A Review of Current Approaches for the Estimate of Fertility Change Due to the Efforts of Family Planning Program

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This paper is trying to review literatures which have made the efforts in estimating the fertility change due to family planning programs. It is useful to have thorough understanding of what has handicapped the ideal evaluation of fertility impact of family planning programs; how scholars have worked on this subject; what is the deficit; and where we may go from now on.

The effect of family planning programs on fertility and growth rate has received a good deal of attention. Ultimately, it seems apparent that any success of family planning programs must be demonstrated in terms of the demographic changes of the decline of fertility. The following discussion will concentrate on the studies of program impacts on the fertility changes and its annexed problems.

There is a general recognition that it is very difficult to demonstrate that a given program has been exclusively responsible for a given decline in fertility. Besides, David (1967) had challenged this sole explanation with the example of fertility trends in Taiwan since the fertility there had been declining before the program began. Also Bogue stated, "There is absolutely no way to answer directly the question, 'what would have happened to the birth rate if there had been no family planning in Korea?'" (Bogue, 1970)

Nonetheless, scholars are carrying on the studies on this subject because of the need for an indicator of program impact on fertility which is urged politically and academically. Whenever one wishes to estimate program impact on fertility, both sides of this equation must be under consideration: the fertility change and program output.

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Estimate of fertility changes is necessary; evaluation of the program output is also required. As to the former, estimate of fertility change can look at the fertility fluctuation of the area through the data available from vital registrations or censuses, or through the sample survey if vital registration and census are not available. The latter, "birth averted", now, is a prevailing method of concluding the program accomplishment. However, there is a big gap existing if we try to connect the births averted to the fertility change. On the one hand, the total births averted by the program, which is often estimated by the program evaluator, can not be credited to the true program output. Due to its own deficits, which will be discussed later, "births averted" method may either overestimate or underestimate the program impact on fertility. On the other hand, the amount of fertility decline should not be thought of as totally the outcome of the family planning program, because the fertility change is an interacting process of many sociological, economic, demographic and biological factors. Then, a third approach, the regression analysis, is developed to explore how much the program effort has contributed to the fertility changes.

This paper will give a general review of these three approaches of estimates of fertility impact of program efforts: the direct measurement of fertility change, the "birth averted", and the regression analysis.

I Direct Approaches

A) Measuring the area fertility data from vital statistics

If there is a reliable vital registration system in one area, the simplest and most common method of estimating the program impact on fertility is to examine and compare the fertility trends before and after the beginning of family planning program. For instance, the island-wide family planning program in Taiwan started in 1964. After examining the percentage decline in crude birth rate from 1951 to 1967, it was found that fertility had been declining 2.3 percent per year

before the beginning of the program, but declined by 4.6 percent after introduction of the program. The analyst may conclude that "it would appear that the family planning program has increased the rate of decline by about 2.3 percentage points per year." (Mauldin, 1968)

Nevertheless, it has been well described that the crude birth rate is not a good index of an areal fertility because of strong influences by such factors as age composition, age at marriage, etc. The fertility decline may be presented in the figures of total fertility rate, but Davis has strongly argued that "one should not attribute all of the post-1963 acceleration in the decline of Taiwan's birth rate (fertility) to the family planning campaign" because "the decline represents a response to modernization similar to that made by all countries that have become industrialized". (Davis, 1967). In fact, most analysts in this field have well realized the socio-economic development having impact on the fertility, and are eager to separate the program impact from others.

Moreover, when we want to compare the fertility trends between two segments of period and draw the curves to show the different paces of decline, a problem of statistical technique is involved. Which years have been chosen as the cutting points would affect the slopes of curves dramatically. Take Taiwan's yearly record of crude birth rates as one example (see Appendix A); if the birth rate of 1956, instead of 1951, was chosen to be the beginning point while computing the percentage decline of fertility before program started, the percentage of decline would not be 2.3 but 2.8. The difference between these figures cannot be easily explained but needs detailed exploration.

(B) Measuring the difference between expected fertility and actual fertility

The comparison of expected and actual fertility after the program started is another way to look at the areal fertility change. The fertility level before program is taken as the expected value of the future fertility. A difference between expected and actual fertility would be attributed to the program efforts. However, in the normal circumstances, fertility in an area or a country is fluctuated seasonally and yearly. Which year or what kind of fertility pattern should be

chosen as the standard of the expected fertility of the population is crucial, especially a case like Taiwan where the fertility is declining for some unclear reasons.

