichung City experiment. For this reason, the interregional diffusion effect should be attenuated and the consequent bias in estimates of total program effects on behavior should be reduced substantially.

[1]Since the appropriate specification and measurement of the environmental and program elements of the model will be subject to controversy for some time, statistical inferences with regard to policy evaluation will also be controversial. Consideration of alternative formulations of the statistical model should gradually narrow the range of uncertainty that now attaches to conclusions about the effect of population policies.

and (3) the family planning program activities that are assumed to reduce unwanted births. Statistical analysis of data on birth rates and factors thought to influence birth rates requires further information about the nature of their interaction, namely, the causal structure or the specification of the model. First the functional form of the statistical model is discussed, and then the time dimensions of the relations it embodies are examined. The theoretical and empirical rationale for the choice of environmental determinants of desired family size is discussed at greater length elsewhere [12].

FUNCTIONAL SPECIFICATION

In mathematical notation, the relationship we want to characterize is

$$B = f(D)g(X,Y,Z,\ldots)p(M_1,M_2\ldots) \qquad (1)$$

where B represents the number of children ever born by a woman of a specific age, f(D) is a function of the child death rate experienced or anticipated by the woman, g(X,Y,Z,...) denotes the number of surviving children parents want which is a function of many environmental factors, X,Y,Z,..., and $p(M_1,M_2\ldots)$ is the relationship between local family planning activities $M_1,M_2,\ldots$ and parents' knowledge of and cost of efficacious methods of birth control that presumably influence the number of "unwanted" births parents are likely to have. The lack of firm empirical or formal theoretical guidance in the choice of an appropriate functional specification for f, g and p means that the final specification of the statistical model must be somewhat arbitrary. Therefore, the parameters of the model are estimated assuming three alternative functional specifications: (1) linear and additive; (2) exponential and multiplicative (loglinear); and (3) nonlinear hybrid that is implied by a plausible characterization of the interaction between the child death rate and the surviving family size goal, as elaborated in the Statistical Appendix and [13].[1] The parameter

[1] In the Appendix, these alternative functional specifications of the estimation equation are derived and shown to yield substantially

estimates are those that minimize the mean squared error between observed and predicted birth rates, based on the specified (exogenous) determinants of fertility and their assumed functional and temporal form.[1]

A more complete portrayal of the causal structure that is thought to underlie Equation (1) is shown in Fig. 4. The intervening variables such as marriage and acceptance of specific birth control methods might be distinguished in a larger simultaneous-equations model which is designed to identify and to estimate the direct and indirect lines of influence from the environment, child mortality, and family planning program activity to fertility. Estimates of the simplified single-equation model, however, are unbiased indications of the net contribution of exogenous factors in determining fertility.[2]

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similar implications for the responsiveness of fertility in Taiwan to current levels of program activity. Therefore, the discussion relies on the least complex linear approximation of the model. Further research is nonetheless needed to determine for this evaluation method the sensitivity of policy conclusions to alternative specification of Equation (1).

[1]For the regression coefficients to be the best (minimum variance) linear unbiased estimates (BLUE) of the model's parameters a number of conditions must hold (Christ [3, Chap. 9]). For purposes here the critical assumption is that the explanatory variables are independent of one another and predetermined or uncorrelated with the disturbances in the equation. The disturbances are intended to represent the net effects of numerous factors, other than those included in the relationship, but which are too numerous or too difficult to measure to have been introduced as separate variables. If disturbances and explanatory variables are not independent, perhaps because the regional allocation of family planning program activity was influenced by omitted factors that also influenced birth rates, the estimates of program impact on birth rates would be biased. Also, if one class of manpower in the program, such as doctors, are influenced in their participation in the program by the prior activity of field workers (generating demand for their services), then the allocation of doctors is no longer independent of the allocation of other workers and can not be introduced into the "reduced form" variety of estimation equation considered here without biasing downward the estimates of the effectiveness of the field workers. For this reason, doctors are excluded from the form of the estimated model reported here.

[2]Later work should explore the relative weight attributed to the submerged direct and indirect causal mechanisms -- for example, the extent to which a reduction in child mortality contributes to

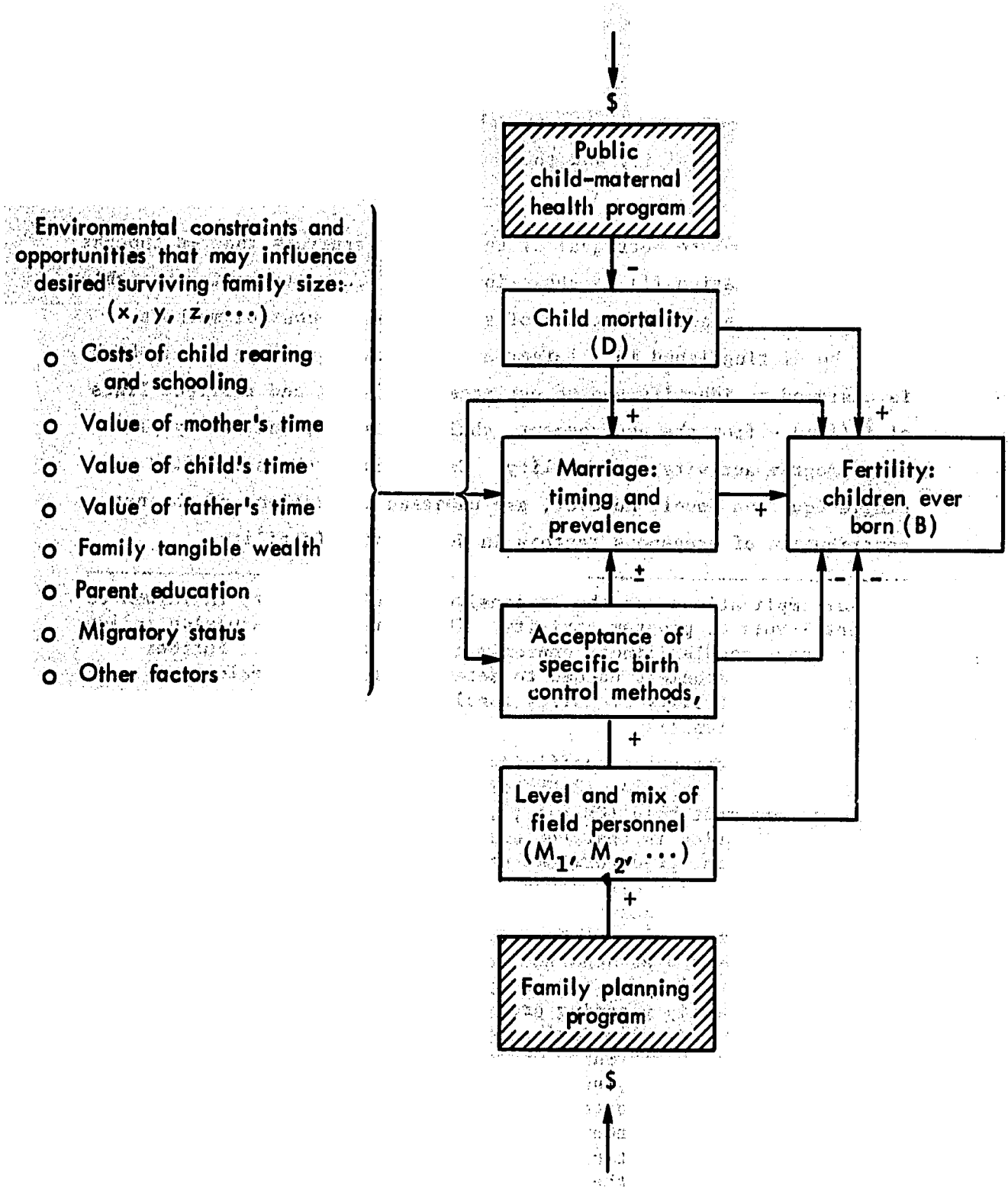

Fig.4 — Causal structure of postulated model determining fertility

How inputs into the family planning program, M_i, influence the number of "unwanted" births parents avert raises further important issues for policy. 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 seem plausible. 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 of a decreasing number of births. It is possible that someday a situation would arise where everyone practiced perfectly reliable birth control and where there were no "unwanted" births. In this utopian setting additional family planning efforts would have no effect on birth rates and hence no value.

To determine if there is statistical evidence of changes in returns to program scale, the input variables are first considered in linear form and then terms of a polynomial expansion are added to the "production function" until higher order terms do not significantly improve the model's fit to the data. There is substantial variation in the outcome of this test among years and age groups, but in general the quadratic term does not improve the fit without the inclusion of the additional cubic term which then meets the t test of significance on individual regression coefficients and the F test on improvement in the overall relationship. In both the linear and the cubic "production function" for family planning services, estimates should be interpreted with caution and only over the mid-range of the observed levels of program activity in the specific year

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lower marital fertility or to later age at marriage, which are summed together in their combined effect on fertility in Equation (1).

TEMPORAL SPECIFICATION

Anticipations about the future are often not fulfilled; it takes an uncertain amount of time to have a child, and children die unpredictably -- therefore, lags and adjustments of a biological and behavioral nature interpose themselves between the observed environment characterized in the model and the observed birth rate the model seeks to predict. Most environmental conditions that modify parents' preferences for children change slowly, at least at the regional level considered here. Death rates, on the contrary, 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 recent losses The 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 actual 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 thirties, and a sizable proportion of her cohort intends to avoid further births, her behavioral response to her child's death, that of seeking another birth, will distinguish her sharply from others in her cohort within a relatively short time.

Though it is not possible from published data for Taiwan to trace the frequency of child deaths to mothers of a specific age, it is possible in each of 361 administrative regions to estimate the age-specific death rate for children for several years prior to observed age-specific birth rates and to examine the strength of the statistical association between these two rates for evidence on the length of this behavioral-biological lag. Experimentation with various discrete and distributed lags for Taiwan is constrained to the few years for which the appropriate data are collected and published. In those years, the association between regional child death

rates and subsequent birth rates is statistically strongest after the lapse of two to four years.[1] These quantitative findings that a two to four-year average behavior-biological lag exists between child deaths and subsequent births is generally consistent with other evidence on the mean length of closed birth intervals for women not practicing contraception [5, 9]. Based on this evidence it is appropriate to lag all environmental variables by the same number of years, hereafter assumed to be three years.

Family planning program inputs, however, represent a more complex problem of measurement and dynamic model specification. The temporal link between environmental conditions and fertility and that between birth control and fertility is asymmetric. Current birth control practices influence birth rates nine months later, and thus the lag between adoption of more effective birth control methods and their maximum impact on birth rates is likely to be about a year, not the two or three required, on average, for a woman to deliver a child. Therefore, program inputs should be lagged a shorter time than environmental conditions. Also, the program is likely to have a persisting effect on contraceptive knowledge in the community, slowly "depreciating" as people forget and as new generations of parents grow up. Thus, all past program inputs must be considered as possible determinants (with perhaps diminishing weights) of the target population's current knowledge of birth control methods. 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 treat the total of all past program inputs as the determinant of current effective knowledge of birth control in the community.[2]

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[1] Distributed lagged relationships were estimated; although they smoothed year-to-year variation in the size and significance of the regression coefficients, they did not improve the overall predictive power of a discrete three-year lag, which is therefore used in this study. See Statistical Appendix and Table J-2 for evidence of year to year variability in lag structure.

[2] Alternative distributed lagged relationships were considered and these results are discussed in the Statistical Appendix. The measure of program inputs used here is the cumulative number to

DATA CONSTRAINTS AND THE FINAL MODEL SPECIFICATION

The dependent variable in the fertility equations estimated in the next section is a birth rate for an age cohort of women in 361 small areas of Taiwan reported in [14]. This is not the dimension of fertility envisioned in Equation (1), namely the number of children born to an individual woman. Formally, many restrictive assumptions are required to assure that the aggregate flow of births across groups of women responds in the same way to differences in the determinants of fertility as does the stock of children ever born across individual women. Given the urgent need to evaluate the impact on fertility of population programs, it is not realistic to wait decades until today's younger parents in Taiwan have completed their childbearing years in order to estimate the program's long-run impact on their completed fertility. Research must in the interim analyze current birth rates for evidence of the short-run effectiveness of population programs to reduce births.[1] To facilitate comparisons among birth rate equations for women of different ages, all age-specific birth rates are normalized to approximately one by dividing the regional birth rate by the respective national age-specific birth rate. The crude birth rate must not only be normalized but also standardized for age and sex composition.[2] All normalized birth rates are thereby expressed as a multiple of the national rates in the particular year,

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the preceding year of man months of program personnel time allocated to the region per thousand women of childbearing age.

[1] Were data available by region on the existing stock of children now living to women by the woman's age (such as might become available from the 1966 Census) a more appropriate form of the model might be estimated incorporating information on both the stock and flow dimensions of fertility for the cross section of regions analyzed in this study.

[2] National age-specific birth rates are applied to the region's age composition to construct an estimate of the number of births that would have occurred in the region if national age-specific birth rates had prevailed. The actual number of births is then divided by this expected number of births based on the regions age and sex composition. See footnote 1 on 9.

and the relative responsiveness of different age groups is reflected in the relative size of the regression coefficients estimated for each of the determinants of fertility.

The adjustment factor for the incidence of child mortality (the reciprocal of the chance of survival from birth to age 15) is estimated from registered age-specific deaths and population in the community three years before the observed birth rate [14]. Among the many environmental constraints and influences that are likely to determine the number of surviving children parents want, only three can be derived from published household registration records:

(1) the duration and extent of child schooling, which is associated with the cost of child rearing;

(2) the extent of adult education which may stimulate demand for higher cost (quality) children and also lower the subjective and pecuniary cost of averting "unwanted" births (that is, acquiring and using birth control effectively) without the aid of a family planning program; and

(3) the agricultural composition of the local male labor force, where it is assumed that the value of a child's labor is greater in agricultural than in nonagricultural activity, increasing the attractions of a large family in agricultural communities, other things being equal.[1]

Finally, family planning program inputs are measured as the local staff employment (cumulative man months to the preceding year) per thousand women of childbearing age (15 to 49). These program inputs are initially regressed against birth rates in a linear form, implying a proportionate relationship between family planning activity

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[1]Many other factors are thought to influence parent demand for children, but the lack of published regional data precludes my analysis of them; for example, it would be of interest to know non-employment income, male and female wages, labor force activity of children and women, education of women by age, migration experience by age, sex, and schooling. It is hoped that publication of some of these data from the household registration system and the long awaited 1966 Census will permit a more extensive study of these probable determinants of desired fertility patterns in Taiwan.

and number of births averted. In the final set of regressions these inputs are treated as a cubic function to determine whether returns to program activity are constant, decrease, or increase with the scale of the program.

