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AREAL VARIATION IN FERTILITY TRENDS IN TAIWAN, 1952-1970: DIFFUSION OR DEVELOPMENT PROCESS

by
John Ellis Anderson

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Sociology)
in The University of Michigan
1974

Doctoral Committee:

Associate Professor Albert I. Hermalin, Chairman
Associate Professor Reynolds Farley
Professor Ronald Freedman
Assistant Professor Ronald Lee

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the lines of statistical volumes, and also translated table headings whenever necessary. The use of the Center's facilities during the first two years of work on the thesis contributed immeasurably to its completion.

The data used in Chapter 6 are from surveys of married women in Taiwan taken in 1965, 1967 and 1970, and are the culmination of the efforts of a great many people at the Taiwan Population Studies Center and the organization that succeeded it, the Taiwan Provincial Committee on Family Planning. These data were kindly made available to me at the Michigan Population Studies Center.

Some of the areal data used in Chapter 5 and all of the data presented in Chapter 7 were compiled by the Division of Population Statistics and Census, Ministry of the Interior in Taiwan under the direction of Mr. T. H. Fan. Of the Chapter 7 data, the rates for 1971 are the result of a survey of records designed by Dr. K. S. Srikantan of the Population Council, and conducted using funds provided by the Population Council, the National Institute of Child Health and Development, and the Ford Foundation.

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CHAPTER 1

INTRODUCTION

This dissertation is a study of fertility rates, and the factors underlying those rates, in Taiwan during a period in which both fertility and its determinants were undergoing substantial change, a period of demographic transition and social modernization. The major part of this study is an areal analysis; that is, the data used consist of measurements, such as fertility rates, that are the attributes of areal subunits of Taiwan, rather than individuals. In addition, a key feature of the study is the attempt to deal not only with areal variation, but with temporal variation as well. The position will be taken that in observing how fertility values are arrayed across both space and time, in looking at the areal variation of fertility trends, much more is to be learned than by studying time series, or areal cross-section separately.

As an introduction, this chapter is brief, containing only two sections: 1) a discussion of the general approach to the subject and data to be taken here, and 2) a short description of each of the chapters that follow. Other introductory matters, the discussion of relevant literature, the development of hypotheses, the review of the setting and the like will be taken up in succeeding chapters.

General Perspectives

This dissertation focuses on the general determinants of fertility. The inputs of the organized family planning program are not introduced into any of the analysis presented here. Nevertheless, this study was written in the tradition of work studying the effectiveness of the Taiwanese program using areal analysis (Hermalin, 1971; Schultz, 1973). Such work embraces two broad fields of empirical study--the evaluation of the effectiveness of family planning programs, and the use of areal data in demographic research, both areas that present a number of problems and dilemmas to the analyst. While this study is concerned with the more general questions about the social and demographic processes involved in fertility change in Taiwan, it is worthwhile to start from the perspective of the problems besetting the areal analyst of family planning program effectiveness.

A major problem in evaluating the effectiveness of family planning programs in reducing fertility in developing countries is that most programs act mainly to make the supply of knowledge and materials readily available, while the demand for contraception is being generated by the process of modernization itself, independent of the family planning effort (Davis, 1967; Raulet, 1970). Davis concludes that, in the case of Taiwan,

> Most of the reduction in fertility . . . has been a matter of individual initiative. To some extent the campaign may be simply substituting sponsored (and cheaper) services for those that would otherwise come through private and commercial channels. (p. 735)

Even though, as in Taiwan, large numbers of women accept modern birth control methods through the program, it is impossible to say how many would have begun using contraception had the program never existed.

The problem is, then, how to disentangle the program effects from ongoing social processes. One must begin by asking what those social processes are, and how they bear on fertility. In the case of Taiwan, this problem is made more acute by the historical fact that the island-wide IUD program dates from 1964, whereas the birth rate has been declining since around 1958.

The use of areal data to approach this problem is justifiable on a number of grounds, and perhaps even preferrable on some to individual level measurement. On purely pragmatic grounds, if one wishes to study variation in fertility before and during the initiation of decline in Taiwan, one must rely on areal data. Only after 1963 are detailed data available from surveys of married women and family planning program records.

Duncan and others (1961) point out that the study of demographic rates may be a case in which correlations on areal units need not be deemed "inferior substitutes" to individual correlations, but have meaningful interpretations of their own. The writers note that "such rates may be included . . . among the characteristics of areal units which have no exact analogue among characteristics of individual" (p. 44). It is certainly true that demographic transition theory is usually described in terms of population rates, and it is the intention of family planning programs to have an impact on aggregate fertility. The value of using areal data is clear if a territory's fertility rate is conceived of as resulting from the interplay of social, economic and demographic factors of the area (Freedman, 1962). This sort of conception of aggregate fertility of an area being a product of the area's "ecological" system is implicit in much of the analysis and

discussion to be presented here.

The present study, in attempting to account for the areal distribution of fertility at various points in time, seeks to draw inferences about processes underlying fertility change, and thereby "explain" areal variation.

> "Explanation" of the areal variation of a phenomenon may require reference to the areal variation of correlated phenomena which, so to speak, constitute the "environment" of the given phenomenon. . . . In some instances it is quite clear that areal differentiation is of interest only because it is assumed to reflect variation in the presumed causal factors which are actually the focus of interest. (Duncan, et al., p. 23, p. 18).

Though causality may flow from social system to the demographic rate, the attempt will be made to use areal variation in fertility and how it changes over time, to make valid statements concerning the social process involved in demographic change. This direction of inference is by no means rare in demographic analysis. A simple, but very relevant, example comes from Demeny's areal work in the demographic transition in Europe in which he remarks that "the variance in fertility is so large that the assumption of natural fertility is highly questionable" (1968, p. 520). Certain inferences of this kind can be drawn, and it is up to the researcher to use areal data to the greatest advantage without overstepping its limitations.

Finally, the problem studied here is one in which the temporal aspect is of great importance and must be dealt with:

> Phenomena subject to areal variation often are subject as well to temporal variation. . . . The pattern of areal variation may undergo change--some areas, for example, may lower their death rates sooner or more rapidly than others. This phenomenon cannot be neglected in an inquiry whose objective is to understand how things work in the real world (Duncan, et al., p. 102).

In studying fertility change, temporal variation cannot be ignored. In fact, it is in the peculiar combination of spatial and temporal variation that, it is hoped, the true nature of Taiwan's demographic transition is to be revealed.

Description of the Chapters of This Study

Chapter 2: Conceptual Problems. This chapter is an attempt to deal with the kinds of problems arising from the use of areal data to examine fertility trends. The question asked is how the social, economic and demographic factors in subareas of a country can work to produce a pattern of areal variation, and conversely how observing areal variation in fertility can be used to draw conclusions about the social processes involved. Three major areas are discussed: 1) a general model of fertility determination; 2) demographic transition theory and areal studies related to it; 3) the theory of innovation diffusion and how it can be applied to fertility change. This last category provides an explanation of areal variation in fertility that could arise without variation in the social and economic factors underlying fertility. A diffusion explanation of areal variation in fertility would stress the treatment of lower fertility as an innovation that took time to permeate all areas of the island. Attitudes and knowledge about contraception are important in this explanation. If the pattern of change is consistent with the conception of lowered fertility as an innovation, that is, for example, if there are areas that lead other areas in the decline in a pattern consistent with a diffusion hypothesis, it is argued that the supply of contraceptive knowledge and materials is an important factor, and the family planning

program could well have had an important effect.

Throughout the thesis the diffusion pattern will be contrasted with a "development" model in which socio-economic modernization is the major factor operating, and indicators of modernization can account for most of the areal variation in fertility trends.

Chapter 3: The Setting. The importance of long term trends in fertility, mortality, and socio-economic development are discussed in this chapter. The emphasis here is on island-wide time series of fertility reaching back to the early years of the twentieth century, rather than on areal variation. The series reveals that the downturn in fertility in the late 1950's appears to be a genuine departure from previous levels. Examination of mortality and socio-economic series indicates that the forces of modernization that are tied to demographic transition were at work during the period that fertility actually did begin to decline.

Chapter 4: Urban-Rural and Regional Differences in Fertility Trends, 1952-1970. This major analysis chapter makes use of a single set of areal data: 22 large areal units--5 major cities, 16 counties or hsiens and one special administration area, contiguous with a major city and classified here as urban. While there are only 22 areal units, there are 18 annual observations (1952-1970, excluding 1962). This yields a total of 396 actual observations of fertility rates over both time and area. This chapter is bivariate in approach, looking only at differences in fertility and fertility trends between urban and rural areas, and among three "regions" of the country. The initial section deals with an examination of change in cross-sectional variation in fertility over the 18 yearly observations.

A later section deals with the calculation of "trend parameters" for each area in order to see, for example, if urban areas began declining earlier than rural areas. A number of methods are used to estimate trend parameters. One of them, the fitting of logistic functions to each area's fertility series, provides a fairly powerful means of summarizing fertility trends in terms of four parameters: initial level of fertility, date of initiation of decline, rate of decline, and final level of fertility.

Chapter 5: Multivariate Analysis of Fertility Trend Parameters. Using the logistic parameters for each of the 22 areal units just described, this chapter is an attempt to use them as dependent variables in a multivariate analysis. The approach used is to see if various socioeconomic or demographic control variables can account for the areal pattern of fertility trends as described by the parameters. The "areal pattern" is defined simply as the urban-rural difference in each trend parameter. Methodologically, the analysis is a very basic analysis of covariance.

Chapter 6: Urban and Rural Differences in Family Size Norms and Contraceptive Experience. The last two analysis chapters bring other, non-areal data to bear on the findings of Chapters 4 and 5. This chapter looks at family size norms and whether or not contraception has ever been used for samples of married women interviewed in island-wide surveys in 1965, 1967 and 1970. A look at such detailed data can complement the understanding gained through the areal-time series analysis. In an approach somewhat similar to Chapter 5, an attempt is made using multiple classification analysis to see to what extent controlling for a number of independent variables accounts

for areal difference in contraceptive experience.

Chapter 7: The Effect of Education, Nuptiality and Marital Fertility on Fertility Change and Differentials, 1966-1971. This last analysis chapter makes use of special education-specific marital fertility rates for Taiwan, and for urban and rural areas for two dates, 1966 and 1971. Using such data, it is possible to decompose change in fertility, or the urban-rural difference, to see the effects of changing marital fertility, marriage patterns and educational attainment. This analysis helps to reveal the complexity behind simple fertility differences between time points or areas that were observed in earlier chapters of the study.

CHAPTER 2

CONCEPTUAL PROBLEMS IN USING AREAL DATA TO STUDY FERTILITY TRENDS

The aim of this dissertation is to draw inferences about the social processes involved in the fertility decline in Taiwan. For the most part, the data being used are areal data; that is, they consist of measurements such as fertility rates of areal subunits of the island measured at a number of points in time over a period of years. Use of such data has important implications on the conceptual level. Unlike the analysis of data from fertility surveys, inferences cannot be made on the individual level. Care must be taken to make statements that have meaning on an aggregate level. Further, some important variables such as desired family size and detailed contraceptive histories are simply not known. The use of areal data from rather large administrative units does have the advantage of covering historical periods for which individual data are not available.

In order to use areal data to the fullest advantage it is worthwhile considering in very general terms how the socioeconomic or "ecological" system of a population bears on its fertility, and how the social processes involved can be manifested in areal differentials at various points in time. Three theoretical frameworks will be briefly discussed: 1) the treatment of fertility determination on the most abstract level, 2) the specific theory of fertility change

known as demographic transition and 3) a general theory of social change taking place through space known as "innovation diffusion."

The Determinants of Fertility

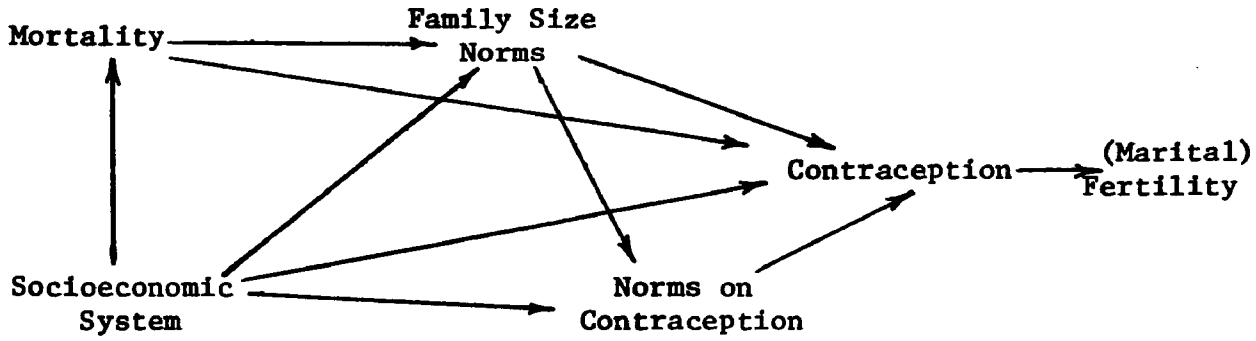
Davis and Blake (1956) provide an exhaustive categorization of the "intermediate variables" through which social organization can effect fertility. In the case of Taiwan, recent change in fertility can be attributed to relatively few of the intermediate variables, mainly "entrance into sexual unions" and the use of contraception and abortion within unions; the average age at marriage has been increasing, but most important has been the adoption of the means to control fertility within marriage mainly by women over age 30.

Freedman (1962, 1968) adds to the Davis-Blake analytic model the sociological concept of "norms." Behavior with respect to the intermediate variables will be in part determined by socially prescribed rules pertaining directly or indirectly to the intermediate variables. Family size norms, which may range from a specific number to a vague concept, certainly will have some effect on fertility related behavior. Also, social norms may govern the intermediate variables themselves, such as an early preferred age at marriage, or the illegality of abortion.

In addition, aspects of social organization may effect intermediate variables apart from or in interaction with normative considerations. For example, economic inequality could result in delayed marriage by a segment of a population. Another more pertinent example is in the case where child mortality has been falling. In this case couples may feel the need to limit fertility in order to keep from

exceeding their normative family size. In such a period of demographic change, pressure builds to re-order values on the intermediate variables, with or without concommitant change in family size norms.

Finally, given the felt need for control of fertility within marriage, independent of either family size norms or norms governing the intermediate variables, the socioeconomic system can vary in its ability to supply the necessary knowledge and materials for the efficient control of fertility. The causal connections between the various factors that have been discussed so far can be arrayed as in the diagram below:



In this case the model has been simplified so that the only intermediate variable operating is called "contraception." It alone has a direct input into fertility. Socioeconomic factors and mortality work not only through the norms governing behavior related to reproduction, but also directly on the intermediate variable in the ways suggested.

How can this rather simplistic discussion of the social determinants of fertility help in making use of areal data to study the process of fertility change? If fertility levels of populations truly come about in a process like the one described above, then any observed areal variation in fertility--which is the chief thing that

can be observed in areal data--must reflect areal variation in one or more of the various elements of the social and ecological system. While areal differences can be caused by such "non-deliberate" factors as fecundity differences, or patterns of breastfeeding, the maximum variation due to such factors is trivial compared to the amount potentially due to "deliberate" factors in the social system. In some populations fecundity differences may be important, but this does not appear to be the case for Taiwan. Differentials in fecundity measures in the 1960's are systematic, but not large (Jain, 1969). Moreover, using mortality as a measure of health conditions, it would appear that in the early 1950's urban areas tended to healthier places to live. Fertility was lower in these areas, the opposite of what would be predicted if fecundity were assumed related with the health factors reflected by mortality rates. It will be assumed here that fecundity differences are not important determinants of areal difference in fertility. Thus, if fertility is higher in area A than area B, it may be that the risk of child mortality is greater in area A, or there are more highly educated women in area B, or perhaps in area B women do not have a traditional taboo against abortion. Each area can, and probably does, vary with respect to the elements of the system sketched here. This is represented in the diagram in Figure 2-1 by arrows from "location" to each element of the system. Location operates independently and merits a direct arrow to contraception if spread of family limitation through the country during the period of fertility change takes time, certain areas being reached early because of proximity to original centers of innovation. The task of the present study is to make persuasive arguments about the

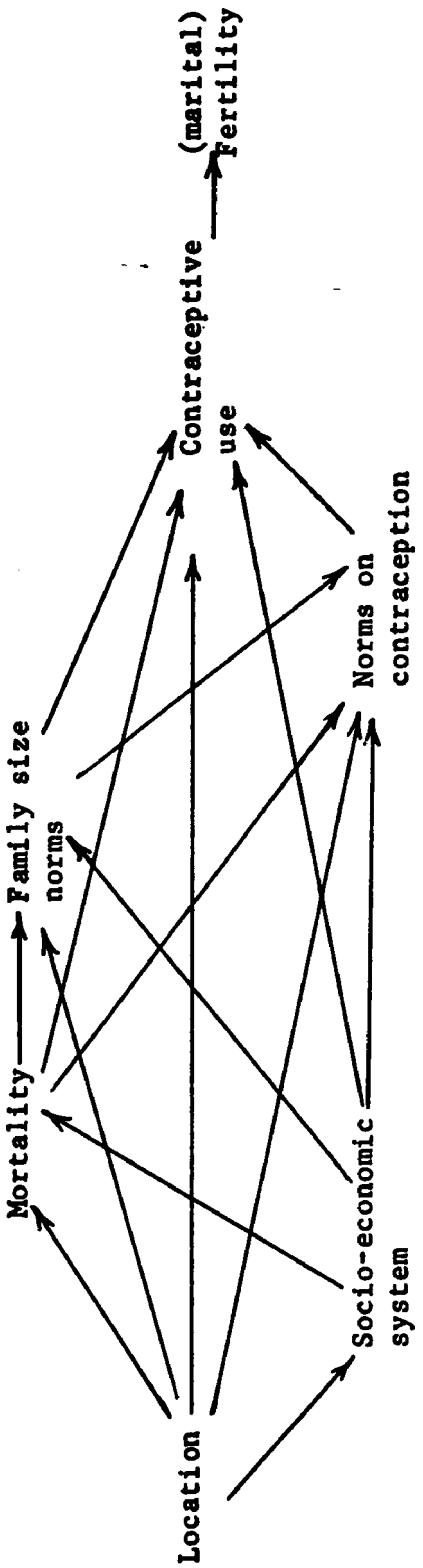


FIGURE 2-1: Possible factors in the determination of areal fertility.

relation of the factors in the diagram from observing for the most part areal variation--and change in variation--in the dependent variable. Using time series of areal units, with data coming from vital registers, neither the norms or contraceptive use can be directly measured. Measures of mortality, various measures of social, economic and cultural characteristics of areas, and indicators of their geographical location are available.

Arguments about the relative importance of normative changes cannot be made directly from these data. Certain arguments about the nature of change can be advanced. For example, a major theme of this study is to argue that by observing fertility trends for a set of areas, areal differentials at any one point in time can be considered to be the product of two forces: 1) long term and persistent differences among areas and 2) differences in the timing and rate of change of fertility. A careful examination of these aspects of fertility trends, rather than the values of fertility itself, should reveal to what extent the areal distribution of fertility is a product of long term differences, or is evolving through a re-arrangement of the elements of the socioeconomic-demographic system.

Demographic Transition

On a strictly demographic level, transition theory postulates certain regular changes in the vital rates of a country undergoing modernization. Mortality rates decline first, then fertility rates, resulting in a temporary period of rapid population growth. According to the theory, mortality is seen as being responsive to broad improvements in the quality of life. For European populations undergoing

the transition in the nineteenth century, the factors responsible include increases in agricultural production and improvement of transportation which eased the impact of recurring localized famines (U.N., 1953, p. 56). For the developing countries undergoing the reduction of mortality more recently, the imposition of modern medical technology and sanitation methods has been important. Because of this, the time involved for countries like Taiwan to enter the transition is greatly reduced so that circumstances may differ from what has been found to be true historically.

Unlike mortality, fertility reduction is seen as requiring changes in familial norms and behaviors which constitute the very fabric of society. The decline of a fertility rate, of course, can reflect changing values on any of the several "intermediate" variables in the Davis-Blake scheme. There could be a trend toward later marriage, or an increase in non-marriage, or a general adoption of the means of family limitation within marriage. When mortality has fallen, tremendous impetus toward some means of fertility control is generated without diminution of family size norms or actual family size.

At the same time, since demographic transition is intimately bound to the process of general social and economic modernization, family size norms are subject to change themselves. Economic modernization is seen as decreasing the value of children:

> With the declining importance of the family as a productive unit, with the growth of impersonal systems for the allocation of jobs, and with the development of economic roles for women outside the home . . . the economic advantages of a large family (decrease) . . . Children are usually more of a burden and less of an asset in an urban setting than in a rural (Coale and Hoover, 1958, p. 11).

It is important to recognize, then, that fertility decline can stem both from demographic pressures independent of change in family size norms, and from normative change itself. Davis, for example, in his "theory of the multiphasic response" (1963) treats the reduction of fertility as arising out of the interplay between rising levels of living, the increasing expense of raising and educating children whose economic worth has diminished, and the increasing probability of child survival. Further, he specifies that curtailment of childbearing to married couples is only one demographic response available in this situation; other responses include migration and later marriage.

Of particular interest to an areal analysis of fertility change is the level of vital rates that characterize pre-transition populations. Both birth and death rates are presumed to be high. The relevant question is how much local variation in fertility existed prior to the sustained decline. Until fairly recently discussion was limited to national populations and the assumption was made, implicitly or explicitly, that "natural fertility" conditions existed in pre-transition populations. That is, marital fertility was assumed to be without deliberate controls, but not necessarily at a biological maximum (Coale, 1969). Non-deliberate controls such as breastfeeding, various taboos on coitus, or nutrition-related fecundity impairments could account for some local variation, but not large differentials. The result of the assumption of natural fertility is that the initial reduction in fertility becomes a phenomenon of innovation of considerable magnitude; individuals for the first time took deliberate action in determining family size. This process presumably is consonant with a pattern of fertility reduction in which location of an area with

respect to the communication network and original centers of decline is important in the timing of local fertility trends.

Recent work has cast some doubt on the validity of the natural fertility assumption in certain historical populations. Wrigley's study of a single English village (1966), for example, strongly suggests deliberate control of fertility in the pre-industrial period. A set of studies from different countries using local areas or provinces as units of analysis have found wide areal variation in pre-decline fertility, which is inconsistent with natural fertility (Carlsson, 1966; Coale, 1969; Demeny, 1968; Livi-Bacci, 1967, 1971; Mathiessen, 1970; Tsubouchi, 1970). These studies merit some attention since like the present study they seek to use time series of fertility measurements on subnational areal units to discuss the process of fertility decline.

Coale's study of Western Europe notes a pattern of increasing fertility and marriage rates from west to east. He discusses the inconsistency of the areal variation in fertility he finds with the assumption of natural fertility, but lack of more than one time point limits his conclusions about the processes involved.

Demeny's more detailed work on the transition in Austro-Hungary yields a pattern of areal diffusion within some localities. He notes that certain provinces have anomolously low fertility; they are rural areas not characterized by low infant mortality or high literacy. Further, while he never accounts for the anomaly of low fertility in rural areas, the pattern of fertility decline he sees <u>within</u> these provinces is one of "time lags determined by geographic location," the classic pattern of spatial diffusion. Demeny observes that:

> The process of transmission need not be interpreted as the spread of contraceptive knowledge . . . . The variance of fertility is so large that . . . the assumption of natural fertility is highly questionable. If so, the diffusion observed within the provinces leading the fertility decline was presumably one of ideas, aspirations and attitudes rather than techniques (p. 520).

Demeny makes explicit the important point that the concepts of innovation diffusion need not be limited to the spread of specific artifacts or techniques, but may also embrace rather broad patterns of behavior. Thus, it is not necessary to assume that the entire population of a locality is completely ignorant of contraception because fertility has yet to decline, but rather that the attitudes toward known techniques may vary from place to place, and spread through space over time. Or, knowledge of specific modern, efficient methods may be lacking, where traditional methods are widely known.

Livi-Bacci finds an even more distinct pattern of geographic spread in his studies of Portugal and Italy. In Italy (1967) there are fairly stable differentials by region with high fertility in the south; though the level of industrialization varies by region, Livi-Bacci suggests that cultural difference are important. In Portugal (1971) fertility declines appeared first in the north, later in the southern provinces so that over the period of his study, areas became less homogeneous with respect to fertility. He also attempts some multivariate analysis (1971), finding that regional effects are maintained after controlling statistically for various modernization indicators.

Matthiessen in his work on Denmark finds that declines in fertility at older ages of childbearing begin at about the same time in the capital, in towns, and in rural areas, but for younger ages

(up to 30 or 35) a distinct pattern of lags in the rural areas is evident, suggesting a diffusion of lower fertility outward from the cities.

Tsubouchi has examined trends in marital fertility for the prefectures of Japan, which may be the only non-Western country to have completed the demographic transition. He finds a pattern that may be interpreted as decline in marital fertility first in central Honshu and spreading later to neighboring areas. By 1965 a striking convergence had occurred with very little difference between areas with respect to fertility.

Carlsson finds a different pattern for Sweden. The timing of fertility declines in urban and rural areas and also in the various regions of the country were similar despite pre-existing differences in level. Carlsson feels that the diffusion concept of change is implicit in treatments of the demographic transition that assume contraception is a recent innovation. As an alternative to the diffusion model he proposes a process of "adjustment." This process would allow for the existence of pre-decline differentials among areas:

> There may have been a 'steady state' in which birth control was practised by part of the population, or it may have been practised with higher fertility targets. The Decline of Fertility is then regarded as an adjustment to a new set of forces defining a new equilibrium level of fertility. The role of motivation, and structural factors bearing on human desires and values, is stressed more than the knowledge of contraception. This type of theory is not dependent on lags or a 'trickle down' pattern of spread (p. 150).

Carlsson's concept of adjustment is somewhat mystifying if it is taken to mean only what he found for Sweden: change beginning simultaneously

in all areas of the country. Some change must have occurred in the factors underlying fertility, and perhaps in Carlsson's case the change occurred in all areas of Sweden at about the same time causing a simultaneous downturn in fertility across the country. It may be best to say that he contrasts a diffusion model with its emphasis on the spread of knowledge through geographic space over time, with a type of modernization model in which location may be, but need not be, related to the onset and timing of the fertility decline. This distinction will also serve as the basis for the examination of Taiwan's fertility decline.

The studies discussed all are similar to the present study in their focus on fertility trends of subnational units. They are for the most part descriptive in that they do not introduce social, economic, demographic or geographical independent variables into the analysis. Livi-Bacci's Portuguese work is the exception. Multivariate analyses of fertility have been done using both subunits of countries (Hermalin, 1968, 1971; Nerlove and Schlutz, 1970; Schultz, 1973) and countries (Heer, 1966; Friedlander and Silver, 1967; Ekanem, 1972) as units of analysis. In these cases, however, the focus is on explaining cross-sectional variation rather than change.

At this point it is worthwhile looking at a theory of just how change can take place across subareas of a country.

Innovation Diffusion

Innovation diffusion theory describes how change can occur through two-dimensional space. It is particularly relevant to the analysis of areal data, where an important aspect of each unit of

analysis is its location in space. Moreover, it provides a means by which areal variation in fertility could occur at a point in time independent of the social, economic and demographic determinants discussed earlier.

Defined simply, innovation diffusion is "the spread (dispersion) of a phenomenon within a given area through time" (Brown, 1970, p. 2). Hägerstrand provides a more elaborate definition:

> If in a subregion of the system a hitherto unknown element is introduced, say for example, a new technical device, a new way of allotting social roles, or a new cultural manifestation, this event constitutes a perturbation that under certain conditions may be transmitted out into the surrounding regions and propagate itself until eventually the whole system has become permeated and at the same time to some degree transformed. A permeation of this kind, either partial or total, is known as a diffusion of innovation (1968, p. 174).

Here lowered fertility rates are being treated as an innovation; the question to be asked is whether fertility appears to have declined first in some locations and spread to others in a regular pattern. Hägerstrand identifies four basic elements of the process of innovation diffusion--patterns of growth, centers of innovation, channels of spread, and receptivity factors. Each of these will be discussed in turn and applied to the fertility transition phenomenon.

Growth Patterns

Writers working with the adoption of innovations have noted that the proportion of persons adopting over time typically takes the form of the S-shaped logistic function (Pembertion, 1936; Griliches, 1957, 1960). That is, starting from a point at which there are no adopters, first there is only a low rate of adoption, followed by an increasingly rapid rate, and finally a diminishing rate of adoption

ending in saturation. Griliches notes that the curve can be expressed by three parameters: (1) "origin" or date at first acceptance; (2) "slope" or rate of adoption; (3) "ceiling" or the final level of adoption after adoption ceases.

A single curve of this kind looks at only how innovation takes place in a single area over time; the other dimension of diffusion--space--cannot be handled with a single curve. Rather, one must compare the curves of several areas with respect to the date of origin of innovation, the rate of adoption and ceiling levels in order to answer questions concerning the spatial spread of new phenomena.

In studying the use of corn hybrids in agriculture, Griliches found that use in a given area at a point in time depended on when the innovation first began being adopted and how fast its use increased thereafter. Since the timing of adoption depended on economic factors such as profitability which vary among agricultural regions, "there may be a tendency for technological change to accentuate regional disparities" (1960, p. 280). In the case of fertility, one might expect divergence or convergence of regional fertility differences depending on the trends in areal differentiation in the factors underlying fertility.

The logistic function as used by Griliches must be modified before it can be applied to the fertility transition. The decline of fertility is a process of decay rather than growth; the curve slopes downward over time rather than upward. In addition, one is not starting from a zero point, but from some pre-decline "equilibrium" level of fertility which quite probably differs from area to area; thus, a fourth parameter--initial level--must be added. In studying fertility

decline, then, one would ask whether areas differ in initial level, date of origin of decline, rate of decline, and final, post-decline level of fertility. In making hypotheses one must postulate factors--socioeconomic development, mortality, or spatial location--that account for differences in these parameters. Figure 2-2 attempts to illustrate some of the possible features of fertility decline viewed in these terms.

Centers of Innovation

The diffusion of innovations is most often seen as beginning at a point in space and radiating outward (Hägerstrand, 1967; McVoy, 1940). Quite often, this point of origin is seen as a metropolitan center. Hägerstrand (1968) has theorized that in part this is due to the "cumulative principle of development"; adoption of an innovation cannot occur until a certain number of necessary elements have been assembled in one place. Here, then, development and location are associated so that if fertility falls first in cities and the decline spreads outward to contiguous and later to remote areas, it becomes difficult to assess which set of factors is most important. Hägerstrand (1967) has found in a study of agricultural innovation in a relatively homogeneous area that centers of innovation may also appear that are not more highly developed than surrounding areas.