C) Measuring the fertility change through surveys

When accurate birth registration or census data is not available, fertility may be estimated by sampling surveys. Data collected from sampling survey can be utilized to apply in such analysis techniques as "the Fertility Pattern Method" (Wishik, 1972), "Numerator Analysis" (Gómez and Reynolds, 1973). Then, observe the fertility change over a certain time period. However, if one is to secure complete data for a time period, it becomes necessary to repeat such studies at period intervals.

If the estimate of fertility of a population based on survey data is accurate, the fertility change still cannot be attributed to the program efforts totally for the same reasons as mentioned in section A) above. In fact, fertility estimates based on incomplete data are never as accurate as good vital registration systems, because these kinds of estimations have involved many assumptions which are often violated by empirical conditions.

Moreover, surveys are subject to sampling errors and biases, and also to the kinds of non-sampling errors (e.g., errors due to inadequate preparation, errors of non-response, response errors), hence they affect all statistical results. Although the non-sampling errors are likely to be reduced in well-executed surveys; however, as U.N. concludes "it has not been possible to provide evaluation of the accuracy of fertility estimates based on the results of sample surveys." One must be very careful when referring to this estimate to appraise the impact of the program.

The "actual" number of births prevented by a family planning program is the difference between the number of births that would take place in the absence of the program and the number that do take place with the program in existence. But this broader sense of "actual" number of births prevented is very difficult to secure because of computational and analytical problems. The direct approaches mentioned above can only directly look at the difference between supposedly

expected fertility and the actual fertility. This difference, however, cannot be all acknowledged as the programs' impacts on the fertility, since fertility can change for many reasons among which the services and information provided by the program is only one of them. A narrow sense of estimation of "birth averted" by the program, which is an approach from the other end of the equation, is to count the program output by measuring the demographic effect of a unit of contraceptive use, but not count the areal fertility directly. It will be discussed in the next section.

II "Births averted" approach

The narrower sense of the estimation of "births averted" (births averted" is a synonym of "births prevented" here), according to Wolfers' definition, is "a measure of the quantitative change in the expectations, assessed in terms of probabilities, of future births to a cohort of women resulting from the adoption or modification of birth control practice by them or their husbands." (Wolfers, 1976, p. 163). To measure the quantitative change in the expectations of future births, three kinds of statistics are needed. First, the estimates of the prolongations of stay in the fecundable state resulting from used of program-provided contraceptives. Second, the average birth interval which would have been required by the couples had they not adopted program methods. And third, the number of program acceptors (or units of acceptance). Combining these three estimates, if they are unbiased estimates, the total births averted by the program can be computed. Following paragraphs will discuss these statistics.

A) The length of prolongations of stay in the fecundable state

The mean effective retention period of contraception device, in Potter's term, is the mean prolongation of stay in the fecundable state (denoted by 'I'). (Potter, 1969) Potter has applied a model to Taiwan IUD first segment data. In computing 'I', Potter takes account of the following factors:

1. Secondary sterility. The basic assumption adopted is that

any acceptor is fertile at the time of her last child-birth prior to insertion, but then she becomes subject to the risk of secondary sterility characteristic of her age class. The risk of development of sterility increases with age, so that the proportion sterile is cumulative with age. The magnitude of this risk is taken from the work of Louis Henry.

2. The risk of marriage dissolution by either mortality or divorce. In Taiwan, these risks are not significantly high. However, in other populations, these risks may be required to be included.

3. Overlap between postpartum amenorrhea and practice of contraception. A woman may adopt a contraceptive device before the end of postpartum amenorrhea. The overlap should not be credited to the effectiveness of contraception. The length of overlap varies from population to population because of different cultural backgrounds. Empirical investigation to find out the overlapped period is needed.

4. The mean time of contraceptive device is retained (R). The estimate of retention time of device is the main subject of the "birth averted" estimation. In fact, "I" is the adjusted value of "R". The mean time of device retained, R, is mainly decided by the monthly termination rates, then adjusted by mortality and sterility. A Life-Table technique has been applied to the clinical data, especially for the IUD program, for manipulating the termination rates (e.g., Potter, 1969a; Tietze, 1973).