IV. EMPIRICAL EVIDENCE FOR TAIWAN

This section discusses the regression estimates of the relationship between birth rates and environmental determinants of desired fertility and family planning program determinants of "unwanted" fertility. Three functional specifications of this relationship are estimated from regional cross-sections of Taiwan and reported in the appendix with variable means, standard deviations, and zero order correlations among program input variables.[1]

SOCIAL AND ECONOMIC DETERMINANTS OF FERTILITY

In each year from 1964 to 1968, between 37 and 58 percent of the interregional variation in age-normalized crude birth rates is explained principally in terms of two features of the local communities: the reciprocal of the child survival rate to age 15 (hereafter referred to as the "child death adjustment ratio") and the proportion of children age 12 to 19 attending school. Regardless of which of the three functional specifications of the model is estimated, the regression coefficients for these two variables are highly significant, that is t ratios are between 5 and 13 (Tables A-1, B, and C).[2]

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[1] See Section III for discussion of functional specification. Because of the high costs of nonlinear regression computations, the nonlinear model is estimated for the linear and cubic production function form only in the case of the age-normalized crude birth rate equations (Tables B and F). The loglinear model yields satisfactory estimates of the marginal effectiveness of program inputs, but its rigid one parameter form does not provide a useful approximation for the contribution of program inputs outside of the narrow range of variable means (Table D). Therefore, the discussion of empirical results relies on the basic linear model in which the family planning program is approximated first by a linear production function (Tables A-1 through A-8) and second by a cubic production function (Table E). As noted earlier, the various specifications of the model do not lead to important differences in policy conclusions.

[2] Throughout this discussion, the t ratio reported in the tables beneath each regression coefficient is used to test statistical confidence in the nul hypothesis that there appears to be no particular effect of the variable on the birth rate.

For example, three years after an unusual decrease (increase) in the child death rate in a community, there is evidence that the birth rate responds with an unusual decrease (increase). Since this pattern is more noticeable among teen-aged women and older women (over 30), the relationship cannot be attributed solely to an autonomous biological feedback mechanism but appears to reflect also a behavioral response on the part of parents to specific child deaths that occur at the initiation and conclusion of the childbearing period.[1] The coefficients estimated for the child death factor generally exceed unity in the nonlinear and loglinear formulations of the model, implying that a lower regional child death adjustment ratio is associated with a sufficiently large reduction in birth rates to reduce the actual number of children likely to survive to age 15 in that region.[2]

The child schooling rate is inversely associated with fertility of all women, except for those aged 45 to 49. The significance of this link and the size of the coefficients for this variable often increase from 1964 to 1968 in the age-specific birth rate equations.[3]

Adult education is weakly related to lower fertility in the first years for which I have regional data on birth rates, 1961 (see Appendix Table J-1), and again in 1966. At the level of age-specific birth rates the relationship vacillates thereafter in sign

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[1]Biologically, child mortality may be linked to the mother's subsequent fecundity if the child is breast feeding and dies while his mother is still subject to postpartum sterility. In this case, the mother ceases to breast feed after the infant's death and her period of postpartum sterility is usually shortened.

[2]This inference assumes that the cross-section differences in birth and death rates continue to hold over time.

[3]To interpret this association for the purposes of policymaking more information is required on what determines interregional differences in school attendance rates. Is it the limited capacity of the school system -- the supply of schooling -- that is restricting attendance? Or is it the willingness of parents to send their children to receive education -- the demand for schooling -- that determines the interregional variation in school attendance rates? The more plausible assumption in the case of Taiwan is that the capacity of school systems constrains the acceptance of students, and enrollment rates reflect the government's educational priorities as well as the differing costs of supplying educational services to communities of differing densities.

and significance from year to year indicating no consistent link between adult education and low birth rates in the period 1964 to 1968.[1]

The local reliance on agricultural employment is positively associated with crude birth rates in 1961 and 1963 and is still weakly related by 1965. But by the time the family planning program had permeated the society in 1966 and 1967, the relationship had reversed. More interesting than the overall effect is the age-specific association. It appears that before the program, birth rates in agricultural regions were distinctly lower among teen-age women and somewhat higher among women over 25 years of age.[2] By 1966 and 1967 there emerges a tendency for birth rates in agricultural regions to be lower among women 30 to 44 in addition to teen-aged women. One obvious interpretation of the changing importance of adult education and agriculture in accounting for fertility patterns in Taiwan is that the family planning program differentially helps the less educated and more remote agricultural populations avert "unwanted" births, for it was principally these groups that were least capable of practicing effective, convenient contraception before the onset of a national program.[3]

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[1]My measure of adult education is seriously deficient: it does not pertain to women of childbearing age, nor is it even adjusted for the substantial regional differences in the age composition of adults. Since younger generations are much better educated than older, regional differences in average adult education measured here may not reflect differences in the schooling of fecund mothers but only indicate differences in age composition caused by internal migration.

[2]With the scarcity of agricultural land in Taiwan, it is plausible that there would be a systematic tendency for marriage and child bearing to be delayed until land ownership or operation were within reach of young men. A similar pattern may be noted in other Asian countries such as Thailand, and this same factor may account for the slower decline in age at marriage in rural compared with urban England during the enclosures and industrial revolution.

[3]This interpretation, however, was directly confirmed only with regard to the greater overall impact of the program in predominantly agricultural regions. See the Statistical Appendix for discussion of interaction terms.

FAMILY PLANNING PROGRAMS BEFORE 1964

Before considering how the large-scale, island-wide Family Planning Program begun in 1964 affected the subsequent level of birth rates in Taiwan, analysis must contend with prior policy efforts to spread family planning that may have had a persisting effect on the regional distribution of birth control knowledge. In about 100 of the 361 administrative regions of Taiwan, public health workers are recorded as having distributed traditional (not IUDs) contraceptives. The only measure available of the regional activities conducted by this program is the number of contraceptive users being served as a percentage of women of childbearing age (15-49) at the start of 1964.[1] Also, an intensive experimental family planning program introducing the IUD was undertaken in Taichung City from February to October 1963, and substantial declines in birth rates in Taichung are attributed to this program, at least in 1964 [5, p. 357]. Lacking precise program data by city precinct, I have introduced a dummy variable in the linear model that is one for the 8 precincts of Taichung and zero elsewhere.

These two measures of pre-program family planning activity are negatively associated with the level of birth rates in 1964 (Table D), but in later years (not reported) they do not exhibit a consistent association with crude birth rates or any age-specific birt rates.[2] The age composition of the pre-program effects on fertilit is consistent with the extensive evaluation of the Taichung experiment [5] in which the program appears to have its most noticeable impact on the birth rates of women aged 35-39 and has a more modest effect among all other women. The traditional contraceptive health

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[1] Contraceptive user records from 1964 were obtained from the records of the Rural Health Chief Dr. S. C. Hsu, of the Joint Commission for Rural Reconstruction.

[2] No regression coefficient for either of the pre-program variables exceeded its standard error except for the age-normalized crude birth rate equation for 1966 when the contraceptor's variable was positive with a t = 1.7.

program exhibits a strong association with lower birth rates among teen-aged women and women over age 30. This is also consistent with my expectations.

THE NATIONWIDE FAMILY PLANNING PROGRAM

From 1964 onward the Family Planning Program's records distinguish three classes of local program personnel: Doctors (MD), family planning workers who are known as Pre Pregnancy Health Workers (PPHW), and Village Health Education Nurses (VHEN). Doctors are trained by the program to perform IUD insertions and are thereafter paid according to the services they render; PPHWs are locally hired women paid entirely by the program to recruit birth control acceptors, principall for the IUD; VHENs are part of a pre-existing health-education-sanitation extension program which shifted its emphasis to devote half of its time to disseminating information about family planning in conjunction with community development activities. A coupon completed by an IUD acceptor and filed by her doctor to obtain part of his fee provides the program with information on who referred the woman to the clinic or doctor. Bonus payments to the PPHW are based, to some degree, on the level of IUD acceptance in her community and the number of her coupon referrals. The VHEN and PPHW currently cost the program about the same amount,[1] and their functions are similar if not exactly substitutable, namely, to promote the acceptance of effective means of birth control in their communities. Program evaluation, therefore, aims primarily at a comparison of the relative and absolute effectiveness of these two classes of field personnel in their implictly assigned task of fostering a local reduction in fertility.

It is more difficult to infer from available statistics how effective doctors have been in achieving a reduction in fertility.

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

The problem is one of measuring the doctor's input and being certain it is independent of other determinants of fertility. Published personnel records of the family planning program indicate only the number of program trained doctors in a region (many in private practice) and not the proportion of their time actually devoted to the delivery of family planning services. Doctors tend to concentrate in urban areas or in high density communities in which education and incomes tend to be above average -- these are areas that typically can best afford the doctors' services. In addition to these socioeconomic factors that influence location of doctors, the local efforts of the program field workers (VHEN and PPHW) to spread information about modern birth control are likely to increase the incentive to doctors to cooperate with the program in order to satisfy the increased demands for modern birth control methods. Treating the number of program doctors in a region as a predetermined program input will, therefore, tend to spuriously attribute to doctors an effect on fertility that is actually due to the activity of local field workers and the socioeconomic characteristics of the community.[1]

RETURNS TO SCALE: THE MARGINAL EFFECTIVENESS OF THE PROGRAM

From 1965 to 1967, the total allocation of both types of field personnel by region is inversely associated with crude birth rates (Tables A-1 and B). However, by 1967 and 1968, the linear approximation of the association between the employment of VHEN or PPHW and

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[1]This problem of treating doctor inputs was neglected in an earlier study of these data by the author [13]. It should be noted that on this score the Path Analysis reported in [5, pp. 329-339] considers doctors in 1964 as influenced by field workers in the same year. According to the correlation matrix estimated in that investigation, crude death rates also affected the doctor ratio as did population density and adult education in the urban areas [5, p. 334]. I am indebted to Rand colleague David Greenberg for urging me to reconsider the manner in which doctors should enter the "reduced form" type equations I estimate. A future study will seek to specify and estimate the determinants of the broader set of simultaneous and jointly determined outcomes, including birth rates, marriage rates, acceptor rates, and doctors' inputs.

the crude birth rate is no longer statistically significant. To determine if changes in returns to scale might account for this weakening of the linear association between program inputs and birth rates, the cubic "production function" is fit to the data (Tables E and F). There appear to be diminishing returns to scale of program activity, particularly in 1967 and 1968, evidenced by the substantial t ratios associated with the higher order terms of the input production functions and by the increased overall coefficient of determination (Table 1)

One interpretation of these facts is suggested in Fig. 5. The slope of the linear regression line (input variable coefficients) decreases sharply in absolute value from 1966 to 1968, and by the latter year the range of observations does not define a linear slope coefficient that is significantly different from zero (that is, there is no apparent impact of program personnel on birth rates). The cubic function, however, more adequately distinguishes the nonlinear returns to scale that occur when the marginal effectiveness of program personnel is much greater in regions where these personnel are relatively scarce than in regions where the program has allocated a greater than average number of field workers.

Nonetheless, even allowing for the cubic production function, the power of program activities to explain interregional differences in fertility declines steadily after 1965. The modest family planning program activity before 1964 increases the explanatory power (R^2) of the environmental model by about 4 percent when analysis focuses on 1964 crude birth rates. The cubic production function of program inputs adds 12 percent to the model's explanatory power (R^2) in 1965, 9 percent in 1966, and 8 percent in 1967, but by 1968 program activities contribute only an additional 2 percent to the overall explanation of interregional variation in crude birth rates (Table 1). In the short span of five years, the regional allocation of family planning activity in Taiwan has ceased to be associated with substantial differences in overall fertility levels across the population

Table 1

PROPORTION OF VARIATION IN BIRTH RATE EXPLAINED BY REGRESSION WITH AND WITHOUT VARIABLES MEASURING ACTIVITIES OF FAMILY PLANNING PROGRAM, 1964-1968[a]

	1964		1965			1966			1967			1968		
	Program Variables[a]		Program Variables[b]			Program Variables[b]			Program Variables[b]			Program Variables[b]		
	Without	With	Without	With Linear	With Cubic	Without	With Linear	With Cubic	Without	With Linear	With Cubic	Without	With Linear	With Cubic
Age normalized crude birth rate	.404	.422[e]	.464	.509[e]	.520[c]	.579	.603[e]	.633[e]	.371	.372	.399[e]	.557	.558	.568[c]
Age specific normalized birth rate														
15-19	.164	.198	.322	.359[e]	.376[a]	.279	.295[d]	.325[e]	.339	.344	.392[e]	.366	.371	.391[d]
20-24	.150	.155	.151	.161	.171	.234	.248[d]	.260	.197	.205	.230[e]	.288	.306[d]	.312
25-29	.098	.100	.271	.280	.281	.358	.370[d]	.378	.326	.329	.350[d]	.208	.208	.234[d]
30-34	.273	.296[e]	.299	.340[e]	.350	.365	.403[e]	.419[d]	.367	.421[e]	.435[c]	.359	.365	.377
35-39	.373	.384[d]	.394	.449[e]	.458	.426	.461[e]	.497[e]	.349	.382[e]	.416[e]	.516	.532[e]	.548[d]
40-44	.280	.304[e]	.307	.344[e]	.355	.394	.422[e]	.450[e]	.301	.344[e]	.395[e]	.478	.496[e]	.507[c]
45-49	.071	.083[c]	.172	.193[d]	.194	.153	.179[e]	.186	.051	.054	.150[e]	.074	.084	.102

Notes:

[a]Two variables represent government activity in family planning before 1964 start of island-wide program: percent of women in childbearing ages (15-49) receiving contraceptives from government health workers and a dummy variable equal to one for the precincts of Taichung City where the intensive pilot family planning program was launched in February 1963 and zero otherwise.

[b]Two program variables measure government activity in family planning after 1963 in the island-wide program: man-months of personnel employed in the region per thousand women of child-bearing age (15-49) by two classes (VHEN and PPHW). In the linear model these variables are considered only in linear form. In the cubic model these variables are considered in linear, squared, and cubed form.

[c]The increase in F ratio for the overall equation when program variables are added is statistically significant at the .1 confidence level.

[d]F ratio test for added program variables significant at .05 level.

[e]F ratio test for added program variables significant at .01 level.

Source: Coefficients of determination (R^2) are from Tables A-1 through A-8, D and E.