Fertility has, of course, quite often been noted to be lower in urban than rural areas. This observation has many times been made for a single point in time so that it cannot be definitely stated whether the differentials reflect a diffusion of lower fertility values, or simply longstanding areal differences. To test a diffusion

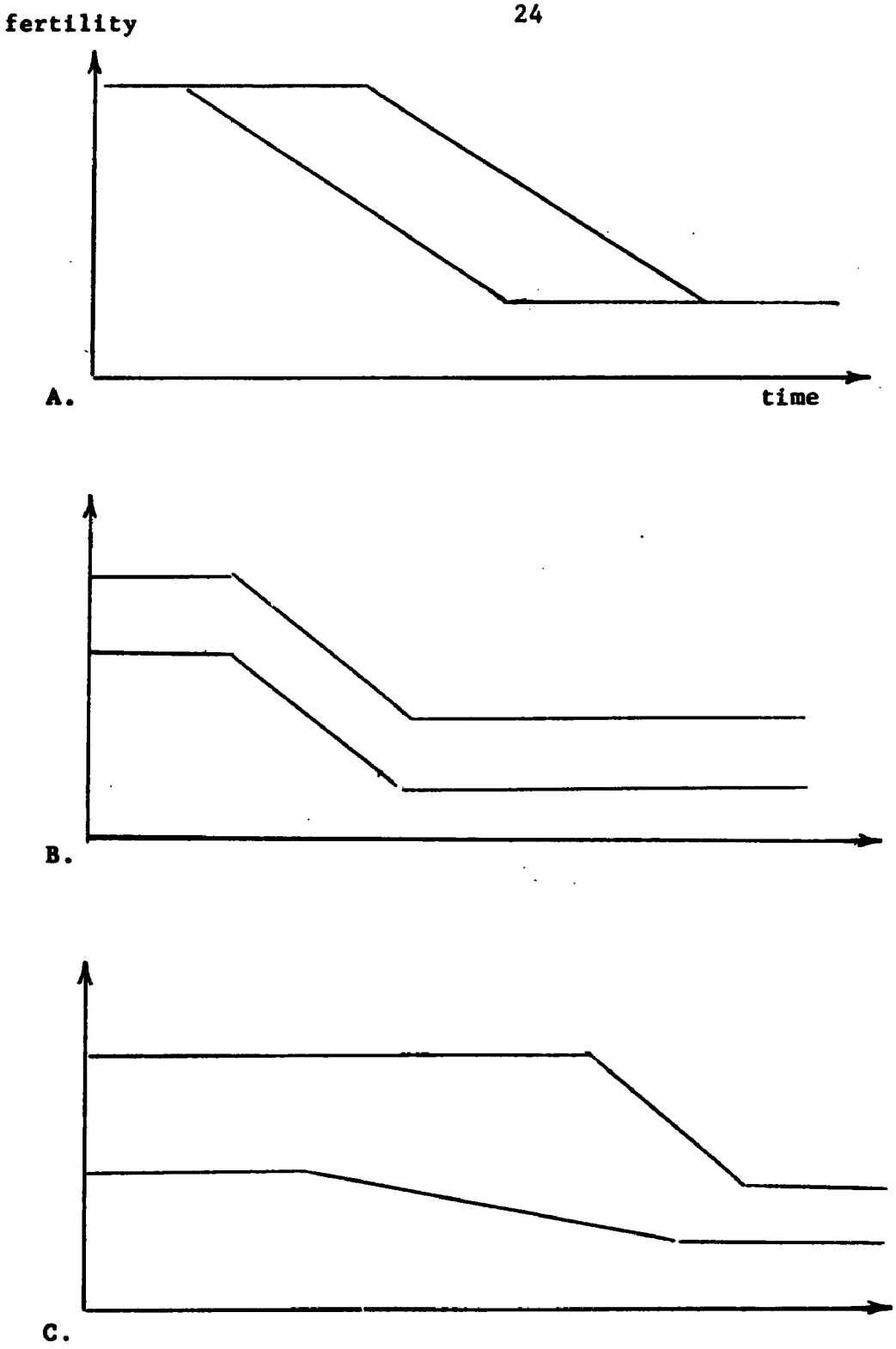


FIGURE 2-2: Hypothetical differences in fertility trends of two areas. A. Initiation date differs between areas, other trend parameters the same; B. Simultaneous decline; C. All four parameters differ.

hypothesis, one must attempt to find earlier decline in centers, followed by declines in other areas.

Channels of Spread

The adoption of an innovation radiating outward from centers implies some spatial pattern of spread. Hägerstrand (1967) posits that this pattern is determined by the flow of information; an individual must learn about an innovation before he can adopt it. A person's relationship to others in a society's web of communication is not wholly determined by proximity in geographical space, of course. However, some translation of physical distance is usually seen as being an important factor in the communication between spatially separated individuals and groups. Areas that are contiguous tend to be alike in terms of many characteristics; this Hägerstrand terms the "neighborhood effect." Gravity models, where the amount of contact between two areas is assumed to be directly proportional to their populations and inversely proportional to the distance between them, have been found to fit very well the adoption of certain innovations (Pedersen, 1970). Such factors as cultural boundaries, roads, waterways or mountain ranges tend to break up regular patterns of spread. In identifying a diffusion of lower fertility, then, one must attempt to discover the spatial pattern by which fertility has fallen, whether, for example, it follows a pattern of lags predictable by distance from original centers of innovation.

Receptivity Factors

This can perhaps be considered a residual category of non-spatial characteristics that can determine the timing of adoption.

Hägerstrand recognizes that the personal characteristic of individuals can play a part; the presence of enterpreneurial types of individuals may well explain why innovations are adopted in some places first. Hägerstrand also includes general development of the area since there must be "time-consuming adjustments and preparations before an adoption can be fitted into pre-existing procedures, habits and value systems" (1968, p. 177). In this category, then, one can place the developmental factors of the general transition theory. Individuals will not adopt the pattern of deliberately limiting their fertility until certain levels of education, of non-traditional employment, and family patterns are reached, and until increased likelihood of child survival has become evident.

It is probably best not to consider "receptivity factors" as such as part of the process of innovation diffusion, reserving that concept for those cases when the pattern of change is locationally determined. In fact, the emphasis here will be on contrasting the case in which social, economic and demographic factors determine the spatial pattern of fertility trends observed to the case in which spatial diffusion appears to be the most important principle operating.

Alternative Models of Fertility Change

In the analysis in following chapters two general models of fertility change will be compared, one in which locational characteristics are important in the timing of fertility decline, the other in which differences in modernization or socioeconomic development account for the spatial pattern observed. A third alternative is also

described. The three patterns are as follows.

Diffusion

A sharply defined pattern of areal spread is expected. Differentials in fertility level may exist from place to place before and after the period of decline, but timing of change is determined by spatial location.

1) There will be evident lags in the initiation of decline reflecting location, e.g., outward from cities, from one region to another.

2) Socioeconomic variables will not be strongly associated with the timing of decline; differentials in fertility level associated with development may persist.

3) The amount of variation in fertility variables at one point in time will increase over time at the beginning of decline; later the amount of variation may decrease.

Development

Here any locational difference in timing will be due to differences in the development of areas.

1) The timing and rate of decline is associated with variables measuring socioeconomic development; this association is independent of locational variables in a multivariate analysis.

2) The amount of variation, and trends in variation will depend on the spatial pattern of the development variables.

Simultaneous Decline

In this model there is very little variation in the timing of decline. This could be due to mortality change or some unmeasured process that somehow effects most of the areas at about the same time.

1) Timing pattern does not reflect the location of areas.

2) The amount of variation does not change markedly over the period of decline.

3) Differences in level associated with development variables may persist.

The models described, of course, are not mutually exclusive. Both locational variables and measures of development may account for part of the variation in the timing of decline. If it can be said that the diffusion pattern fits the data best, that is, for example, if some areas clearly begin declining earlier, and this difference is not due to developmental differences between areas, it will be argued that fertility trends across areas are consistent with the idea that the information and materials necessary for efficient, modern contraceptive practice took time to permeate all geographic areas of the country. Such a time-lag dominated diffusion pattern, it will be argued, is most consistent with the hypothesis that the family planning program has had an impact on fertility, independent of the social processes going on. If differences in socioeconomic modernization account for the spatial pattern of the timing of decline, the time-lag pattern may simply reduce to the development model under which it may be more difficult to argue that the program is effective net of ongoing social change. It is, of course, possible that even given a development pattern of fertility change, the program could be having an effect in speeding fertility decline. Using areal analysis program effectiveness can never be finally proved or disproved. It will simply be argued here that an effective program is most consistent with a pattern of fertility decline in which lower fertility appears to behave as an innovation, spreading from one area or social stratum to another.

The analysis that follows will concentrate on the period 1952-1970, with a detailed look at the last five years of that period. Treating fertility decline as an innovation requires that birth rates be falling for the first time, or at least falling from some stable long term plateau. The value of this assumption will be treated in the review of demographic trends in the following chapter.

CHAPTER 3

THE SETTING

In order to correctly interpret findings in the analysis of fertility trends after 1950, it is important to understand a number of facts about the longer demographic record in Taiwan. During the period of 1895-1945 Taiwan was a colony of Japan, and the colonial administrators developed a registration system that yields series of demographic measures as far back as 1905. This is fortunate for anyone studying fertility trends since as Barclay (1954, p. 248) remarks, fertility as high as Taiwan's in the colonial period may be fairly common in the world, but it is rare in countries with accurate records of vital statistics. Three basic points will be argued in the following discussion: 1) While there was some fluctuation in fertility levels prior to the late 1950's, the decline in fertility rates starting at that point appears to be the first sustained decline of any magnitude due to deliberate action, supporting the treatment of fertility decline as a process of innovation; 2) Areal variation that is observed in the early 1950's, particularly between urban and rural places, seems to reflect longstanding differences extending well back into the colonial period and perhaps beyond; 3) Trends in mortality since about 1920, and in socioeconomic development since the early 1950's suggest a climate in the late 1950's which was conducive to fertility decline.

Trends in Island-Wide Fertility Since 1900

The trends in fertility measures for the entire population of Taiwan over the last seven decades are consistent with the interpretation that the use of deliberate means of family limitation on a mass scale began in the late 1950's. Figure 3-1 shows that the crude birth rate in the early 1950's was very close to the level observed in the 1930's. After 1955 the rate falls to the lowest levels recorded in the series. Total fertility rate shows a similar pattern in Figure 3-2.

Both rates exhibit an upward trend prior to 1930, but this has been interpreted as the result of non-deliberate factors. Liu (1973, p. 9) suggests that "better health conditions" had a positive effect on fecundity. Also, Taeuber (1961, p. 104) cautions against relying too heavily on the accuracy of the earliest statistics. Taeuber concludes that,

> The fertility of the years from 1955 to 1957 was little if any lower than that of 1940, just as that of 1940 was little if any higher than that of 1905 (pp. 120-121).

Barclay also characterizes trends in the Japanese era as insubstantial:

> Fertility probably was declining very slightly from 1930 into the period of World War II. But if fertility did change at all, it changed very little, and at the end of Japanese rule in Taiwan was at practically the same level as at the beginning (p. 246).

Age specific fertility rates for the island are available since 1949, and Figure 3-3 indicates that when decline began, it was confined to women in the older ages of child bearing, a pattern typical of the beginning of fertility decline in historical populations (Coale, 1969). In fact, women over the age of 30 account for four-fifths of the 40% decrease in total fertility rate (TFR) after 1952:

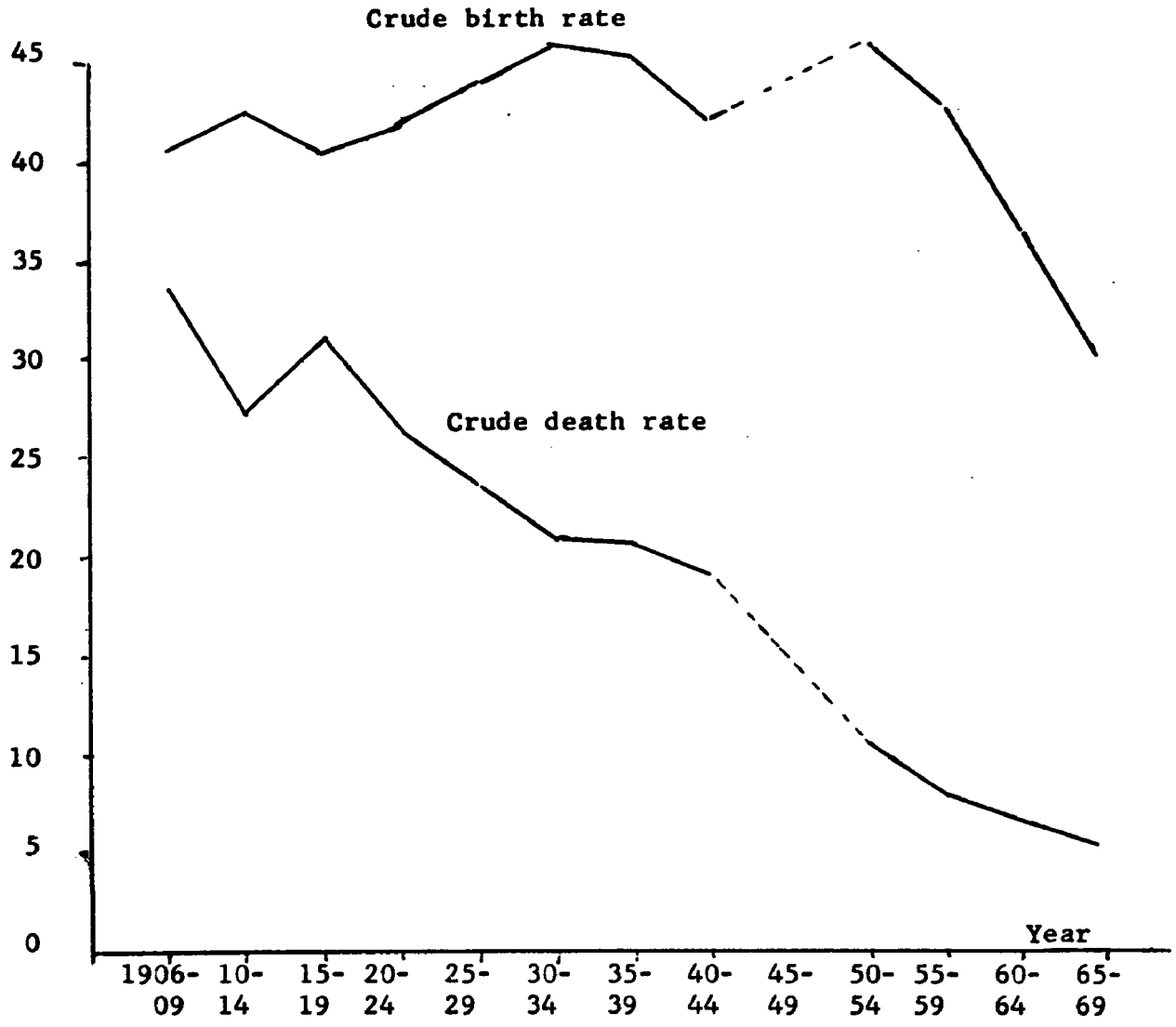


FIGURE 3-1: Demographic transition in Taiwan; births and deaths per thousand population 1906 to 1969. Source: Liu, 1973, p. 10.



FIGURE 3-2: Total fertility rate for all Taiwan 1905-1940, five year averages 1950-54, 1955-59, 1960-64 and 1969-70. Source: Barclay, 1954, p. 246; Taiwan Demographic Reference , Vol. II, Table 14-1; Taiwan Demographic Fact Books 1963-1969.

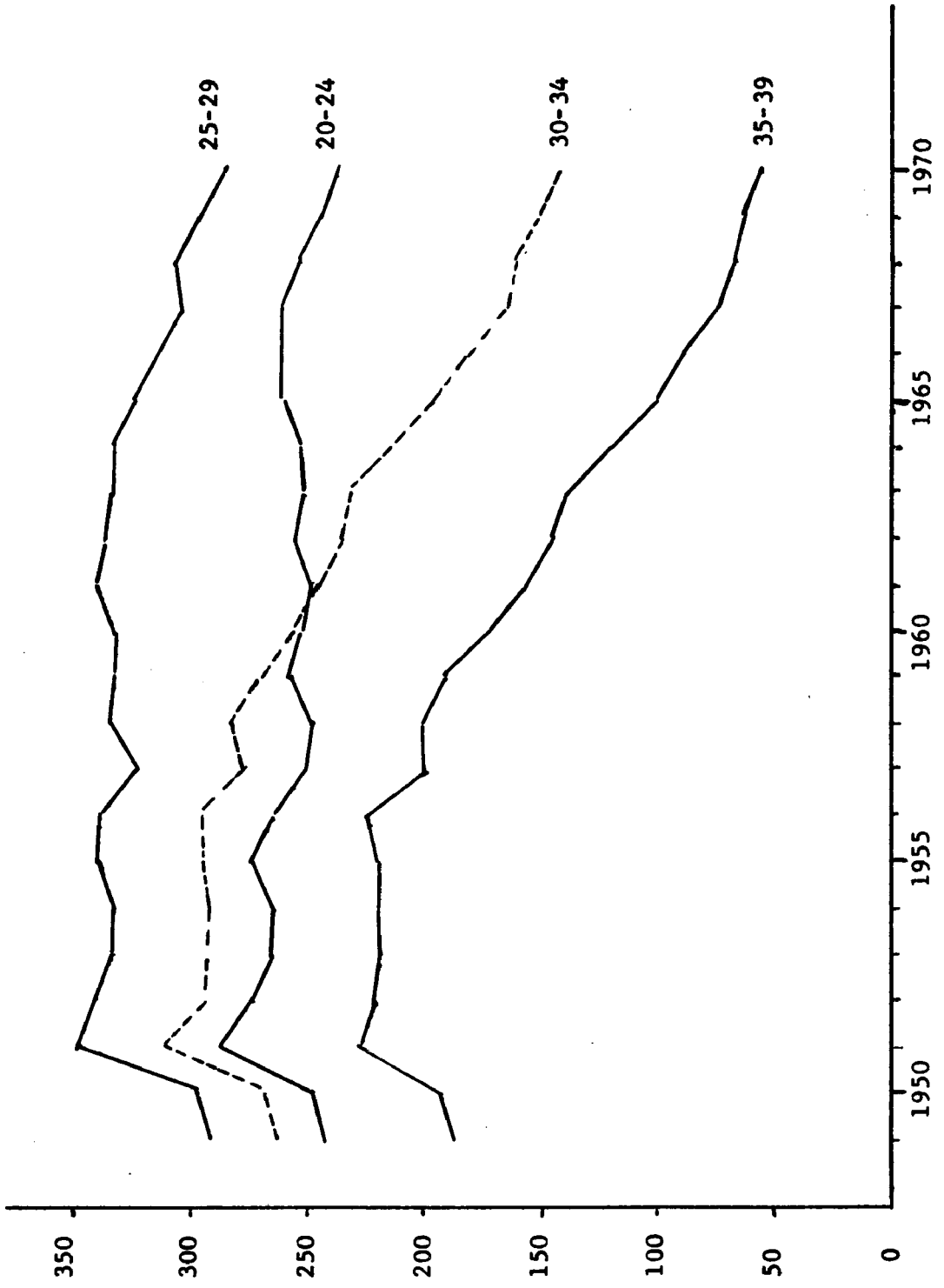


FIGURE 3-3: Four age-specific fertility rates for all Taiwan, 1949-1970.
Source: Taiwan Demographic Reference, Vol.II, Table 14-1;
Taiwan Demographic Fact Books 1963-1970.

TFR 1952	6620
TFR 1970	3950
Percent decrease:	40.3
Due to women less than 30:	8.0
Due to women 30 and over:	32.3

Further analysis will reveal that change below age 30 is due largely to change in nuptiality patterns, while above 30, changes in marital fertility are the main cause.

Areal Variation in Fertility

While the evidence just reviewed suggests that there was no great increase in family planning practice prior to the 1950's, there was considerable variation among geographical areas of the country as illustrated in the total fertility rates in Table 3-1. Here the units of analysis are the major cities (of which there are 5) and seven prefectures. Combining later units (16 hsiens, 5 cities and one special area) allows for comparison in fertility between the 1930's and the post-colonial period on a set of approximately equivalent areal units.

Barclay interprets the data as indicating that rural-urban differences are not meaningful since there is as much variation among cities and among prefectures, as between cities and prefectures. He suggests that regional and cultural differences may be more important than urban and rural location (pp. 249-252).

Table 3-1 shows, however, that on the average it is clear that cities have lower fertility even though there is some overlap in the ranges of the two categories. Further, comparison with the later data

TABLE 3-1. Total Fertility Rate for Prefectures and Major Cities, 1930, 1935, 1952-54 Average

	1930	1935	1952-54 Avg*
Prefecture			
Taipei	6674	6386	6459
Hsinchu	6901	6674	6451
Taichung	7354	7045	6682
Tainan	7540	7231	6734
Kaohsiung	6983	6922	6747
Taitung	5830	6118	6915
Hualien	6736	6304	6883
Mean Prefectures:	6860	6669	6696
Cities			
Taipei	5727	5541	5515
Keelung	5686	5686	6153
Taichung	6530	6035	6087
Tainan	6262	5974	5935
Kaohsiung	7004	7004	6498
Mean Cities:	6242	6048	6038

*Average of 3 years for hsiens constituting prefecture.

SOURCE: Barclay, p. 251; Demographic Reference of Taiwan, Vol. II.

show that the pattern of differential TFR between cities and prefectures was very similar in the 1930's and the early 1950's. In addition to Barclay and Taeuber, the persistance of rural-urban fertility differentials in the post World War II era has been noted by others (see for example, Freedman, Peng, Takeshita, and Sun, 1963; Collver, Speare and Liu, 1967).

It is the conclusion of both Barclay and Taeuber, looking at the longer historical record, that the degree of areal variation in the early 1950's as revealed in Table 3-1 is longstanding and was probably not the result of a process of change. Barclay states that

> There is no way to determine, then, whether or not the observed differences in Taiwan might have presaged further declines in the segments of Taiwanese that were exposed to outside influence. But two things are certain: such a decline had not proceeded very far, and its progress was extremely slow. It may have been nothing more than a continuation of differences that existed before the arrival of the Japanese in Taiwan (p. 254).

Taeuber makes a similar inference from the evidence:

> The fertility of the Chinese in Taiwan was high, and it was highly resistant to change. There were differences as among areas and sub-cultural groups. Birth rate, gross reproduction rates and age ratios were lower in urban than in rural areas, whether due to selectivities in migration, differential survival or faulty allocations. These were continuing characteristics of the people, not measures or heralds of early transition to lower fertility (p. 121).

While fertility itself may not have been changing, important factors bearing on fertility were. Mortality may be the most important of these factors.

Mortality Trends Since 1900

Mortality is one of the key variables in the theory of demographic transition. As discussed in Chapter 2, falling mortality can create the impetus to decrease childbearing in the absence of any change in family size norms. The fertility of Taiwanese couples seems particularly sensitive to mortality on a personal level; whether or not a couple has experienced the death of a child has been found to be one of the strongest predictors of their contraceptive behavior (Rutstein, 1971).

As shown in Figure 3-1, the crude death rate began declining around 1920. In the beginning of the Japanese period Taiwan had a reputation as an unusually unhealthy place to live and had a crude death rate of around 33 per thousand. The Japanese were able to cut the death rates considerably through means that were inexpensive on a per capita basis (Barclay, p. 169). The death rate dropped with the control of epidemics of cholera and plague (Liu, 1973, p. 11). The immediate effect of improving health standards on fertility, as mentioned earlier, may well have been to increase fertility to some extent.

After the end of the colonial period improvement of mortality conditions continued as modern medical technology was made available to the general population. Improvements were made especially in the areas of infant and child mortality. As a result, while crude death rate (CDR) continued to drop to extreme low levels, child mortality decreased even further proportionately. The following abbreviated series of readings are mean CDR's and deaths per 1000 population age 1 - 4 of the 22 major cities and hsiens:

	CDR	Death rate 1-4
1951-53	10.29	20.71
1959-61	6.96	7.91
1971	5.03	2.87

Analysis has shown that infant mortality is seriously under-reported in Taiwan. The reported mortality rate at ages 1-4 may actually be somewhat high (Sullivan, 1973). The use of mortality 1-4 as an indicator of the probability of child survival is a compromise; death rates at older childhood ages are extremely low, and there is little areal variation.

Urban-rural differences in health conditions have apparently existed for some time, similar to fertility levels. In the post-colonial period, differentials have persisted, and do not appear due to age structure or completeness of registration, explanations that probably would call for depressed mortality in rural areas. Differentials in mean mortality rate 1-4 are shown below:

	6 Urban Areas	16 Other Areas
1951-53	16.0	22.5
1959-61	6.9	8.3
1971	1.9	3.2

Despite the persistent differential, the early reduction of mortality, according to Barclay, entailed a "leveling off of some of the initial inequities in health conditions" (p. 169). For the Japanese period he noted the following series of coefficients of variation (i.e., standard deviation divided by the mean) for CDR and infant mortality ✓

rate (which he does not define) using the seven prefectures as areal units of analysis.

	CDR	Infant Mortality
1906	19.2	--
1915	17.7	13.2
1925	15.2	10.8
1930	9.6	9.3
1935	5.6	6.3

In other words, as mortality reductions proceeded there came to be less total variation among the areas, relative to the mean which was also changing. In the post colonial era variation among areas measured in this way continued to decrease at least until around 1960 (using 22 areal units of analysis):

	CDR	Mortality 1-4
1951-53	.20	.26
1959-61	.15	.20
1971	.15	.35

The trend in mortality, then, suggests that the effects of improving conditions were felt across the entire island, and that while some disparities continue, there was a movement toward equalization of the risks of death. The effects of lower mortality, an important factor in the complex of processes involved in demographic modernization, were brought to bear in all the geographic areas of the island.

Trends in Socioeconomic Development

Taiwan has developed rapidly in the past 20 years. Prior to World War II the Japanese did much to increase the output of the economy, but their system was geared toward agricultural production complementary with Japan's industrial production, and native Taiwanese were kept out of the modern sector. To increase agricultural output the existing system of small holdings, intensively cultivated, was maintained, while the use of irrigation, chemical fertilizer and high-yield hybrid seed was emphasized. The island was administered through the indigenous village organization in which each locality was "self-contained, self-sufficient and resistant to outside influence" (Liu, p. 4). The social supports to high fertility were little changed throughout the colonial period and as Barclay remarks, "since nothing occurred to diminish the strength of familial institutions, there is no reason why fertility should have declined" (p. 258).

Following the departure of the Japanese in 1945, there was a period of disruption due to war damage. Economic development began in the early 1950's and has proceeded with a rapid pace ever since. Land reform was instituted allowing the tillers of small holdings to own their land. Intensive cultivation of small farms continued to be the dominant pattern of agriculture, a pattern that held a number of advantages for economic development. It absorbed the excess labor force, typical of developing countries in the throes of demographic transition, until the non-agricultural sector expanded (Liu, p. 11). Further, many of the initial industries were closely related to farming as in the case of the chemical fertilizer industry.

Table 3-2 displays a number of indicators of socioeconomic development for Taiwan in the post colonial era. It is evident that the economy has become industrialized over the period so that by the late 1960's less than half of the labor force is engaged in agriculture, though the farm sector at 40% is still large compared to western modernized countries.

Indicators of education, use of mass media and mortality and health all show substantial change in the direction of modernization.

The trends in mortality and socioeconomic modernization point to the period since the early 1950's as being one in which the climate was conducive to the fertility decline which did in fact occur. A final factor of importance in understanding fertility trends is the island-wide family planning program begun in 1964. Credit for initiating the decline, of course, cannot be laid to the program, since the onset of decline was several years prior to the beginning of the program. The facts do suggest, however, that the program has had considerable impact in spreading efficient contraception through all segments of the population. Freedman, Hermalin and Sun, for example, note that between 1964 and 1970 the number of IUD insertions to married women ages 20-44 was equal to one third of the married women 20-44 during that seven year period (1971, pp. 15-16).

In the pilot phase of the program, confined to one city, it was found that use of birth control was more common among more modern women prior to the program. Program IUD acceptance was not related to modernity indices, suggesting that the program had a role in diffusing family planning to lower socioeconomic strata (Freedman and Takeshita, 1969, pp. 354-355).

TABLE 3-2. Indicators of Economic and Social Development for Taiwan Area, Republic of China, 1952-1969

	1952	1956	1960	1964	1970
Economic Indicators					
Gross National Product (GNP) Index[a]	100	133	172	254	439
Per Capita Real National Income Index[a]	100	111	125	168	233
Savings as Percentage of National Income	4.8	4.9	6.9	15.6	22.8
Agricultural Production Index	100	121	143	178	237
Total Industrial Production Index[c]	100	155	245	410	1115
Electric Power Production Index	100	158	255	419	930
Percent of Net Domestic Product from Industry	18	22	25	28	33
Percent of Male Labor Force over 11 in Non-Agricultural Occupation	42	45	49	50	63
Education Indicators					
Percent of Population 6 and over who are Illiterate	42	37	27	22	15[e]
Percent of Primary School Graduates Enrolled in Junior High School	34	47	51	55	80
Communication & Transportation Indicators					
Daily Newspaper Circulation per 1000	28	40	55	70	--
Radios per 1000 Families	34	105	350	555	621[e]
Posting of Domestic Letters per Capita	8	17	33	32	37
Long Distance Calls per Capita	0.6	1.0	1.4	108	2.2

(Table continued)

TABLE 3-2 (Continued)

	1952	1956	1960	1964	1970
Health Indicators					
Death Rate per 1000	10	8	7	6	5
Life Expectancy for Males	51	59	61	64	66[e]
Population per Doctor	1610	1537	1553	1520	1399

[a]At constant price of 1964, and adjusted for gain or loss due to changed terms of trade.

[b]1968 data.

[c]Includes manufacturing, mining, electricity, gas and water.

[d]For male labor force over 14 years of age.

[e]1969.

SOURCE: Council for International Economic Cooperation and Development, Taiwan Statistical Data Book, 1970, 1972.