Several problems are involved in the estimate of termination rates and required careful attention. First, the construction of life-table is based on the aggregation of a cross-sectional data which is not quite valid to explain the longitudinal behaviors of the individuals. Second, the incomplete observation contained in a segment of data which are used to construct the life-table seriously damaged the accuracy of estimates of termination rates. It was discovered that as a result of containing incomplete observations, the termination rates calculated from the Potter's life-table are sharply different from the results from Tietze's life-table (Jain & Sivin, 1977). Therefore, a well-executed follow-up research is very important for reducing the proportion of incomplete observations, and improving the quality of

estimates. Third, the fertility behavior as well as contraceptive behavior are strongly age-sepcific. For every step of estimating the effective retention period of contraceptive use, age-specific consideration is important too, because some variables, such as fecundity, mortality, termination rate, are varied among age-groups. Age group specific data are necessary in doing the estimate of "birth averted". Besides, the variations within the oldest age-group or the youngest age group of childbearing-age women are also significant.

B) The birth interval in the absence of program methods

The most common measure of potential fertility employed in calculations of births averted is the direct use of the reciprocal of age-specific fertility rates, either unmodified or modified by a factor recognizing the possibility of higher fecundity of contraceptives acceptors. However, "the most important theoretical problem in the estimation of births averted is the accurate computation of appropriate durations per birth" (Wolfers, 1976, p. 167). How to select a baseline of fertility for computing the birth interval which the program acceptors would have in the absence of program is still a controversy. Because a higher than average potential fertility of the acceptors is only a proposition (Wolfers, 1976, p. 172); the acceptors may have used other methods before accepting program methods; and the fertility behavior will be subject to change due to rapid social changes. All these factors complicate the deciding of a potential fertility for acceptors.

C) The problems of estimating births averted by the programs

By definition, the mean period of contraceptive use (I) divided by the birth interval (D) is the birth prevented by a unit of contraceptive (B). That is, B=I/D. Then this unit of averted birth multiplied by the total units of contraceptives offered by the program will give the total number of births averted by the program. Prior to this estimation, the empirical data about duration per birth, use-effectiveness of contraceptives, accidental pregnancy rates and penalty per pregnancy,(1) sterility, mortality, postpartum anovularity overlap,

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(1) Penalty per accidental pregnancy is equivalent to the (continued)

and substitution function of program method (i.e., the contraceptive experience before program started) of the population under research must be collected. The procedure involved many assumptions and costly works that inhibit program evaluators from doing timely and effective evaluation.

Besides the problems discussed above there are still other difficulties. While the program is introducing methods other than sterilization and IUDs, things are getting more complicated. Because using pills and conventional contraceptives involves the problems about wastage, interruption of practice, frequencies of practice, and the combined use of more than one method, etc., which will increase the difficulty of estimation of effectiveness. No statement can be made about "absolute" births averted. The conversion factors (f) employed in Couple Year of Protection method (Wishik, 1973) may substitute the "R" value to be treated as mean period of effective use of one unit contraceptive. However, it is only a crude approximation, not a good estimate.

It is very easy that program administrators and evaluators overestimate the program outcomes by oversimplifying the process of estimation since they are eager to present the program accomplishment, and often overlook the influencing forces other than program efforts. On the other hand, it may be underestimated because the long-term and indirect effects of program efforts cannot be shown in the short period of evaluation of births averted.

In order to understand the causes of fertility change, the role of family planning programs in human fertility behavior and the interactive relations of family planning programs among other causes in a society, regression analysis based on conceptual models has been applied in the fertility study. The question greatly concerned is whether the family planning program is a direct contributor to the changes in fertility rather than a passive recipient of the gains brough about by modernization trends within the society. Hermalin's

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mean period of ovulatory exposure to pregnancy risk required to yield one pregnancy in the absence of program contraception.

early work is an example. He employed the regression analysis in Taiwan's areal data to evalute the effectiveness of the family planning program after taking into acount the socioeconomic and demographic characteristics related to fertility (Hermalin, 1968).

Ⅲ The Regression Analysis of Areal Fertility Data

Since the evaluation of family planning programs is often based on the macro-population viewpoint, the following discussion will focus on the analysis of areal data rather than the individual behavior.

This regression analysis of areal data typically has the following features as Hermalin point out: (Hermalin, 1976, p. 247)

(i) for all or some subset of local areas within a country or other territorial unit, one has a series of characteristics whose influence on fertility is to be determined (these are the independent variables);

(ii) one or more of these measures reflects inputs into the program either in terms of manpower, supplies, money, or some intermediate effect of such inputs such as acceptances;

(iii) a measure of fertility (or some characteristics assumed to bear directly on fertility) as dependent variable, which reflects the effects of the program and other factors; and

(iv) a method of analysis which enables one to appraise the relative impact of the independent variables on the dependent variable.