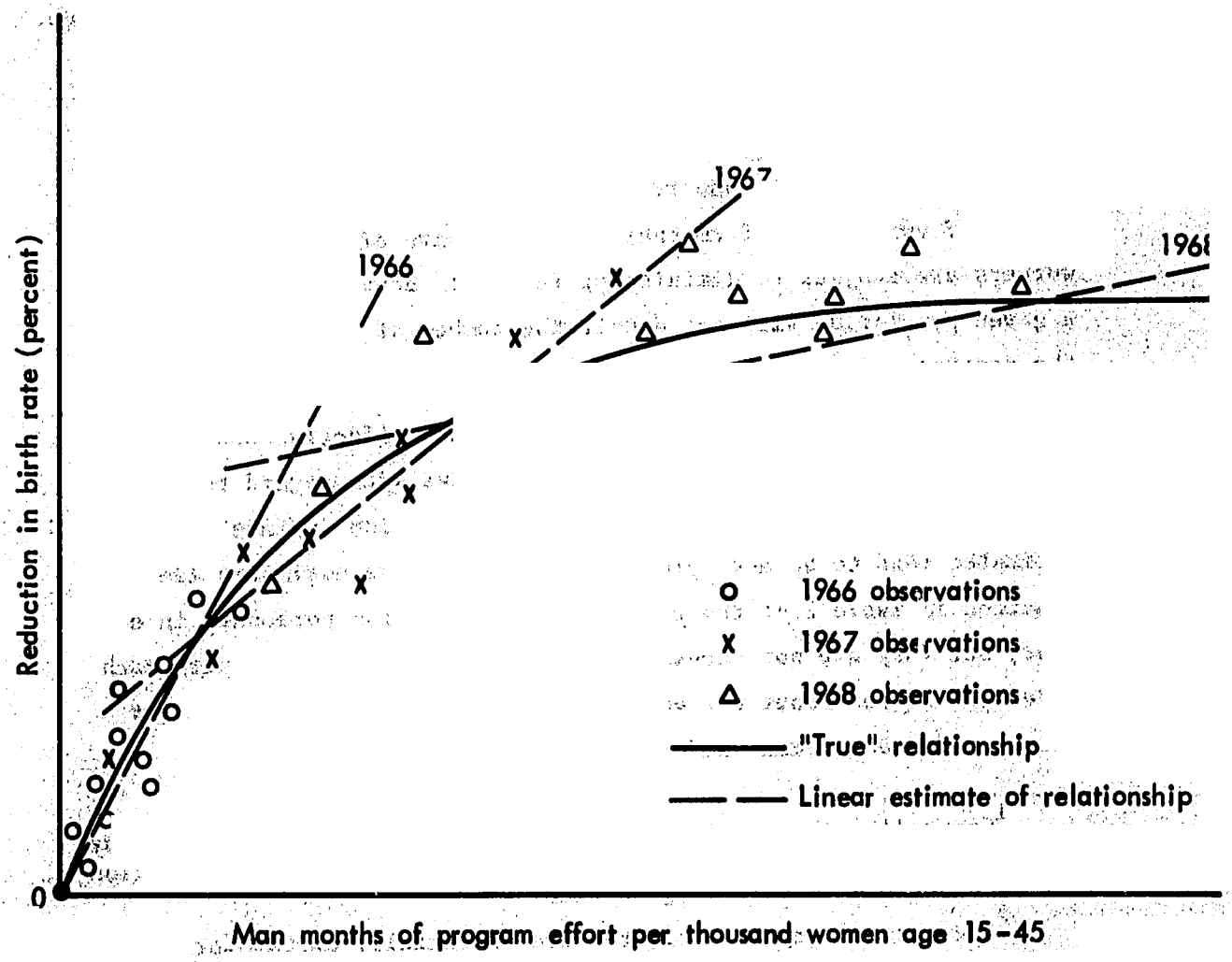

Fig. 5 -- Postulated explanation of regression results

Regardless of whether people live in a region intensively served by the family planning program or not, by 1968 they appear to be about equally successful in regulating their fertility; therefore, further expansion of a family planning program may not reduce the birth rate substantially. Analysis of fertility data from additional years will be needed to confirm or reject this interpretation of incipient trends The marginal effectiveness of of program personnel diminishes from 1965 to 1968 as the program expanded, and in each single year the marginal effectiveness of personnel was relatively lower in regions where program activity was relatively greater. Both independent pieces of evidence confirm that more intensive efforts of field workers are subject to diminishing returns: doubling personnel for a given population will not double the number of births averted by the program.

Not only is the estimate of the marginal effectiveness the correct criterion for incremental policy choices with regard to personnel mix, it is also the slope of the regression surface for which estimates tend to be most precise.[1] Illustrative estimates are also reported in Table 2 of the total impact of program personnel in each year, but they are not necessarily reliable since they require much more information about the entire production function surface for which evidence is scant and of uncertain quality.[2]

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[1]Generally, observations are clustered about the variable means providing the greatest information about the slope of the production function surface in this neighborhood.

[2]These total impact estimates are essentially extrapolations of the regression surface to regions where there has been no program activity. Since very few such regions existed in Taiwan after 1965, and these may have been atypically high fertility areas, the regression surface in this neighborhood is poorly defined or the model is misspecified for these extreme points. For example, political reasons were probably responsible for excluding various aboriginal regions in the central mountains of Taiwan from the early phases of the national family planning program. These areas also have high birth rates that may stem in part from factors omitted in this analysis which could be attributed to the lack of a family planning program When these 20-odd regions are dropped from the cross-sectional sample, marginal effects of the program did not change substantially, but total impact estimates declined.

Table 2

ESTIMATED MARGINAL EFFECTIVENESS AND TOTAL IMPACT OF PROGRAM ON BIRTH RATE[a]

	1964	1965		1966		1967		1968	
	Total[b]	Marginal	Total	Marginal	Total	Marginal	Total	Marginal	Total
Pre-1964 Activity:									
Contraceptors Supplied	.9	.0	0	0	0	0	0	0	0
Taichung City Pilot Program	.2	0	0	0	0	0	0	0	0
National Program Field Personnel:									
Village Health Education Nurse (VHEN)	0	18.	3.0	17.	5.7	8.2	4.7	1.5	0
Family Planning Worker (PPHW)	0	11.	6.3	2.8	7.4	1.4	9.2	.66	4.9
Total Impact	1.1		9.3		13.1		13.9		4.9

Explanation:

To illustrate how to derive estimates of the cost per averted birth from these results, the marginal and average cost-effectiveness of PPHW in 1966 are computed. If one-tenth of a man month of PPHW were employed in 1965 in a region with exactly a thousand women of childbearing age, where previous PPHW effort had been average for the sample (that is, 1.608 man months in 1964 and 1965), it would elicit a further reduction in the 1966 crude birth rate of about .28 percent (that is, .1 times 2.8 = .28, see above). Since 149 births were recorded in Taiwan in 1966 per thousand women of childbearing age, this additional input of personnel which cost the family planning program about U.S.$4.25 [11] would have averted .42 additional births at a marginal cost of about U.S.$10.20 per birth. All past program effort in the region is associated with a 6.6 percent reduction in the birth rate (6.3 plus the additional .28) or would have averted 9.83 births per thousand women. The average cost per averted birth is then about U.S.$7.40. For future policy decisions, the program can only expand or contract at the margin, and thus it is the marginal cost of $10.20 that is relevant to the allocation of further resources.

Notes:

[a]Marginal effectiveness and total impact of program activity is estimated on the basis of the linear age-standardized equation using the cubic production function for program inputs in 1965 through 1968 (Table E) and using the two preprogram variables in 1964 (Table D). See also notes to Table 1.

[b]No marginal effectiveness is computed because of form of pre-1964 program activity variables. In the case of the Taichung City dummy variable, the estimates suggest the program was associated with a 9 percent reduction in age-standardized birth rates, but that when this reduction is averaged across all of Taiwan, it would have reduced the Taiwan birth rate by only .2 percent. See also notes to Table 1.

For example, if the estimates of the marginal effectiveness of, say, the PPHW as reported in Table 2 are translated into the approximate cost of averting a birth, this marginal cost figure increases as the program expands from about U.S.$2.60 in 1965 to $10.20 in 1966, $20.40 in 1967 and to $43.20 in 1968.[1] According to the cubic production function estimated for a single year, say for 1966, age-standardized birth rates (plotted in Fig. 6), if only a third of a man-month of a PPHW's time were allocated to a community per thousand women of child-bearing age during the preceding years of the program (1964 and 1965), an increase in PPHW time of one-tenth of a month would be associated with one fewer birth (approximate cost U.S.$5). If the community had already benefited from the average regional allocation of 1.6 PPHW man months, an increment of two-tenths of a man-month of further PPHW field work would be associated with one fewer birth (cost U.S. $10).

EFFECT OF PROGRAM ON AGE-SPECIFIC BIRTH RATES

Another possible explanation of the weakening relationship between program inputs and the level of crude birth rates emerges from an analysis of program effects on women of different ages. Table 3 summarizes the linear regression coefficients that approximate the average effectiveness of the two classes of field workers on the crude and age-specific birth rates for the years 1965 through 1968. Clearly, the impact of the family planning program's activities is different for different age groups of women; overall, program inputs are most noticeably linked initially to lower birth rates among the youngest (15-19) and older (30+) women where the explanatory power of the regression model increases markedly with the inclusion of the program input variables (Table 1) and the size and statistical significance of their regression coefficients are noteworthy. By 1967 and 1968, however, program inputs are frequently associated positively with the level of birth rates among younger women, and this reversal effect is

[1] It is assumed, according to Robinson's program cost estimates, that the cost per personnel month for either class of field worker is N.T.$1700 or U.S.$42.50. These costs have apparently not changed appreciably as the program expanded from 1964 to 1967. See [11] or Table I, and for derivation of marginal cost figures, see explanation to Table 2.

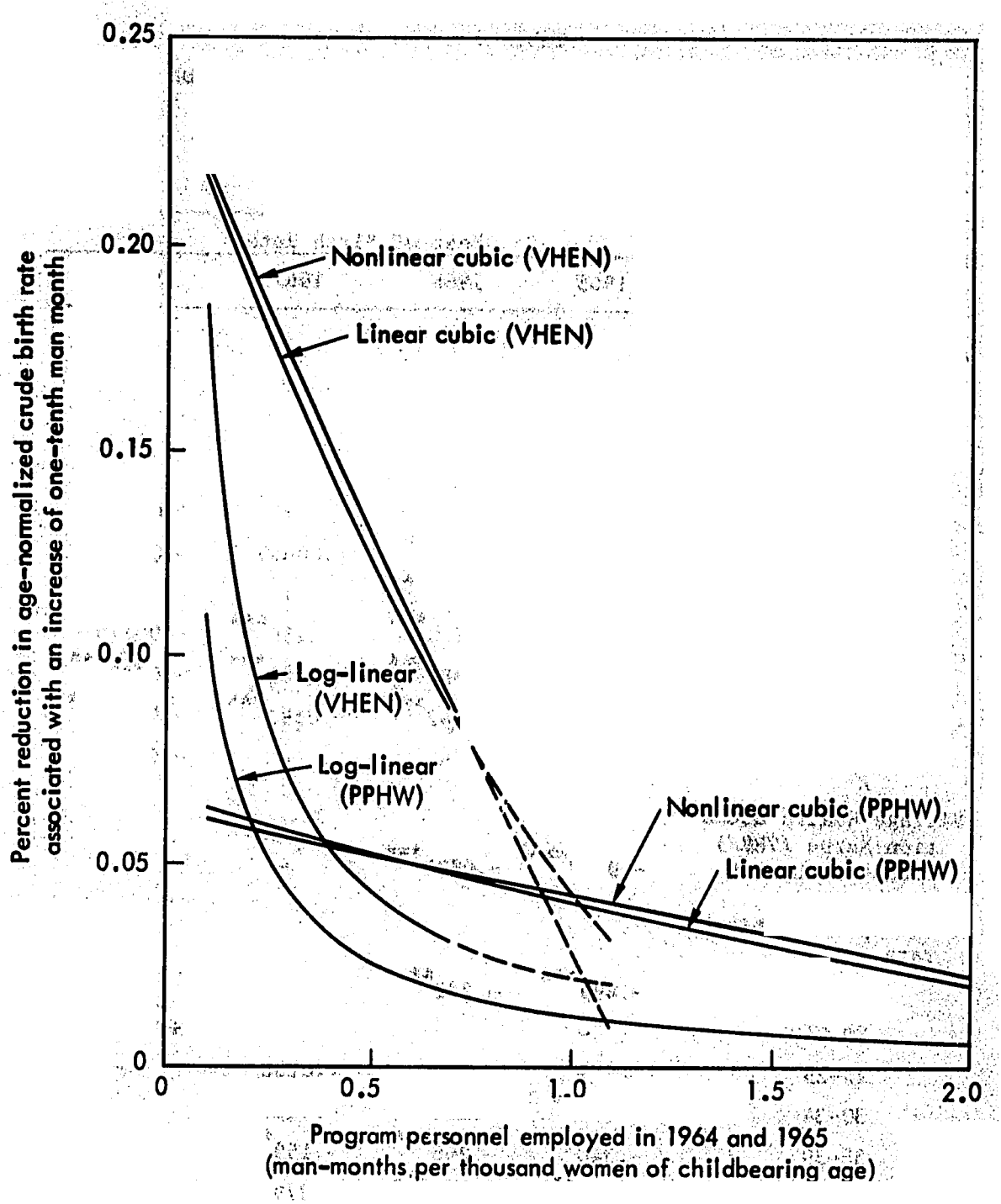

Fig.6—Marginal effectiveness of program personnel in reducing 1966 crude birth rate

Table 3

LINEAR ASSOCIATIONS BETWEEN FIELD WORKER INPUTS AND CRUDE AND AGE-SPECIFIC BIRTH RATES, 1965-1968[a]
(statistical significance of regression coefficients is indicated by asterisks)[b]

Type of Field Worker and Birth Rate	Year of Birth Rate			
	1965	1966	1967	1968
Pre Pregnancy Health Worker (PPHW)				
crude-birth rate	-.0606***	-.00882**		
Age-specific birth rate				
15-19	-.205***	+	+	+.0156
20-24	-.0225*	+.0117**	+.00659*	+.00788**
25-29	-.0149*	-.00802**	+	+
30-34	-.791***	-.0238***	-.0255***	-.00776*
35-39	-.197***	-.0386***	-.0391***	-.0289***
40-44	-.209***	-.0542**	-.0591***	-.0430***
45-49	-.210	-	-	-.0523*
Village Health Education Nurse (VHEN)				
crude-birth rate	-.0967***	-.0831***	-	-
Age-specific birth rate				
15-19	-.499***	-.232**	-.0891	+
20-24	-	-	-	+.0211
25-29	+	-	+.0138	-
30-34	-.124**	-.124***	-.0667**	-
35-39	-.340***	-.268***	-.159***	-.0669*
40-44	-.432**	-.335***	-.279***	-.0955*
45-49	-.949**	-.654***	-	-

Notes:

[a]Regression coefficients from Table A-1 through A-8.