Using an areal analysis Hermalin (1971) finds that according to the causal model he posits, above age 30 the program seems to be effective only in the more backward sector (where this sector is defined as a group of areas having high fertility before the beginning of the program). He concludes that his indicates program success in the high initial fertility areas:

> The fact that program acceptance is highly associated with lower fertility in a homogeneous group of areas which are less modern, with lower knowledge of and access to other forms of contraception, is strong indication that the program has been successful in this sector. At the same time, the absence of any effect from acceptances to fertility in the other two subsets would seem to indicate that there is substitution of program methods for other contraceptive use taking place there (1971, p. 32).

The program, then, may be seen as playing a role in closing the gap between disparate socioeconomic groups and geographical areas. Evidence from a series of island-wide surveys between 1965 and 1970 suggests that such a gap in contraceptive use is being closed.

Freedman, Coombs and Chang (1972) report that the practice of contraception rose rapidly in the last half of the 1960's, particularly among less modern women. For example, the proportion of married women 22-39 who had ever used contraception is reported in Table 3-3 by two measures of modernization. It is clear that differentials do persist by both educational attainment and residence, but proportionately greater gains in contraceptive experience were made in the less modern categories. It is interesting to note that the variation found in <u>ideal family size</u> across modernization categories is much less than that for contraceptive experience. Ideal numbers of children are "universally concentrated in the three-four range" (p. 287). It is

TABLE 3-3. Percent Ever Using Contraception Married Women 22-39

	1965	1967	1970
Education			
None	19.4	32.9	50.9
Primary	31.9	42.3	53.7
Junior High	51.4	58.3	71.4
Senior High +	60.2	65.5	79.2
Residence			
Rural Township	21.4	32.9	48.2
Urban Township	25.7	40.1	53.8
Small Cities	31.7	44.0	62.2
Large Cities	43.3	55.4	69.1
Total	28.1	41.1	55.5

SOURCE: Freedman, et al. 1972, Table 7, p. 286.

difficult to appeal to differences in demand for contraceptive goods and services (as measured by desired number of children) to account for contraceptive experience, since there is much less variation in ideal numbers than in practice. The pattern of change suggests that there was little difference in demand, only in access to or knowledge or contraception, differences that diminished over the five year period surveyed. The notion of diffusion from one social stratum to another, or from one place to another may well be the best framework through which to view the changes taking place.

Conclusions

For the period of 1961-70, data are available both from sample surveys and from the registration system with which it is possible to describe the changes taking place in fertility in fine-grained detail. These data, however, can only describe changes that were set into motion prior to the period they cover. In order to discuss the origins of change one must rely on more meager sets of data. The long term data and the detailed information on the more recent period discussed in this chapter can perform complementary roles in the understanding of the changes taking place. In the analysis chapters that follow, both the long and short periods will be treated.

The discussion of the historical demographic record, and some recent findings in this chapter should support the model that 1) the forces of social, economic and demographic change worked together to make the time ripe for the fertility change that began in Taiwan in the late 1950's; and 2) that the change probably represented large segments of the population using efficient means of deliberate fertility control for the first time.

CHAPTER 4

URBAN-RURAL AND REGIONAL DIFFERENCES IN FERTILITY TRENDS, 1952-1970

In this chapter the number of variables discussed is limited in order to focus the discussion of the issues involved. Only two rather elementary variables are used as independent variables; the dependent variables are the age specific fertility rates for four age groups. One set of areal data is used: 18 yearly observations for each of 22 areal units, for the period 1952 to 1970 (excluding 1962), which yields 396 observations for each dependent variable.

The basic question asked is whether there are differences in the trends in fertility of the areal units consistent with one or more hypothesized pattern of fertility change. A number of methodologies are proposed to deal with this question. There are two basic approaches--comparison of a series of areal cross-sections, and the computation of key parameters for the trends of individual areas. These two approaches represent two ways of "slicing" the data. The results are remarkably consistent in what they have to say about urban-rural and regional differences in fertility trends.

The Use of Cross-Sections

By cross-sections it is meant here an analysis in which each variable is measured at one time point; independent variables may be "lagged"--measured at some point in time prior to the dependent

variable--but each variable is measured only once. Cross-sectional multivariate models have been used fairly frequently in studies of fertility determinants using areal units of analysis (Hermalin, 1968, 1971; Nerlove and Schultz, 1970; Schultz, 1973; Livi-Bacci, 1970).

Cross-sectional correlations, of course, do not necessarily imply dynamic causal relationships. Further, as Hermalin points out (1971, pp. 23-24), when using areal units independent variables such as mortality depend on long-term environmental factors that change slowly, so that geographical differentials tend to persist. This kind of reasoning tends to throw into question the meaning of mortality-fertility associations. A high areal correlation between mortality and fertility may simply indicate lack of change in the factors underlying both vital processes, rather than a causal connection between the rates of birth and death. Another problem with cross-sectional analysis will be illustrated later in this chapter. Fertility levels across areas at one time point may reflect long term areal differences, or differences in the timing and rate of change in fertility, or most likely some combination of these two factors. Thus, in terms of the determinants of fertility, a given cross-sectional differential or correlation may have different meanings at different points in a time series.

The use of cross-sections in the present discussion will employ two independent variables, both measures of location and both time invariant, a rural-urban dichotomy and a three-part regional specification. The approach, which owes much to Carlsson's discussion (1966), is to see if differences in trends in fertility rate are revealed by observing the trend in cross-sectional variation in fertility from 1952-1970.

The Independent Variables

The urban-rural variable (UR) divides the 22 areal units into (1) the 5 major cities plus one small area contiguous to Taipei City, and (2) 16 other areas or hsiens. It has a number of conceptual and operational drawbacks. It is both a locational variable--fixing an area with respect to the hierarchy of urban places or communication network--as well as an indicator of modernity or socioeconomic development, since urban areas are more modern or developed than the other areas in a number of measurable dimensions; location and socioeconomic development are in a sense confounded. The locations of the six urban areas are shown in the map in Figure 4-1.

On the other hand, urban and rural location is certainly one of the most important variables available; many variables including fertility are highly associated with UR. For some age-groups and years it will be seen later, more than half the areal variation in fertility is explained by UR.

A final shortcoming of the variable is that the "rural" category actually includes the population of several sizable cities. This should be kept in mind even though reference is made to urban versus rural comparisons.

At some points in the ensuing discussion another independent variable will be introduced--region. This is a trichotomous variable that simply divides the areas into northern, middle, and southern sectors; no attempt was made to make the three categories represent any kind of "natural" regions. This variable is included in order to see whether urban-rural differences are, in fact, more important than local variations that occur across the island.

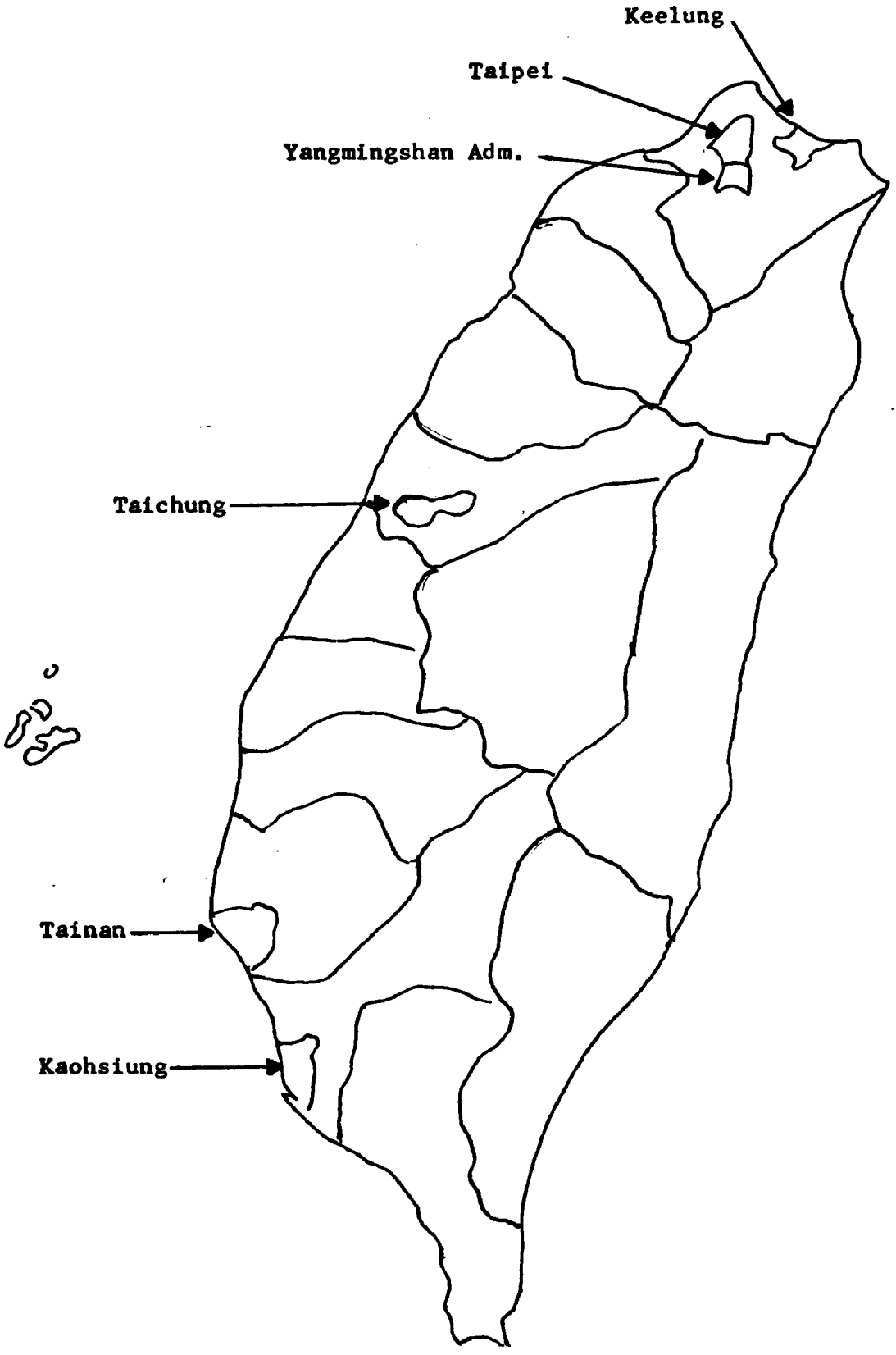


FIGURE 4-1: The 22 major cities and hsiens of Taiwan, showing the location of 6 urban areas.

Methodological Procedures

For each year the grand mean and subgroup means for major cities and the other hsiens were computed, as well as a number of measures of dispersion and association. The format is essentially one-way analysis of variance. This analysis was performed across the 22 areas for each yearly time point 1952-1970 (excluding 1962) yielding 18 separate cross-sections. The use of unweighted means is justified by the goal of illuminating trends in areal differentiation. To the extent that population size and fertility are correlated, if small rural places tend to have higher birth rates, the unweighted mean fertility will tend to be higher than the actual island-wide rate. But the purpose here is to discover the pattern of areal differentiation. Each area is treated as a unit and small places are as important as metropolises in discovering differences.

A number of measures of dispersion are possible with the data format. The variance and coefficient of variation measure the total amount of variation among all areas at a point in time. Eta square measures the association between subgroups of a categorical variable such as UR and a dependent variable in terms of the proportion of variance explained. All of these measures are related, having components in common, as illustrated below:

(1) $\text{variance}(x) = \frac{\sum_i (x_i - \bar{x})^2}{n} = \frac{TSS}{n}$, where TSS is the "total sum of squares."

(2) $\text{coefficient of variation} = \frac{\text{variance}(x)}{\bar{x}} = \frac{TSS/n}{\bar{x}}$

(3) $\text{eta}^2 = \frac{\sum_j n_j (\bar{x}_j - \bar{x}_.)^2}{TSS} = \frac{BSS}{TSS}$, where BSS is the "between group sum of squares."

Observing eta square--which is the ratio of two values--over time may be misleading since the same trend in eta square could result from completely different trends among the components. For this reason, trends in BSS and TSS will be examined separately. Since 'n' does not change over time, TSS trends will be proportionately the same as trends in the variance. TSS is considered a measure of "dispersion"--an increase in this means that the areas are becoming less alike in general with respect to fertility. BSS measures what will be called "differentiation"; an increase in BSS means that subgroup means are becoming less alike. Unlike TSS, BSS depends on an independent variable, such as UR or region.

Overall Trends--Age Effects

Figure 3-3 of the last chapter documents the trends for the four major age-specific fertility rates. Age differences are quite pronounced. Below age 30 there is very little decrease, while at older ages there is a considerable decline. These differential trends by age group have led to a lowering of the average age of childbearing, while total fertility has fallen. In 1952 the age group 30-34 had the second highest birth rate behind 25-29. By the late 1960's the 20-24 age group was in second place by a substantial margin.

For the age groups below age 30 there is little evidence of sustained decline, except in the last few years. Both 30-34 and 35-39 have had steadily dropping birth rates since the late 1950's. It will become clear that fertility determinants and the meaning of trends are quite different for older and younger women. Generally, above age 30 there has been only slight change in proportion married, and

declines can be attributed with considerable confidence to women achieving controlled fertility within marriage. Below 30 nuptiality plays an important role, and change or lack of change will have an accordingly more complex interpretation at these ages.

Urban-Rural Differences in Fertility Trends by Age

Tables 4-1 to 4-4 show the trends in means for the five major cities and other areas separately; these series are plotted in Figures 4-2 to 4-5. It is important to note that with the exception of 20-24, there are differentials in mean fertility level, with cities lower, prior to the beginning of any evident sustained decline. This means that differentials between urban and non-urban places are probably not solely the result of some areas leading the fertility decline and others lagging.

Age group 20-24 provides a good example of divergence caused by a leading sector. Taking three year averages at the beginning, middle and end of the series as in Table 4-5 shows that between 1952 and 1960 both cities and other areas changed little. In the 1960's, however, cities had declined considerably more in both percentage and absolute terms--12 vs. 4% and 32 vs. 11 births per thousand women.

For 25-29 differences exist between the rural and urban sectors throughout the early period. Cities fell furthest both proportionally and absolutely and more of the decline is concentrated in the early part of the series for the urban category.

Above age 30 cities also declined earlier and further in percentage terms. In absolute terms, however, the other areas, starting from a higher pre-decline level, actually declined so much in the 1960's

TABLE 4-1. Mean Fertility Rate* 20-24, Sums of Squares and Explained Variance (eta) for UR Variable, 1952-1970

	Grand Mean All Areas	6 Urban Areas	16 Other Areas	BSS 1000	TSS 1000	3 Year Average Eta
1952	272	263	275	.652	8.616	
1953	267	261	269	.299	7.149	.27
1954	266	257	270	.733	6.820	
1955	276	269	279	.377	9.424	
1956	269	267	269	.023	8.747	.13
1957	255	249	258	.380	16.295	
1958	254	257	253	.069	11.890	
1959	263	255	266	.534	13.561	.09
1960	259	258	259	.008	12.569	
1961	251	242	254	.675	10.965	
1963	257	240	264	2.624	12.646	.32
1964	259	249	262	.759	12.453	
1965	266	257	269	.613	14.0	
1966	280	259	287	3.431	30.338	.32
1967	256	236	263	3.201	17.496	
1968	262	237	271	5.212	15.321	
1969	250	227	259	4.550	16.074	.54
1970	243	222	251	3.851	14.856	

*Age specific fertility rates per 1000 women in all Tables.

TABLE 4-2. Mean Fertility Rate 25-29, Sums of Squares and Explained Variance (eta) for UR Variable, 1952-1970

	Grand Mean All Areas	6 Urban Areas	16 Other Areas	BSS 1000	TSS 1000	3 Year Average Eta
1952	339	332	342	.447	10.4	
1953	335	330	337	.210	6.63	.25
1954	331	318	336	1.43	10.5	
1955	342	325	348	2.34	6.86	
1956	341	332	345	.716	6.09	.48
1957	327	307	334	3.13	12.1	
1958	336	319	343	2.37	7.03	
1959	334	307	344	5.96	9.83	.66
1960	335	314	343	3.58	9.55	
1961	343	316	353	5.96	12.9	
1963	338	310	348	6.54	11.5	.73
1964	336	307	347	6.87	12.7	
1965	328	292	341	10.8	14.7	
1966	322	288	334	9.28	15.6	.78
1967	298	274	307	4.82	9.72	
1968	313	288	323	5.25	12.7	
1969	302	281	310	3.85	8.79	.54
1970	299	288	303	.907	10.1	

TABLE 4-3. Mean Fertility Rate 30-34, Sums of Squares and Explained Variance (eta) for UR Variable, 1952-1970

	Grand Mean All Areas	6 Urban Areas	16 Other Areas	BSS 1000	TSS 1000	3 Year Average Eta
1952	290	273	296	2.28	11.2	
1953	288	271	295	2.48	7.77	.56
1954	288	263	297	5.15	11.7	
1955	295	275	303	3.42	8.12	
1956	295	266	305	6.70	11.2	.70
1957	277	248	288	6.90	14.8	
1958	280	252	290	6.50	12.2	
1959	270	236	282	9.34	13.1	.76
1960	259	225	272	9.45	18.2	
1961	250	223	260	5.81	16.4	
1963	232	209	241	4.73	15.0	.57
1964	220	193	230	5.95	18.9	
1965	201	169	213	8.52	21.2	
1966	190	161	201	6.95	20.9	.55
1967	164	146	171	2.79	15.0	
1968	168	152	174	2.18	17.5	
1969	157	143	162	1.46	9.82	.35
1970	152	139	156	1.27	12.6	

TABLE 4-4. Mean Fertility Rate 35-59, Sums of Squares and Explained Variance (eta) for UR Variable, 1952-1970

	Grand Mean All Areas	6 Urban Areas	16 Other Areas	BSS 1000	TSS 1000	3 Year Average Eta
1952	217	190	227	5.93	12.7	
1953	214	189	224	5.14	10.5	.65
1954	214	192	223	4.05	12.3	
1955	217	190	217	6.13	13.9	
1956	221	187	234	9.33	15.6	.72
1957	199	165	211	9.17	17.6	
1958	202	167	215	9.98	16.8	
1959	193	160	205	9.01	19.0	.72
1960	177	137	192	12.8	26.6	
1961	162	125	176	11.1	23.1	
1963	145	117	155	6.64	22.1	.60
1964	126	97	137	6.82	21.0	
1956	107	73	119	9.03	24.5	
1966	96	70	106	5.53	22.1	.50
1967	79	59	86	3.05	18.6	
1968	74	60	74	1.66	13.1	
1969	69	55	75	1.67	11.9	.37
1970	63	51	68	1.34	8.60	

TABLE 4-5. Percentage and Absolute Decline in 4 Fertility Rate Means for Three Periods, 1952-1970

Age Group and Period	Percent			Absolute		
	Grand Mean	6 Urban Areas	16 Other Areas	Grand Mean	6 Urban Areas	16 Other Areas
20-24						
Total	6	12	4	16	32	11
1	4	3	4	11	8	11
2	2	9	0	5	24	0
25-29						
Total	9	12	8	30	41	26
1	-1	4	-2	-3	14	-11
2	10	8	10	33	27	35
30-34						
Total	45	46	44	130	124	132
1	9	15	8	29	41	25
2	36	31	36	101	83	107
30-34						
Total	68	71	68	147	135	153
1	18	26	15	30	49	36
2	50	45	53	103	86	117

Periods: Total 1952-54 Average to 1968-70
1 1952-54 Average to 1959-61
2 1959-61 Average to 1968-70

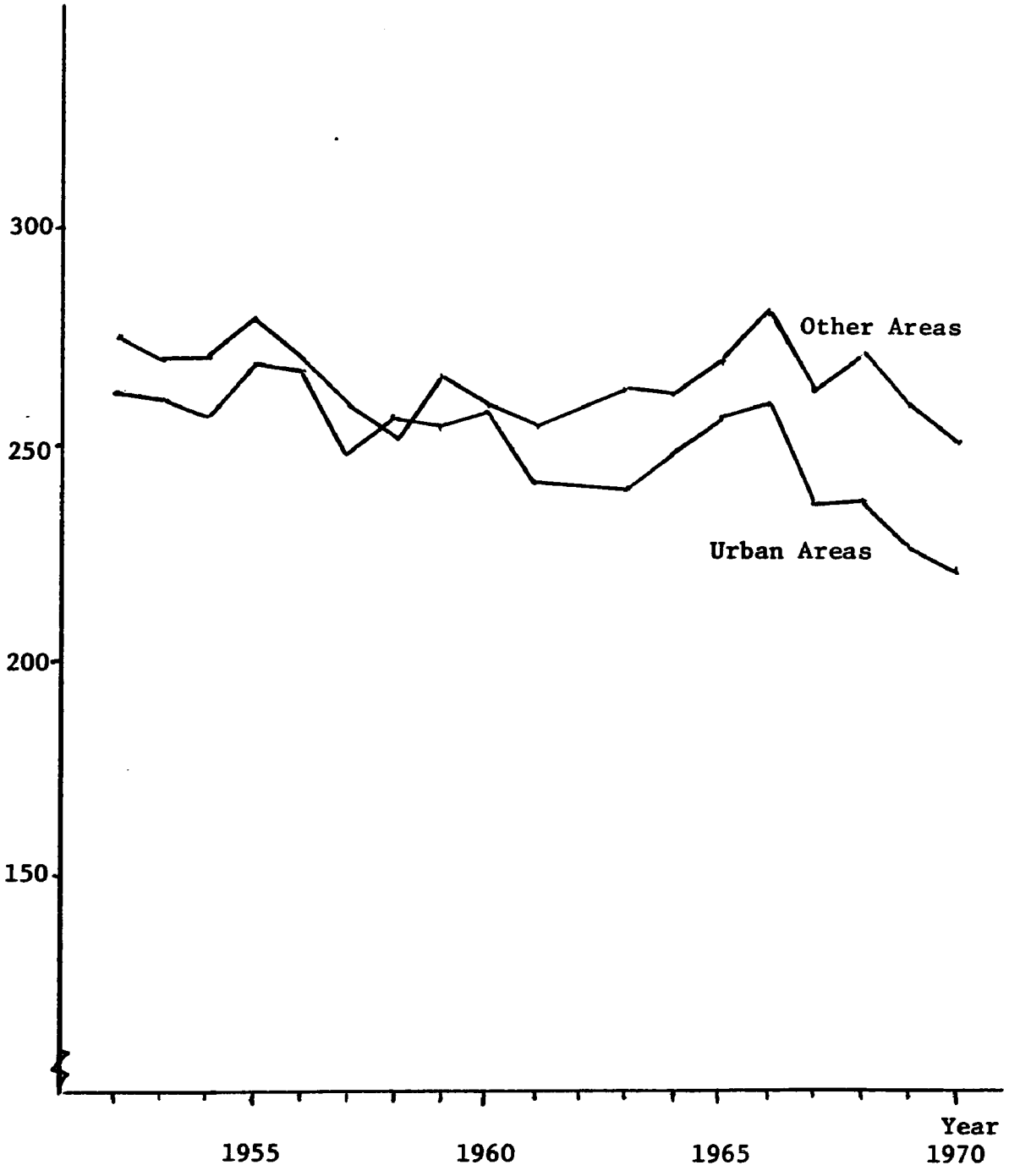


FIGURE 4-2: Mean fertility rate 20-24, 1952-1970 for 6 urban areas and 16 other areas.

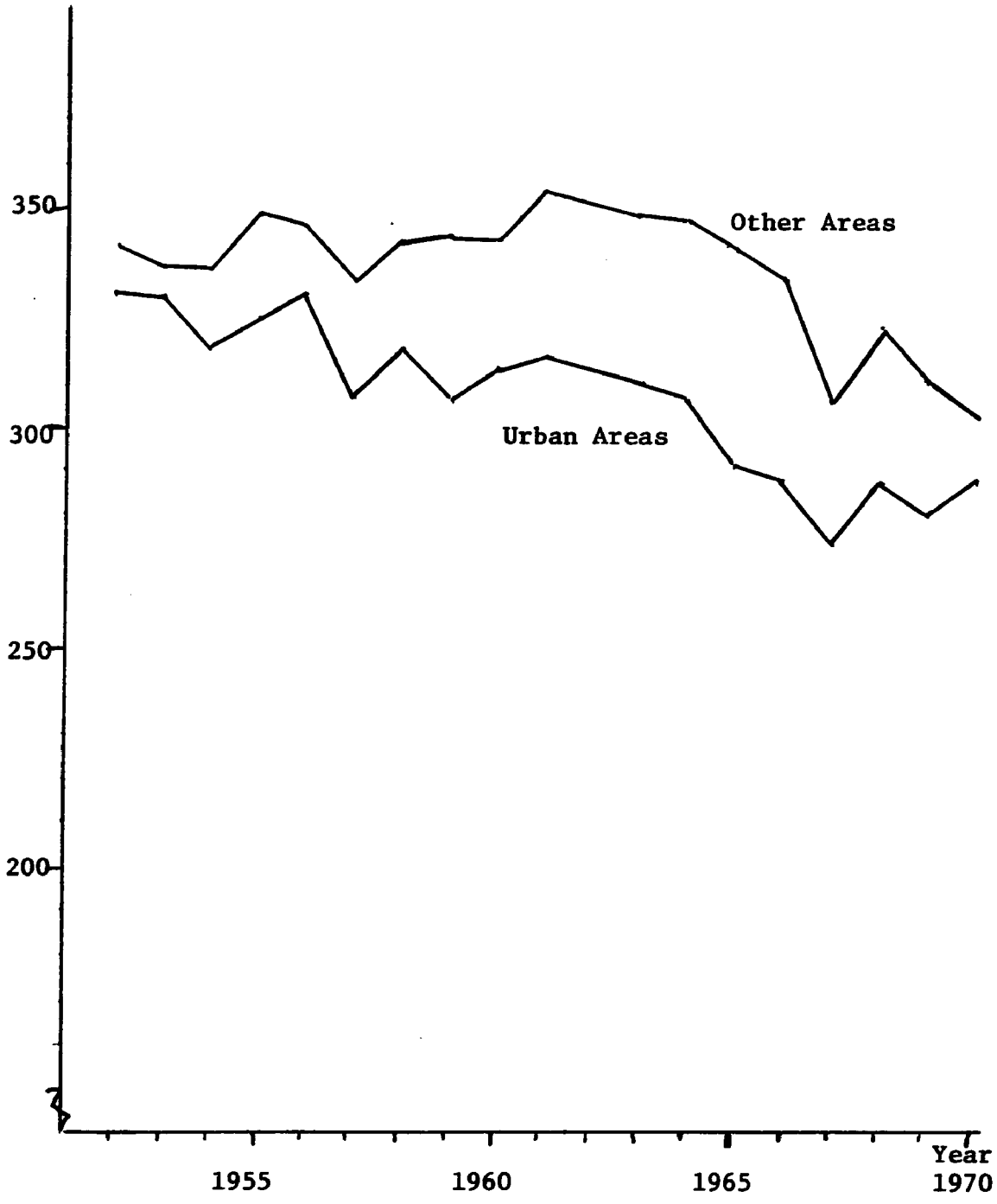


FIGURE 4-3: Mean fertility rate 25-29, 1952-1970 for 6 urban areas and 16 other areas.

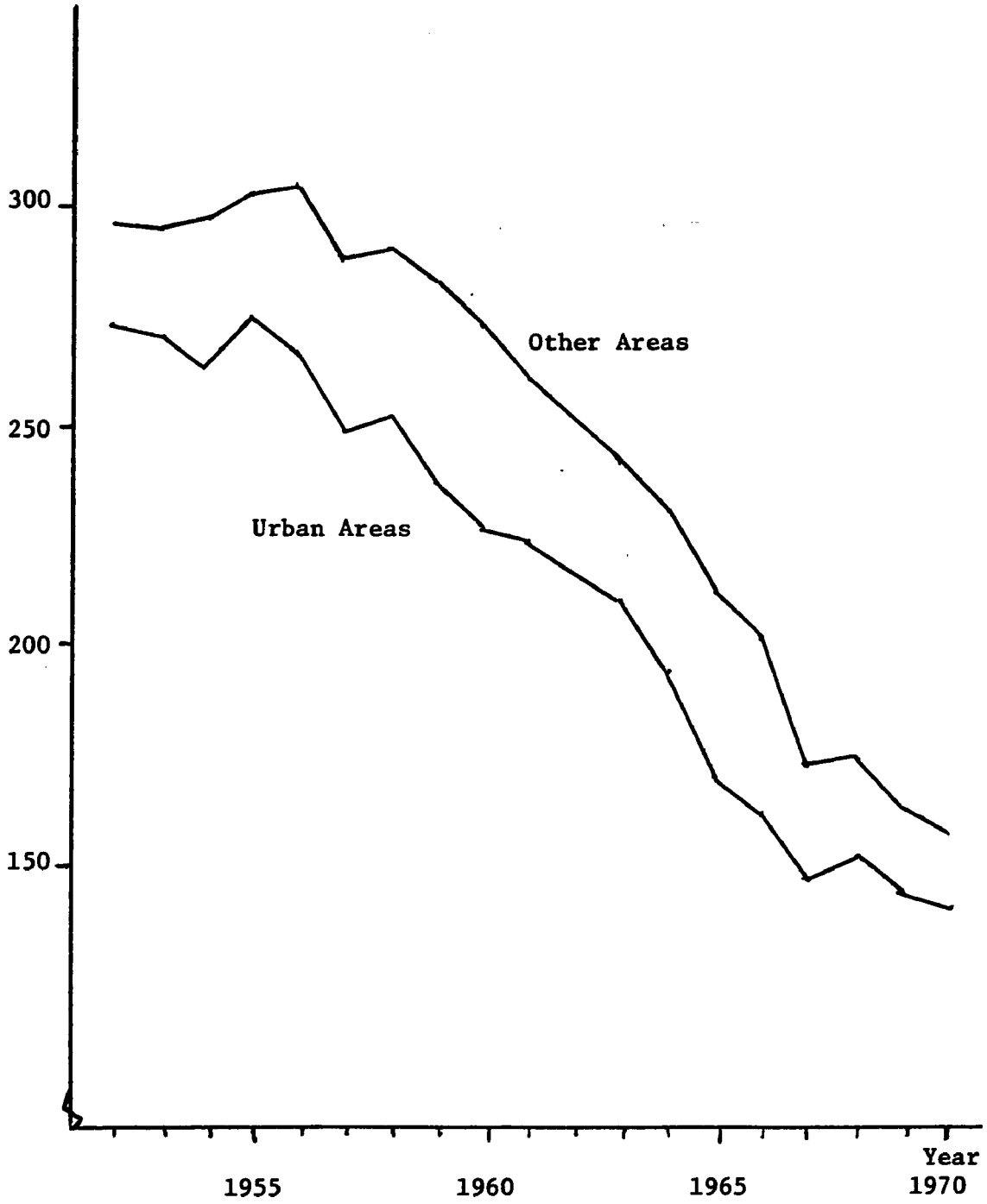


FIGURE 4-4: Mean fertility rate 30-34, 1952-1970 for 6 urban areas and 16 other areas.