The structure of multivariate analysis provides a mode of testing hypothesis to see whether among areas within a country there is a relationship between levels of fertility and program input or acceptance rates. For instance, in Simmons' study of the Indian Investment in Family Planning, he took literacy, urbanization, per capita income, and program efforts as four measures of independent variables which he assumed would affect the fertility level. But he used acceptance as dependent variable by assuming the program acceptors will reduce their fertility. In other words, he hypothesized that in the absence of

government family planning program the acceptors would not have reduced their fertility in India. The presumption is that program efforts would be the predominant force among other socioeconomic factors in influencing the acceptance rate in India. After the regression analysis of aggregate data of 246 districts he concluded that the analysis is "largely consistent with the hypothesis that past variation in the number of family planning acceptors by district has been the result of variation in the impacts to the family planning program."; but the acceptance rate is not consistent with the differences in the socio-economic conditions in the districts (Simmons, 1971, p. 119).

Hermalin's analysis in Taiwan's areal data is another example (Hermalin, 1968). The analysis utilized a path analysis model to examine the relation of program acceptance rate to fertility in 282 areas of Taiwan. In his model, the recent level of fertility in the local area is the dependent variable, and the prior fertility of the area, the acceptance rate, the ratios of health workers and doctors, plus such socioeconomic and demographic variables as educational levels of the females, density, and crude death rates are the independent variables. After arranging all variables in temporal sequence, a mode of multivariate analysis--path analysis-- was carried out. By path analysis, a set of standardized Beta coefficients, called path coefficients, was obtained. These path coefficients represent the net effect of one variable upon another while controlling for the other variables in the model. Through these path coefficients, Hermalin concluded "IUD acceptances do give a noticeably negative effect on subsequent fertility" (Hermalin, 1968, p. 11).

However, applying a multiple regression analysis in processing data must meet some requirements and therefore confront some limitations. A primary requirement for a multiple regression analysis is a theory or conceptual framework. The task of multiple regression is to help "explain" the variance of a dependent variable, such as fertility. But the human behavior, including fertility behavior, is so complex that it has many facets and many causes. A conceptual model is an interrelated set of variables that present a systematic view of phenomena by specifying relations among variables, with the purpose of

explaining the phenomena. It is a framework to help identifying the sources of the variable's variation, i.e., fertility change in this particular case. Many theories or conceptual models were abandoned or modified after careful analysis. Nevertheless, none of the theories concerning fertility variation is overwhelmingly acceptable by scholars in this field by now. Most of research scheme designed for evaluation of the demographic impact of a family planning program was derived from a wide range of conceptual model such as Freedman's conceptual scheme proposed in 1961-62, if the reseacher is a sociologist. And there is no agreement in general. The arguments come from the different backgrounds and philosophies of the researchers and the nature of complexity of social phenomena. Therefore, there are controversial arguments about whether the economic development or the family planning program is more important to fertility decline. Also there is disagreement on the subjects like income and fertility between the economist Becker and the sociologist Blake (Blake, 1968). The basic difference in ideology certainly forms the gap among various approaches to the fertility study.

Another problem concerned with the conceptual framework is the uncertainty of reciprocal influence from fertility to the other variables. For instance, the female employment may be looked at as one of the independent variables affecting the fertility by some researchers but be treated as a dependent variable because of it being an echo of fertility change in some other investigations. A detailed discussion of the direction of causation between fertility and female employment has been presented in Terry's article (Terry, 1974).

Besides the difficulty of constructing a conceptual model mentioned above, there are more constraints when the conceptual model is transformed to the statistical model (i.e., regression equation) to test hypotheses. For the regression model of studying fertility, Hermalin has pointed out six required assumptions (Hermalin, 1976, p.258) which are also the limitations when applying regression analysis in social research:

(i) the data are interval scales (or dichotomous);

(ii) fertility is a linear function of the other characteristics;

(iii) there is no reciprocal influence from fertility to the other variables;

(iv) the disturbance term population each has zero mean and equal variance;

(v) the error terms are uncorrelated with one another;

(vi) the error term is not correlated with any of the predictor variables.

It may be easier to satisfy the requirement of interval scale in the research of areal data. Nevertheless, it is not possible to say that any of the empirically social research has not violated any one of the other five assumptions because of the complexity of human behavior. The linear regression has not proved suitable in the relationship of income to fertility in the early Indianapolis study. A J-shape curve has been observed for the United States as a whole (U.N. 1973, p. 99).