[b]No coefficient reported unless statistically significant from zero at 10 percent level. * -- coefficient significant at 5 percent; ** -- significant at 1 percent; *** -- significant at .1 percent.

particularly noticeable between the employment of PPHWs and the birth rate among women 20 to 24. This positive effect offsets the continued strong negative impact of program personnel on birth rates among women 30 to 49. To confirm this seemingly perverse trend will again require a longer time span of data, but this tentative evidence is consistent with the hypothesis that where reliable birth control methods are understood and accessible, marriage may not be delayed and child spacing may not be practiced more widely -- quite the contrary. Many factors are responsible for the close child spacing that occurs in most low-fertility, high-income, industrialized countries,[1] and there is reason to anticipate that these forces are today emerging in Taiwan, providing mothers with the incentive to concentrate their years of childbearing now that reliable means to control fertility are readily available.[2]

On the other hand, among the prime candidates for family planning assistance, women over 30 that are already likely to have the number of children they want, the distribution of field workers is strongly associated with substantial declines in birth rates. For each tenth of a man-month of VHEN effort per thousand women of child bearing age the 1965 birth rate for women 30-34 is reduced on average 1.2 percent, for women 35-39, 3.4 percent, for women 40-44, 4.3 percent (Table 3). For the VHEN, who were used sparingly in the program, this average impact does not diminish abruptly until 1968. The average effectiveness of PPHWs drops sharply from 1965 to 1966, but thereafter is relatively constant among women 35-39 (Table 3). When the cubic production function is fitted to the input variables predicting age-specific birth rates the pattern of diminishing returns reemerges strongly (Table E, plotted in Fig. 7). In 1966, for example, one-tenth of a man-month of PPHW activity per thousand women of childbearing age is

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[1] With increased educational opportunities for women in Taiwan and their growing role as members of the labor force, the time a mother allocates to forming a family has an increasingly high opportunity cost. One response to this change in the relative value of a mother's time is to space her children relatively close together.

[2] Another explanation of this phenomenon would be that the rise in birth rates for young women in 1968 is an "echo" effect of their having adopted birth control from the program in earlier years to delay or space births.

associated with a 1.64 percent decline in birth rates among women aged 35-39 if only half a man month had been previously allocated to the group. If the national average program allocation of 1.6 man-months had served this group, the marginal impact of an additional tenth of a man-month would be to reduce the birth rate only .97 percent. As shown in Fig. 7 the marginal effectiveness schedule of PPHWs on the birth rate of women 35 to 39 has not diminished unambiguously from 1966 to 1968, but on the contrary has remained quite stable as cumulative program inputs have increased and traced out new portions of the production function

The relative age-specific impact of the two types of field worker is more complex and must be regarded as tentative given the unequal reliance on these two classes of personnel. Among the youngest (15-19) and older women (35+) the VHEN is on average and at the margin more effective in lowering birth rates than is the PPHW, although this is less certain in 1968 when the VHEN is no longer an important factor in the program.[1] The PPHW, on the other hand, is on average more effective in 1965 among women 30 to 34. The PPHW is trained in the family planning program to systematically contact and recruit mothers in their thirties with a recently recorded birth, whereas the VHEN is taught to disseminate the principles and practices of public health, sanitation, hygiene, home economics, and family planning to the entire village population; therefore, the observed pattern of differing age-specific effectiveness of these two classes of field worker is plausible.

TOWARD AN OPTIMAL MIX OF PROGRAM PERSONNEL

The VHEN are relatively more effective at the margin of their employment in the program than the PPHW in reducing the crude birth

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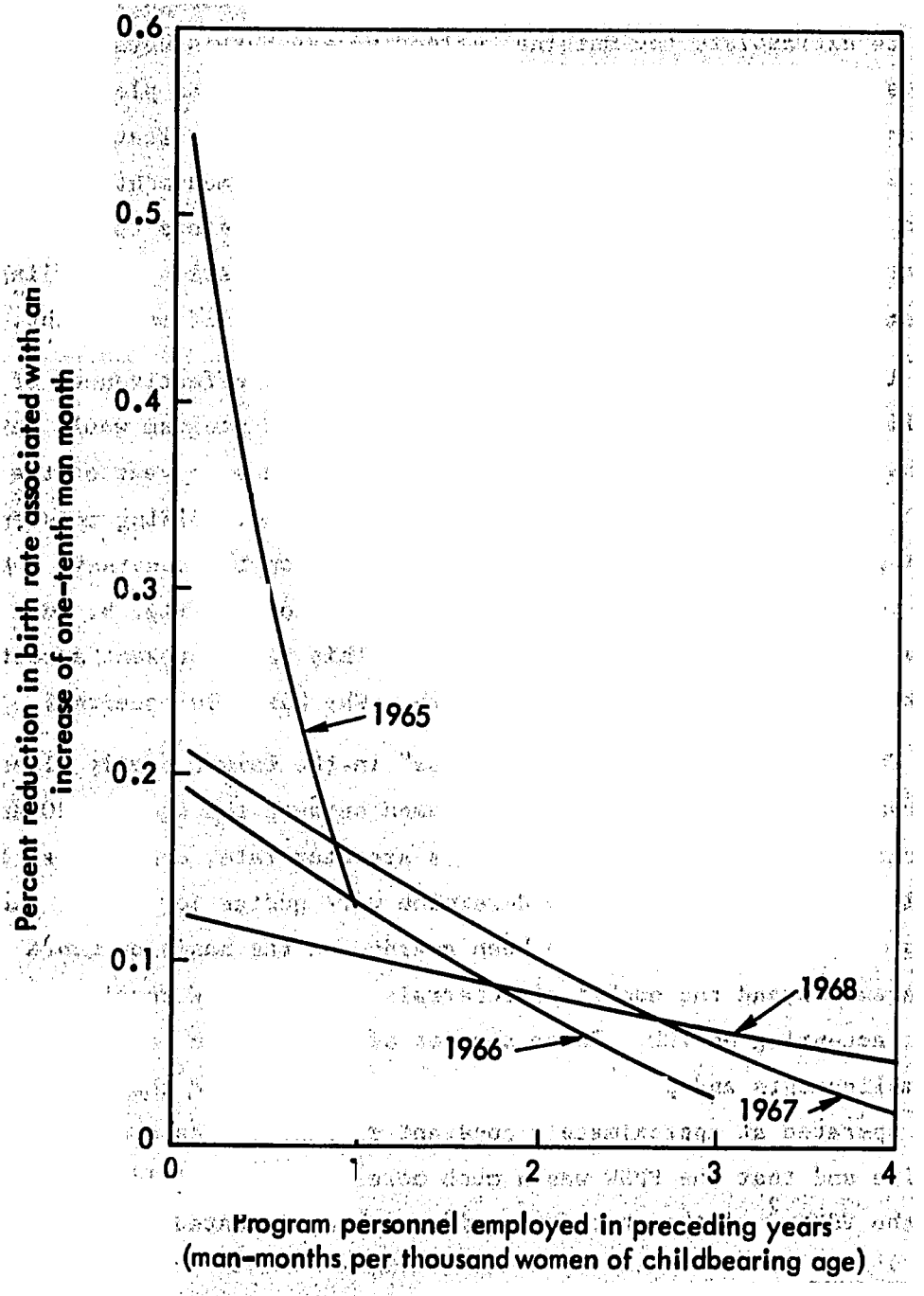
[1]These generalizations are supported by the relative size of (statistically significant) regression coefficients from the linear approximation of the production function (Table 3 in which average and marginal effectiveness are assumed equal) and by the relative average and marginal effectiveness of the personnel inputs evaluated at the average input level for the national sample based on the cubic production function estimates (Table E).



Source: Table E-1

Fig. 7—Marginal effectiveness of PPHW in reducing birth rates among women aged 35 to 39

rate in every year, 1965 through 1968 (Table 2). Though it is hazardous to extrapolate the marginal effectiveness curves beyond the solid line segment where observations are clustered, such as plotted in Fig. 6, it nonetheless appears that regardless of model specification VHENs who were employed for an average of about one-quarter man-month up to 1966 could have been employed for fully one man-month before their marginal effectiveness would have been driven down to the levels prevailing, on average, for PPHWs who were employed one and one half man-months.

If these estimates of the relative marginal effectiveness of these two field workers are approximately correct, the program would have had a substantially greater impact on birth rates in each year of the program if more VHENs and fewer PPHWs had been hired, holding constant total program expenditures. The program has, on the contrary, over time increased its reliance on the PPHW, as shown in Fig. 8, and begun to remove VHENs from the program. This may represent a costly departure from optimal staff structure. Why has this occurred?

The principal measure of "success" in the Taiwan family planning program has been the percentage of women between the ages of 20 and 44 accepting an IUD insertion.[1] This acceptor rate, computed at the local level, has been used to determine work quotas for PPHWs, and bonus incentive payments have been awarded on the basis of quota achievements and the number of referrals a local PPHW receives from women accepting an IUD. These sources of information on program accomplishments and personnel effectiveness suggested that the program operated at approximately constant returns to scale as it grew in size and that the PPHW was a much more effective field worker than was the VHEN.[2] Although recent evidence has indicated that <u>referral</u>

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[1] It may be that IUD insertions are only "counted" if they are performed by a program-trained doctor who centrally filed a coupon for his fee reimbursement. This conceivable source of bias and underenumeration of IUD acceptances is not discussed in published statistics or program literature.

[2] See, for example, Robinson's estimates which suggest the average cost of an IUD insertion did not rise markedly in the Taiwan program in the first several years of program expansion [11]. See also Table I.

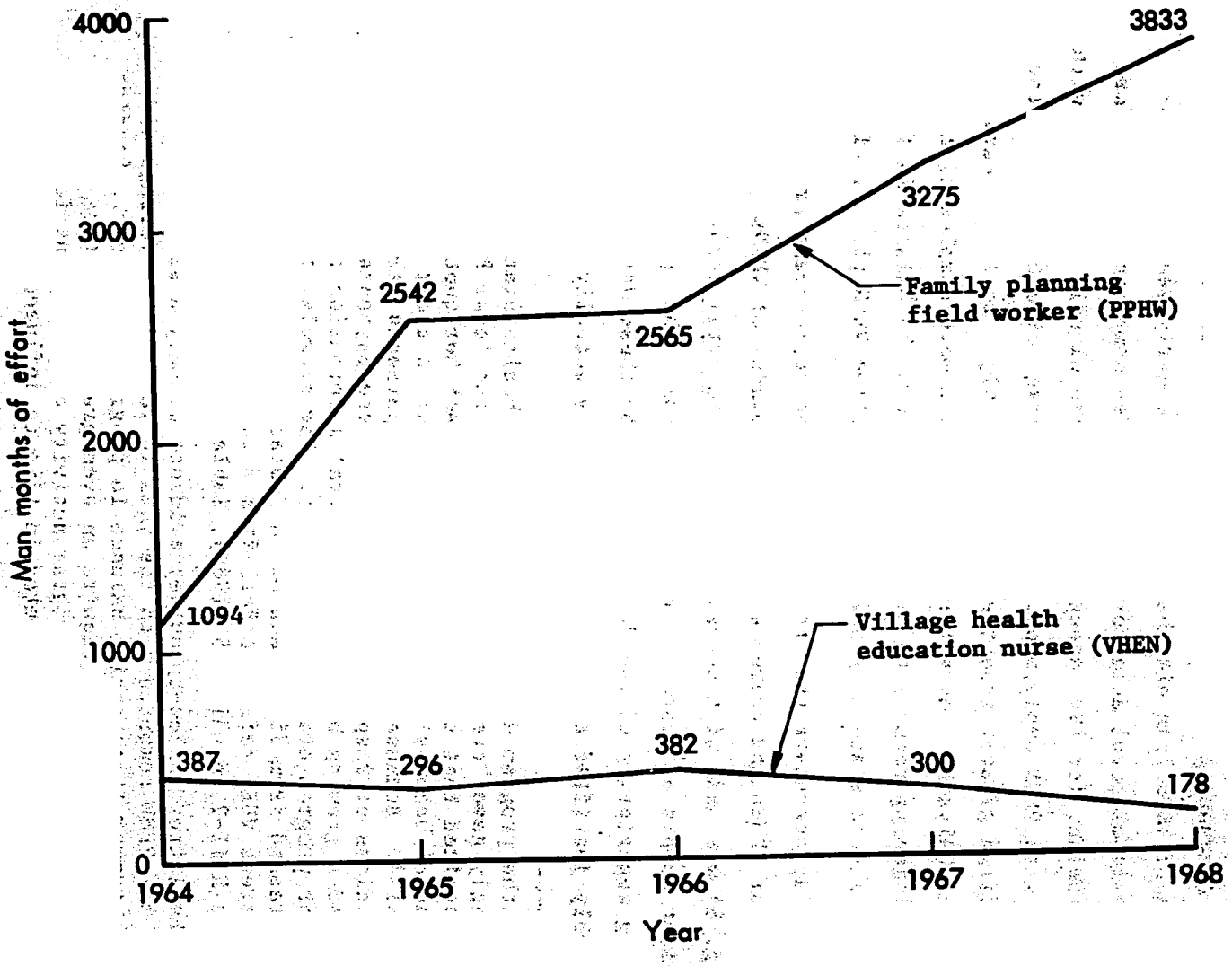

Fig. 8 — Personnel employed in family planning field program: Taiwan, 1964-1968

information became increasingly biased in favor of the PPHW (because of the differential incentives),[1] a follow-up survey of IUD acceptors conducted in 1966 confirmed that acceptors report the PPHW as their primary source of information on the IUD eight times as often as they report the VHEN [5, p. 318]. Since only six times as many man-months of PPHW as VHEN were employed in the program through 1966, the PPHW exhibited somewhat greater average effectiveness in fostering the acceptance of IUDs than did the VHEN in these early years. Regression analysis of local acceptor rates provides some confirmation for this conclusion, for 1964 acceptances are more closely associated with PPHW than with VHEN employment, with the average effectiveness of the PPHW one-fifth greater than the VHEN [13, p. 41]. In later years, regression analysis of acceptor rates paints a more complex picture, where diminishing returns to program scale turn the balance in favor of the more scarce and marginally more effective VHEN [13, p. 41].

One may speculate that the decision made to increase program employment of PPHWs and decrease program employment of VHENs (as shown in Fig. 8) was made with access only to the referral information from the first couple of years of program operation. The apparently overwhelming superiority of the PPHW indicated by these data would have reasonably justified the employment decisions actually made.[2]

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[1] As the program developed, doctors and health station workers increasingly gave "credit" for referrals to the local PPHW, for they recognized that this would help her reach her quota (and receive her financial bonuses) while having no effect on their status [5, pp. 316-317]. Because the bonus incentive payments were awarded to only one class of responsible personnel, these payments apparently introduced a growing bias in the referral information that was intended for program evaluation purposes. For example, the PPHW referrals increased from 36 percent of the total in 1964 to 62 percent in 1968, whereas VHEN referrals fell from 7 to 3 percent in this period [5, Table XIII-2, p. 317; 15 (1968), Table 12, p. 16].