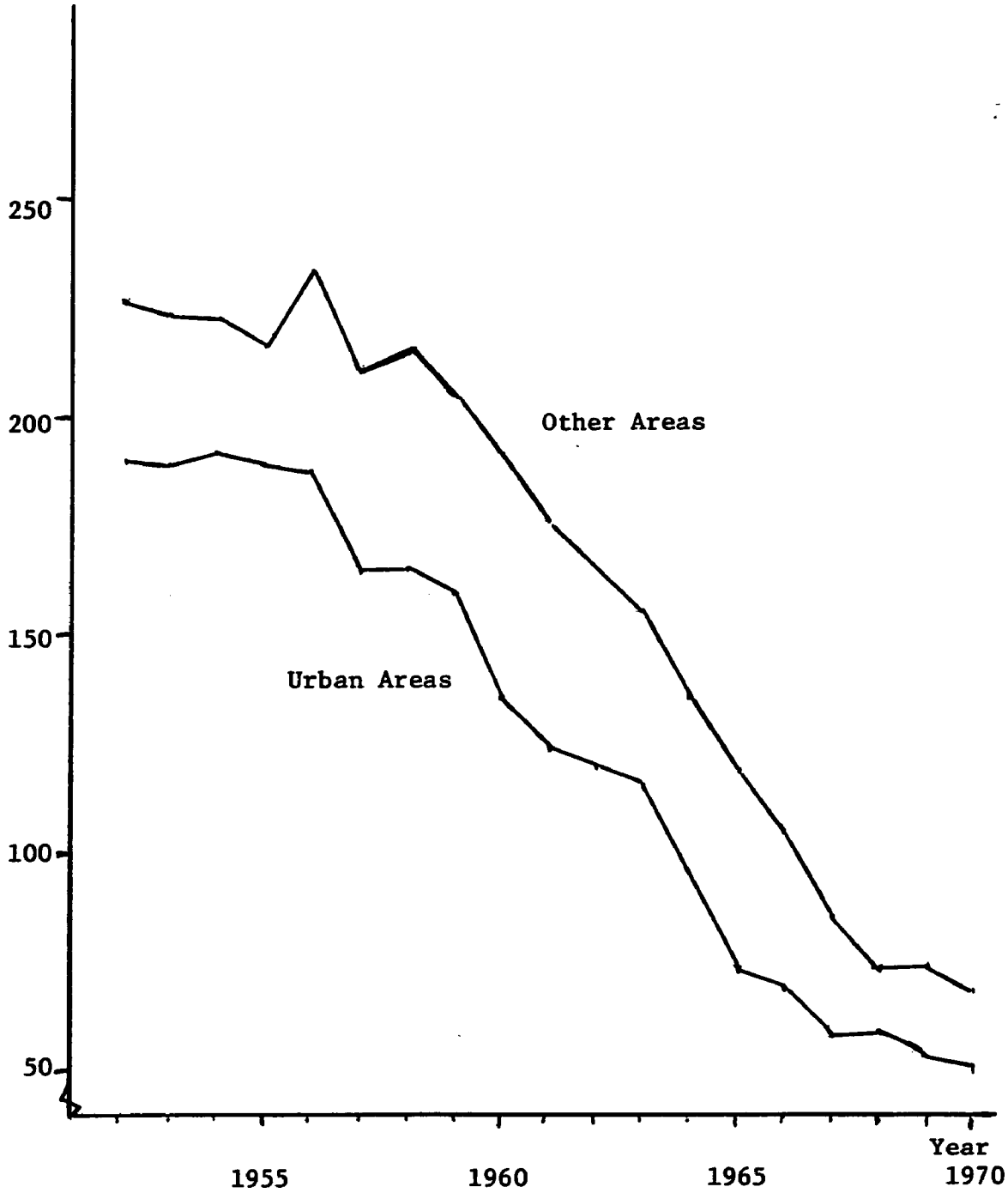


FIGURE 4-5: Mean fertility rate 35-39, 1952-1970 for 6 urban areas and 16 other areas.

that their 18 year total reduction is greater than the cities' in births per thousand women.

Comparatively, across age groups, a few generalizations can be made. By dividing the series in half and comparing the amount of decrease computed in two different ways, all age groups show a period in which the cities acted as a leading sector. For the age groups over age 25 this is the first period, and the second half of the series is a catch-up phase in which the other areas are declining faster than cities. For 20-24 cities are declining fastest at the end of the period and the following phase has not yet occurred.

Trends in Dispersion and Association

In Tables 4-1 to 4-4 the series of etas for each age group also reflect the leading-lagging pattern with the sequence beginning earlier for each successive age group. An increase in eta can be interpreted as an increase in the relative amount of total variation accounted for by differences in the subgroup means for the UR variable. As eta increases cities and other areas become less alike in terms of fertility, relative to total variation.

Returning to Tables 4-1 to 4-4, it can be seen that each age group's eta increases and then decreases over time. The three year averages in the table indicate this pattern clearly:

Age Group	Period of Peak Explained Variance
20-24	1968-70
25-29	1965-67
30-34	1958-60
35-39	1955-57, 1958-60

All age groups except 20-24 have a peak period followed by a convergence in explained variance. Also, the diffusion of lower fertility outward from cities that is revealed by this pattern appears to happen earlier at older age groups.

As noted earlier, eta is the quotient of two values--BSS and TSS--each of which has its own interpretation. The trends in these two components are represented in Figures 4-6 to 4-9. TSS, measuring total dispersion without reference to UR, has what could be characterized as an upward trend which turns downward toward the end of the series for the oldest age groups. There is considerable fluctuation from year to year for all four age groups.

The trend in BSS for the UR variable are much the same as the trend in eta. Each age group has a peak, a year when the differences in subgroup means were greatest, and the peak is earlier the older the age group.

For comparative purposes the value for BSS for the regional variables was also plotted in the figures. Differentiation by region over age 25 is generally less than the differentiation by the UR categories. Since a small number of cases is being used, and since region has one more category than UR, region would be expected to explain more variance, all things being equal. Later when explicitly comparing the explanatory power of UR and region, eta's will be adjusted for degrees of freedom (Blalock, 1972, pp. 354-355; p. 413). Above age 30 the BSS for regions begins dropping before BSS for UR and is near zero by the mid-1960's. Where fertility has dropped the most--above age 30--strictly locational differences in fertility become insignificant while differences based on the urban-rural variable, which is highly associated

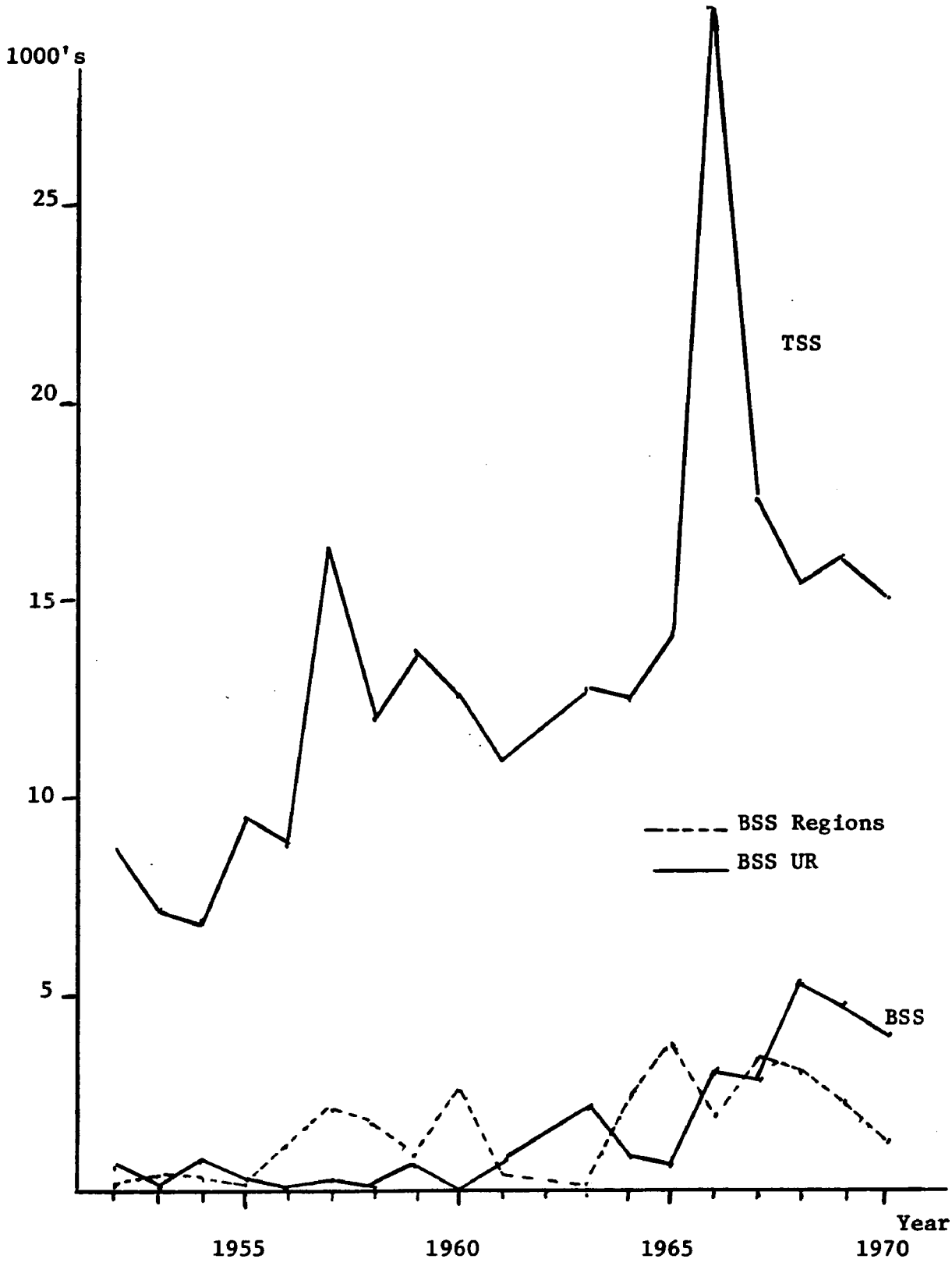


FIGURE 4-6: Total sums of squares (TSS) for fertility rate 20-24, 22 areas, 1952-1970; Between group sums of squares (BSS) for 2 categorical independent variables, Regions and Urban-other areas (UR).

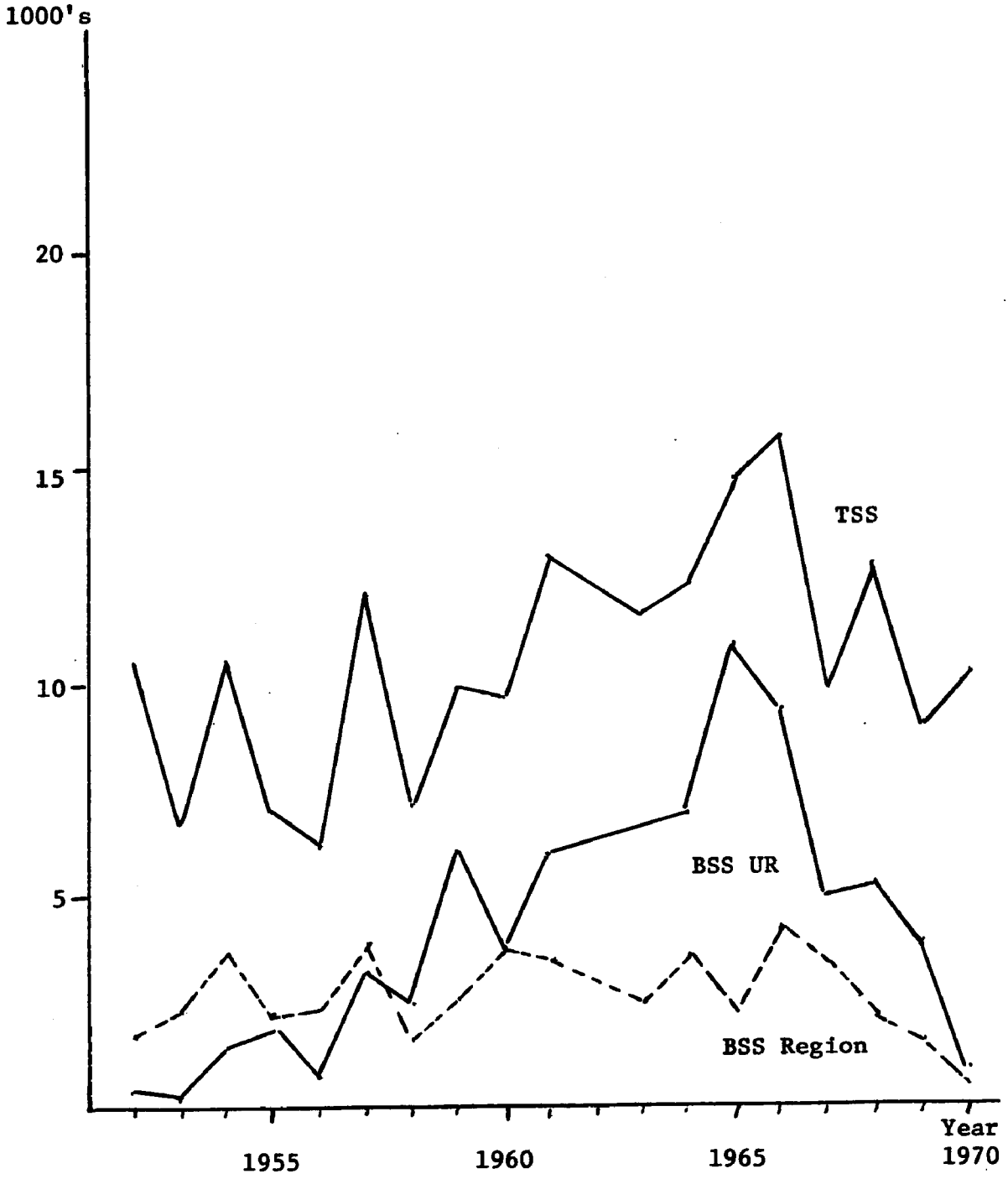


FIGURE 4-7: Total sums of squares for fertility rate 25-29, 22 areas, 1952-1970; between group sums of squares for two categorical independent variables, Regions and Urban-other areas (UR).

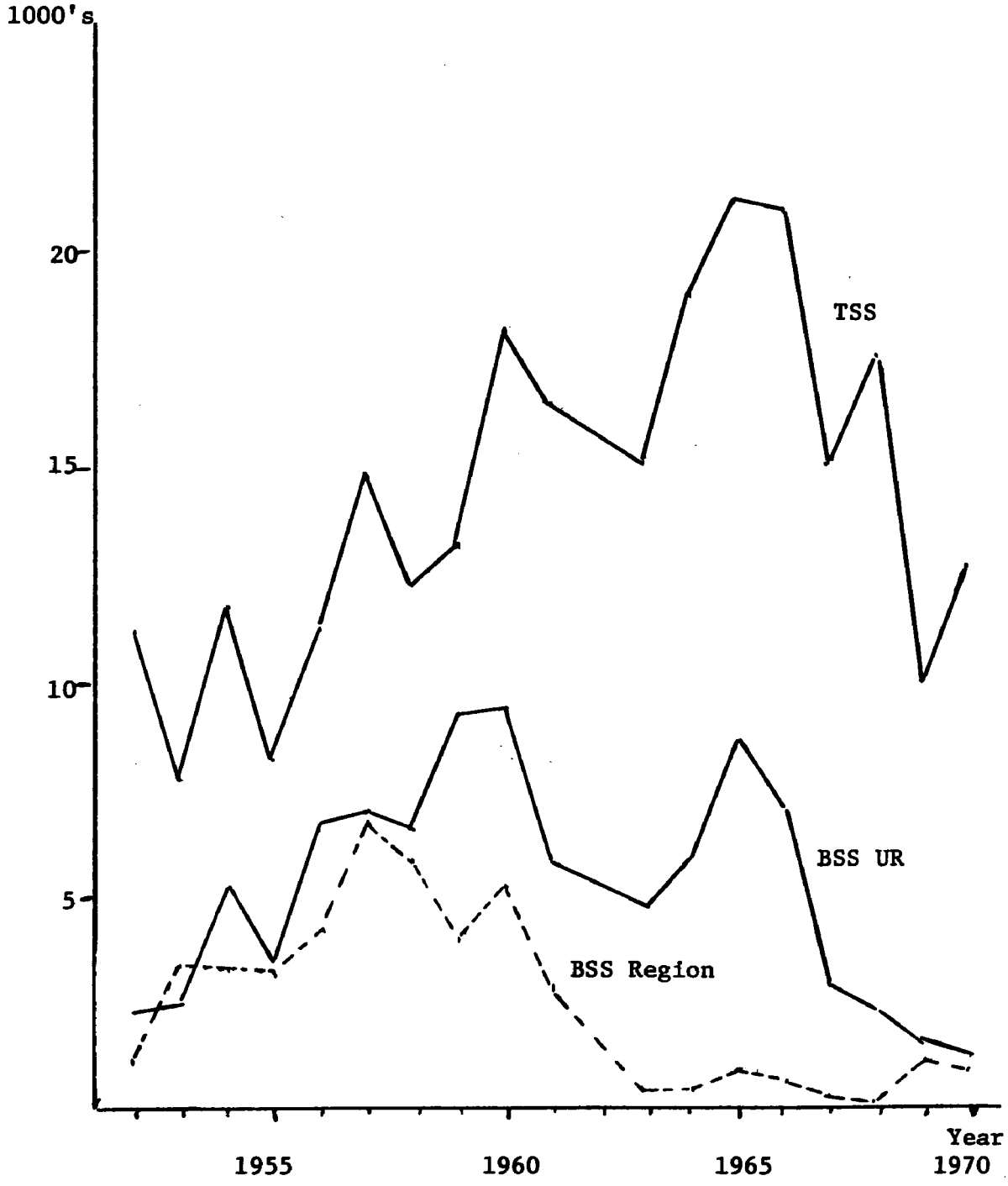


FIGURE 4-8: Total sums of squares for fertility rate 30-34, 22 areas, 1952-1970; between group sums of squares for 2 categorical independent variables, Regions and Urban-other areas (UR).

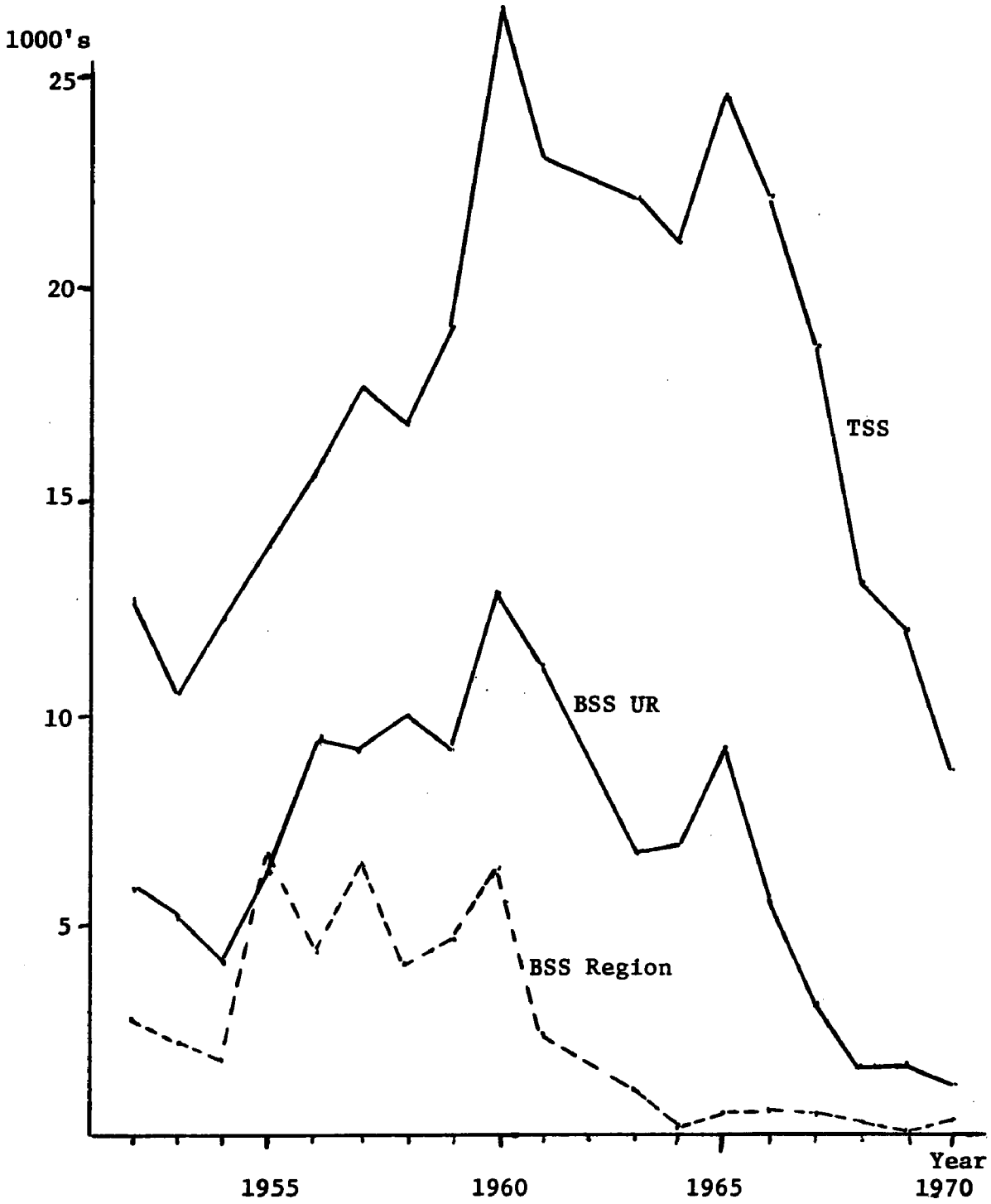


FIGURE 4-9: Total sums of squares for fertility rate 35-39, 22 areas, 1952-1970; between group sums of squares for two categorical independent variables, Regions and Urban-other areas (UR).

with many modernity characteristics, continue to be important for a few more years.

This initial analysis using cross-sections may be considered a test, in crude form, of a hypothesis contrasting locational and socioeconomic development of areas as being important in the timing of fertility decline. The findings may be summarized in a number of points.

1) Both urban-rural and locational variables are important at younger ages where declines in fertility have just begun and are probably the result of nuptiality changes.

2) In the period of decline, urban, areas tend to respond first; also, the "wave of differentiation" passes first at the older ages, later at the younger ages.

3) As fertility falls, differentiation based strictly on location (i.e., region) tends to decline in importance early, while rural-urban characteristics maintain their associations longer.

If for the moment, the urban-rural dichotomy is taken to be a measure of socioeconomic development, the findings tend to support the development model. On the other hand, it was observed earlier that UR is both a measure of development and location. The pattern observed here appears to be one in which level of urbanization is important in the timing of decline, whether this is due to differential development or diffusion of lower fertility outward from cities. Which of these two models is most consistent with the data is a question which must be deferred until the multivariate analysis of Chapter 5. In the present chapter the approach will continue to be descriptive. This discussion, hopefully, has set the theme for further discussion in this chapter of trend differences. Before turning to additional approaches to this problem, it is useful at this point to introduce some treatment of the effects of nuptiality and marital fertility in determining fertility.

At different ages the fertility rate for all women is composed of various portions of these two components. It is worthwhile to look at the effects of these two factors before proceeding to further discussion of the fertility of all women.

The Effects of Proportions Married and Marital Fertility on Fertility Rates, 1961-1970

Unfortunately, age and marital status were not tabulated together until 1959 in the Taiwanese registration system. Thus, the relative importance of marital fertility and nuptiality in decline in fertility cannot be measured until after the decline was under way in the older age groups. However, certain generalizations can be made from viewing the second half of the series that aid in the interpretation of other findings.

A given age specific fertility rate, F, can be expressed in terms of two factors according to the following relationship, assuming negligible illegitemacy:

(1) $F = PM \times MF$, where PM is the proportion married for that age, and MF is the number of births per 1000 married women of that age.

Change in fertility rate can be expressed in terms of change in each of these components, plus a residual "interaction term" (Kitagawa, 1955). As shall be seen, the effects of change in the components vary considerably by age group.

Trends in Nuptially 1959-1970

Looking first at the grand means in the first column of Table 4-6 it is evident that proportion married declined for the two age groups

TABLE 4-6. Mean Proportion Married for 5 Age Groups, 1959, 1965 and 1970

Age Group and Year	Grand Mean	6 Urban Areas	16 Other Areas	Eta
15-19				
1959	13.6	13.7	13.4	.023
1965	10.1	10.1	10.1	.001
1970	8.3	7.6	8.3	.217
20-24				
1959	63.9	59.6	63.9	.469
1965	59.5	56.0	59.5	.357
1970	51.3	46.9	51.3	.476
25-29				
1959	89.3	85.9	89.3	.560
1965	89.5	85.6	89.5	.643
1970	89.1	85.3	89.1	.696
30-34				
1959	91.2	88.9	91.2	.591
1965	93.1	90.7	93.1	.678
1970	93.6	91.2	93.6	.737
35-39				
1959	89.4	87.2	89.4	.628
1965	91.5	89.2	91.5	.640
1970	90.6	88.5	90.6	.754

below 25 while at older ages changes were of small magnitude. This reflects, but does not measure directly, an increasing age at marriage. There appears to be little change in the proportion who ever marry during this brief series.

Cities have lower proportions married in nearly every year and age group. Trends exhibited by the grand mean are the same for both the five largest cities and other areas despite the constant difference in level. Differences may well be due to migration of single women to cities rather than actual differences in proportions marrying in rural and urban communities.

Components of Change in Fertility

Tables 4-7 to 4-10 present the mean components of change in four age specific fertility rates for the periods 1961-1970, 1961-1965 and 1965-1970. For 20-24 it is evident from the grand means in the first column that the slight decrease over the 10 year period was due entirely to the decline in proportion married; had PM remained unchanged ASF would have <u>increased</u> by 39 points because marital fertility increased within this period. During the first half of the period, fertility to all women increased, but it decreased after 1965 due to the decline in PM which is concentrated in the second half of the series.

The main difference in cities and non-urban areas is that cities did not increase in marital fertility quite as much as other areas after 1965. Marital fertility contributed to an increase of 7 points in cities and 20 points in other areas.

Two points should be made. First, at 20-24 marital fertility added to increased fertility in both sectors, so a general adoption of

TABLE 4-7. Mean Components of Change in Fertility Rate (F) 20-24, For 3 Periods

	Grand Mean	6 Urban Areas	16 Other Areas
Total 1961-1970			
F 1961	251	242	254
F 1970	243	222	251
D	7.8	20.3	3.1
Component due to:			
Marital Fertility	-39.1	-27.5	-43.4
Proportion Married	40.5	43.1	39.5
Interaction	6.4	4.8	7.0
1961-1965			
F 1961	251	242	254
F 1965	266	257	269
D	-14.9	-15.3	-14.7
Component Due to:			
Marital Fertility	-22.1	-20.5	-22.7
Proportion Married	6.7	5.4	7.1
Interaction	.4	-.2	.8
1965-1970			
F 1965	266	257	269
F 1970	243	222	251
D	22.7	35.7	17.8
Component Due to:			
Marital Fertility	-16.6	-7.2	-20.0
Proportion Married	36.8	41.1	35.1
Interaction	2.5	1.8	2.7

NOTE: Negative sign indicates this component caused increase in F.

TABLE 4-8. Mean Components of Change in Fertility Rate (F) 25-29 For 3 Periods

	Grand Mean		6 Urban Areas		16 Other Areas	
Total 1961-1970						
F 1961	343		316		353	
F 1970	299		288		303	
D		43.7		27.3		49.8
Component Due to:						
Marital Fertility		41.9		25.1		48.2
Proportion Married		2.1		2.2		2.0
Interaction		-.2		0		-.3
1961-1965						
F 1961	343		316		353	
F 1965	328		292		341	
D		14.7		24.0		11.3
Component Due to:						
Marital Fertility		13.9		22.9		10.6
Proportion Married		.7		1.1		.6
Interaction		.1		0		.1
1965-1970						
F 1965	328		292		341	
F 1970	299		288		303	
D		29.0		3.3		38.6
Component Due to:						
Marital Fertility		27.9		2.2		37.5
Proportion Married		1.2		1.1		1.2
Interaction		-.1		0		-.1

TABLE 4-9. Mean Components of Change in Fertility Rate (F) 30-34 For 3 Periods

	Grand Mean	6 Urban Areas	16 Other Areas
Total 1961-1970			
F 1961	250	223	260
F 1970	152	139	156
D	98.3	84.2	103.5
Component Due to:			
Marital Fertility	101.2	85.8	107.0
Proportion Married	4.8	-2.6	-5.6
Interaction	1.8	.9	2.2
1961-1965			
F 1961	250	223	260
F 1965	201	169	213
D	49.2	54.8	47.1
Component Due to:			
Marital Fertility	52.1	55.7	50.7
Proportion Married	-3.4	-1.0	-4.3
Interaction	.6	.1	.8
1965-1970			
F 1961	201	169	213
F 1965	152	139	156
D	49.0	29.3	56.4
Component Due to:			
Marital Fertility	50.0	30.3	57.2
Proportion Married	-1.1	-1.2	-1.1
Interaction	.3	.2	.3

TABLE 4-10. Mean Components of Change in Fertility Rate (F) 35-39 For 3 Periods

	Grand Mean	6 Urban Areas	16 Other Areas
Total 1961-1970			
F 1961	162	125	176
F 1970	63	51	68
D	98.9	75.0	107.9
Component Due to:			
Marital Fertility	101.3	76.9	110.5
Proportion Married	-6.1	-4.3	-6.7
Interaction	3.7	2.4	4.2
1961-1965			
F 1961	162	125	176
F 1965	107	73	119
D	56.1	52.5	57.4
Component Due to:			
Marital Fertility	57.9	53.4	59.6
Proportion Married	-2.8	-1.1	-3.5
Interaction	1.0	.3	1.3
1965-1970			
F 1965	107	73	119
F 1970	63	51	68
D	42.9	22.5	50.5
Component Due to:			
Marital Fertility	44.1	23.8	51.8
Proportion Married	-2.1	-1.8	-2.2
Interaction	.8	.5	.9

contraception certainly cannot be said to be a major factor. Second, reductions in proportion married, the factor responsible for the fertility decline that did occur, had a roughly equal impact in both sectors, accounting for declines of 43 and 39 points for cities and other areas respectively.