The reciprocal influence is another serious problem. It has been discussed above. And the last three assumptions are more possible to be violated in the fertility research since human fertility is an interactive function of biological, demographic, socioeconomic, and psychological factors. These factors are also interacting with each other besides their direct function to fertility. Thus, it is very possible to violate the assumption of 'uncorrelation'. Especially while most of the investigators only take a few of the variables into their fertility research scheme, they probably grasp very minor effects of the variables and lose more important ones. They have often circled a particular section in the general fertility model to study this particular section as it is associated to the disciplines of sociology, economics, or psychology in which they are interested. The broad universe sometimes is ignored. Nevertheless, the research model is opened to many factors other than the variables within the model, if we consider the real environment setting. It is so complicated, therefore, it is hard to find a predominant and clear stream of influence to the fertility through a simplified model. Moreover, this partial and simplified model often leaves a large proportion of variation unexplained. The path coefficients of residuals to the fertility

in the path analysis are often found to reach .7 or more. (One reason for this is the non-linearity problem, mentioned above.)

Up to now none of the conceptual models constructed by one investigator has been completely accepted by another investigator. Researchers are always trying to modify a relevant past model and construct a new one. Then the models are different, the operational definitions are different, also the data available are different. Finally, the study findings are not comparable so we cannot find out a conclusive result for the basis of policy decision-making.

It is the very rare case that Hermalin tried to compare in his study and Schultz's study. Both studies utilized the same data resources in their fertility analysis of Taiwan. Hermalin has replicated Schultz's linear regression model, then compared the correlations and regression coefficients to observe i) the results obtained by two analyses using the same conceptual model and the same operational definitions, ii) the effect of varying the operational definitions slightly, and iii) the effect of varying the conceptual model slightly." (Hermalin, 1976, p. 268) Through this replication and comparison, he concludes that two studies have reached the same conclusion that field workers in Taiwan have greater impact in those areas where have a higher pre-program fertility.

CONCLUSION

Directly measuring the fertility change of an area where family planning programs have been going on is the simplest way to measure the program impact. But the interpretation of this measurement is ambiguous and causes arguments. The "births averted" method is a convenient and concrete indicator while being used to measure the program output. But there is a tendency to attribute all of the births averted to the program efforts in spite of its deficits in the estimation process.

The regression analysis may be a better way to abstract the program's impact from the complexities of socioeconomic influences when studying the areal fertility, but the results of regression analysis are likely to vary as a result of differences in conceptual models, operational definitions, processing of data, and techniques of estimation.

Comparison studies like Hermalin's work may be a good approach to study the effect of differential data processing as well as the effects of differential conceptual models and estimation procedures. Above all, conceptual model is the most critical problem in fertility study as well as other social researches.

Appendix A

The Crude Birth Rate of Taiwan Area, 1951-1977

YEAR	RATE(‰)	YEAR	RATE(‰)
1951	49.97	1965	32.68
1952	46.62	1966	32.40
1953	45.22	1967	28.01
1954	44.63	1968	28.81
1955	45.29	1969	27.72
1956	44.84	1970	27.16
1957	41.39	1971	25.64
1958	41.65	1972	24.15
1959	41.18	1973	23.78
1960	39.53	1974	23.42
1961	38.31	1975	22.98
1962	37.37	1976	25.93
1963	36.27	1977	23.76
1964	34.54		

Source: 1977 Taiwan-Fukien Demographic Fact Book, Republic of China, published by ministry of The Interior, Republic of China, 1978, p. 994.

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家庭計畫對生育率影響的估量方法綜述

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中 文 摘 要

自家庭計畫大力推行以來，有關家庭計畫本身對生育率下降所能產生的影響，很受到一般學者及政策執行者的關注；因此，自一九六〇年代後期，有關家庭計畫的成效及其對生育率影響的論述就不斷的出現。在這些論述中，因研究者著眼點的不同，依估量方式可大致歸爲三類：第一種方式是直接衡量家庭計畫推行前後的生育率變化；第二種是由家庭計畫成果（即避孕方法接受數）估量它所能避免的孩子出生數，來分別闡述家庭計畫的成效；第三種方式則是採用迴歸分析的方法，欲將家庭計畫的影響力自各項社會經濟因子中提携出來，並藉以判斷家庭計畫或各項社會經濟發展對生育率的影響孰大。本文旨在概述學者利用這三種不同估量方法的研究，並討論此三種方法的優劣點，以爲未來研究或工作的參考。

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