[2] The latter follow-up survey evidence of only a slight superiority for the PPHW compared with the VHEN in receiving referrals did not, however, temper the changing balance in program employment. Studies of the sort reported here require an even greater lead time because they rely on the effect of program activity on subsequent fertility and could not have been completed in time to influence hiring policies until 1967, at the earliest.

A sharply contrasting image of the relative effectiveness of field personnel emerges when a broader and, I would argue, more appropriate measure of program "success" is adopted -- namely, the program's contribution to reducing the birth rate. As observed earlier, both the marginal and average effectiveness of the VHEN to reduce birth rates exceeds that of the PPHW from the first years of the program. Possible reasons why personnel exhibit very different records of "success" in promoting IUD acceptances and obtaining IUD referrals on the one hand, and in facilitating the fall in birth rates on the other, may be found in the type of training and orientation these two classes of workers received and in the different incentive systems under which they functioned.

V. SOME UNANSWERED QUESTIONS

Evaluation of population programs involves the resolution of two issues. For a given level of effort, which of alternative programs is most effective? Also, what level of overall effort is warranted given the importance of the problem and the effectiveness of the preferred program strategy? This study has addressed the first issue, which will provide the necessary framework for analyzing the second and more difficult question of global evaluation. If one shares the view that expenditures on population policies and programs internationally are not yet approaching optimal levels, consideration of this second issue can be postponed.

The actual empirical problems of evaluation of population programs are similar to those encountered in the evaluation of most welfare programs: Measures of the value of program output are unsatisfactory, and the process of relating program inputs to program outputs is not known with certainty. To simplify the task here, I approximated program output by its effect on the birth rate and used multivariate statistical techniques to measure the independent effect of program activity and of other forms of social and economic forces on actual birth rates.

In this important area of social policy, it is disconcerting that different approaches to evaluation yield different conclusions with regard to the overall impact of the program, changes in returns to the scale of program activity, and the relative effectiveness of various classes of field workers. More research will be needed to determine the reasons for these differences in policy conclusions, but plausible explanations for these inconsistencies imply a number of guidelines for policy formulation and program evaluation.

First, analysis of intermediate outcomes in a family planning program, such as the number of IUD acceptors served, may not accurately reflect the final impact of the program on birth rates, especially when various workers receive different incentives for disseminating intermediate products. There is an obvious need to focus more analytical

study on what social and economic forces account for existing patterns of fertility in order to isolate the contribution of population programs to the reduction in birth rates. It must be recognized, however, that this approach requires more lead time than may be available for some policy decisions.

Second, day-to-day information on the functioning of the program should be drawn from unbiased sources to improve short-run policy making and to assure that these operational guidelines approximately coincide with those derived from necessary long-term studies of the program's impact on birth rates. Incentives built into the organizational structure of the population program must be aligned to motivate individuals to accomplish the objective of the program, or in this case to increase the effectiveness of contraceptive practices of the population and convince them of the value and safety of modern birth control methods. The emphasis initially placed in Taiwan on a single contraceptive method, the IUD, as the principal basis for record keeping, program evaluation, and field staff remuneration may have excessively discounted the role of other birth control methods. If demands for all forms of birth control had been monitored, whether they were satisfied within or outside of the program, a different image of program success might have emerged at an earlier date.[1]

Third, a potential problem with the analysis of nonexperimental data is that statistical associations between treatments (levels and mixes of program activity) and outcomes (levels of birth rates) may not denote cause-and-effect relationships. The geographical distribution of program activity in Taiwan may parallel some social forces that were neglected in an evaluation design, such as that

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[1]Greater reliance on the marketplace for dissemination of birth control services and supplies might increase the effectiveness of programs and provide the means for monitoring demand satisfied through the market. For example, field staff might offer potential clients discount vouchers that had cash value to a doctor or contraceptive supplier equal to the public sector program costs of providing that particular service or good. Great caution must be exercised, however, when any such incentive scheme is used in order to determine precisely how these payments bias the flow of information about the program's success. Many such schemes have been used in experimental form in Taiwan, but they are far too rare in other programs.

used here.[1] If these forces were themselves responsible for variation in birth rates, this effect might be spuriously attribted to program activity.

It would be advisable, therefore, where it did not compromise the objectives of the program to plan the geographic distribution and mix of program activities with the aid of some random selection process. For example, the same total expenditure per capita could be allocated to each region, but the decision where and when to build and staff schools or health or family planning facilities would be independent of other community characteristics. Eventually, all communities would have all facilities, but in the interim this mode of advanced planning would permit the unbiased evaluation of the effects of each program on fertility, as well as related decisions of individuals and households regarding migration, marriage, labor force participation, and schooling.

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[1] Table H-4 shows that the simple correlations between the regional allocation of program field workers and socioeconomic variables in the model are not substantial, but the associations between doctors (MD) and agricultural composition and adult education are greater, as anticipated earlier. Freedman and Takeshita also suggest that their two (program) input variables (doctors and combined field worker total) are not very strongly correlated with the non-program variables they analyzed in relation to the regional pattern of IUD acceptances [5, p. 327].

VI. SUMMARY AND CONCLUSIONS

The problems of evaluating population programs are not easily resolved; indirect inferences or arbitrary assumptions cannot be avoided at one stage or another for there are unobserved links in the complex chain of events that relate policy instruments to ultimate policy objectives. I have argued in this report that the tenuous link between the distribution of family planning services and the resultant decline in births must be subject to scientific verification if the evaluation of population programs is to be improved.

The approach adopted here has been to observe births directly and develop a conceptual and statistical framework within which it should be possible to obtain unbiased estimates of the average, and more important, marginal effects of program activities on birth rates. The policy conclusions drawn from this methodology in the case of the family planning program in Taiwan differ systematically from those derived from other approaches. The program's initial impact on the birth rate in 1966 and 1967 appears to have been large than previously estimated, but the program has also been subject to sharply diminishing returns as increased personnel were applied to reducing the birth rate. Although this analysis does not indicate why the program's impact has been so substantial or transitory, it may be due to the initial innovative effect of birth control information disseminated by the program's field staff; it is clearly not entirely a consequence of the acceptance of the particular contraceptive (IUD) emphasized by the program.

Strong evidence is found for the importance of the constraints and opportunities of the parent's environment (schooling rates and child mortality) in explaining parents' diminished birth rates. Without changes in the family environment it is doubtful whether the program would have reduced the birth rate as substantially as it did.[1] In some countries, promoting the changes that bring about the increased

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[1] More evidence on this point is presented in the Statistical Appendix.

demand for family planning can be as important as answering this demand with a well structured, carefully evaluated supply of family planning services. Priorities in the public sector among health, child nutrition, education, and family planning programs may, therefore, appropriately differ from country to country. One should not overlook the fact that very few countries with the per capita income of Taiwan have invested as heavily in public health and education; these policies are presumably responsible for a large share of Taiwan's notable decline in child mortality and rapid rise in school enrollment.

As family planning programs the world over sharply reduce the number of "unwanted" births due to ignorance and accident, it is becoming increasingly evident that there are numerous ways by which governments can influence the relative attractiveness to parents of having many versus few children, and thus governments can indirectly influence the number of offspring parents want.

Three major opportunities for policy to affect reproductive motivations have thus far been identified in this and other Rand studies. The first strengthens the child's position in the family by compelling school attendance and prohibiting his early labor force participation, thereby inducing parents to invest more heavily in the future of each of their offspring. The second increases the woman's economic opportunities to perform functions that are competitive or incompatible with childbearing. The third reduces infant and child mortality and thereby reduces the number of births required to provide parents with their desired number of surviving offspring.

An important task for empirical research not attempted here is to determine the extent to which public policies can accomplish these changes in family setting and effectively foster the desired changes in reproductive behavior. The contribution of direct and indirect population policies must be documented, and their side effects, both good and bad, assessed. This information is needed to enable society to make an intelligent choice of the policies that are most equitable in narrowing the apparent divergence between private and social interests in having children.

To apply cost effectiveness evaluation techniques to alternative policies that seek to change birth rates, whether by direct provision of birth control information and services in a family planning program or by indirect emphasis of policies that promote the adoption of a smaller family size goal, one needs a comprehensive theory of the principal determinants of fertility. Although such a theory is in its early stages of development, it is far enough along to see that it is very much worth pursuing both conceptually and empirically. If agreement can be reached on how to measure the independent effect of family planning programs and other indirect population programs on slowing population growth, much improved information and management techniques could be applied to increase the effectiveness of these population policies. The notion that fertility and population growth obey Malthusian laws and are not amenable to the self-interested behavior of parents is a counterproductive myth that denies the need for a supporting theory of fertility and impedes our better understanding of the motivations for reproduction and their important implications for policy.

STATISTICAL APPENDIX

ALTERNATIVE MODEL SPECIFICATIONS

Equation (1) on page 12 expresses the relationship between birth rates and environmental and program input variables. Three functional specifications of this equation are estimated to judge the sensitivity of policy conclusions to these alternative functional forms. Linear and nonlinear regression estimates of the parameters to the fertility and family planning model represented by Equation (1) are presented in the tables that follow. Symbols are defined in the next section.

Linear Model

The simplest formulations of the model assume each variable exerts its influence on birth rates in a linear and additive form, without any interaction or nonlinearities:

$$B_t = \beta_0 + \beta_1 D_{t-3} + \beta_2 S_{t-3} + \beta_3 E_{t-3} + \beta_4 A_{t-3} + \beta_5 V_{t-1} + \beta_6 P_{t-1} \qquad \text{(a1)}$$

Regression results for this specification for all age specific and age standardized birth rate equations are shown in Tables A-1 through A-8 and D.

Cumulated inputs to the family planning program, however, are not likely to elicit a constant level of effect on birth rates as time passes and the program expands relative to the population it serves. Therefore, the program input variables are introduced into the linear model as an unrestricted cubic polynomial function, where independent parameter estimates are obtained for the linear, squared and cubed values of the input variable. This formulation permits one to determine whether there is statistical evidence of changes in returns to scale of local program activity:

$$B_t = \beta_0 + \beta_1 D_{t-3} + \beta_2 S_{t-3} + \beta_3 E_{t-3} + \beta_4 A_{t-3} + \beta_5 V_{t-1} + \beta_6 V^2_{t-1} + \beta_7 V^3_{t-1} + \beta_8 P_{t-1} + \beta_9 P^2_{t-1} + \beta_{10} P^3_{t-1} \qquad \text{(a2)}$$

This form of the model is estimated for all birth rate equations and the results for β_2 through β_{10} are shown in Table E.

Nonlinear Model

If it is assumed that parents systematically frame their reproductive goals in terms of wanting a specific number of children to survive to adulthood, then there is reason to expect a multiplicative relationship to exist between the reciprocal of the child survival probability (or death adjustment ratio) and the environmental constraints and opportunities that influence the number of surviving children parents on average want. The environmental variables that are thought to influence parents' family size goal are often approximated for an individual couple by a binary variable -- for example, the husband is employed in the agricultural labor force or he is not. For a community birth rate the explanatory variable thus becomes an average characteristic, in this case, the proportion of adult males employed in agriculture. Since it is hypothesized that reproductive behavior differs, on average, by a particular amount between the two groups, this aggregate variable should enter linearly into the desired surviving family size function, which is in turn multiplied by the child death adjustment ratio.

The death factor is also raised to an exponent which is not restricted to unity, for parents may systematically overcompensate or undercompensate for the incidence of child mortality. For example, if parents not only compensated for the expected incidence of child deaths but also hedged by having additional children under a regime of heavy child mortality, this exponential term would increase. If, on the other hand, parents were slow to recognize and react to the decline in child mortality this exponential parameter would decrease.

How to treat family planning program input variables in this functional form is unclear; they might logically be viewed as arguments influencing the size of surviving family parents want, or they could be viewed as independent of child death rates and independently determining the number of "unwanted" children parents have. Both extreme alternatives yield similar results, but the second approach is adopted in this report. The nonlinear model is initially

estimated assuming a linear relationship between program inputs and birth rates.[1]

$$B_t = D_{t-3}^{\beta_1} \left\{ \beta_0 + \beta_2 S_{t-3} + \beta_3 E_{t-3} + \beta_4 A_{t-3} \right\} + \beta_5 V_{t-1} + \beta_6 P_{t-1} \qquad \text{(a3)}$$

These results are summarized only for the age-standardized birth rate equation in Table B. Program input variables are added in squared and cubed form to obtain the cubic production function estimates for the family planning program in the regressions reported in Table F. As shown in Fig. 6 the linear and nonlinear model estimates with the cubic production function for the family planning program yield very similar results. To reduce computation costs subsequent experimentation is based on the linear approximation of the cubic model.

Logarithmic-Linear Model

The simplest production function drawn from the economic literature is of the Cobb-Douglas type. This functional specification has the attraction of allowing for multiplicative interactions among varibles, which seems appropriate with regard to the child death adjustment ratio. It also implies diminishing returns to scale of each type of program activity and unitary elasticity of substitution between activities. On the other hand, the extremely rigid form of the variable interactions do not recommend this formulation where the ratio of input variables is volatile. Moreover, since the agricultural variable and the program input variables are zero in some regions, and the logarithm of zero is undefined, an additional parameter, δ, was estimated by nonlinear regression techniques.[2] Alternative values of δ

[1] Because this functional specification of the model cannot be expressed in a form for estimation that is linear in parameters, several nonlinear estimation programs were used. The final estimates reported below (Tables B and F) are derived from the Nonlinear Parameter Estimation and Programming package by Yonathan Bard for the IBM computer facility by K. M. Maurer and D. Weinschrott.

[2] For example, the value of δ estimated for the 1966 age standardized birth rate was .03. Between .01 and .001 no appreciable effects in relative coefficient sizes or significance were noted.

modify the pattern of diminishing returns implied to program inputs, but does not change their rankings at the margin. For simplicity, the value of δ is assumed to be .001 and this amount was added to all program input and agricultural variables. Ordinary least squares was then used to estimate the loglinear model of the following form:

$$B_t = \beta_0 D_{t-3}^{\beta_1} S_{t-3}^{\beta_2} E_{t-3}^{\beta_3} (A_{t-3} + \delta)^{\beta_4} (V_{t-1} + \delta)^{\beta_5} (P_{t-1} + \delta)^{\beta_6} \quad (a4)$$

The regression results are shown in Table C. Figure 6 suggests that the loglinear model is more rigid in its restrictions on the relationship between fertility and program inputs, but it nonetheless implies the same ranking of input productivities as did the linear and nonlinear models.