At 25-29, the age of heaviest childbearing in Taiwan, there has been only small change in the proportion married. Most of the decline in this period is due to declining MF, presumably because of the adoption of contraception by some sector of the population. The non-urban areas actually decreased more than cities in the 10 year period. The small decline for cities in the second half of the period may suggest that the leading sector will not decline much further at this age group.

At age 30 and above substantial declines have occurred because of decreasing rates of fertility within marriage. Since proportions married actually increased to some extent this factor contributes against the decrease in overall fertility. Differentials in fertility level remain substantial at these ages. Fertility is falling faster in the outlying regions, since this period is the "catchup" phase of fertility decline.

Over this short run series, then, there is little evidence of nuptiality being a factor in the fertility decline in those age groups that have accounted for most of the decline. For these ages the control of fertility within marriage is the major cause of fertility decline to all women. Below age 25 the dwindling proportion married is an important factor. The puzzling finding is the increase in marital fertility at the younger ages at a time when there is a general declining trend in period measures of fertility. A number of factors could be involved,

such as fecundity improvement related to improving nutritional standards, or increased coital frequency in modern nuclear households (Jain, 1969). The changing marital patterns could result in a shift in the distribution of women by marital duration which would be more favorable to high fertility (Hermalin, 1971).

These questions will be pursued in greater detail in Chapter 7 using a set of age-education specific marital fertility rates for the years 1966 and 1971 for urban and rural areas.

Variation in Fertility Trends of Areas

The first section of this chapter dealt with a series of areal cross-sectional analyses for each point in the time series. A second approach to the data is to compare the separate time series for each of the areal units. Twenty-two time series of 18 observations will be compared here, rather than 18 cross-sections of 22 areas.

Earlier it was stated that a declining trend in fertility could be most simply expressed in terms of four parameters:

1) Initial pre-decline "equilibrium" level of fertility
2) A date at which fertility began to decline
3) A subsequent slope or average annual rate of decline
4) A final post-decline level of fertility

As a means of treating hypotheses concerning the determinants of fertility decline, then, one could proceed by computing estimates of these "trend parameters" and then use these parameters as dependent variables in a second stage of the analysis. This procedure was employed by Griliches (1957, 1960) in a study of the adoption of innovations. Griliches' use of logistic functions to estimate the trend parameters will be borrowed here in modified form to fit the downward sloping fertility trends.

Unfortunately, the logistic approach is only possible for age groups above 30 since the fertility of younger age groups has not declined enough to be described meaningfully by the logistic function.

In order to discuss trends at younger ages alternative strategies were used for estimating dates of first decline and rates of change. These were calculated for all four age groups and will be discussed first.

Initiation of Decline

Selection of a date of decline for a series presents two major problems. First, the series of birth rates for a single areal unit contains both a secular trend and a certain amount of yearly fluctuation. Short-run change may be in the opposite direction of the trend (Croxton and Cowden, 1955, pp. 240-259). Second, the choice of a given amount of decrease as signalling the beginning of a genuine decline--e.g., a 10% or 25 births per thousand women reduction--is essentially arbitrary.

Least-squares curve fitting does not completely solve the problems of initiation date selection. The goal of determining a single time-point demands a discontinuous function.

The procedure adopted here is to compute the year in which fertility first fell a specified amount below initial levels using several sets of arbitrary criteria. The average dates reported in Table 4-11 were calculated using the following specifications:

1) Three year running averages of each areas series for each fertility rate were computed.
2) The date of first decline was computed as the middle year of the first three year average that was less than a specified amount of 1952-54 average.
3) Eight separate criteria were used, four based on a percent decline, four based on absolute decline in births per thousand women:

TABLE 4-11. Mean Year of First Decline Calculated Using 8 Sets of Criteria (see text) for 4 Age Groups

	Percentage Decline				Absolute Decline			
	Grand Mean	Urban Areas	Other Areas	Eta	Grand Mean	Urban Areas	Other Areas	Eta
20-24								
a	59.2	59.5	59.1	.03	59.2	59.5	59.1	.03
b	62.1	61.3	62.4	.08	63.7	61.5	64.5	.19
c	67.0	66.3	67.3	.06	66.5	65.2	67.0	.13
d	70.0	68.3	70.6	.23	68.9	67.5	69.4	.16
25-29								
a	60.7	58.2	61.7	.26	60.3	67.8	61.3	.27
b	64.2	60.0	65.8	.47	64.0	59.8	65.6	.45
c	68.8	64.7	70.3	.62	67.2	61.7	69.3	.67
d	70.5	69.0	71.0	.39	68.8	64.7	70.4	.63
30-34								
a	58.0	56.8	58.4	.27	57.9	56.7	58.4	.29
b	59.0	57.5	59.6	.37	59.0	57.7	59.6	.32
c	60.8	59.5	61.3	.35	60.5	59.3	60.9	.27
d	62.1	60.8	62.6	.32	61.1	60.1	61.4	.23
35-39								
a	57.0	55.8	57.4	.25	57.0	56.0	57.4	.23
b	58.0	56.7	58.4	.31	58.4	57.2	58.9	.31
c	59.1	57.5	59.7	.39	59.5	58.3	59.9	.29
d	60.2	58.5	60.9	.49	60.5	59.3	60.9	.31

	Percent	Absolute
a)	2%	5 births per thousand women
b)	5	15
c)	10	25
d)	15	35

4) Areas that never reached the specified amount of decline were assigned the year 1972. Analysis of variance was performed using UR and region as independent variables.

Results

The pattern of timing in initiation of decline in Table 4-11 is remarkably consistent among the various criteria and across age groups. Comparing grand means, there is a tendency for earlier decline the older the age group above age 25. By these criteria, cities show a definitely earlier initiation at every age. There are only two exceptions (at 20-24) out of 32 possible comparisons.

A relevant question is whether variation by region is more important than variation by the urban-rural dichotomy. Eta-square measures of variance explained must be adjusted to take into account the different number of degrees of freedom of the two variables. When this is done as in Table 4-12 it is clear that UR is the more powerful predictor for age group 25-29, but for other age groups the differences are less clear (see the note at the bottom of Table 4-12 for details about the adjustment procedure). UR is generally stronger, particularly among criteria using larger amounts of change. In all 17 comparisons favor UR, 10 the regional variable and 5 are ties.

Generally, then, initiation of decline as revealed here is earlier in the cities, and UR is at least as good as and probably a better predictor of date of first decline than region.

TABLE 4-12. Proportion of Variance Explained (Eta-square Adjusted) in Year of First Decline for 4 Age Groups and 2 Independent Variables

		Percentage Decline		Absolute Decline	
		UR	Region	UR	Region
20-24					
	1	0*	.14	0*	.14
	2	0*	0	0*	0*
	3	0*	0*	0*	0*
	4	.01	.03	0*	.11
25-29					
	1	.02	0*	.03	.01
	2	.18	0*	.17	0*
	3	.35	0*	.42	0*
	4	.11	0*	.36	0*
30-34					
	1	.02	.16	.04	.12
	2	.10	.04	.06	.08
	3	.08	0*	.03	0*
	4	.06	0*	0	0*
35-39					
	1	.02	.13	.01	.11
	2	.05	.06	.05	.02
	3	.11	.02	.04	0*
	4	.20	0*	.05	0*

*Adjustment yields $eta^2 \leq 0$

NOTE:

$$Eta^2_{adj.} = \frac{Eta^2(N-1)-(K-1)}{N-K}$$

Where N = no.of cases and

K = no.of categories.

(Blalock, 1972, p. 413)

Individual Rates of Change

In order to get estimates of the average annual rates of change of the birth rates, the first procedure to be used was simply to fit a linear slope through the points according to the following regression equation:

$\hat{F} = a + bt$, where F is the fertility rate and t is year.

This was done for each of the 22 areal units. Each area's rate of change could then be described in terms of births per thousand women per year.

For theoretical reasons, such a single linear trend is undesirable. Fertility trends have been discussed previously as having a pre-decline equilibrium level followed by a point at which fertility begins a decline. A number of curves were fitted, including polynomials, which lacked the desirable characteristic of linear functions--a parameter, the slope, which is easily interpreted and readily compared statistically across areas. The logistic function was sutiable only for the oldest age groups and will be discussed in the next section.

The procedure finally used is a compromise: the time series was divided into a number of segments, and linear regressions performed on each segment. In this way different rates of change were obtained for different segments of the series. The regression equation of fertility on year was obtained separately for each areal unit for 1952-57, 1958-64, and 1965-70. Three lines obtained in this way for one area are shown in Figure 4-10. It is somewhat disturbing that the three segments do not connect to form an unbroken throughout the series. What the figure represents is a least squares solution to the average rate of change in the three separate segments and not necessarily good estimates of

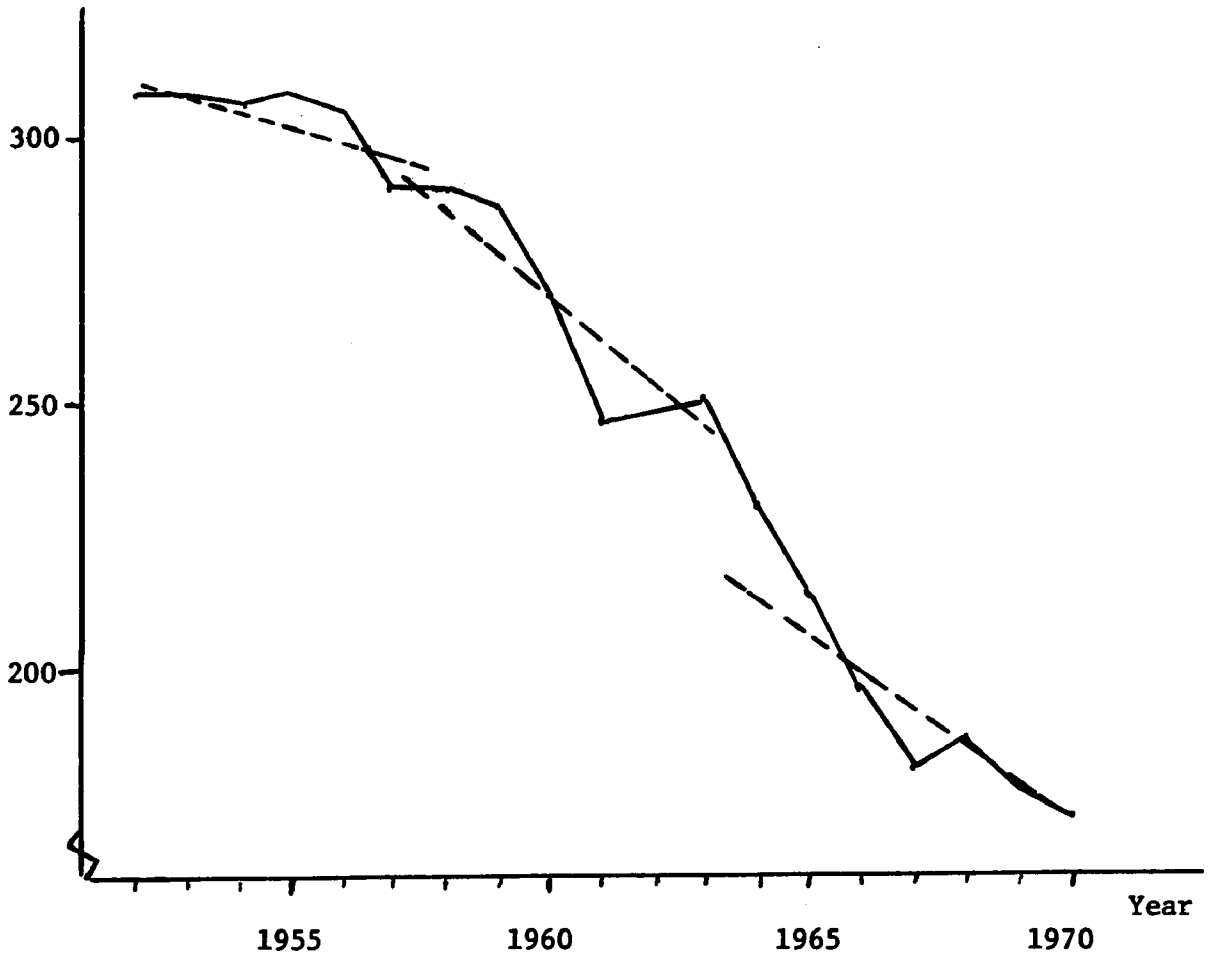


FIGURE 4-10: Lines fitted to 3 segments of one area's series of fertility rate 30-34, Taichung Hsien.

fertility levels in the whole series. The three time segments used here are also not necessarily the best ones to use in describing each area's trend.

18 Year Series

Table 4-13 contains an analysis of variance with individual areal slopes for the full 18 year series as the dependent variable. Looking first at the grand mean of slopes, it is evident that the rate of change of fertility increases with age. The average yearly rate of change for fertility at 20-24 is less than one birth per thousand women per year--a rate of change that is equivalent to a fertility reduction of about 5% over the 18 year period. The rate of 10 per year for 35-39 is equal to the two-thirds reduction that actually occurred in that age group.

Cities have greater average rates of decline than other areas below age 30 and the other areas decline faster at the older ages. Interpretation is difficult since it is known that the trends are non-linear, but the pattern seems to indicate the leading of cities in the decline at younger ages, and the catching up of non-urban areas at the older age groups.

Adjusted eta-square measures indicate that at younger ages the urban-rural difference is most important, but that for ages above 30 regional differences are more important. The failure of UR to account for any variation in average rate of change over age 30 underscores the fact that declines have been felt across all strata at these ages.

Three Segment Linear Trends

In the three part series separate rates of the annual average rate of change were calculated for the periods 1952-57, 1958-64, and

TABLE 4-13. Mean Regression Slopes of Year on Fertility Rate, 18 Year Series For 4 Age Groups

Age Group	Grand Mean	6 Urban Areas	16 Other Areas	Eta^2(adj.) UR	Eta^2(adj.) Region
20-24	-.78	-1.85	-.38	.18	.04
25-29	-1.94	-2.85	-1.60	.10	0
30-34	-8.78	-8.56	-8.86	0	.12
35-39	-10.00	-9.31	-10.26	0	.13

1965-70. Below age 30 the grand means in Table 4-14 show a similar pattern of decrease in the early period, and average near zero in the middle segment followed by the most rapid decrease in the final period. This may reflect a change in timing causing a decline from the peak "baby boom" year of 1951, followed by a stable period before the onset of secular decline, which was mainly the result of declining proportions married. In any case, the trends at these ages are complicated due to the increase of fertility within marriage.

Above age 30 mean rates of change for all areas are rapid after 1958. At 35-39 the rate actually diminishes by the 1965-70 period as the base fertility rate has become small.

Comparing across the urban-rural categories, at 20-24 cities have an accelerating decline throughout the period, whereas rural areas have actual positive change in the middle period. By 1965-70 both sectors are decreasing but cities more rapidly.

At 25-29 cities change faster in the first two segments, but have a rather low rate of decline in the last period. It may be that cities have reached a point where not much more decline can be expected at this age group, the modal age of childbearing in Taiwan.

Above age 30 the cities have faster decline in 1952-57, but other areas decline faster thereafter.

Finally, Table 4-14 presents the adjusted eta squared terms as an indication of the relative explanatory power of the two independent variables. UR is generally the best predictor of rate of change at the younger ages, and region is best at the older ages, similar to the pattern found for the 18 year series. The strongest associations are found for both UR and region in 1965-70 above age 30 when the highest fertility

TABLE 4-14. Mean Regression Slopes of Year on Fertility, Rate for Three 6 Year Segments for 4 Age Groups

Age Group and Period	Grand Mean	6 Urban Areas	16 Other Areas	Eta^2(adj.) UR	Eta^2(adj.) Region
20-24					
1952-57	-1.91	-1.16	-2.19	0	.25
1958-64	-.04	-2.31	.92	.21	0
1965-70	-5.16	-7.83	-4.16	.22	.06
25-29					
1952-57	-.94	-3.15	-.12	.02	0
1958-64	.29	-1.28	.88	.07	0
1965-70	-5.39	-.73	-7.14	.31	.07
30-34					
1952-57	-1.15	-3.73	-.18	.07	.07
1958-64	-9.73	-8.69	-10.13	0	.25
1965-70	-9.71	-5.49	-11.29	.30	.30
35-39					
1952-57	-1.95	-3.77	-1.27	.05	.09
1958-64	-12.40	-11.16	-12.87	0	.31
1965-70	-8.54	-4.49	-10.00	.40	.19

regions were falling fastest as part of the catch-up phase of decline.

This section is consistent with the cross-sectional analysis in indicating the general pattern of change across areas and age groups. The analysis suffers to the extent that the three rigidly defined segments do not reflect the timing patterns that actually occurred.

The next section presents an analysis that allows each area's trend to be treated as having a rate of decline that can change continuously over time.

The Use of Logistic Functions to Get Trend Parameters

The logistic function has been used fairly often to describe the adoption of innovations, and when modified it can be used to describe a declining trend in fertility with considerable economy. The standard logistic function has the property of starting from a zero asymptote, rising at an increasing and then decreasing rate, and finally approaching an upper asymptote. To apply the function to a declining trend in fertility, one must start from some initial level and decline to a lower asymptote. The form of the function used here, then, is a standard logistic subtracted from a constant as shown below:

$$(1)\quad \hat{F} = P(1) - \frac{P(2)}{1 + e^{-[P(3) + P(4)t]}}$$

where F is age specific fertility rate and t is year.

The four parameters have the following interpretations:

P(1), the initial pre-decline level of fertility, or upper asymptote.

P(2), the total amount of decline; P(1) - P(2) is equal to the post-decline asymptote.

P(3) and P(4) determine the rate at which F is declining at a given date in the series.

For each of the 22 areal units the logistic function was fitted using least squares criteria to the time series of fertility rates from 1952 to 1970; this was done for two age groups--30-34 and 35-39. The explained variation for the logistic curves of each area is presented in Table 4-15, and it is evident that the fit is excellent for the fertility series; only one area has less than 90% of the variance in fertility over time accounted for by the non-linear function. It is also clear from the table that since there is so much change in fertility over time that the linear function does nearly as well as the logistic in most areas. While this is true, the logistic accounts for a substantial proportion of variation unexplained by the linear trend in nearly every case. Figure 4-11 presents the same rural area's fertility trend as Figure 4-10, with the logistic fitted to it. The function fits the series quite well.

For each area, then, one can plot an estimated fertility curve free from the yearly fluctuations that might otherwise obscure the trend. The parameters of each area's fertility trend can be used to describe the trend. Rather than interpret the parameters P(3) and P(4) directly, each area's logistic function was solved for various features of the curve that describe the timing of decline in more intuitively meaningful terms. As a measure of the date of initiation of decline, each area's logistic was solved to find the point at which $P(1) - \hat{F}$ (the amount estimated fertility had fallen from pre-decline equilibrium) was equal to some minimum value. The problem remains that picking a point of initiation of decline on the smooth curve must be arbitrary. Several values were used as minimum values to signal a decline--5, 10, 15 and 25 births per 1000 women. Also obtained by solving each area's function

TABLE 4-15. Explanatory Power of Linear and Logistic Functions: Proportion Of Total Variance Over Time Explained

Area	30-34		35-39	
	Linear	Logistic	Linear	Logistic
Taipei Hsien	.92	.96	.93	.97
Ilan Hsien	.88	.94	.93	.96
Taoyuah Hsine	.88	.92	.95	.98
Hsinchu Hsien	.86	.96	.89	.98
Miaoli Hsien	.90	.93	.90	.93
Taichung Hsien	.95	.98	.95	.99
Changhwa Hsien	.89	.97	.94	.99
Nantou Hsien	.96	.99	.92	.98
Yunlin Hsien	.92	.97	.95	.99
Chiayi Hsien	.94	.99	.97	.99
Tainan Hsien	.89	.99	.94	.99
Kaohsiung Hsien	.93	.99	.95	.99
Pingtung Hsien	.90	.97	.95	.99
Taitung Hsien	.57	.98	.67	.98
Hualien Hsien	.91	.98	.89	.99
Penghu Hsien	.30	.68	.47	.71
Taipei City	.95	.97	.93	.96
Keelung City	.92	.95	.96	.97
Taichung City	.94	.99	.91	.99
Tainan City	.95	.98	.97	.99
Kaohsiung City	.97	.98	.93	.97
Yangmingshan Adm.	.84	.91	.90	.98

	function	Measure of Proportion of variance explained
linear	$F = a + bt$	r^2
logistic	$\hat{F} = P(1) - \frac{P(2)}{1 + e^{-(P(3) + P(4)t)}}$	$1 - \frac{\sum_t (F_t - F)^2}{\sum_t (F_t - \bar{F})^2}$

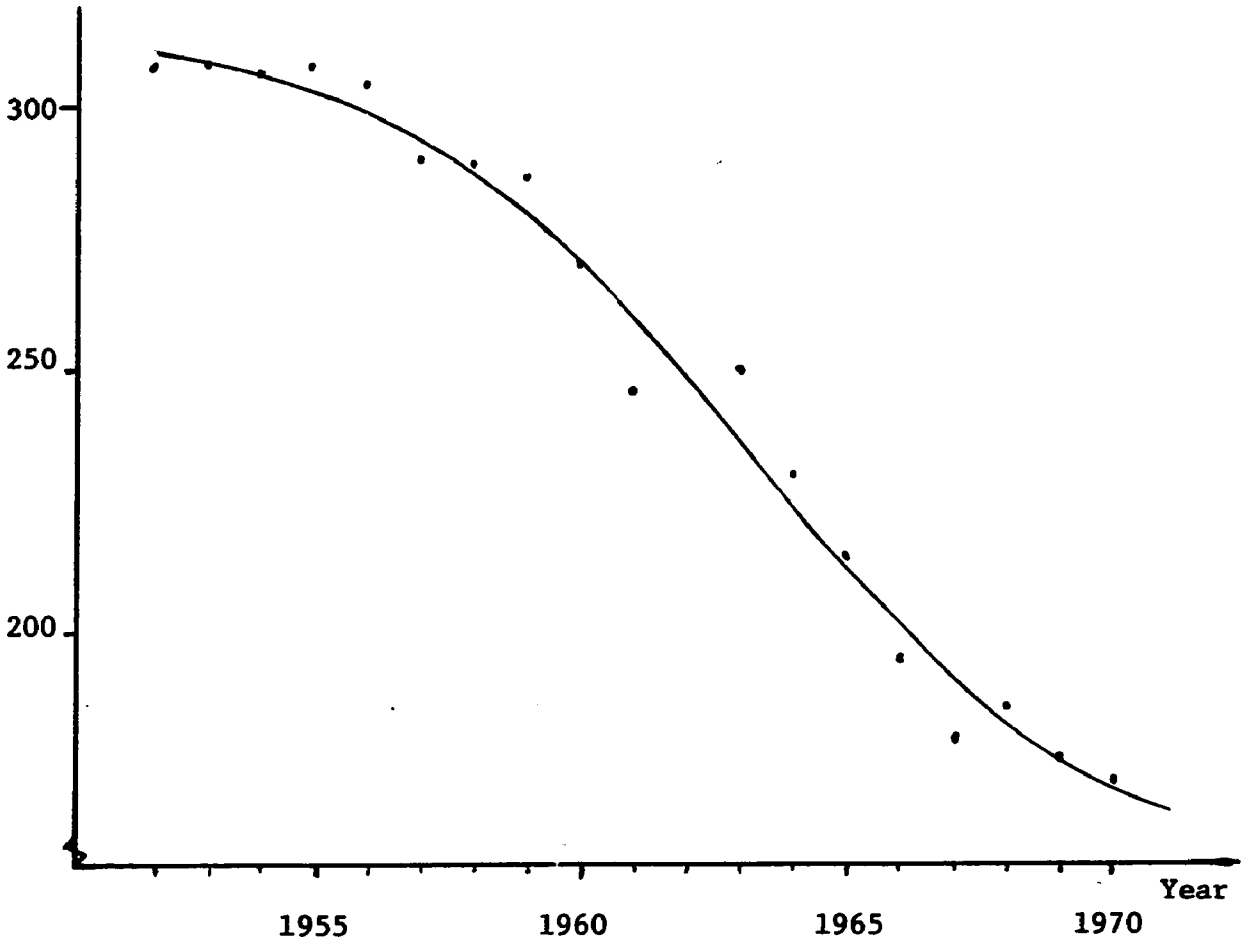


FIGURE 4-11: Logistic curve fitted to fertility rate 30-34, Taichung Hsien.

were the point of inflection--the point in the curve where half the decline has been reached and the decreasing slope reaches its maximum--and the rate of decline at the inflection point. (See Appendix II for a full explanation of the logistic function and its solution).

Logistic Trend Parameters for Areas

The grand means for all areas in the first columns of Tables 4-16 and 4-17 indicates that the rates for both age groups declined about the same amount on the average--180 points. The decline appears to have begun about the same time for both ages.

A number of points can be made concerning the urban-rural differences.

1) Pre-decline difference exist for both 30-34 and 35-39 between cities and other areas.

2) For 30-34 the difference persists at the same level at the lower asymptote, as the areas in both sectors declined about the same amount on the average. At 35-39 the logistic parameters indicate that there was a convergence as the areas with high initial fertility declined furthest.

3) There are striking differences in the initiation of decline, cities on the average passing each criterion point from 2 to 4 years earlier for both ages.

4) The measure of rate of change shows that while areas outside the major cities declined later, they tended to decline faster once they began the period of decline.

The timing pattern, observed, then, is one very consistent with a diffusion of controlled fertility outward from cities.

Tables 4-16 and 4-17 allow for a comparison of the explanatory power of the two independent variables, UR and region. Both predictors explain a fair amount of variation in pre-decline level, but the process of decline was such that only UR remains associated with final level, as estimated by the logistic function. This is the same general finding

TABLE 4-16. Mean Values of Parameters of Logistic Functions* Fitted to Trend in Fertility Rate 30-34, 1952-70

	Grand Mean	6 Urban Areas	16 Other Areas	Eta (adj.) UR	Region
Pre-decline level P(1)	301	285	307	.38	.54
Amount of decrease P(2)	185	186	184	0	0
Final level P(1)-P(2)	117	99	123	0	0
P(3)	-23.5	-21.8	-24.1	0	0
P(4)	.365	.345	.373	0	0
Mean date (year) $P(1) - \hat{F}$ first equalled 5	52.7	49.8	53.8	.26	0
10	55.0	52.5	56.0	.28	0
15	56.4	54.1	56.4	.30	0
25	58.3	56.3	59.0	.32	0
Date of point of inflection	64.4	63.6	64.8	.21	0
Rate of change (births per 1000 women per year) at inflection point	-15.4	-13.4	-16.1	.23	.42

*$$\hat{F}_t = P_{(1)} - \frac{P(2)}{1 + e^{-(P(3) + P(4)t)}}$$

TABLE 4-17. Mean Values of Parameters of Logistic Functions Fitted to Trend in Fertility Rate 35-39, 1952-70

		Grand Mean	6 Urban Areas	16 Other Areas	Eta (adj.) UR	Eta (adj.) Region
Pre-decline level P(1)		226	205	235	.56	.39
Amount of decrease P(2)		181	172	184	0	.17
Final level P(1)-P(2)		45.6	32.8	50.4	.29	0
P(3)		-24.2	-22.7	-24.8	0	0
P(4)		.383	.368	.389	0	0
Mean date (year) $P(1)-\hat{F}$ first equalled	5	53.0	50.2	54.1	.34	.13
	10	55.0	52.5	56.0	.36	.08
	15	56.3	53.9	57.1	.37	0
	25	57.9	55.8	58.7	.39	0
Date of point of inflection		63.1	61.8	63.6	.47	0
Rate of change at inflection point		-16.8	-14.8	-17.5	.30	.67

that surfaced in the first section of this chapter--regions have become more homogeneous over the period of decline, while urban-rural differences remain.

Measures of the initiation are associated with UR, but not with regions. In other words, the pattern of lags across the urban-rural dichotomy, suggesting the origin of decline in cities, is much more sharply defined than the pattern occurring among regions. This is a similar, but much stronger, finding than the results of the analysis of initiation dates using different methods.

Both region and UR are related to the speed of decline once it was under way. Region appears to be the stronger. It appears that the more backward areas with the latest initiation dates are falling faster. Such factors as the general availability of contraceptives could aid late declining areas in bringing fertility more rapidly under control than the earlier declining areas.

Trend Differences and Cross-Sectional Variation

The foregoing discussion illustrates that using the four parameters of the modified logistic function makes it possible to describe trend differences with economy. One purpose of such a description is to aid in the interpretation of cross-sectional differences and associations at various points in time. This can be illustrated using the mean trend parameters for urban and rural areas.

Parameters P(1) and P(2) define the upper and lower asymptotes of the trend while P(3) and P(4) determine the timing pattern of the trend. More specifically, two curves with the same P(3) and P(4) will have the same inflection point; to the extent that P(2) (the total amount of

decline) is markedly different, the slopes of the two curves may be different at various points. The two values P(3) and P(4) can be considered timing parameters in the sense that they determine where the curve is centered.

Using mean parameters for cities and mean parameters for other areas, a mean fertility curve for the two sectors can be defined for each sector. Such curves are illustrated in Figure 4-12. At each point in the series, the estimated difference between urban and non-urban mean fertility can be obtained free of yearly fluctuation. Reading down the first column of Table 4-18 it is evident that this difference increases and then decreases. For 35-39 there is actually less difference at the final reading than at the beginning.

In the second column of the table the same estimates for mean urban fertility are used as in column 1. For rural areas in the second column the fertility values were estimated using the mean P(1) and P(2) for rural areas, but the urban values for P(3) and P(4), the timing parameters. The estimate of rural fertility given here is what would have obtained had rural areas started from their actual pre-decline level and headed toward their actual estimated post-decline asymptote, but had their curve centered at the same point as urban areas.

Thus, the rural-urban differences in column 2 can be considered the difference due to long-term difference with timing differences removed. There is almost no change in urban-rural difference over the period of decline at age 30-34, and there is a convergence at 35-39. Comparing columns 1 and 2 it is apparent that timing of decline accounts for its largest amount of the urban-rural difference (40%) in the middle of the series when urban areas were leading the decline. The effect

TABLE 4-18. Urban and Non-Urban Differences in Estimated Fertility and Fertility Estimated with Timing Parameters the Same for Urban and Non-Urban Areas for Three Time Points and Two Age Groups

	(1)	(2)	(3)	(4)
	Mean Logistic Estimate	Estimate with Non-urban Areas Having Urban Timing Parameters (P(2) & P(3))	Urban-Non-urban Difference Due to Timing of Decline	(3)/(1)
30-34				
1952				
Urban	282	282		
Non-urban	305	304		
Difference	23	22	1	.04
1961				
Urban	227	227		
Non-urban	268	250		
Difference	41	23	17	.41
1970				
Urban	115	115		
Non-urban	146	138		
Difference	31	23	8	.26
35-39				
1952				
Urban	201	201		
Non-urban	233	230		
Difference	32	29	3	.09
1961				
Urban	132	132		
Non-urban	189	157		
Difference	57	25	22	.39
1970				
Urban	42	42		
Non-urban	66	60		
Difference	24	18	6	.25

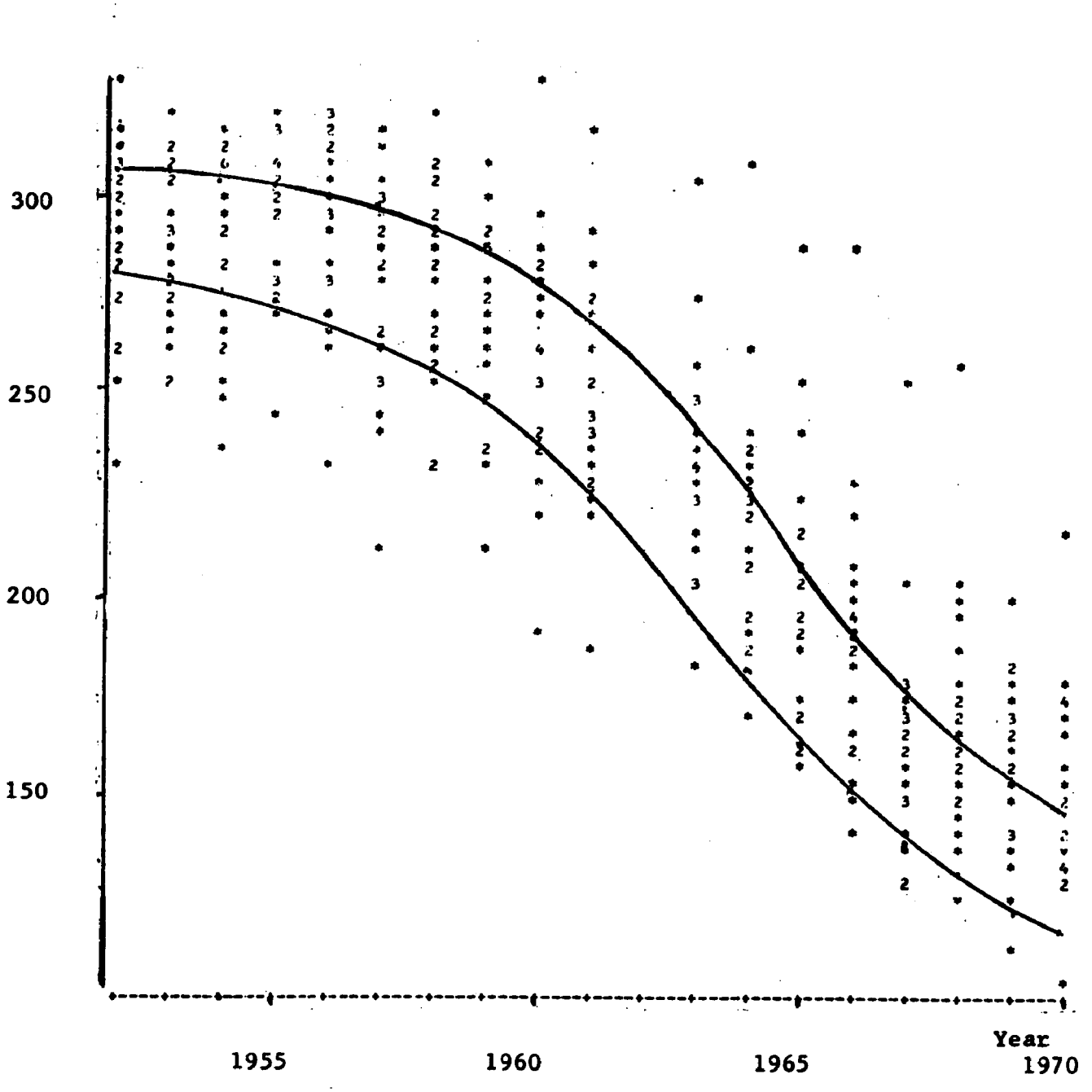


FIGURE 4-12: Scatter plot of fertility rate 30-34 vs. year, showing mean logistic trend for 6 urban areas (lower curve) and 16 other areas (upper curve).

of timing obtained in this way is still fairly great at the end of the series, accounting for a quarter of the difference in both age groups.

What does this mean in terms of interpreting cross-sectional fertility differences at any point in time? If one wants to interpret lower fertility in cities as meaning that the cities are a leading sector in the fertility decline and lower fertility will diffuse outward to non-urban places one is only partly right. Urban-rural fertility differences have components of both long term difference and difference in the initiation and rapidity of the decline. Long term differences appear to account for the majority of the average difference, but it is a variable majority.

The differences in timing seem to suggest a diffusion pattern of change might be operating with contraceptive information and supply and attitudes necessary for fertility control taking time to permeate all geographical areas of the country. Differences in level appear to decline with time, particularly over 35, but they remain important.

Conclusions

The analysis in this chapter using a variety of methodological approaches reveals a certain consistency. Since timing differences appear to be fairly important in the decline, the model of simultaneous decline may be discarded. The picture that emerges is one in which fertility began declining a few years earlier in the major cities than outside them. Other areas, starting at a later date than cities, were able to move toward controlled fertility at a more rapid rate.

This suggests that cities, as natural centers of innovation, were where large sectors of the population were able to find out about and

develop the necessary attitudes for efficient contraceptive use, a practice which spread later to more remote areas according to the diffusion model.

However, the diffusion-like pattern of decline may really result from declining mortality and general socioeconomic development, and the fact that these factors are related to level of urbanization. In the next chapter the relationship of various socioeconomic and demographic independent variables, urban-rural location, and fertility trend parameters will be examined in order to test the development model against the innovation diffusion model.

CHAPTER 5

MULTIVARIATE ANALYSIS OF FERTILITY TREND PARAMETERS

The theme of this chapter is the question posed at the end of Chapter 4: The pattern of fertility change with respect to urban and rural areas suggests an innovation diffusion of lower fertility. Does this pattern actually result from the different levels of and rates of socioeconomic development in the two kinds of areas? In short, can the diffusion pattern be said to reduce to a development model of fertility change? Bringing the relatively limited number of socioeconomic and demographic independent variables to bear on this question is the purpose of this chapter.

The basic methodological approach that will be employed is to see to what extent controlling for each of a set of independent variables accounts for the relationship between the trend parameters and the UR variable. For example, does the observed pattern of urban areas declining earlier appear to be due to relationship of education to timing of decline and the distribution of educational attainment across areas? The small number of variables, plus the limited degrees of freedom in the data set restrict the analysis from going very far beyond the level of first order partial correlation and analysis of covariance. The development or diffusion model will be supported or not supported, though

by no means will the analysis allow for unambiguous rejection of one or the other.

Level of Analysis

The dependent variables--the trend parameters obtained through the logistic function as described in the last chapter--are the result of a time series procedure. They are summary measures of fertility over the 1952-1970 period. Measures of the various independent variables are available for each of the 22 areal units for various points in the 1951-1970 period. Only for mortality variables is there a complete series corresponding to the fertility rate series. For measures of industrial composition and educational attainment definitional changes occur throughout the series making measures at different points noncomparable. Other variables such as measures of density, distance to urban centers and ethnic composition are measured at only one point in the series, even though variation over time is possible (though probably not considerable for these measures). Finally, variables UR and region are time-invariant.

The problem of the analysis, then, is to somehow combine these different types of variables in a single analysis that speaks to the problem of interest. The computation of trend parameters using the logistic function is the first step toward this end. Instead of 396 fertility observations (18 years times 22 areas) this procedure results in a set of four summary measures for each of the 22 areal units. These variables can be used in combination with independent variables measured at one point or another in the series, measured as an areal cross-section of the 22 units. In terms of causality it makes sense to get

measurements of independent variables for the early part of the series, before the onset of decline.

Independent variables that were used were measured in the early 1950's; this is intended to represent pre-decline level. Some variables were measured around 1960 also, about the time decline was first underway in most areas. For variables for which these two time points were available, the difference between the two observations was also employed in order to approach the question of whether the rate of change in the variable was related to timing parameters of the fertility trend. A number of variables were measured whenever the data were available; these are meant to represent long term levels.

Using the 22 units of analysis, then, the questions posed in this chapter are posed in terms of how cross-sectional variation in the socio-economic, cultural and demographic variables, before and during the fertility decline, are related to the parameters of the trends.

Dependent Variables

Four basic trend parameters were described in the previous chapter--pre-decline level of fertility, date of initiation of decline, rate of decline (measured at the inflection point of the logistic curve) and final level. Of these the first three will be used as dependent variables in this chapter. The fourth, final level, will not be used because, for a number of reasons, its meaning can be questioned. For most areas the final predicted level of fertility has not been reached or even approached at the end of the series. For several logistic estimates actually predicted <u>negative</u> values of fertility at the end of the decline. As noted in the last chapter, the logistic fits very well

the fertility levels over the time points observed; for some areas, apparently, the trend had yet to begin leveling off at the last time point and the function predicts absurdly low (in some cases negative) levels of fertility in the distant future. There is a fair amount of difference in the actual mean level of fertility in 1970 and the predicted final asymptote as shown below:

Age group	Mean Fertility Rate 1970	Mean Final Level Predicted by Logistic	Difference
30-34	152	117	35
35-39	63	46	17

In fact, 1972 values for fertility rate 30-34 and 35-39 stand at 117 and 41 respectively, at or below the predicted mean terminal level with no end to the decline evident. Extrapolating beyond the period observed seems of dubious value.

Pre-decline level also is based on extrapolation and is slightly above levels at the beginning of the series:

Age group	Mean Fertility Rate 1952	Mean Logistic Pre-decline Level	Difference
30-34	290	301	-11
35-39	217	226	-9

Differences in this case are somewhat smaller. Also, observing the scatter plot of fertility versus year as in Figure 4-12 in the last chapter suggests that the assumption of a stable plateau in the early to middle 1950's may not be unrealistic.

Pre-decline level of fertility (PDL) is simply the upper asymptote of the logistic function fit by least squares methods to each area's time

series in fertility. The other two parameters used are obtained through solving the logistic for values that make more sense theoretically than the actual other parameters of the function. Since the logistic is a smooth function there is no actual date at which it begins to slope downward. The date of initiation of decline used here (DOD) is defined at the point where each area's logistic trend drops 18 births per thousand women below PDL. This represents approximately 10% of the total predicted decline on the average. This is essentially an arbitrary solution for the initiation date, but several criterion points were used in Tables 4-16 and 4-17 in the last chapter with very similar findings.

The rate of decline (RATE) is measured at the point of inflection; this is the maximum rate of change the logistic attains. RATE measures the "steepness" of the logistic and presumably the rapidity with which fertility was brought under control once it began falling. Though all slopes are negative, this variable is coded as a positive number for each area.

The intercorrelations of the three parameters for the two age groups are indicated below:

	30-34		35-39	
	DOD	RATE	DOD	RATE
PDL	-.46	.04	-.11	.25
DOD		.53		.58

Initiation date and PDL are fairly highly correlated at 30-34. This may be in part due to the fact that the higher the base level of fertility the less a proportionate decline is represented by the absolute criterion of 18 births per thousand women. The correlations also

indicate a slight tendency for high initial level areas to fall faster, at least at 35-39.

The fairly substantial positive correlations between initiation date and rate of decline show that areas entering decline later tend to move toward controlled fertility much faster.

Independent Variables

The definitions of all variables used in this chapter can be found in Table 5-1. Table 5-2 presents the mean values of the set of independent variables for the urban and rural areas and regions.

The measure of agricultural labor force (AF), not surprisingly, shows a rather strong relationship to UR at both points that it is measured--a correlation of .90. AF is so closely tied to UR that its inclusion in the same model as the urban-rural is questionable on statistical grounds.

Percent married at age 20-24 (PM) is taken as a surrogate for age at marriage. The earliest date it is available is 1959. UR is a fairly strong predictor of PM.

The measure of female education (ED) also has a strong relationship to UR, and a somewhat weaker one with region. Definition changes (see Table 5-1) mark the time series comparability of this variable.

Crude death rate (CDR) was lower in cities and the association with UR appears to increase in contrast to the general trend of mortality "homogenization" across the island as discussed in Chapter 3. The measure of child mortality (CM) is consistent with the general long term finding as the association with UR weakens over the 1950's.

The ethnic distributions indicate that percent Fukienese--the dominant group in terms of numbers--is not related to UR while the percent

TABLE 5-1. Definitions of Variables

A. Dependent Variables

PDL	Pre-decline level of fertility estimated by logistic function fitted to 1952-1970 series of age-specific fertility for each area.
DATE	Year that fertility began falling; estimated from logistic function as the point in series where estimated fertility first passes 18 births per thousand women below PDL, approximately 10% of average total decline at 30-34 and 35-39.
RATE	Rate of decline at point of inflection of the logistic function; the maximum rate of decline, coded as a positive number.
FL	Final level of post-decline fertility implied by the logistic function.

B. Areal Variables

UR	Dichotomous variable, UR=1 for 16 non-urban hsiens, =0 for 5 largest cities and one small area contiguous to Taipei City.
REG	Divides the island into three regions: Northern, Middle and Southern.
DEN	Density, population per square kilometer measured in 1961.
DTC	Distance to the nearest of 5 largest cities; mean distance of local areas comprising each city or hsien.
DTT	Mean distance to nearest city of 25,000 or greater.

C. Social, Economic, Cultural and Demographic Independent Variables.

AF	Proportion of males 12 and older in the labor force in agriculture and fishing.
AF_{53}	Three-year average AF 1952, 1953 and 1954.
AF_{60}	Three-year average AF 1959, 1960, 1961.
DAF	Difference $AF_{53}-AF_{60}$.
PM	Proportion married 20-24, 1959, 60 and 61 avg.
ED_{53}	Proportion of all women 6 and older who are primary graduates and above, average 1952-1954.
ED_{60}	Proportion of all women 12 and older who are primary graduates and above, average 1959-61.
CDR_{52}	Average crude death rate 1951-1953.
CDR_{60}	Average crude death rate 1959-1961.
DCDR	Difference $CDR_{52}-CDR_{60}$.
CM_{52}	Mortality rate age 1-4, average 1951-1953.

(Table Continued)

TABLE 5-1. (Continued)

CM_{60}	Mortality rate age 1-4, average 1959-1961.
DCM	Difference $CM_{52}-CM_{60}$.
MIG	Migration rate, average annual net migration per 1000 population, 1959-1966.
FU	Proportion of population Fukienese, 1956.
HAK	Proportion Hakka, 1956.
ML	Proportion Mainlander, 1956.
ABO	Proportion Aborigine, 1956.

Table 5-2. Analysis of Variance, Independent Variables by UR and REG

Independent Variable	Mean	s.d.	Subgroup Means: Urban Areas	Rural Areas	Regions: North	Middle	South	Eta (adj.) UR	REG
DEN	1385	2981	4165	343	2581	570	1051	.56	0
DTC	37.0	33.0	0	50.8	23.5	45.7	41.1	.68	0
DTT	15.4	19.6	0	21.2	6.1	13.9	25.0	.45	.29
AF_{53}	.54	.23	.22	.66	.40	.65	.57	.90	.37
AF_{60}	.49	.22	.18	.61	.35	.61	.51	.90	.42
DAF	.05	.03	.03	.05	.05	.04	.05	.23	0
PM	.63	.06	.58	.64	.61	.64	.63	.42	0
ED_{53}	.25	.08	.34	.22	.31	.24	.21	.67	.43
ED_{60}	.39	.10	.49	.35	.46	.38	.33	.65	.48
CDR_{52}	10.3	2.0	8.3	11.0	9.5	10.8	10.6	.63	0
CDR_{60}	7.0	1.0	5.7	7.4	6.6	7.3	7.0	.75	0
DCDR	3.3	1.1	2.6	3.6	2.9	3.5	3.6	.37	0
CM_{52}	20.7	5.3	16.0	22.5	17.1	23.0	21.8	.52	.39
CM_{60}	7.9	1.6	6.9	8.3	7.4	8.4	7.9	.34	0
DCM	12.8	4.3	9.1	14.2	9.7	14.6	13.9	.50	.41
MIG	.89	11.0	13.6	-3.8	7.3	-3.8	-.6	.71	.30
FU	.72	.22	.74	.71	.66	.70	.78	0	0
HAK	.14	.19	.03	.18	.16	.19	.07	.30	0
ML	.11	.09	.23	.06	.17	.06	.09	.84	.42
ABO	.04	.09	0	.05	.01	.05	.05	.15	0

of the second most numerous group, the Hakka, is related, with more Hakka in rural areas. While virtually all aborigines are found in rural areas, their numbers are too small to make much difference in hsien level fertility. Mainlanders, that is Chinese coming from mainland China in recent years, are concentrated in the urban areas to the extent that UR has an adjusted correlation ratio of .84 with percent mainlander, the second highest correlation in Table 5-2.

The Hakka group is particularly concentrated in a number of rural hsiens in the northeastern area of the island:

Hsien	Proportion Hakka
Taoyuan	.43
Hsinchu	.57
Miaoli	.67
Hsien & City Average	.14

Because the representation of the Hakka group displays this much variation from place to place, but is only moderately associated with UR, proportion Hakka will be used as a measure of ethnic differentiation among the hsiens and major cities.

Net migration, measured 1959-66 is generally positive in cities and negative for rural areas and is quite strongly associated with UR (eta-.71). Measures of density and distance to urban centers are by their very definition related to UR fairly strongly. The distance measures are means of the distance of each local administrative area that comprise each city or hsien from cities or towns. All urban areas are coded zero on this measure.

Hypotheses

Because of limitations in the data set the analysis will not be as elaborate statistically as might be desirable in testing a diffusion of lower fertility versus a socioeconomic development determined model of fertility change. The best that can be hoped for is that the fairly low level partial correlation analysis of covariance strategy employed here is suggestive of one or both models of fertility change.

As a first step, both independent, dependent and control variables can be categorized as below:

Dependent Variables

1. Long-term fertility parameters
   a. Pre-decline level
2. Timing of decline parameters
   a. Date of initiation of decline
   b. Rate of decline

Independent Variables

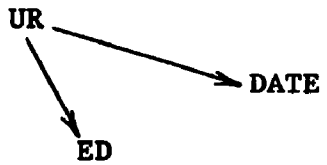
1. Major Cities - Other Areas dichotomous variable (UR)

Control Variables

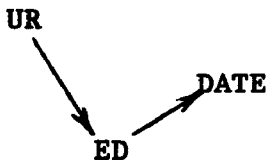
1. Socioeconomic variables
   a. Measures of educational attainment of women, labor force composition
2. Demographic variables
   a. Mortality measures
   b. Nuptiality measures
   c. Migration measures
3. Locational variables
   a. Density, distance to urban centers
4. Cultural variables
   a. Ethnic composition measures

Any hypothesis dealing with the origin of decline in fertility will presumably be chiefly concerned with the timing parameters. Long term differences may have different causes and may be argued to reflect normative variation. It should be clear how locational and socioeconomic variables relate to the general hypotheses. Demographic control variables may turn out to have effects apart from the other two classes of independent variables. It may be difficult to assign causal relationships of a single direction among demographic variables. Marriage change, migration and reduced fertility may all be responses to the same pressure, brought on by mortality change and modernization, but the three factors may interact in fairly complicated ways.

The strategy of the analysis will be as follows: Using analysis of covariance in its most elementary form the relationship between UR and each of the dependent variables (as measured both by the difference in rural and urban means and by the product moment correlation between UR treated as a dichotomous variable and the dependent variable) will be examined to see if the relationship is maintained while controlling for each control variable in turn. For example, the mean date of decline is earlier in cities than in other areas, and this pattern suggests diffusion. But the pattern could be due to 1) higher levels of education in cities and 2) earlier decline where education is high, a finding consistent with the development model. These two possible patterns could be diagrammed as suggested by Blalock (1972, p. 445):



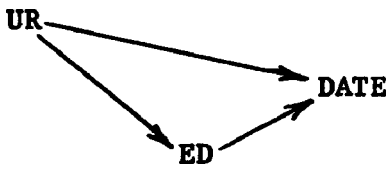
"Diffusion"



"Development"

According to Blalock, the association between UR and DATE should become zero when controlling for ED if the development model is accurate.

Of course, causality could operate as in both models as below:



In this case the association between UR and DATE will not go to zero when ED is controlled, but it may be reduced somewhat. Measuring the association between trend parameters and UR both by correlation and difference in means, and using both partial correlation and analysis of covariance is made possible by the fact that UR is a dichotomous variable. As such, it can be treated exactly like a continuous variable, so that correlation and partial correlation coefficients can be calculated. Also, it is a two-part categorical variable. The model used in analysis of covariance can be written in regression terms:

$\hat{D} = a + bU$, where U = 0 if the area is urban
U = 1 if it is a non-urban area
D = trend parameter such as date of decline.

Thus, the regression coefficient 'b' represents the difference in mean date of decline between urban and non-urban areas:

$\hat{D} = a + b(0)$ for urban areas

$\hat{D} = a + b(1)$ for other areas.

Adding a control variable (such as 'E,' education) yields:

$\hat{D} = a + bU + cE$.

Since each variable's multiple regression coefficient represents that variable net of other independent variables, 'b' in this case is an "adjusted mean," the difference in the two sectors mean date controlling for education; thus, if 'b' becomes close to zero, it can be said that the control variable such as 'E' accounts for the areal variation in 'D' as measured by the difference in 'D' between urban and other areas.

Viewing the analysis more strictly in terms of the analysis of covariance model presented by Blalock (1972, pp. 491-497) the assumption is made that the relationship (or slope) between education (or other control variable) and date of decline (or other dependent variable) is the same in both urban and other areas. The assumption is made owing to difficulty in evaluating the difference in slopes due to small numbers of cases. The inability to deal with the possibility of such "interaction" effects remains a weakness of this part of the analysis that must be borne in mind. In favor of the covariance model, it can be said that the partial correlation analysis, which does not depend on any assumptions about slopes, shows effects in the same direction as the covariance analysis.

If factors such as labor force in agriculture, education and mortality seem to account for the UR difference in the timing of decline, then some support is given to the model that states demand for family limitation generated by the modernization process itself, as postulated in demographic transition theory, is important in determining the spatial pattern of decline. If, on the other hand, the UR pattern is explained by the geographical variables, if relative remoteness of the areas as measured by mean distance to urban centers accounts for the pattern, the diffusion model gains support. Even if the locational measures are

not important, if UR differences appear to be independent of the distribution of the various socioeconomic variables across the island, the diffusion pattern can be said to be supported to the extent that the urban-rural pattern of the timing of decline reflects diffusion outward from the cities of lower fertility. To the extent that the diffusion model is supported, proximity to original centers of diffusion is a main factor, and by implication the spread of knowledge, attitudes and materials through the network of communication is the process involved.

Zero-Order Relationships

The correlations between UR and the three dependent variables for the two age groups are of medium level as indicated below:

	30-34	35-39
PDL	.43	.59
DOD	.37	.43
RATE	.31	.37

Since UR is scored zero for cities and 1 for other areas, the positive correlations indicate that pre-decline fertility was higher in rural areas, rural areas had a later date of first decline, and the non-urban areas had a greater rate of decline, once fertility began to fall.

The zero order correlations between these six dependent variables and the set of independent variables are shown in Table 5-3 and the intercorrelations among the independent variables in Table 5-4. A few remarks should suffice on these tables.

The highest correlations with PDL are for education (-.60 and -.79), migration (-.42 and -.68), percent mainlander (-.49 and -.62) and

TABLE 5-3. Zero Order Correlations Between Six Dependent Variables and Independent Variables

Independent Variables	Dependent Variables: 30-34 PDL	30-34 DOD	30-34 RATE	35-39 PDL	35-39 DOD	35-39 RATE
UR	.43	.37	.31	.59	.43	.37
FU	.10	-.02	.25	.13	-.19	.07
HAK	.14	.06	-.10	.16	.20	.11
ABO	-.03	.27	.05	0	.43	.18
ML	-.49	-.35	-.43	-.62	-.40	-.57
MIG	-.42	-.28	-.34	-.68	-.08	-.34
DENS	-.30	-.37	-.37	-.49	-.32	-.45
DTC	.22	.45	.22	.33	.57	.28
DTT	.21	.57	.27	.41	.59	.23
AF_{53}	.40	.48	.48	.57	.53	.55
PM	.31	.15	.17	.35	.26	.19
ED_{53}	-.60	-.24	-.51	-.79	-.19	-.49
CDR_{52}	.22	.40	.20	.36	.45	.25
CM_{52}	.35	.29	.19	.38	.47	.32
AF_{60}	.42	.45	.45	.59	.50	.54
ED_{60}	-.58	-.27	-.49	-.81	-.16	-.46
CDR_{60}	.25	.51	.24	.50	.41	.20
CM_{60}	.10	.20	-.03	.19	.31	.29
DAF	-.03	.31	.34	-.01	.36	.24
DCDR	.15	.22	.13	.16	.40	.25
DCM	.40	.29	.24	.39	.46	.29

TABLE 5-4. Zero Order Correlations Among Selected Independent Variables

	HAK	ABO	ML	MIG	DEN	DTC	DTT	AF_{53}	PM	ED_{53}	CDR_{52}	CM_{52}	UR
FU	-.82	-.52	-.16	-.11	-.06	-.33	-.16	.06	-.03	-.31	-.07	.07	-.07
HAK		.16	-.26	-.28	-.22	.31	.11	.27	-.11	-.10	-.01	-.15	.37
ABO			-.08	.06	-.19	.69	.51	.25	.65	.12	.74	.64	.26
ML				.76	.78	-.53	-.34	-.94	-.34	.83	-.53	-.67	-.85
MIG					.43	-.50	-.39	-.70	-.15	.74	-.34	-.37	-.73
DEN						-.42	-.28	-.69	-.44	.65	-.58	-.40	-.58
DTC							.76	.67	.69	-.42	.80	.75	.70
DTT								.49	.49	-.38	.65	.69	.49
AF_{53}									.48	-.76	.65	.60	.91
PM										-.32	.84	.79	.47
ED_{53}											-.35	-.36	-.69
CDR_{52}												.91	.65
CM_{52}													.55

percent in agriculture (.40 and .57). These are characteristics of areas which are fairly highly associated with UR.

For DOD the highest correlation is with DTT, the distance to the nearest town, suggesting a diffusion pattern.

For RATE there is a high correlation with education (-.51 and -.49)--a faster rate of decline is associated with lower educational attainment, a relationship that may at first seem at odds with what might be expected. It will turn out that RATE will require a more complex model than other dependent variables with date of decline having an important role as an intervening variable.

Finally, it is evident from Table 5-4 that several of the independent variables are, not surprisingly, highly correlated with UR. The measure of labor force in agriculture, in particular, is so strongly related to UR ($r = .91$), that the value of attempting to assign net effects to each variable is certainly questionable. Proportion mainlander is nearly as high ($r = -.85$). Education has a correlation near the upper range of acceptability ($r = -.69$) as does migration and mean distance to large cities ($r = .73$ and $.70$).

Covariance Analysis

An analysis of covariance was performed using the six dependent variables and the set of socioeconomic, demographic and locational variables as control variables. The analysis measures whether the association between UR and each dependent variable is maintained when controlling for each independent variable in turn. The association between UR and the trend parameters was measured in two ways: a difference in subgroup means and a correlation between UR and the dependent variable. The

association between UR and the dependent variable controlling for the dependent variable is the adjusted difference in means in the analysis of covariance (Blalock, 1972, pp. 491-497), and the partial correlation coefficient.

Pre-Decline Level

The independent variables are all taken to represent levels at the beginning of the fertility decline. They are, in fact, measured at different times, the latest being 1959-1966 annual average for net migration. The implications of temporal priority must be borne in mind when interpreting the relationships.

In Table 5-5 it is evident that the variables that are able to account for or reduce the association of UR and pre-decline fertility level are the same for both age groups, a finding that lends some credence to the results. In both cases the measure of education appears to explain the pre-decline fertility whether measured by the difference of subgroup means or correlations. It seems, then, that the different levels of education of women, an indicator of modernization or socio-economic development, coupled with the link between education and pre-decline fertility ($r = -.59$ and $-.79$) is what is responsible for most of the areal pattern of pre-decline levels of fertility, as measured by the dichotomous UR variable. Child mortality appears to account for a moderate amount of areal variation at least at 30-34; it would be expected that pre-decline fertility would have, over the long run, worked out in response to mortality levels. Since the analysis here is limited to only one control variable at a time, it may well be that the effect of a variable such as CM is due to a high correlation with another

TABLE 5-5. Analysis of Covariance; Relationship of UR and Pre-decline Fertility Level Controlling for Various Independent Variables

Age Group	Independent Variable	Mean PDL	Difference Rural - Urban		Correlation UR vs. PDL	
			Unadj.	Adjusted*	Zero Order	Partial**
30-34		301	22.5		.43	
	DTT			22.8		.39
	HAK			23.0		.41
	CDR_{52}			26.1		.39
	CM_{52}			17.8		.30
	PM_{60}			19.1		.34
	ED_{53}			2.1		.04
	MIG			13.8		.20
35-39		226	29.8		.59	
	DTT			25.9		.49
	HAK			31.1		.58
	CDR_{52}			31.1		.50
	CM_{52}			27.1		.50
	PM			27.5		.51
	ED_{53}			4.5		.10
	MIG			10.4		.19

*Difference in mean fertility of urban and rural areas controlling for independent variable in analysis of covariance.