First Differenced Model

If it were assumed that many regionally stationary factors are responsible for many of the differences across regions in fertility, and these factors were too numerous or too difficult to measure to include in the equation predicting fertility, first differencing the predictive equation should eliminate the regional -- or level -- effects that are due to the stationary factors. The remaining systematic changes in fertility over time are assumed to occur in response to changes in the environmental factors and changes in program activity. The same model can be used to approach problems of measurement error where the underenumeration of births, for example, differs by region but is constant over time within regions. The specification of the dynamic lag structure implicit in the model is put to a more severe test by this reformulation of the model in terms of first differenced variables. This specification assumes that all the influence of the explanatory variable is captured in its recent change rather than its past level and changes. Clearly in the case of fertility determination, past levels of child schooling are important for current fertility choices just as are current levels of child schooling, and the first differenced model by focusing only on contemporaneous changes in variables over a short span of three to five years neglects much of this persistent influence of included environmental variables. The

age-specific model estimated and reported in Table G is based on the following formulation derived from the simple linear model.

$$\frac{B_{1968} - B_{1964}}{B_{1964}} = \beta_0 + \beta_1 \frac{D_{1965} - D_{1961}}{D_{1961}} + \beta_2 \frac{S_{1965} - S_{1961}}{S_{1961}}$$

$$+ \beta_3 \frac{E_{1965} - E_{1961}}{E_{1961}} + \beta_4 V_{1967} + \beta_5 P_{1967} \qquad \text{(a5)}$$

BASIC VARIABLE DEFINITIONS

Variable means, standard deviations, and zero-order correlations are reported in Tables H-1 through H-4. General descriptive data on the family planning program are reported in Table I, and variables are defined below.

B_t: Birth rate in year t, normalized by national birth rate in specific year and standardized for age/sex composition in the case of the crude birth rate [14].[1]

D_t: Reciprocal of the child survival probability from birth to age 15 in year t [14].[2]

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[1]The Census in December of 1966 is thought to have caused a bunching in birth registrations in late 1966, and thus an over-statement of birth rates in 1966 and an understatement of birth rates in 1967. The adjustment factor has been estimated as about 3 percent [14 (1966)]. Since there is no obvious way to determine how to distribute this bunching of births at the local level, the unadjusted figures are used here. The adjusted data appear to be merely averaged from year to year, which would eliminate potentially significant variations across regions and over time in the timing of births. Caution should therefore be observed if coefficient signs vacillate from 1966 to 1967.

[2]This variable is derived from published mid year population and deaths by age data by local administrative unit for 1961 and 1963 through 1967. For 1962 local Chinese sources for the number of deaths by age were obtained for about two-thirds of the administrative regions. To check the reliability of these data, the child death rates implied by these data for 1962 were regressed on the child death rates

S_t: Proportion of persons enrolled in school over age 11 of the number of children 12 to 19 in year t. Observations in 1961 and 1965 are used to linearly interpolate estimates for intervening years [14]

E_t: Proportion of adults over age 12 that are no longer in school who have completed a primary education in year t. Observations in 1961 and 1965 are used to interpolate linearly estimates for intervening years [14].

A_t: Proportion of male labor force employed in agriculture in year t. Observations in 1961 and 1965 are used to interpolate linearly estimates for intervening years. [14].

V_{t-1} Number of man month of Village Health Education Nurse's time allocated to the family planning program through year t-1 per thousand women in the region between the ages of 15 and 49 [15].

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derived from published sources for 1961 and 1963. The following relationship was obtained by ordinary least squares:

$$d_{1962} = \underset{(9.31)}{.658}\, d_{1961} + \underset{(5.48)}{.449}\, d_{1963}$$

$R^2 = .456$ number of observations is 236

where d is the death rate for children from birth to age 15, and t statistics are reported below each coefficient in parentheses. In those instances where death rates for the two adjoining years did not predict well the 1962 derived death rate, further investigation led us to accept unusually high 1962 death rates from several areas (e.g., Kao-Hsiung and Hua-Lien Hsien) where health teams were dispatched during the fall 1962 cholera epidemic. Four observations of unusually low 1962 death rates were rejected as implausible and probably due to coding or copying errors. The above estimated relationship was then used to predict an interpolated value for the child death rate in 1962 for the 129 administrative regions for which I had no satisfactory direct information. The 1962 child death adjustment variable is, therefore, a hybrid of observed values and interpolated values where the weights for interpolation were estimated from the observed portion of the sample.

P_{t-1}: Number of man months of Pre Pregnancy Health Worker's time allocated to the family planning program through year t-1 per thousand women in the region between the ages of 15 and 49 [15].

EXPLORATION OF VARIANTS OF SIMPLE LINEAR MODEL

Length of Environmental Lag

The child death adjustment ratio is included in the model lagged two, three, and four years to estimate the intensity of the lagged relationship to birth rates over time. The parameters are reported in Table J-2 for the age-normalized birth rate equations. The strongest association occurs with a four year lag in 1965, with a three year lag in 1966 and 1968, and with a two year lag in 1967. The correlation of birth and death rates with any specific discrete lag is clearly subject to much variation from year to year. Although this time series is too short to support firm conclusions, it suggests that the most appropriate discrete lag is that of three years. Across age specific birth rate equations, the three year lag is also generall strongest for teen-age women and women 30 years and older, but the two and three year lags proved about equally significant in accounting for variation in the birth rate among women 20 to 29.

Distributed Program Lags

Program personnel inputs were considered with the intention of estimating a distributed lagged relationship between these program inputs and subsequent birth rates. Initially each year's program inputs were introduced as separate explanatory variables but the results did not fall into place. Program inputs for 1964 and 1966 tended to be more strongly associated with the level of birth rates in subsequent years than were inputs in 1965 and 1967. The inputs were not associatec with birth rates in the same year, but inputs lagged one, two, or three years accounted for about the same fraction of the variation in birth rates with substantial differences across years and age groups. The cumulative inputs to the preceding year performed as well as arbitrary

but plausible lag structures that placed heavier weight on year t-1 and t-2 than on t-3 and t-4.

Pooling four cross-sections for 1965 to 1968, analysis of age-normalized crude birth rates yielded separate lagged program input coefficients that behaved more regularly, diminishing after a lag of one year. Assuming an exponential decline in the effectiveness of past program activity, as is implied, say, by the studies of the expected life of IUD insertions [6], the input variable was defined as follows:

$$I_t = \sum_{j=1}^{\infty} M_{t-j} (1 - \delta)^{j-1}$$

Incorporating these input variables into the basic fertility equation, nonlinear estimating procedures suggested a value for δ of .3, but the standard error for this parameter estimate did not inspire confidence in its significance.

Interaction Effects

A number of hypotheses bearing on interaction among fertility, program activities, and environmental change were examined in detail for Taiwan but are only summarized here. Adding interaction terms to the basic linear model is the typical mode of hypothesis testing.

It seems likely, when more than one input to the family planning program is analyzed, that the marginal productivity of one would not be independent of the amount of others used in the same locality. Two polar alternatives are encompassed in the models estimated; the elasticity of substitution between the two field worker inputs is assumed equal to zero in the linear and nonlinear models and equal to one in the loglinear model. The inadequacies of the rigid loglinear formulation are noted. The addition of an interaction term defined as the product of the two input variables (V·P) should be positively related to birth rates if one input substitutes for the other, driving down its marginal product.[1] When this variant of the

[1] For example, assume the equation estimated is of the form:

$$B = f(D,X,Y,Z) + \beta_1 V + \beta_2 P + \beta_3 VP,$$

then the marginal effect of V on B is

model is estimated for 1966 age standardized and age specific birth-rate equations, the parameter estimate for the interaction variable vacillates in sign and is not significantly different from zero. Thus, contrary to expectation, there does not appear to be much substitutability between the two types of field workers studied here.

Another line of reasoning suggests that additional features of the environment and the population would influence the effectiveness of field workers as well as influence the number of births parents might want. For example, it was anticipated that parents in the rural-agricultural areas of Taiwan would have less adequate sources of information about modern birth control than those living elsewhere before the family planning program. Therefore, birth rates in these rural areas would be more responsive to family planning program activities, for the services provided by the program would be scarcer and more "costly" to obtain in these more remote rural regions.

Interaction terms were, therefore, defined as the sum of the man months of program activity multiplied individually by the four environmental variables: child death, child schooling, adult education, and agriculture. The program inputs were more effective in 1966 in regions that were preponderantly agricultural, exhibited low child mortality, and had a high proportion of children in school. No clear link was found to adult education, although I anticipated that the program would have been more effective among less educated segments of the population for much the same reason as argued above with regard to agriculture.

A third line of inquiry implicitly proposed a dynamic model of behavior adjustment, in which it is assumed that program activities are more valuable to parents and more effective in reducing their birth rates if the parents' environment is rapidly changing in directions that induced them to want fewer births. By this reasoning, a

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$$\frac{\partial B}{\partial V} = \beta_1 + \beta_3 P ,$$

and I hypothesize that $\beta_1 < 0$ and $\beta_3 > 0$ if V and P are substitutes.

stationary environment, whether primitive and traditional or sophisticated and modern, would have permitted parents sufficient time to locate, evaluate and adopt means to regulate their fertility. In this stationary state a family planning program that promotes the adoption of innovative behavior would meet with less success than would a program serving a population subject to new environmental pressures that required their adoption of innovative behavior, such as improved birth control. To test this hypothesis, the rate of change in each environmental variable is multiplied by the sum of program inputs in each region and these new variables are added to the simple linear model for 1966 birth rates. In areas where child death rates fell most rapidly from 1961 to 1965 the family planning program appeared to be more effective in reducing birth rates, particularly among teen-agers and among women 30 years and older. Also, in localities where the proportion of children in school increased most dramatically in this period the program appears to have been somewhat more effective. Neither agricultural composition or adult education change variables exhibited a strong systematic relationship with program effectiveness. Although this evidence confirms that the speed at which environmental change occurs is helpful in predicting program impact in a region, the variables measuring only program activity levels still accounted for most of the reduction in birth rates attributable to the program, regardless of recent rates of environmental change.

Table A-1

LINEAR REGRESSION ON AGE-NORMALIZED CRUDE BIRTH RATES
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year) VHEN	PPHW	
1964	-.737	1.72	-.247	.0459	.0184			.404
	(4.36)	(10.8)	(5.32)	(0.55)	(0.58)			
1965	-.163	1.20	-.364	.149	.0248			.464
	(1.39)	(11.0)	(6.37)	(1.55)	(0.69)			
196[illegible]	.0256	1.04	-.365	.161	.0563	-.0967	-.0606	.509
	(0.22)	(9.61)	(6.65)	(1.75)	(1.62)	(3.29)	(5.02)	
196[illegible]	-.873	2.18	-.553	-.293	-.00856			.579
	(5.10)	(13.3)	(10.0)	(3.32)	(0.27)			
196[illegible]	-.633	1.99	-.569	-.295	.0106	-.0831	-.00882	.603
	(3.58)	(11.9)	(10.5)	(3.43)	(0.33)	(4.52)	(2.28)	
196[illegible]	-.831	2.01	-.505	-.0132	-.0570			.371
	(3.81)	(9.72)	(6.41)	(0.11)	(1.25)			
196[illegible]	-.776	1.98	-.513	-.0149	-.0562	-.0164	-.00138	.372
	(3.40)	(9.31)	(6.44)	(0.12)	(1.23)	(0.92)	(0.39)	
196[illegible]	-2.96	4.00	-.398	-.0289	.0318			.557
	(9.96)	(14.1)	(6.33)	(0.29)	(0.87)			
196[illegible]	-2.89	3.95	-.407	-.0300	.0320	-.0107	-.000855	.558
	(9.15)	(13.4)	(6.36)	(0.30)	(0.88)	(0.89)	(0.33)	

Table A-2

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 15-19
(beneath each regression coefficient is its t statistic)

Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year) VHEN	PPHW	R^2
1964	-6.24	6.77	-.272	.878	-.303			.164
	(6.18)	(7.10)	(0.98)	(1.76)	(1.60)			
1965	-5.11	5.50	-.345	1.49	-.370			.322
	(8.81)	(10.2)	(1.23)	(3.15)	(2.10)			
1965	-4.36	4.89	-.346	1.53	-.248	-.499	-.205	.359
	(7.39)	(9.03)	(1.26)	(3.31)	(1.43)	(3.39)	(3.39)	
1966	-6.82	7.89	-7.27	.195	-.480			.279
	(7.93)	(9.56)	(2.63)	(0.44)	(2.97)			
1966	-6.56	7.67	-.703	.147	-.434	-.232	.0130	.295
	(7.25)	(8.99)	(2.54)	(0.33)	(2.68)	(2.46)	(0.66)	
1967	-6.68	7.45	-.830	1.14	-.267			.339
	(8.74)	(10.3)	(3.01)	(2.67)	(1.68)			
1967	-6.53	7.34	-.848	1.13	-.263	-.0891	.00474	.344
	(8.17)	(9.89)	(3.05)	(2.65)	(1.65)	(1.43)	(0.39)	
1968	-11.4	12.3	-.774	.334	-.316			
	(9.88)	(11.1)	(3.16)	(0.86)	(2.23)			
1968	-12.1	12.8	-.702	.341	-.320	.0471	.0156	.371
	(9.88)	(11.2)	(2.82)	(0.88)	(2.26)	(1.01)	(1.57)	

Table A-3

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 20-24
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
1964	-.500 (2.03)	1.44 (6.20)	-.130 (1.92)	.117 (0.96)	-.0183 (0.40)			.150
1965	.477 (3.54)	.646 (5.17)	-.253 (3.87)	-.0660 (0.60)	-.0361 (0.88)			.151
1965	.556 (3.97)	.581 (4.51)	-.254 (3.89)	-.0612 (0.56)	-.0230 (0.56)	-.0431 (1.23)	-.0245 (1.71)	.161
1966	.233 (1.08)	1.03 (4.94)	-.345 (4.95)	-.423 (3.79)	.0428 (1.05)			.234
1966	.130 (0.57)	1.11 (5.14)	-.324 (4.64)	-.438 (3.94)	.0431 (1.06)	-.0119 (0.50)	.0117 (2.33)	.248
1967	.213 (0.93)	1.03 (4.70)	-.437 (5.28)	-.111 (0.86)	-.00303 (0.06)			.197
1967	.149 (0.62)	1.07 (4.79)	-.424 (5.09)	-.109 (0.86)	-.00290 (0.06)	-.00537 (0.29)	.00659 (1.79)	.205
1968	-.534 (1.66)	1.76 (5.73)	-.377 (5.54)	-.287 (2.66)	.0641 (1.63)			.288
1968	-8.67 (2.57)	2.02 (6.38)	-.343 (5.00)	-.284 (2.66)	.0618 (1.58)	.0211 (1.64)	.00788 (2.88)	.306