**Controlling for independent variable.

control variable such as ED (although in this case the correlation is of moderate size: -.36).

Other demographic variables--migration and age at marriage (i.e., PM)--have some slight effect, but problems of causality must be considered. Not only were these variables measured at a later date than PDL, but "multi-phasic response theory" (Davis, 1963) would suggest that these variables have causal interrelationships with fertility level with causation probably not in a single direction. The correlations here suggest that out-migration is high in areas of high pre-decline fertility ($r = -.42$ and $-.68$ for PDL vs. MIG) which is consistent with the theory; the correlations also indicate that areas of high long-term fertility above age 30 had high proportions married at young ages, a finding that is a bit harder to interpret.

In any event, results suggest that at least one measure of socioeconomic modernity--education--is involved in bringing about the pattern of areal differentiation existing prior to the beginning of fertility decline. Whether the process involved was one in which more modern women were better able to control fertility at this time, or one in which differences in family size norms were important, is, of course, impossible to say from the long range view of areal data. It can only be suggested that the fact that these are long term differences is consistent with a normative hypothesis.

Date of Decline

On the average, there was a 3 year lag between the decline of fertility in urban areas and rural areas. As is evident in Table 5-6, controlling for mean distance to the nearest town accounts for two-

TABLE 5-6. Analysis of Covariance; Relationship of UR and Date of Initiation of Decline (DOD) Controlling for Various Independent Variables

Age Group	Independent Variable	Mean Date	Difference Rural - Urban		Correlation UR vs. DOD	
			Unadj.	Adjusted	Zero Order	Partial
30-34		57.1	3.05		.37	
	DTT			.94		.12
	HAK			3.31		.37
	CDR_{52}			1.57		.16
	CM_{52}			2.46		.26
	PM			3.16		.34
	ED_{53}			3.17		.29
	MIG			2.89		.25
	DCDR			2.78		.31
	DCM			2.48		.32
	DAF			2.49		.30
35-39		56.8	3.06		.43	
	DTT			1.32		.20
	HAK			2.92		.39
	CDR_{52}			1.70		.20
	CM_{52}			1.76		.23
	PM			2.81		.36
	ED_{53}			4.09		.42
	MIG			5.65		.55
	DCDR			2.25		.31
	DCM			1.85		.35
	DAF			2.50		.36

thirds of this difference at 30-34 and better than half the difference at 35-39. The unadjusted differences for the two age groups are 3.05 and 3.06; controlling for mean distance to the nearest town these differences are .94 and 1.32. This can be interpreted as support of the diffusion model: Fertility began falling earlier in cities because these served as centers of innovation, and areas that were further removed from urban centers adopted the pattern of controlled fertility later. The relative remoteness of urban and rural areas accounts for most of the difference in timing across UR.

Crude death rate and child mortality rate had the next greatest effect. The effect of child mortality is greater at the older age group. Change in mortality has a smaller contribution toward areal fertility differences according to the model than absolute mortality rate at the beginning of the period. Apparently long term differences in mortality are more important than change in bringing about demographic pressure and decreased fertility, but it should be remembered that mortality had been undergoing change for a long time prior to the period under investigation.

Neither the cultural or educational measures seem to go very far in explaining the areal pattern of fertility change. In fact, the model suggests that holding education constant would result in increased urban-rural differences in timing of decline.

Apparently, then, a diffusion pattern outward from cities to most remote areas is not inconsistent with the data. Remoteness of areas is a more important determinant of the areal pattern of initiation of decline than were measures of mortality which hold the key to most

demographic theories of fertility change. The diffusion model thereby gains some measure of support.

Rate of Decline

The findings with respect to this dependent variable are consistent with the diffusion model in one important respect. The rate of decline is fastest the later fertility began declining. This is evidenced by the fairly strong positive correlations between DOD and RATE (r = .53 and .58) where RATE is expressed as a positive number.

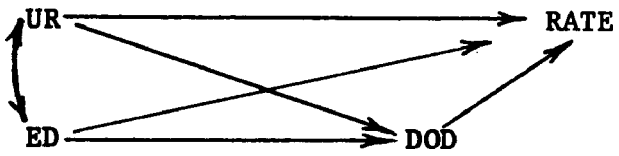
RATE is negatively correlated with education (r = -.51 and -.49), see Table 5-3) indicating that higher education areas declined at a lower rate than low education areas. Thus, education has an effect in the opposite direction as would be expected if one hypothesized that socioeconomic development would enable areas to move toward controlled fertility rapidly.

Turning to Table 5-7 it is evident that education is the one variable that can account for the UR pattern. Migration and child mortality have some effect at one or both age groups, but ED is by far the most powerful control variable. At 30-34 the direction of UR differences in rate of decline is reversed when ED is controlled; if educational attainment had been held constant, urban areas would have fallen faster than rural areas.

The use of date of decline as an intervening variable can help shed some light on the process involved. Pre-decline level could also be used, but PDL is not particularly strongly associated with rate of decline (r = .04 and .25 for the two age groups), while DOD is (r = .53 and .58). The model incorporating DOD can be diagrammed as below:

TABLE 5-7. Analysis of Covariance; Relationship of UR and Rate of Decline Controlling for Various Independent Variables

Age Group	Independent Variable	Mean Rate	Difference Rural-Urban		Correlation UR vs RATE	
			Unadj.	Adjusted	Zero Order	Partial
30-34		15.4	2.72		.31	
	DTT			2.04		.21
	HAK			3.52		.37
	CDH_{52}			2.70		.24
	CM_{52}			2.62		.25
	PM			2.62		.27
	ED_{53}			-.67		-.06
	MIG			1.15		.10
	DCDR			2.72		.28
	DCM			2.24		.35
	DAF			1.99		.23
30-39		16.8	2.71		.37	
	DTT			2.47		.30
	HAK			2.80		.35
	CDR_{52}			2.58		.27
	CM_{52}			1.99		.24
	PM			2.63		.32
	ED_{53}			.46		.05
	MIG			1.85		.18
	DCDR			2.34		.30
	DCM			2.17		.29
	DAF			2.37		.31



There are two possible approaches given the model, both of which will be considered. First, the problem can be treated in the analysis of covariance format treating initiation date as simply an additional control variable. The second strategy is to make use of the presumed causal model to see what sort of indirect and direct effects among the variables are implied given the correlations among them and assuming the model is correct.

The analysis of covariance strategy is illustrated in Table 5-8. It is evident that controlling for initiation date alone results in considerable reduction in the difference across UR. The unadjusted differences of 2.72 and 2.71 are reduced to 1.17 and 1.05 for the two age groups. This finding says that over half--but by no means all--of the differential in RATE is due to the fact that urban areas declined earlier, and later declining areas were able to bring fertility under control faster, once decline began.

The adjusted differences reported in Table 5-8 when various other variables are controlled in addition to DOD show effects in two directions. For several, especially DTT, HAK, and CDR, the difference expected with the introduction of the control variable is <u>greater</u> than the difference holding only DOD constant. This seems to say that these variables are distributed in such a way with respect to both DOD and RATE as to <u>depress</u> rural-urban differences in rate of decline. In other words, the distribution of initiation date across rural and urban areas

TABLE 5-8. Analysis of Covariance; Relationship of UR and RATE of Decline Controlling for Date of Decline and Various Independent Variables

Age Group	Independent Variable	Mean Rate	Difference Rural - Urban		
			Unadj.	Controlling for DOD	Controlling for DOD plus indep. var.
30-34		15.4	2.72	1.17	
	DTT				1.51
	HAK				1.88
	CDR_{52}				1.85
	CM_{52}				1.35
	PM				1.00
	ED_{53}				-2.31
	MIG				-.32
	DCDR				1.29
	DCM				.98
	DAF				.81
30-34		16.8	2.71	1.05	
	DTT				1.60
	HAK				1.20
	CDR_{52}				1.61
	CM_{52}				1.03
	PM				1.11
	ED_{53}				-2.08
	MIG				-2.06
	DCDR				1.11
	DCM				1.03
	DAF				1.15

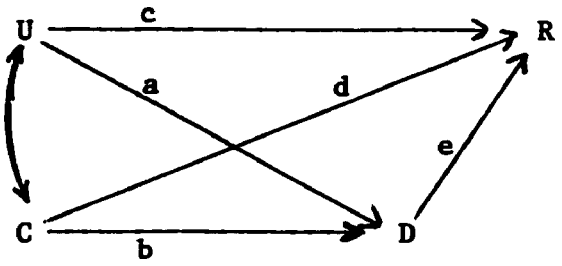
accounts for much of the observed pattern of slow rates of change in cities and fast rates in other areas. But remoteness, ethnicity and mortality are distributed in such a way as to work in the opposite direction, net of initiation date. That is, more remote areas tend to have slower rates of change, but also have later dates of decline which is related to faster rates.

Finally, education and net migration act strongly in the opposite direction. Controlling for these two variables in addition to DOD results in predicted differences in the opposite direction of the differences observed. Fertility declines faster in urban areas if education and DOD are held constant. Education has this effect without the DOD control, but adding DOD strengthens the effect of education considerably. Since some of these interrelationships are a bit hard to describe verbally, some of them are best described with specific reference to the causal model via path analysis.

If the model is assumed to be correct, the correlations among the variables can be used to solve for causal "path coefficients" (Duncan, 1966). The coefficients for the model are presented in Table 5-9. Note that among the path coefficients DOD has the largest effect on RATE (the path coefficient 'e') in every case but one. Further, several variables--distance to town, percent Hakka, crude death rate and child mortality (at 30-34)--have direct or net effects in the opposite direction of the zero order relationship between RATE and the variables, the effect that was being alluded to earlier with reference to adjusted differences.

The case of crude death rate can serve as an example. The correlation of .20 and .25 between this measure and RATE (see Table 5-3)

TABLE 5-9. Path Analysis, Dependent Variable RATE of Decline



U: UR
C: Control variable
D: DOD
R: RATE

$$r_{UR} = c + (d)(r_{UC}) + e(a + (b)(r_{UC}))$$

Age Group	Independent Variable	r_{UR}	r_{UC}	Path Coefficients a	b	c	d	e
30–34		.31						
	DTT		.49	.11	.51	.17	-.12	.54
	HAK		.37	.40	-.09	.21	-.20	.47
	CDR_{52}		.65	.19	.27	.21	-.13	.51
	CM_{52}		.55	.30	.13	.15	-.04	.49
	PM		.47	.38	-.03	.11	.04	.48
	ED_{53}		-.69	.38	.02	-.26	-.57	.49
	MIG		-.73	.35	-.03	-.04	-.23	.48
	DCDR		.42	.33	.08	.15	-.04	.49
	DCM		.53	.30	.13	.11	.04	.48
	DAF		.31	.30	.21	.09	.17	.44
35–39		.37						
	DTT		.49	.19	.49	.21	-.25	.63
	HAK		.37	.41	.05	.16	-.06	.52
	CDR_{52}		.65	.24	.30	.22	-.14	.55
	CM_{52}		.55	.25	.33	.14	.01	.52
	PM		.47	.39	.08	.15	-.04	.49
	ED_{53}		-.69	.57	.21	-.28	-.56	.60
	MIG		-.73	.80	.50	-.28	-.49	.66
	DCDR		.42	.32	.27	.15	-.03	.53
	DCM		.53	.26	.32	.16	-.03	.53
	DAF		.31	.30	.21	.14	.01	.52

indicates that the higher mortality the faster fertility declined, a finding that may be somewhat at odds with demographic transition theory. The path model illustrates that this positive correlation is the result of the relationship of CDR to UR and DOD. The higher CDR, the later decline began, and the later date of decline the faster the rate of decline. Holding UR and DOD constant, a higher CDR would have resulted in a slower rate of fertility decline, as evidence by the negative direct effect or path coefficient from CDR to RATE.

Similar logic could be applied to the other variables mentioned. The question could be asked how these relationships among the variables work to determine the spatial pattern of rate of decline. To discuss this the "fundamental theorem of path analysis" can be used to advantage. In Table 5-9 the formula is shown giving the expansion of the correlation between UR and RATE in terms of correlations and path coefficients. Re-arranging the terms for the case of CDR (or other independent variable), the following decomposition of the UR-RATE correlation coefficient is possible:

correlation between UR and RATE	direct effect	effect thru CDR: direct	effect thru CDR: thru DOD	effect thru DOD net of CDR
r_{UR} =	c +	$(d \cdot r_{UC}$	+ $e \cdot b \cdot r_{UC})$ +	$e \cdot a$

The various effects can be traced through the diagram accompanying Table 5-9. For the case of CDR the coefficients are given below:

$$.31 = .21 + ((-.13)(.65) + (.51)(.27)(.65)) + (.51)(.19)$$

Interest here centers on explaining the observed areal pattern of the rate of change in fertility (as measured by r_{UR}). This correlation

coefficient can be broken into components according to the model. As grouped above there are three major components:

1) 'c' or the direct effect of urban or rural location on rate of change net of both CDR and date of decline. For this case this term is positive indicating that there would have been faster decline in non-urban areas had there been no variation in CDR or DOD.

2) The effect through CDR; this contributes to the correlation r_{UR} since CDR is correlated with UR. There are two sub-components--'$d \cdot r_{UC}$' due to the direct effect of mortality on rate of decline and '$e \cdot b \cdot r_{UC}$' due to CDR's effect on DOD and DOD's effect on RATE. Note that these two sub-components are about equal and of opposite direction. Thus, the contribution of CDR to the correlation r_{UR} both by itself and through DOD is about zero. This effect shows up in Table 5-7, also. Holding only CDR constant across areas makes almost no difference in the difference between urban and other areas' rates of decline.

3) 'e·a,' the component due to the direct effect of UR on DOD and DOD on RATE. This relationship contributed toward the high rates in rural areas compared with cities.

This exercise, then, shows that the areal distribution of CDR worked according to the model to bring about slower declines in locations of high mortality, consistent with demographic theory, but that the relationship of mortality and date of decline (also consistent with the theory) served to obscure this effect.

When education is the control variable the result is considerably different:

$$.31 = -.26 + ((-.57)(-.69) + (.49)(.03)(-.69)) + (.49)(.38)$$

The educational distribution has the net effect of contributing toward increased differences; the net effect of ED is <u>negative</u> (-.57) indicating that net of DOD and UR high education is associated with low rates of fertility change. If educational levels were equalized across the island, urban areas would have declined faster than rural areas as observed in

adjusted differences in Tables 5-7 and 5-8 and evidenced here by the net effect of UR on RATE (-.26). There is little relationship between ED and DOD. The pattern of high rates in rural areas comes about through the strong relationship between ED and RATE, and ED and UR plus the UR-DOD and DOD-RATE connection net of education. The high education areas had slow rates of decline regardless of where they were located and when their fertility started declining.

Why should education have an effect in this direction? It may be that since education is strongly related to long term differences, that where education is highest, contraception and abortion have been fairly widespread, larger proportions of women have been adjusting their behavior to the changing circumstances of life--increased survivorship of children, perhaps normative change accompanying modernization--and in their use of family limitation methods have been more sensitive to the large scale social change taking place over the long run.

In more backward areas, where there may have been less of a tradition of use of contraception and abortion, social and demographic modernization may have created a climate of "demographic pressure" among women over age 30 in which the means of family limitation were adopted rapidly once they became widely known and available. Individual level data surveyed in Chapter 5 tends to support this picture. In the mid-1960's there were fairly substantial differences in contraceptive use between women in high and low educational categories and between urban and rural residents. The contraceptive experience of the least modern sector was increasing faster than among the most modern women who initially had the most contraceptive experience.

Summary and Conclusions

The questions posed in this chapter are approached in terms of how the spatial distribution of the various control variables, measured mainly at the beginning of the period of observation, are related to the parameters of the 1952-1970 trends in fertility rate. Because of the limited number and coarseness of the areal units "spatial distribution" here means primarily differences between the six urban areas and the sixteen other areas. While the results are limited by the necessary crudity of spatial measurement, they are suggestive of the types of social processes that could be involved.

Long term pre-decline differences in fertility levels between rural and urban areas appear to be strongly related to educational differences across the island. This suggests that there was greater use of the means of family limitation in high education areas, whether this was due to greater access and knowledge, or lower family size norms. The fact that differences in pre-decline level reflect stable, long term levels may be argued to reflect normative differences, rather than differences in knowledge, and practice of family limitation, which would presumably result in changing differentials as family limitation became more widespread.

Such a spread of controlled fertility within marriage was hopefully observed in the measure of date of initiation of decline. Here the relative remoteness of the areas accounts for much of the urban-rural difference. Thus, it seems that the innovation diffusion gains some support. Controlled fertility spread through the island in such a way to suggest that proximity to centers of innovation were of prime importance in determining when an area would begin moving toward low

fertility. No other variable--socioeconomic, cultural or demographic--is as powerful as mean distance to the nearest town in explaining date of decline.

The rate at which areas moved toward low fertility was strongly related to two factors: the educational level and the date of initiation of decline. Areas with low education and late initiation dates had the most rapid fertility decline. This may mean that contraception was more easily available at a later date allowing larger proportions of couples to adopt contraception immediately once demand was felt. Though it was not measured in this analysis, the family planning program's effect can probably be felt on this component, since it has been found, according to one model, to have been most effective in backward, high fertility areas that were entering the decline during this period (Hermalin, 1971).

In the last chapter it was illustrated how the difference in mean fertility rate between urban and rural areas could be considered to be the result of both long term differentials and differences in the timing of decline, and that the mix of these two components was different at different points in the period of decline. The results of the present chapter illustrate that these components themselves are the results of different processes involved in modernization and demographic transition. This fact should be cause for even more serious reflection on the interpretation of single time point cross-sectional differentials and correlations.

Finally, in terms of the models set out in Chapter 2, the diffusion pattern gains some support in the findings of this analysis. However,

measures of mortality are second to remoteness in their ability to account for differences in initation date, suggesting that the interrelationships of the vital processes in the demographic transition are also at work. Education, as a measure of development, appears to be related to long term differences, and to the timing of decline in a way not predicted by the development hypothesis. The fertility decline is apparently far more complex than the models described in Chapter 2. If a choice must be made, the diffusion model fits the data best, although apparently it is not the only kind of process operating.

CHAPTER 6

CHANGE IN FAMILY SIZE NORMS AND CONTRACEPTIVE EXPERIENCE, 1965-1970

In much of the foregoing discussion it has been implied that declines in fertility, particularly to women over age 30, reflect the adoption of contraception by increasing proportions of women. Using areal data, actual measures of contraceptive behavior are not generally available. Another important factor not likely to be found in an areal data set is a measure of ideal family size. Normative differences are important differences in fertility. If it is argued that areal variation reflects the diffusion of low fertility attitudes and behavior, the alternative hypothesis that areal difference is simply due to differing preferences for numbers of children must be considered.

For Taiwan measures of ideal family size and contraceptive experience are available from surveys of married women taken in 1965, 1967 and 1970; in the case of Taiwan, then, inferences suggested by areal analysis can be reviewed in light of the experience of individual women. Even though the period covered by the surveys does not begin until about seven or eight years after the initiation of the fertility decline, the pattern of change in this period is helpful to understanding the change in fertility over the longer period of transition.

TABLE 6-1. Mean Ideal Number of Children for Married Women 22-39 by Residence, and Educational Attainment, 1965, 1967 and 1970

	1965	1967	1970
Residence			
Major Cities	3.7	3.5	3.5
Small Cities	3.8	3.7	3.6
Urban Townships	3.9	3.8	3.8
Rural Townships	4.2	4.1	3.9
Education			
Senior high or more	3.2	3.0	3.0
Junior high	3.6	3.3	3.3
Primary	3.9	3.8	3.8
None	4.1	4.1	4.0
Mean, all women 22-39	4.0	3.8	3.8
No. of women	3049	4145	2491

Family Size Norms

Measures of ideal number of children show slight downward shifts over the five year period, but still remained in the range of moderately large families. As evident in the last row of Table 6-1, the average number of children desired decreased from 4.0 to 3.8 between 1965 and 1970. (The measure used here is the response to a question "If you were just getting married and could have just the number of children you want, how many would you like to have"?) A more detailed look at change in ideal family size indicates that the trend over the period was toward three or four children, and away from larger numbers; only a small proportion of women (5 to 7%) wanted two or fewer children in the three surveys, although there is some indication that the two child family is gaining popularity among younger women (Freedman, et al., 1972, p. 284).

There is a regular pattern of decreasing ideal number of children from low strata to high, and from rural to urban places. The measure of residence used here is similar to the one used in Chapters 4 and 5 of the areal analysis; "major cities" refers to the same areas used in that analysis, but here the category "other areas" has been divided into small cities, urban townships and rural townships, forming with major cities a gradient from most to least urbanized places. There is a stable differential of about half a child between the extreme categories, though all categories decrease somewhat over the period of study.

For the educational attainment categories the differentials are wider, amounting to about one child between the two extreme categories. Education has been found to have the strongest association of several modernization indicators to the measure of ideal number of

children (Freedman, et al., 1972, p. 286). In Chapter 5 it was argued that long-term differentials between urban and rural places, as measured by "pre-decline level" of fertility, were closely related to normative differences. Although there is no real way to make the connection, it is worth noting that the measure of education employed in the areal analysis was the most important variable in explaining the long-term rural-urban fertility difference, and here the education measure is a powerful predictor of normative differences.

The magnitude of change in family size norms, at least in the late 1960's, is not great in comparison with the amount of fertility change going on at the same time. Freedman and associates found, in looking at the data set employed in this chapter that "the decline in average ideal number of children has been less than the decline in children ever born" (1972, p. 285). Normative change, then, is probably lagging behind actual fertility decline, rather than being a prime force in the process. Fertility declines themselves can probably be best described in terms of the elimination of unwanted births and not in terms of a movement toward a small family ideal.

Table 6-2 exhibits the proportion of married women who want no additional children in 1965 and 1970. This measure increases slightly over the period. Above age 30 the measure was at high levels at the first observation point: 80% of all married Taiwanese women between 30 and 39 wanted no more children. The proportion of those who desire no more children is generally greater in more urbanized settings, but the difference is a matter of only a few points. Areal differences could be due to difference in the average number of children already

TABLE 6-2. Proportion of Married Women for Two Age Groups Who Want No More Children, by Residence, 1965 and 1970, and 1965 Standardized on Parity Distribution of Rural Townships

	1965		
	Actual	Standardized	1970
22-29			
Major Cities	.36	.34	.37
Small Cities	.29	.30	.35
Urban Townships	.32	.32	.36
Rural Townships	.29	.29	.26
All Areas	.31	.31	.32
30-39			
Major Cities	.82	.86	.87
Small Cities	.84	.88	.85
Urban Townships	.79	.79	.83
Rural Townships	.78	.78	.84
All Areas	.80	.80	.84

born; standardizing on parity as in Table 6-2, however, makes only a small amount of difference.

Contraceptive Experience

The period of 1965 to 1970 was a period of extremely rapid change in contraceptive practice among married women in Taiwan. In each of the two broad age groups considered here, the proportion of women who have ever used contraception (including sterilization) roughly doubled, as evidenced in Table 6-3. Moreover, it was a period in which women's contraceptive practice was brought into line with their desired fertility. In 1965 80% of women 30-39 wanted no more children, yet only 38% had ever practiced some means of contraception. By 1970 72% had used contraception. It should be stressed that the measure of contraceptive experience used here is simply whether or not the women had ever used some means of contraception, without regard to how long practice was maintained, or whether the woman was currently protected. The use of this measure indicates how great an innovation the use of contraception was in Taiwan, since the proportion who had ever practiced was able to rise so rapidly.

Difference in contraceptive practice by residence are fairly marked, while increases occur in all categories in Table 6-3. More rural categories exhibit greater proportional increase at both ages. For the younger age group the residence categories explain about as much variation in proportion ever using contraception in 1965 as in 1970. But above age 30 the explanatory power diminishes over the period, indicating that women at all levels of the urban-rural spectrum are becoming more alike with regard to contraceptive experience. In

TABLE 6-3. Percent of Married Women Ever Used Contraception (Including Sterilization) for Two Age Groups, by Residence, 1965, 1967 and 1970

	1965	1967	1970
22-29			
Major Cities	28.4	39.0	50.1
Small Cities	20.3	25.4	48.2
Urban Townships	14.8	22.5	34.6
Rural Townships	9.5	15.0	26.2
Total 22-29	15.9	23.3	35.2
Eta^2(unadj.)	.038	.044	.040
30-39			
Major Cities	55.3	66.5	82.0
Small Cities	41.2	58.9	73.4
Urban Townships	34.2	55.4	69.9
Rural Townships	31.0	47.0	66.7
Total 30-39	37.8	55.1	71.7
Eta^2(unadj.)	.036	.023	.017

TABLE 6-4. Percent Married Women Ever Used Contraception for Two Age Groups by Two Indicators of Modernization, 1965 and 1970

	1965	1970
Newspaper Readership		
(22-29)		
Daily	40.8	59.5
Frequently	18.7	41.8
Seldom/Never	17.8	41.6
Can't Read	9.7	27.5
Eta^2(unadj.)	.065	.062
(30-39)		
Daily	73.6	85.4
Frequently	61.8	81.5
Seldom/Never	42.5	78.8
Can't Read	29.2	68.0
Eta^2(unadj.)	.085	.021
Education		
(22-29)		
Senior high or more	45.5	71.0
Junior high	31.0	57.8
Primary	18.9	30.7
None	8.4	28.3
Eta^2(unadj.)	.054	.070
(30-39)		
Senior high or more	60.2	90.0
Junior high	51.4	86.3
Primary	31.9	73.5
None	19.4	64.7
Eta^2(unadj.)	.055	.024

short, the practice of contraception manifests a pattern of spread very similar to that of lower fertility described in Chapter 4. Above age 30 there is a convergence across rural and urban areas as the use of contraception becomes more prevalent even in the most remote area.

Such a diffusion model of change is equally applicable to the pattern of contraceptive adoption occurring across categories of the two non-spatial modernization indicators in Table 6-4. In both the case of education and of newspaper readership the explanatory power of the independent variable remain at the same level or increases for younger married women, but decreases for those over 30. The difference in contraceptive experience between major cities and the most rural areas increases for younger women, and decreases for older. Thus, it might not be unfair to state that contraceptive practice is spreading from high to low strata, from most to least modern women. For older women the diffusion process has proceded to the point where the least modern women are catching up; for younger women the process is still at the stage where the most modern women are maintaining their lead in contraceptive experience.

To what extent is the urban to rural diffusion pattern the result of the areal distribution of such individual traits as education and newspaper readership, and their relation to contraceptive practice? This question is similar to the one posed in the multivariate analysis of fertility trend parameters. With categorical independent variables the method of multiple classification analysis can be used (Andrews, et al., 1967). Proportions who have ever used contraception can be computed for each urbanization category controlling for education, newspaper readership and other modernization indicators. Such

adjusted proportions are similar to the adjusted means in the covariance analysis in Chapter 5. The model is very similar and also assumes no interaction among the predictor variables.

As a brief means of describing the effect of controlling the various independent variables in Tables 6-5 and 6-6 the difference in proportion ever using contraception between the two extreme categories--major cities and rural townships--is presented. For the younger age group the unadjusted difference in extreme categories increases from 19 to 24 over the 5 year period. The independent variables account for slightly less than half this difference in 1965 and 1970. At 30-39 the independent variables in combination can account for nearly two-thirds of the major city-rural township difference in 1965. By 1970 the unadjusted gap narrows and the predictors account for only about half of it. Above age 30 the predictors explain less variance at the later date, in terms of R^2 adjusted for degrees of freedom, as women in all categories become more alike in their use of contraception.

The lesson of this multiple classification analysis appears to be that the limited number of independent variables used here can account for substantial proportions of the difference in contraceptive experience between urban and rural places. Two of the independent variables--newspaper readership and exposure to mass media--can be considered measures of accessibility to the means of communication and the dissemination of new ideas. The fact that these variables are in every case at least as important as education may lend some support to the interpretation that a diffusion process is at work on the individual level. As observed in the last chapter, education and

TABLE 6-5. Multiple Classification Analysis; Percent Ever Used Contraception 22-29 by Residence, Controlling for Selected Indicators of Modernization, 1965 and 1970

	Mean	Model: 1	2	3	4	5	6
1965	15.9						
Major Cities		28.4	25.0	23.8	--	25.5	23.5
Small Cities		20.3	17.9	18.1	--	18.2	17.8
Urban Townships		14.8	15.1	14.6	--	15.0	15.6
Rural Townships		9.5	11.5	11.9	--	11.2	12.2
Eta^2(unadj.)		.038					
R^2(adj.)			.067	.075	--	.060	.080
1970	35.2						
Major Cities		50.1	44.8	44.3	44.9	--	42.5
Small Cities		48.2	45.8	46.2	45.9	--	44.4
Urban Townships		34.6	35.3	34.6	34.4	--	35.2
Rural Townships		26.2	28.7	29.3	29.5	--	30.0
Eta^2(unadj.)		.040					
R^2(adj.)			.070	.073	.073	--	.095
Difference between Major Cities and Rural Townships:							
1965		19	13	12	--	14	11
1970		24	16	15	15	--	12

Models:
1. Unadjusted mean values.
2. Subgroup means adjusted for education.
3. Means adjusted for newspaper readership.
4. Means adjusted for mass media exposure (low, medium, high).
5. Means adjusted for number of modern objects owned (0-3, 4-5, 6-7, 8 and more).
6. Means adjusted for all three modernization variables measured in each year.