Table A-4

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 25-29
(beneath each regression coefficient is its t-statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
1964	1.06	.0593	-.139	-.169	.0409			.098
	(7.50)	(.44)	(3.57)	(2.42)	(1.54)			
1965	1.10	-.0100	-.260	.00589	.103			.271
	(13.2)	(0.13)	(6.45)	(0.09)	(4.09)			
1965	1.12	-.0266	-.260	.0104	.107	.0188	-.0149	.280
	(12.9)	(0.34)	(6.48)	(0.15)	(4.21)	(0.87)	(1.69)	
1966	1.52	-.247	-.369	-.277	.0947			.358
	(11.2)	(1.90)	(8.47)	(3.97)	(3.72)			
1966	1.61	-.319	-.384	-.269	.0971	-.00446	-.00802	.370
	(11.3)	(2.37)	(8.78)	(3.87)	(3.81)	(0.30)	(2.57)	
1967	.423	.748	-.356	-.0513	-.0106			.326
	(3.35)	(6.24)	(7.81)	(0.73)	(0.40)			
1967	.380	.778	-.350	-.0500	-.0113	.0138	.000855	.329
	(2.88)	(6.34)	(7.60)	(0.71)	(0.43)	(1.34)	(0.42)	
1968	.987	.135	-.220	-.116	.123			.208
	(4.20)	(0.60)	(4.42)	(1.47)	(4.27)			
1968	.982	.139	-.220	-.116	.123	-.00139	.000308	.208
	(3.93)	(0.60)	(4.34)	(1.47)	(4.25)	(0.15)	(0.15)	

Table A-5

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 30-34
(beneath each regression coefficient is its t statistic)

Year or Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composiition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
1964	-.812 (3.13)	1.84 (7.50)	-.325 (4.57)	.0148 (0.12)	.0292 (0.60)			.273
1965	-.173 (0.95)	1.28 (7.52)	-.450 (5.06)	.104 (0.70)	.0105 (0.19)			.299
1965	.0717 (0.39)	1.07 (6.29)	-.451 (5.21)	.120 (0.83)	.0514 (0.94)	-.124 (2.68)	-.0791 (4.16)	.340
1966	-1.21 (4.13)	2.61 (9.24)	-.650 (6.86)	-.459 (3.03)	-.0989 (1.79)			.365
1966	-.741 (2.45)	2.23 (7.82)	-.692 (7.46)	-.450 (3.05)	-.0683 (1.26)	-.124 (3.94)	-.0238 (3.59)	.403
1967	-1.11 (3.76)	2.42 (8.61)	-.847 (7.95)	.268 (1.63)	-.210 (3.41)			.367
1967	-.655 (2.21)	2.11 (7.68)	-.925 (8.97)	.257 (1.63)	-.206 (3.49)	-.0667 (2.88)	-.0255 (5.59)	.421
1968	-3.03 (6.14)	4.21 (8.93)	-.647 (6.19)	.0403 (0.24)	-.129 (2.14)			.359
1968	-2.74 (5.23)	3.98 (8.12)	-.676 (6.37)	.0379 (0.23)	-.127 (2.10)	-.0130 (0.65)	-.00776 (1.83)	.365

Table A-6

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 35-39
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
1964	-3.45 (7.70)	4.41 (10.4)	-.472 (3.84)	-.233 (1.05)	.151 (1.79)			.373
1965	-2.57 (6.81)	3.50 (10.0)	-.830 (4.53)	.499 (1.62)	.0933 (0.82)			.394
1965	1.94 (5.15)	2.98 (8.64)	-.832 (4.75)	.538 (1.83)	.198 (1.79)	-.340 (3.62)	-.197 (5.11)	.449
1966	-4.01 (7.07)	9.12 (11.1)	-1.08 (3.94)	-.328 (0.74)	.0159 (0.10)			.394
1966	-3.13 (5.36)	4.85 (8.81)	-1.45 (8.08)	-.257 (0.90)	-.120 (1.15)	-.268 (3.63)	-.0386 (3.02)	.461
1967	-3.44 (5.30)	4.76 (7.73)	-1.64 (7.02)	1.05 (2.90)	-.284 (2.10)			.349
1967	-2.61 (3.94)	4.21 (6.83)	-1.78 (7.71)	1.03 (2.90)	-.274 (2.08)	-.157 (3.03)	-.0391 (3.83)	.382
1968	12.3 (12.5)	13.0 (13.8)	-1.07 (5.12)	.868 (2.62)	-.288 (2.38)			.516
1968	11.1 (10.8)	12.1 (12.5)	-1.19 (5.67)	.857 (2.62)	-.280 (2.35)	-.0669 (1.70)	-.0289 (3.46)	.532

Table A-7

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 40-44
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
1964	-4.23	4.90	-.555	.463	.256			.280
	(6.23)	(7.64)	(2.98)	(1.38)	(2.01)			
1965	-.328	4.35	-1.02	.305	.0786			.307
	(5.97)	(8.56)	(3.82)	(0.68)	(0.47)			
1965	-2.56	3.76	-1.02	.344	.196	-.432	-.209	.344
	(1.59)	(7.35)	(3.93)	(0.79)	(1.19)	(3.10)	(3.66)	
1966	-8.00	9.12	-1.08	-.328	.0159			.394
	(9.38)	(11.1)	(3.94)	(0.74)	(0.10)			
1966	-6.83	8.19	-1.18	-.315	.0964	-.335	-.542	.422
	(7.71)	(9.81)	(4.34)	(0.73)	(0.61)	(3.63)	(2.79)	
1967	-5.17	6.17	-1.76	1.61	-.0282			.301
	(5.42)	(6.80)	(5.10)	(3.02)	(0.14)			
1967	-3.83	5.26	-1.98	1.57	-.0122	-.279	-.0591	.344
	(3.94)	(5.83)	(5.85)	(3.04)	(0.06)	(3.67)	(3.96)	
1968	-17.7	18.1	-1.22	.986	-.136			.478
	(12.1)	(12.9)	(3.95)	(2.01)	(0.76)			
1968	-15.9	16.7	-1.40	.971	-.123	-.0955	-.0430	.496
	(10.4)	(11.7)	(4.50)	(2.00)	(0.70)	(1.64)	(3.47)	

Table A-8

LINEAR REGRESSION ON NORMALIZED BIRTH RATE OF WOMEN AGE 45-49
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
1964	-.699 (4.45)	7.57 (5.11)	.585 (1.36)	-.925 (1.19)	-.0122 (0.04)			.071
1965	-8.82 (6.62)	7.86 (6.37)	1.12 (1.73)	1.28 (1.18)	.994 (2.46)			.172
1965	-7.74 (5.62)	7.00 (5.54)	1.12 (1.75)	1.31 (1.21)	1.16 (2.87)	-.949 (2.76)	-.220 (1.56)	.193
1966	-10.87 (6.02)	10.7 (6.17)	.222 (0.38)	.578 (0.62)	.425 (1.25)			.153
1966	-9.59 (5.07)	9.66 (5.42)	.203 (0.35)	.499 (0.54)	.565 (1.67)	-.654 (3.32)	-.0126 (0.30)	.179
1967	-1.57 (0.71)	2.84 (1.36)	-2.06 (2.60)	2.26 (1.84)	-.269 (0.59)			.051
1967	-.846 (0.37)	2.35 (1.10)	-2.17 (2.71)	2.24 (1.82)	-.258 (0.56)	-.190 (1.06)	-.0233 (0.66)	.054
1968	-11.8 (3.65)	12.53 (4.07)	-.752 (1.10)	.470 (0.43)	-.221 (0.56)			.074
1968	-9.97 (2.92)	11.1 (3.47)	-.909 (1.31)	.459 (0.42)	-.204 (0.52)	-.0374 (0.29)	-.0523 (1.89)	.084

Table B

NONLINEAR REGRESSION ON AGE-NORMALIZED CRUDE BIRTH RATE
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		Sum of Squared Residuals
						VHEN	PPHW	
1964	.986 (29.3)	1.59 (11.8)	-.217 (5.33)	.0472 (0.68)	.0217 (0.79)			6.637
1965	1.03 (25.2)	1.10 (10.7)	-.341 (6.56)	.156 (1.89)	.0215 (0.67)			7.929
1965	1.07 (26.2)	.937 (8.77)	-.344 (6.80)	.163 (2.01)	.0502 (1.58)	-.0962 (3.26)	-.0609 (5.04)	7.260
1966	1.29 (34.0)	1.79 (13.1)	-.512 (10.4)	-.232 (3.07)	-.00732 (0.26)			6.360
1966	1.34 (34.1)	1.60 (10.9)	-.529 (10.9)	-.243 (3.24)	.00937 (0.33)	-.0848 (4.57)	-.00944 (2.41)	5.972
1967	1.20 (20.6)	1.55 (10.4)	-.487 (6.77)	-.0172 (0.16)	-.0417 (1.00)			12.689
1967	1.22 (19.8)	1.51 (9.64)	-.497 (6.84)	-.0212 (0.19)	-.0416 (1.00)	-.0218 (1.22)	-.00236 (0.67)	12.632
1968	1.06 (25.1)	3.16 (15.2)	-.363 (7.00)	-.00964 (0.12)	.0243 (0.80)			8.463
1968	1.08 (22.6)	3.10 (13.6)	-.370 (7.01)	-.00740 (0.09)	.0245 (0.80)	-.00946 (0.78)	-.00080 (0.31)	8.447

Table C

LOGLINEAR REGRESSIONS ON AGE-NORMALIZED CRUDE BIRTH RATE
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year) VHEN	PPHW	R^2
1964	154 .47)	1.57 (9.66)	-.0996 (6.13)	.0153 (0.54)	.0161 (2.53)			.419
1965	152 .21)	1.12 (10.2)	-.152 (8.09)	.0294 (0.93)	.0195 (2.92)			.499
1965	212 .79)	.930 (8.54)	-.142 (7.90)	.0286 (0.95)	.0265 (4.07)	-.0282 (3.32)	-.0323 (5.64)	.547
1966	306 .46)	1.90 (12.7)	-.193 (11.8)	-.106 (3.77)	.0190 (3.36)			.631
1966	325 .3)	1.57 (10.0)	-.189 (11.9)	-.104 (3.85)	.0223 (4.05)	-.0320 (4.89)	-.0159 (4.18)	.659
1967	266 42)	1.96 (8.64)	-.164 (6.62)	-.0401 (0.91)	.00526 (0.60)			.357
1967	270 47)	1.84 (7.57)	-.161 (6.46)	-.0454 (1.03)	.00511 (0.58)	-.00958 (0.99)	-.00867 (1.51)	.361
1968	60 44)	3.44 (12.8)	-.142 (7.26)	-.0507 (1.41)	.0228 (3.29)			.543
1968	-.253 (6.10)	3.33 (10.9)	-.141 (7.20)	-.0538 (1.49)	.0230 (3.29)	-.00176 (0.26)	-.00472 (0.83)	.544

Table D

LINEAR REGRESSION ON 1964 BIRTH RATES INCLUDING MEASURES OF PRE-1964 FAMILY PLANNING PROGRAM ACTIVITY
(beneath each regression coefficient is its t statistic)

Age Group (normalized)	Constant Term	Child Death Adjustment (ratio)	Schooling (proportion)	Education (proportion)	Agricultural Composition (proportion)	Preprogram Contraceptors (proportion)	Taichung Program (dummy)	R^2
Crude birth rate	-.758	1.75	-.234	.0354	.0257	-.396	-.0996	.422
	(4.53)	(11.0)	(5.08)	(0.43)	(0.81)	(2.63)	(2.04)	
15-19	-6.47	7.04	-.196	.724	-.225	-3.27	-.373	.198
	(6.50)	(7.48)	(0.72)	(1.46)	(1.19)	(3.65)	(1.29)	
20-24	-.488	1.43	-.123	.131	-.0220	-.0202	-.104	.155
	(1.97)	(6.11)	(1.81)	(1.07)	(0.47)	(0.09)	(1.44)	
25-29	1.07	.0475	-.139	-.161	-.0376	.0911	-.017	.010
	(7.52)	(0.35)	(3.56)	(2.27)	(1.39)	(0.71)	(0.42)	
30-34	-.859	1.89	-.308	-.0156	.0454	-.708	-.101	.296
	(3.34)	(7.79)	(4.36)	(0.12)	(0.93)	(3.07)	(1.34)	
35-39	-3.48	4.44	-.445	-.243	.161	-.696	-.233	.384
	(7.78)	(10.5)	(3.63)	(1.09)	(1.91)	(1.73)	(1.79)	
40-44	-4.36	5.05	-.506	.382	.300	-1.92	-.283	.304
	(6.49)	(7.94)	(2.74)	(1.14)	(2.36)	(3.18)	(1.45)	
45-49	-7.17	7.79	.656	-1.04	.0499	-2.78	-.422	.083
	(4.57)	(5.25)	(1.52)	(1.33)	(0.17)	(1.97)	(0.92)	

Table E

LINEAR REGRESSION COEFFICIENTS FOR ONLY PROGRAM PERSONNEL INPUTS WITH CUBIC PRODUCTION FUNCTION
(beneath regression coefficient is its t statistic)

Dependent Variable and Type of Personnel	1965			1966			1967			1968		
	Linear	Squared	Cubed	Linear	Squared	Cubed	Linear	Squared	Cubed	Linear	Squared	Cubed
Age-normalized crude birth rate												
VHEN	-.2286	.175	-.0351	-.244	.141	-.0268	-.132	.0621	-.00824	.0318	-.0478	.00992
	(1.97)	(0.73)	(0.31)	(2.96)	(1.03)	(0.49)	(1.90)	(1.02)	(0.56)	(0.62)	(1.21)	(1.33)
PPHW	-.200	.123	-.0244	-.0651	.0127	-.000528	-.0576	.00972	-.000376	-.0190	.00170	-.0000162
	(3.20)	(1.96)	(1.58)	(4.00)	(2.56)	(1.50)	(3.56)	(3.13)	(2.55)	(1.27)	(0.67)	(0.14)
Age 15-19												
VHEN	-.993	.325	.145	-.622	.297	-.0740	-.549	.121	.0176	.0850	-.123	.0327
	(1.71)	(0.27)	(0.26)	(1.45)	(0.42)	(0.26)	(2.30)	(0.58)	(0.41)	(0.43)	(0.80)	(1.14)
PPHW	-.897	.600	-.116	-.284	.0794	-.00438	-.219	.0375	-.00146	-.120	.0179	-.000557
	(2.88)	(1.92)	(1.51)	(3.35)	(3.08)	(2.39)	(3.94)	(3.51)	(2.88)	(2.07)	(1.82)	(1.28)
Age 20-24												
VHEN	-.0881	.00506	.0339	-.0452	-.0118	.0149	-.0574	.0327	-.00776	.0737	-.0496	.00939
	(0.63)	(0.18)	(0.25)	(0.41)	(0.06)	(0.20)	(0.79)	(0.51)	(0.59)	(1.34)	(1.16)	(1.17)
PPHW	-.0764	.0182	.00379	-.0375	.0146	-.000939	-.0316	.00558	-.000149	-.00948	.00229	-.0000678
	(1.03)	(0.24)	(0.21)	(1.73)	(2.23)	(2.00)	(1.85)	(1.70)	(0.96)	(0.59)	(0.84)	(0.56)
Age 25-29												
VHEN	0.543	-.0976	.0510	-.0220	-.0120	.0169	.0253	.0165	-.00754	.00106	.00943	-.00256
	(0.63)	(0.55)	(0.61)	(0.32)	(0.10)	(0.37)	(0.63)	(0.47)	(1.05)	(0.03)	(0.30)	(0.47)
PPHW	-.0499	.0331	-.00695	-.00674	-.00229	.000279	.00576	.000483	-.0000797	.0376	-.00570	.000214
	(1.08)	(0.72)	(0.61)	(0.50)	(0.56)	(0.95)	(0.61)	(0.27)	(0.93)	(3.20)	(2.85)	(2.42)
Age 30-34												
VHEN	-.381	.483	-.186	-.292	.186	-.0446	-.167	.0660	-.0111	.0546	-.0454	.00574
	(2.07)	(1.26)	(1.04)	(2.01)	(0.77)	(0.46)	(1.84)	(0.83)	(0.68)	(0.65)	(0.69)	(0.46)
PPHW	-.256	.182	-.0431	-.0288	-.00479	.000747	-.0779	.0111	-.000535	-.00676	-.00233	.000188
	(2.60)	(1.84)	(1.77)	(1.01)	(0.55)	(1.20)	(3.68)	(2.73)	(2.78)	(0.27)	(0.55)	(1.01)
Age 35-39												
VHEN	-.857	.827	-.252	-.939	.790	-.234	-.687	.384	-.0681	-.0145	-.114	.0284
	(2.31)	(1.07)	(0.70)	(3.42)	(1.73)	(1.27)	(3.44)	(2.19)	(1.91)	(0.09)	(0.88)	(1.17)
PPHW	-.542	.322	-.0687	-.198	.0345	-.00130	-.218	.0331	-.00139	-.125	.0111	-.000263
	(2.72)	(1.60)	(1.39)	(3.66)	(2.10)	(1.11)	(4.67)	(3.70)	(3.29)	(2.57)	(1.34)	(0.72)
Age 40-44												
VHEN	-1.34	1.71	-.655	-1.11	.683	-.113	-1.07	.419	-.0448	-.0269	-.0972	.0188
	(2.44)	(1.49)	(1.22)	(2.65)	(0.98)	(0.40)	(3.71)	(1.65)	(0.87)	(0.11)	(0.51)	(0.52)
PPHW	-.677	.417	-.0846	-.333	.0836	-.00557	-.348	.0475	-.00175	-.230	.0277	-.000997
	(2.29)	(1.40)	(1.16)	(4.03)	(3.32)	(3.11)	(5.16)	(3.66)	(2.85)	(3.17)	(2.25)	(1.83)
Age 45-49												
VHEN	-1.65	1.52	-.672	-1.00	.342	-.0929	-1.29	-.0988	.194	.0445	-.325	.093
	(1.20)	(0.53)	(0.50)	(1.09)	(0.23)	(0.15)	(1.91)	(0.17)	(1.60)	(0.08)	(0.76)	(1.16)
PPHW	-.0663	-.0554	-.0135	-.118	.0117	.000727	-.646	.108	-.00458	-.339	.0423	-.00155
	(0.09)	(0.07)	(0.07)	(0.65)	(0.21)	(0.19)	(4.09)	(3.57)	(3.19)	(2.10)	(1.54)	(1.27)

Table F

NONLINEAR REGRESSION COEFFICIENTS FOR ONLY PROGRAM-PERSONNEL INPUTS WITH CUBIC PRODUCTION FUNCTION
(beneath regression coefficient is its t statistic)

Dependent Variable and Type of Personnel	1965			1966			1967			1968		
	Linear	Squared	Cubed	Linear	Squared	Cubed	Linear	Squared	Cubed	Linear	Squared	Cubed
Age-normalized crude birth rate												
VHEN	-.222	.147	-.0119	-.243	.120	-.00851	-.141	.0545	-.00151	.0169	-.0252	.00126
	(1.91)	(0.61)	(0.11)	(2.92)	(0.86)	(0.15)	(2.05)	(0.89)	(0.12)	(0.33)	(0.63)	(0.17)
PPHW	-.179	.0812	-.00414	-.0625	.0101	-.0000279	-.0535	.00691	-.0000132	-.0214	.00192	-.0000013
	(2.88)	(1.29)	(0.27)	(3.81)	(2.03)	(0.08)	(3.32)	(2.23)	(0.09)	(1.42)	(0.75)	(0.01)

Table G

REGRESSION ON FIRST DIFFERENCES IN BIRTH RATES: 1968-1964[a]
(beneath each regression coefficient is its t statistic)

Dependent Variable: Birth Rate by Age of Women	Constant Term	Child Death Adjustment (ratio)	Child Schooling (proportion)	Adult Education (proportion)	Agricultural Composition (proportion)	Family Planning Program Man Months (cumulative inputs to prior year)		R^2
						VHEN	PPHW	
15-19	.209	-1.01	.0239	.192	-.111	.0336	.0120	.0093
	(2.53)	(0.85)	(0.44)	(0.56)	(0.64)	(0.69)	(1.18)	
20-24	-.00828	-.288	.00795	.121	-.0507	.0145	.00805	.0258
	(0.31)	(0.76)	(0.46)	(1.09)	(0.91)	(0.92)	(2.46)	
25-29	-.0279	.330	.00800	.0419	-.0357	-.0256	-.00241	.0248
	(1.58)	(1.31)	(0.69)	(0.57)	(0.97)	(2.46)	(1.17)	
30-34	-.186	.708	-.0284	-.0312	-.0291	-.0153	-.00354	.0357
	(9.55)	(2.54)	(2.23)	(0.39)	(0.71)	(1.33)	(1.48)	
35-39	-.297	.384	-.0342	-.0650	-.0339	-.0339	-.0151	.0566
	(9.73)	(0.88)	(1.71)	(0.51)	(0.53)	(2.22)	(4.02)	
40-44	-.408	-.166	-.0430	.118	-.0507	-.00118	-.0154	.0719
	(14.1)	(0.40)	(2.27)	(0.98)	(0.83)	(0.69)	(4.33)	
45-49	-.0950	1.60	.0209	-.330	.0634	-.0467	-.0248	.0134
	(0.82)	(0.96)	(0.30)	(0.71)	(0.28)	(0.69)	(1.68)	

Note:

[a]Each birth rate is expressed as the difference between the rate in 1968 and 1964 over the 1964 lev The environmental independent variables are represented by the difference between 1965 and 1961 over the 1961 level, and the family planning program inputs are measured as the cumulative inputs through 1967.

Table H-1

MEANS AND STANDARD DEVIATIONS OF DEPENDENT VARIABLES:
NORMALIZED BIRTH RATES

	Year	Mean	Standard Deviation		Year	Mean	Standard Deviation
Crude Birth Rate	1964	1.080	.175	Age 30-34	1964	1.097	.243
	1965	1.097	.202		1965	1.116	.275
	1966	1.138	.202		1966	1.103	.282
	1967	1.075	.234		1967	1.116	.316
	1968	1.125	.228		1968	1.104	.315
Age 15-19	1964	1.176	.862	Age 35-39	1964	1.184	.452
	1965	1.223	.884		1965	1.247	.608
	1966	1.207	.776		1966	1.229	.573
	1967	1.256	.800		1967	1.254	.684
	1968	1.217	.741		1968	1.251	.724
Age 20-24	1964	1.060	.213	Age 40-44	1964	1.234	.634
	1965	1.050	.184		1965	1.319	.827
	1966	1.058	.189		1966	1.293	.839
	1967	1.081	.218		1967	1.349	.971
	1968	1.086	.194		1968	1.341	1.03
Age 25-29	1964	1.037	.119	Age 45-49	1964	1.100	1.30
	1965	1.050	.122		1965	1.358	1.84
	1966	1.048	.129		1966	1.227	1.50
	1967	1.049	.131		1967	1.408	1.92
	1968	1.056	.135		1968	1.276	1.71

Table H-2

EANS AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES

	Year	Means	Standard Deviation
Child Death Adjustment:	1961	1.090	.0498
	1962[a]	1.106	.0821
	1963	1.078	.0497
	1964	1.068	.0531
	1965	1.061	.0330
	1966	1.058	.0364
Child Schooling:[b]	1961	.3517	.185
	1965	.4270	.161
Adult Education:[b]	1961	.3877	.0901
	1965	.4238	.0880
Agricultural Male Employment:[b]	1961	.5720	.273
	1965	.5579	.270
Contraceptors	1964	2.215	4.80

Notes:

[a]1962 child deaths were not published by all small regions. See discussion in part C of Statistical Appendix.

[b]Education and agricultural variables are linearly interpolated for 1962-1964.

Table H-3

PROGRAM INPUT VARIABLES IN MAN-MONTHS PER THOUSAND WOMEN AGE 15 TO 49
(unweighted sample of 361 areas)

		Village Health Education Nurses (VHEN)				Pre Pregnancy Health Workers (PPHW)				Doctors (MD)			
		1964	1965	1966	1967	1964	1965	1966	1967	1964	1965	1966	1967
Mean		.148	.129	.164	.158	.413	1.195	1.080	1.174	.541	1.557	2.100	2.250
Standard Deviation		.261	.257	.353	.327	.645	1.517	1.228	.889	1.058	2.100	2.367	2.479
Correlations													
VHEN	1964	-											
	1965	.1237	-										
	1966	.1095	.2384	-									
	1967	.0844	-.0249	.2072	-								
PPHW	1964	-.0887	-.1802	-.1446	-.1479	-							
	1965	-.0774	-.1869	-.1537	.0075	.3559	-						
	1966	-.0694	-.2179	-.1844	-.0418	.3878	.8620	-					
	1967	.0089	-.0061	-.1292	-.2431	.2920	.2269	.4397	-				
MD	1964	.1687	-.0920	-.0983	-.0806	.1332	.0224	.0582	.0373	-			
	1965	.1109	-.0832	-.0914	-.0957	.1259	.0145	.0708	.0894	.8143	-		
	1966	.0857	-.0286	-.0527	-.0766	.1237	.0229	.0985	.1172	.6154	.8887	-	
	1967	.0815	-.0312	-.0532	-.0767	.1071	.0090	.0911	.1133	.5905	.8469	.9757	-

Table H-4

CORRELATIONS BETWEEN ENVIRONMENTAL AND PROGRAM INPUT VARIABLES

	Age Normalized Crude Birth Rate		Child Death Adjustment		Child Schooling Rate		Adult Education Rate		Agricultural Employment	
	1964 (1)	1968 (2)	1961 (3)	1965 (4)	1961 (5)	1965 (6)	1961 (7)	1965 (8)	1961 (9)	1965 (10)
Variables:										
Environmental										
(1)	-									
(2)	.831	-								
(3)	.579	.595								
(4)	.636	.692	.712	-						
(5)	-.411	-.411	-.278	-.285	-					
(6)	-.578	-.517	-.417	-.373	.700	-				
(7)	.135	.166	.258	.316	.069	.018	-			
(8)	.192	.234	.298	.375	-.031	-.073	.927	-		
(9)	.331	.363	.334	.297	-.521	-.539	.080	.179	-	
(10)	.337	.367	.343	.303	-.516	-.554	.095	.192	.988	
Program Cumulative Inputs to Preceding Year										
VHEN 1965	-.122	-.192	-.136	-.121	-.016	.054	-.056	-.056	.037	.033
VHEN 1966	-.132	-.191	-.160	-.151	-.071	.035	-.083	-.085	.087	.075
VHEN 1967	-.050	-.108	-.137	-.130	-.082	-.042	-.050	-.060	.042	.026
VHEN 1968	-.031	-.042	-.125	-.077	-.091	-.104	-.041	-.049	.051	.039
PPHW 1965	-.222	-.196	-.111	-.189	-.042	.027	-.025	-.021	.096	.086
PPHW 1966	-.042	-.040	-.121	-.126	-.108	-.073	-.035	-.029	.052	.052
PPHW 1967	-.049	-.046	-.134	-.133	-.098	-.067	-.050	-.047	.030	.033
PPHW 1968	-.107	-.105	-.191	-.199	-.089	-.040	-.090	-.084	.016	.016
MD 1965	-.381	-.352	-.181	-.211	.256	.380	.070	.027	-.364	-.365
MD 1966	-.410	-.405	-.234	-.259	.296	.381	.002	-.055	-.379	-.365
MD 1967	-.406	-.414	-.253	-.281	.296	.381	.002	-.055	-.379	-.365
MD 1968	-.403	-.419	-.262	-.291	.296	.369	-.013	-.071	-.371	-.355

Table I

SERVICE, MANPOWER AND EXPENDITURES OF TAIWAN FAMILY PLANNING PROGRAM: 1963-1967

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

Notes:

[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 as in Note (a). Village health education nurses employed jointly by Rural Health-Community Development Authorities and Family Planning Program. Prepregnancy 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," to be presented at the Annual Meetings of the Population Association of America, April 1969.

n.a. = not available or nil.

Table J-1

LINEAR REGRESSION ON AGE-NORMALIZED CRUDE BIRTH RATES FOR 1961 AND 1963
(beneath each regression coefficient is its t statistic)

Year of Dependent Variable	Constant Term	Child Death Adjustment (ratio) 1961	Child Schooling (proportion) 1961	Adult Education (proportion) 1961	Agricultural Composition (proportion) 1961	R^2
1961	-.483 (2.96)	1.53 (9.93)	-.247 (5.49)	-.0867 (1.08)	.0857 (2.80)	.422
1963	-.539 (3.18)	1.53 (9.53)	-.243 (5.22)	.0162 (0.19)	.0803 (2.52)	.402

Because explanatory variables are not available from published sources on a consistent basis for years before 1961, these tentative regression results are not based on the appropriately lagged explanatory variables as reported in other regression results.

Table J-2

ALTERNATIVE LAGS FOR CHILD DEATH VARIABLE IN LINEAR REGRESSION ON AGE NORMALIZED CRUDE BIRTH RATE[a]

	t-3 Only		t-2	t-3	t-4	
	Coefficient (and t's)	R^2	Coefficients (and t's)			R^2
1965	.982 (8.95)	.520	.243 (1.06)	.325 (2.17)	1.44 (5.89)	.575
1966	1.74 (10.3)	.633	.164 (1.28)	1.66 (5.93)	-.109 (0.53)	.635
1967	1.79 (8.27)	.399	1.25 (3.12)	.721 (2.48)	1.05 (2.09)	.444
1968	3.82 (12.1)	.568	.567 (2.67)	3.10 (7.07)	.266 (0.73)	.578
Average Size of Coefficient	2.083	b	.556	1.452	.662	b

Notes:

[a]Other variables included were child and adult education, agricultural composition and the cubic function of cumulative man months of family planning effort for VHEN and PPHW separately identified. See Table A-9 for three year lag form.

[b]Not applicable.

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