TABLE 6-6. Multiple Classification Analysis; Percent Ever Used Contraception 30-39 by Residence, Controlling for Selected Indicators of Modernization, 1965-1970

	Mean	Model: 1	2	3	4	5	6
1965	37.8						
Major Cities		55.3	49.5	46.9	--	47.3	45.4
Small Cities		41.2	37.0	36.9	--	35.7	34.6
Urban Townships		34.2	34.7	35.4	--	35.9	35.9
Rural Townships		31.0	34.5	35.3	--	35.0	36.3
Eta^2(unadj.)		.036					
R^2(adj.)			.083	.089	--	.091	.107
1970	71.7						
Major Cities		82.0	79.3	79.5	78.5	--	77.7
Small Cities		73.4	77.5	72.1	71.6	--	71.5
Urban Townships		69.9	70.1	70.3	70.3	--	70.2
Rural Townships		66.7	68.4	68.2	68.8	--	69.3
Eta^2(unadj.)		.017					
R^2(adj.)			.024	.025	.026	--	.031
Difference between Major Cities and Rural Townships:							
1965		24	15	12	--	12	9
1970		15	11	11	10	--	8

Models:
1. Unadjusted mean values.
2. Subgroup means adjusted for education.
3. Means adjusted for newspaper readership.
4. Means adjusted for mass media exposure (low, medium, high).
5. Means adjusted for number of modern objects owned (0-3, 4-5, 6-7, 8 and more).
6. Means adjusted for all three modernization variables measured in each year.

accessibility to new ideas may explain different parts of the overall process of change, which has not been broken down here.

Conclusions

It appears that normative differences exist between urban and rural places with regard to family size, and these norms are changing, but not rapidly. The differentials by urbanization are generally smaller in magnitude than the differences across non-areal categories of women, such as education. The individual level data examined here indicate that there was in 1965, seven or eight years after the initiation of fertility decline, considerable potential for rapid adoption of contraception; 4 out of 5 women age 30-39 wanted no more children, but fewer than 2 out of 5 had ever tried any means of contraception. As a result, the experience of contraception increased rapidly over the next five years. The use of contraception appeared to spread from modern to least modern women, from urban centers to remote areas, in a pattern very similar to the change in fertility rates observed using areal data. Measures of individual linkage to communication networks (such as newspaper readership) as well as education seem to account for a large part of the urban-rural difference in contraceptive experience.

CHAPTER 7

THE EFFECTS OF EDUCATIONAL ATTAINMENT, NUPTIALITY AND MARITAL FERTILITY ON FERTILITY CHANGE AND RURAL-URBAN FERTILITY DIFFERENCES 1966-1971

Introduction

This chapter makes use of a special set of data: age-specific rates of marital fertility for each of five educational categories for Taiwan and for major cities and hsiens for two recent years. Together with age-education specific rates of marriage and distributions of women by age and educational attainment they make possible a decomposition of change in fertility rates between 1966 and 1971, and of the rural-urban differences in fertility, in terms of changes in three factors:

1) marital fertility within education groups,
2) proportions married within education groups, and
3) the distribution of all women by education group.

Most of the foregoing analysis has concentrated on change in period rates of fertility. The last chapter, an exception, dealt with difference in family size norms and contraceptive experience of a sample of individual women. The data used in the present chapter allow for some direct translation of the effect of change in what has been called "socioeconomic development" (measured here by education) on the period rates of fertility. Effects of changing nuptiality patterns and marital fertility patterns can likewise be examined.

In indentifying patterns of time lags in fertility decline and describing what has been called the "diffusion" pattern of fertility change it has been maintained (at least implicitly) that what is spreading through the population is the efficient use of modern means of fertility control. If this is in fact true, it would be expected that most of the change in fertility is due to change in marital fertility within educational categories. To the extent that trends in educational composition can account for the fertility change and differences, it can be argued that the development model is supported. This would be true if, for example, it could be shown that the main reason fertility declined (or was lower in cities) was that education increased (or was higher in cities), and education was associated with marital fertility. Not surprisingly, the findings of this chapter reveal that both change in educational attainment and marital fertility within educational groups are important, and the relative contributions vary with age.

The data used here, then, allow for the treatment of fertility change in terms of themes already sounded in this study. By examining the complex of changes behind a single differential in period fertility, the analysis can help flesh out the understanding of trends gained in earlier chapters.

The Data

In 1966, special tables were constructed giving birth rates by age by educational attainment (five categories) for married women. These tables were published in the 1966 Taiwan Demographic Fact Book. Also published were tables giving the distribution of women by marital status and educational attainment (1966 Fact Book; Tables 11 and 14). These

tabulations were made separately for the entire island and for each of the 22 major cities and counties (hsiens). The figures are based on a complete enumeration of the population.

To get comparable rates in 1971, it was necessary to take a sample of the records of the separate administrative areas, since the appropriate records were not centralized. Thus, the 1971 figures are not based on the entire population, but on a sample. Further, with the sample it was only possible to get estimates of rates for the island and two sub-regions--the five major cities and the 16 hsiens. The 1966 figures were then aggregated to get comparable sets of rates for the two sub-regions.

The island-wide rates for crude birth rate, total fertility rate, and age-specific rates that are used here are computed from the subsidiary education-specific rates and distributions and may be slightly at odds with published rates because of rounding, sampling variation in 1971, and other minor discrepancies. The 1966 educational distributions and proportions married are taken at year-end, rather than mid-year.

Methodology

The techniques used are a variation of the "components of difference in two rates" method (Kitagawa, 1955, 1964). Each age-specific fertility rate (F) can be thought of as resulting from three "factors":

1) MF_e: the set of birth rates to married women in each educational category.

2) P_e: the proportion married in each educational class.

3) R_e: the proportion of all women in each educational class.

There are five educational classes arranged in an ordinal scale: illiterate, literate, primary graduates, junior graduates, and senior

graduates and above. Each of the three factors, then, consists of a set of five rates or proportions. Each age-specific fertility rate can be expressed:

$$F = \sum_{e}(MF_e)(P_e)(R_e), \text{ where "e" runs over all educational classes.}$$

The components method as used here is simply a systematic means of presenting several conventional standardization analyses at once. Using the formula for F, first the value of the rate is computed for 1966; then the value of F is calculated substituting the 1971 value for each factor in turn, while holding the other two at 1966 levels. Three components are thereby obtained. (Appendix III should be consulted for a more complete description of the method).

The "component of change due to marital fertility rates," then, is the amount F would have changed had only the marital fertility rates changed to 1971 levels, while proportions married and educational distribution had remained unchanged. Interpretation must be cautious, however, since in reality there is no reason to believe that change in one factor is independent of change in another. In fact, there is good reason to believe that marital fertility and proportions married are causally related.

A fourth component is necessary to complete the analysis of change in a rate. An interaction term, equal to the difference in the sum of the other three components, and the actual change must be included. The size of this term depends on how change in the three factors are interrelated. If more than one factor changes a substantial amount, the interaction term probably will be large. It will be small if change is

due mainly to one factor, or change in the factors is uncorrelated.

A final note should be added on interpreting changes in period fertility rates. Change in a five year period for such rates may reflect only change in the timing of childbearing unrelated to long term trends in family size. The general downward trend of most of the period rates is consistent with the trend in Taiwan over the last 15 years.

The age specific fertility rates can be considered true cohort rates. Women age 15-19 in 1966 and 1971 are two consecutive five year cohorts; change in a single age group's fertility rate is change between successive waves of women at the same stage of life.

Marital Fertility and Educational Attainment

The general negative association between fertility and education that has been found in Taiwan is borne out by the education-specific marital fertility rates used in this paper. However, the association between marital fertility and education does not appear to be particularly strong, nor even monotonic. The weak negative association was maintained below age 30, despite substantial changes in fertility levels between 1966 and 1971. In Figure 7-1, marital fertility for women 15-19 has almost the same pattern across educational groups in both years. Between 1966 and 1971 there was an increase in every category. Marital fertility for women 20-24 has a less distinct relationship in the same direction, and also has increases in all educational categories except for "literate" (Figure 7-2).

Why should birth rates for young married women be increasing at a time of general decline? One cannot appeal to changing patterns of contraceptive use, since very small proportions have been users at these

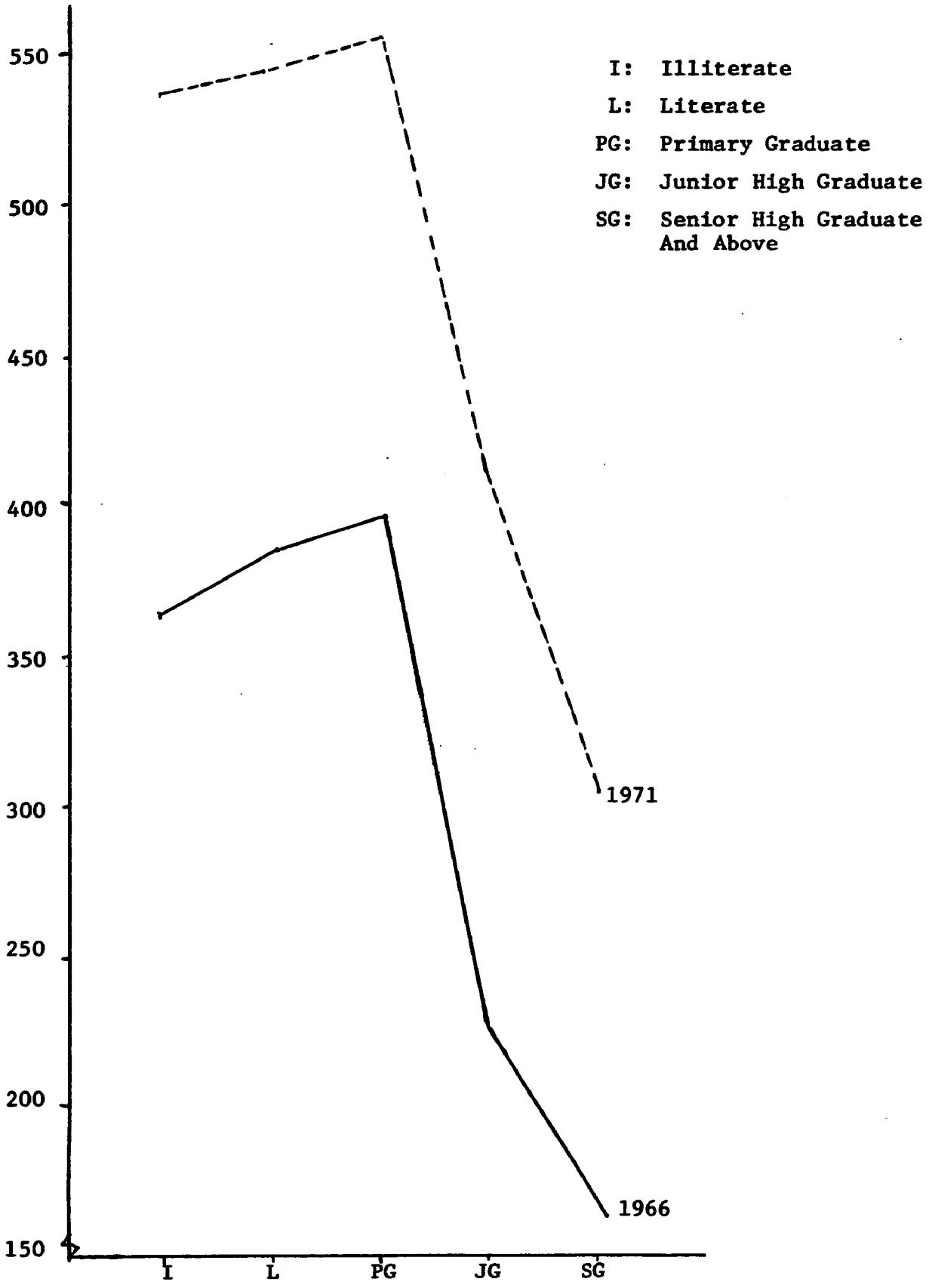


FIGURE 7-1: Marital fertility, women 15-19, by education, 1966 and 1971.

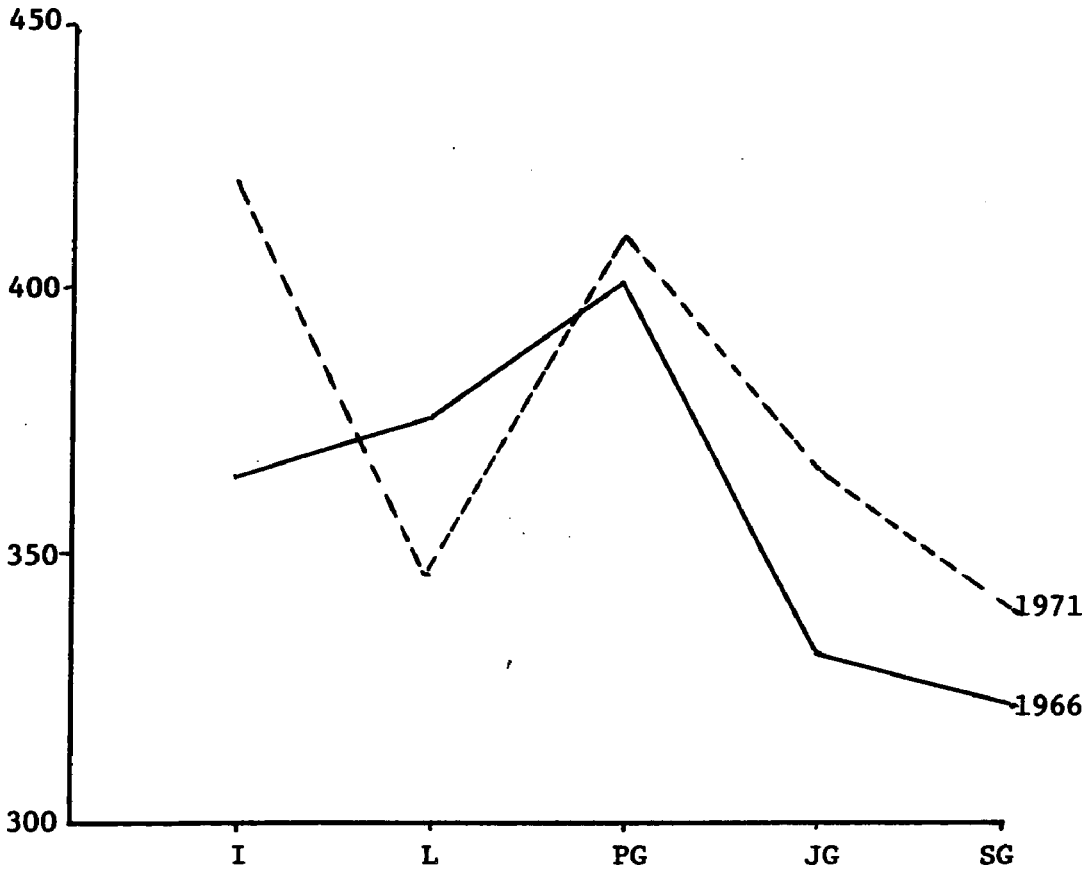


FIGURE 7-2: Marital fertility, women 20-24, by education, 1966 and 1971.

ages. Several non-deliberate factors could be behind the rising fertility rates. For example, there could be increases in fecundity related to rising levels of nutrition, or increased frequency of coitus could accompany the shift to modern nuclear households (Jain, 1969). Within five year age groups, there could be shifts in single year proportions married, or in the distribution of married women by duration of marriage. Hermalin (1971) estimates that 25 to 40% of the observed 1965-68 increase in marital fertility for women 15-19 was due to the shift in marital duration distribution.

Some of the increases may be due to women becoming pregnant before marriage in greater frequency. There appears to be a trend toward greater pre-marital conception in recent years. In the Knowledge and Attitude Survey conducted in 1971, women age 20-29 were more likely to have been pre-maritally pregnant the more recently they had been married:

Duration of Marriage	Percent Pre-maritally Pregnant
Less than 5 years	32.3
5 or more years	20.4

A testable hypothesis concerning the effect of declining proportions of well-educated women who marry at young ages will be discussed later. Above age 25, declines in marital fertility occur in every educational group. Marital fertility for women 25-29 has across-the-board decreases and a negative association is maintained (Figure 7-3).

At age 30-34 (Figures 7-4 and 7-5) and above, the pattern can be termed one of convergence. The decreases are greatest in the low education classes, erasing the negative association that existed in 1966. Widespread adoption of contraception is probably behind the declines;

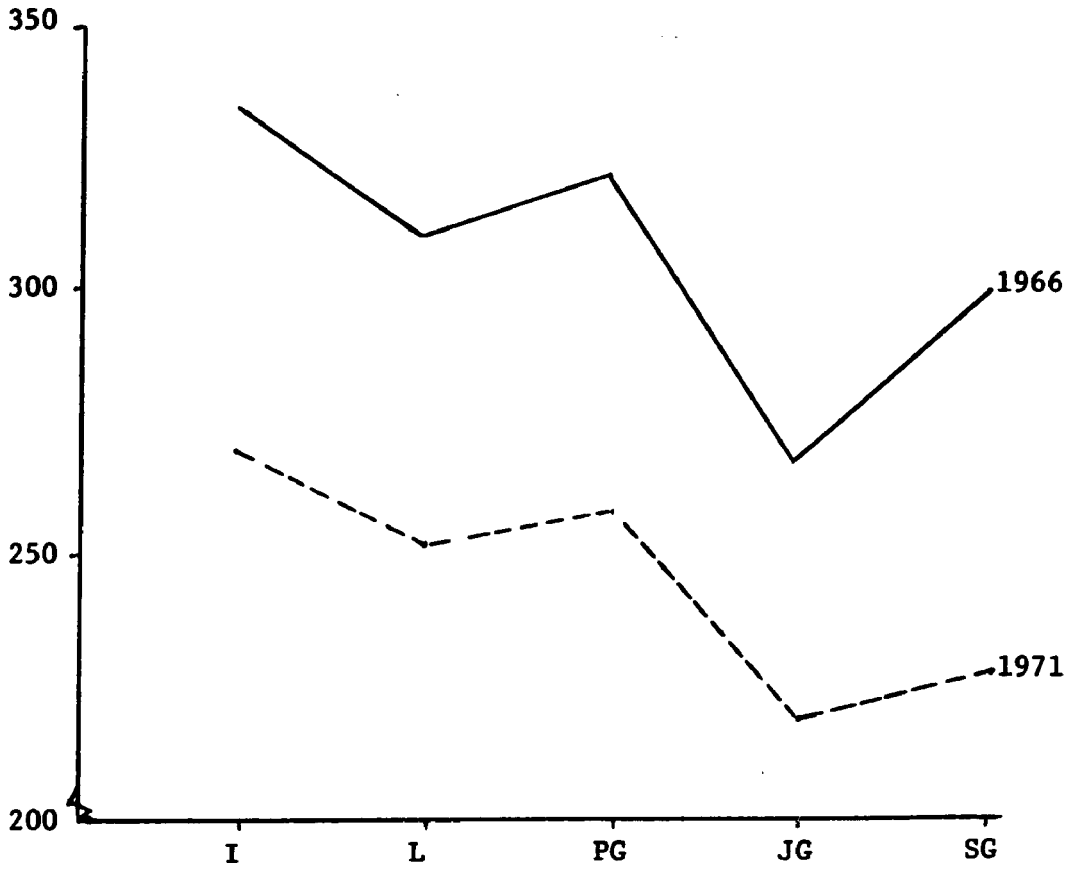


FIGURE 7-3: Marital fertility, women 25-29, by education 1966 and 1971.

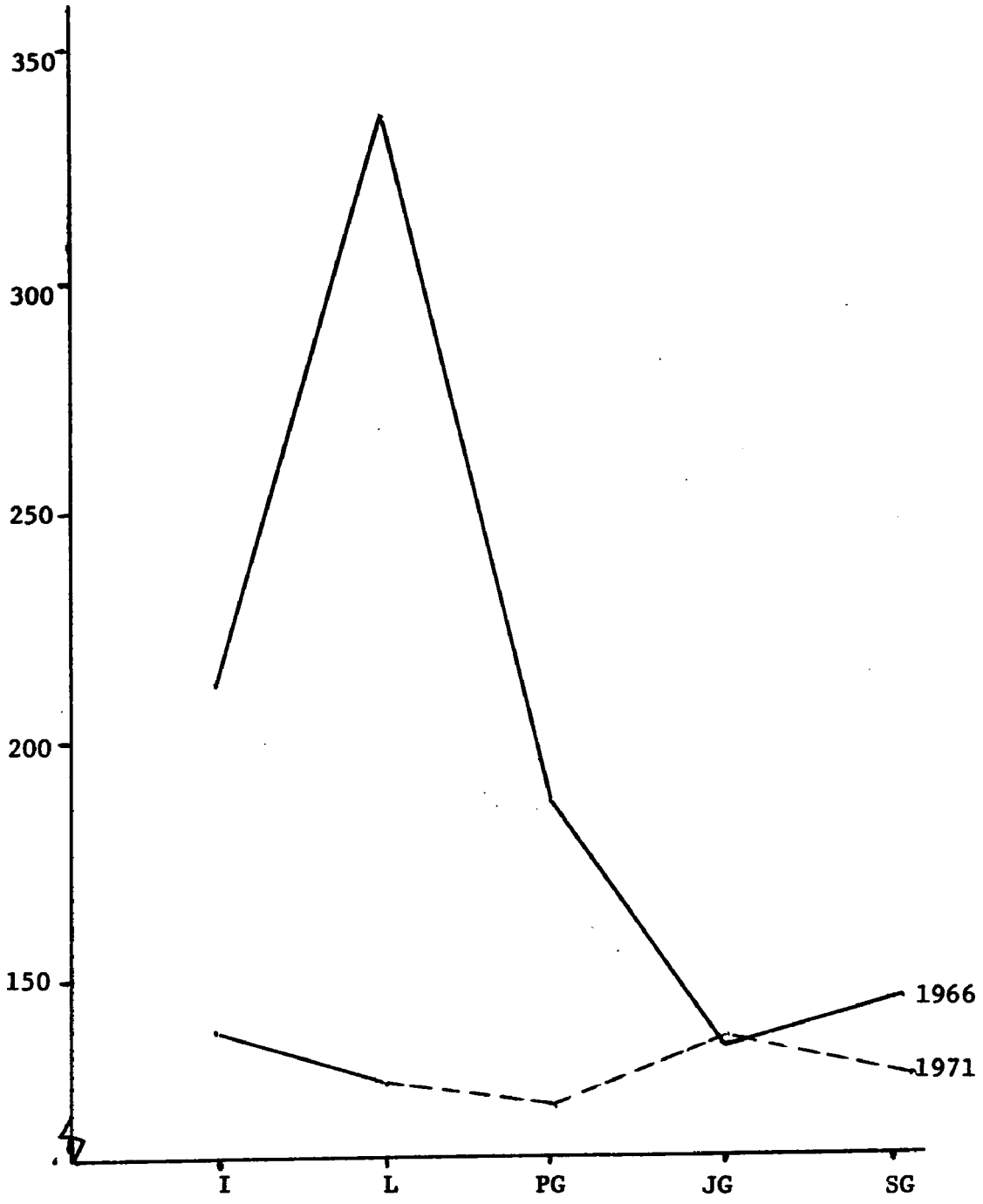


FIGURE 7-4: Marital fertility, women 30-34, by education, 1966 and 1971.

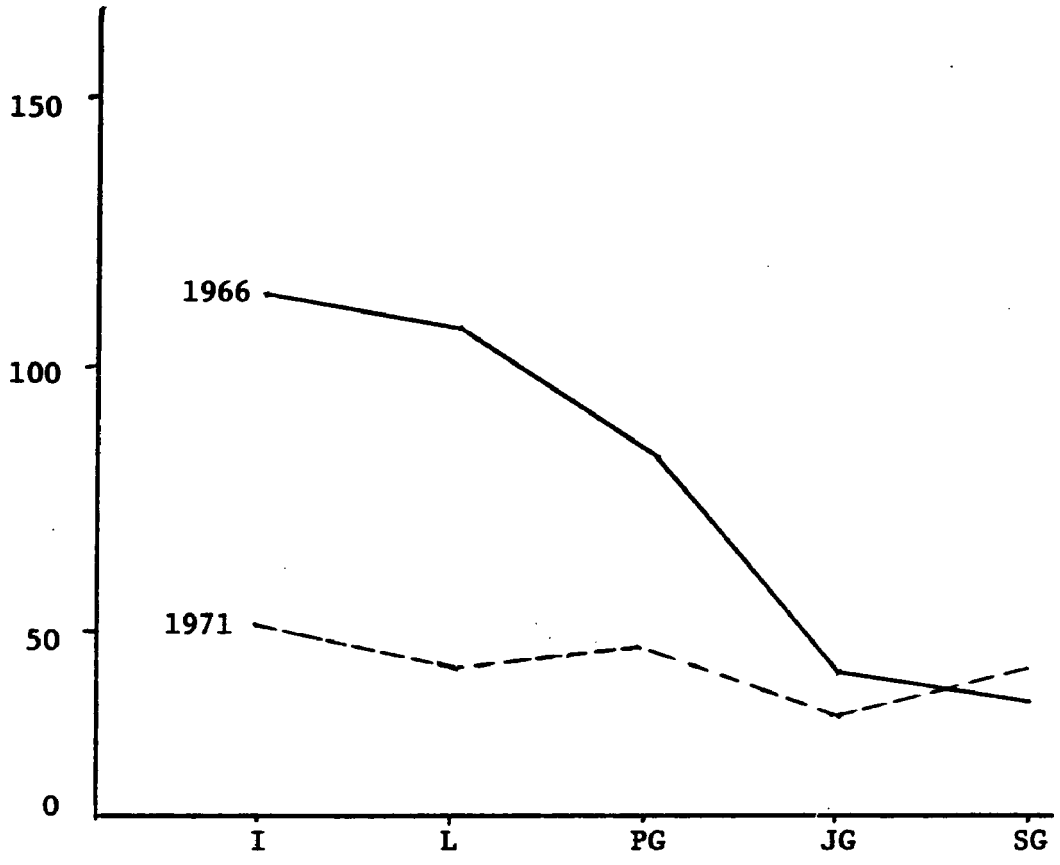


FIGURE 7-5: Marital fertility, women 35-39, by education 1966 and 1971.

family limitation for older women has proven highly popular to women from all strata of society. Marital fertility differentials may indicate a lagging on the part of poorly educated women, but by 1971 these women have caught up.

Proportions Married and Education

For the youngest two age groups the marital proportions in Table 7-1 show a monotonic negative relationship with education--increasing proportion married with decreasing education. This is true in both years.

Further, the trend is toward an even stronger association; the amounts of decrease were greatest for the high education groups. Eta-square measures the proportion of variance in percent married (treated as a dichotomous variable) explained by the 5 educational categories (treated as a nominal variable). Between 1966 and 1971 eta-square increased for the three youngest age groups, indicating a greater disparity between educational groups with respect to proportion married at the later date. Above age 30 there is only slight change in proportion married in an upward direction, reflecting the preponderance of males of these ages in the population.

These findings reflect, but do not measure directly, the trend toward an older average age at marriage. There appears to be no trend in the proportion who actually do get married.

Educational Distribution

Changes in the percentage distribution of women by educational attainment bear witness to the increasing education of the population. In 1971, women were more highly concentrated in the higher educational

TABLE 7-1. Proportion of Women Married, by Education And Age: Taiwan, 1966 and 1971

Education and Age		1966	1971	DIFFERENCE 1966-1971
15-19				
Illiterate		.170	.191	-.021
Literate		.137	.175	-.038
Primary Graduate		.083	.084	-.001
Junior High Graduate		.036	.016	.020
Senior High Graduate and Above		.040	.013	.027
Total		.087	.072	.015
Eta^2		.016	.038	
20-24				
Illiterate		.741	.738	.003
Literate		.709	.704	.005
Primary Graduate		.593	.545	.048
Junior High Graduate		.40C	.338	.062
Senior High Graduate and Above		.245	.171	.074
Total		.574	.480	.094
Eta^2		.089	.135	
25-29				
Illiterate		.926	.939	-.013
Literate		.931	.931	0
Primary Graduate		.880	.889	-.009
Junior High Graduate		.810	.811	-.001
Senior High Graduate and Above		.697	.691	.006
Total		.886	.870	.016
Eta^2		.044	.055	
30-34	T	.930	.935	-.005
35-39	T	.923	.938	-.015
40-44	T	.890	.918	-.028
45-49	T	.839	.877	-.038

classes than in 1966. This intercohort change was greatest for the youngest age groups (Table 7-2). Indexes of dissimilarity between distributions for the two years are generally smaller at the older age groups, indicating the more rapid improvement in educational attainment of women in the more recent years when younger women were educated.

Marital Fertility for All Women by Education

Before proceeding with the decomposition of change in birth rates, it is worth looking at the birth rates for all women across educational classes. Here, as illustrated in Figure 7-6, in contrast to marital fertility rates, the relationships between fertility and education are much stronger and monotonic. The reason for this is that fertility for all women depends on both proportion married and marital fertility, and proportion married is highly associated with education below age 25. Above 25, there is much less variation in proportion married across educational groups, so that fertility for all women has the same pattern as marital fertility.

For the youngest two age groups, then, any observed association of fertility rate and education is due largely to later marriage on the part of highly educated women, and probably not to differential contraceptive use.

Decomposition of Change in Crude Birth Rate, Total Fertility Rate, and Age-Specific Fertility Rates

Table 7-3 presents the decomposition of crude birth rate and total fertility rate. It can be seen that the major factor for both rates is change in marital fertility rates--accounting for around three-quarters

TABLE 7-2. Percentage Distribution of Women by Education and Age: Taiwan, 1966 and 1971

Education and Age	1966	1971	Difference 1966-1971	Index of Dissimilarity
15-19				
Illiterate	7.6	4.1	3.5	
Literate	10.9	7.6	3.3	
Primary Graduate	63.4	53.9	9.5	
Junior High Graduate	14.8	25.3	-10.5	
Senior High Graduate & Above	3.2	9.0	-5.8	
Total	99.9	99.9		16.3
20-24				
Illiterate	15.8	7.6	8.2	
Literate	13.5	11.2	2.3	
Primary Graduate	49.4	49.9	-.5	
Junior High Graduate	10.8	11.7	-.9	
Senior High Graduate & Above	10.5	19.6	-9.1	
Total	100.0	100.0		10.5
25-29				
Illiterate	27.1	16.9	10.2	
Literate	19.9	15.5	4.4	
Primary Graduate	39.7	44.2	-4.5	
Junior High Graduate	6.5	9.8	-3.3	
Senior High Graduate & Above	6.7	13.6	-6.9	
Total	99.9	100.0		14.6
30-34				
Illiterate	29.7	28.4	1.3	
Literate	18.7	22.3	-3.6	
Primary Graduate	40.8	35.3	5.5	
Junior High Graduate	6.3	6.9	-.6	
Senior High Graduate & Above	4.5	7.1	-2.6	
Total	100.0	100.0		6.8
Age 35-39				10.7
Age 40-44				8.5
Age 45-49				8.1

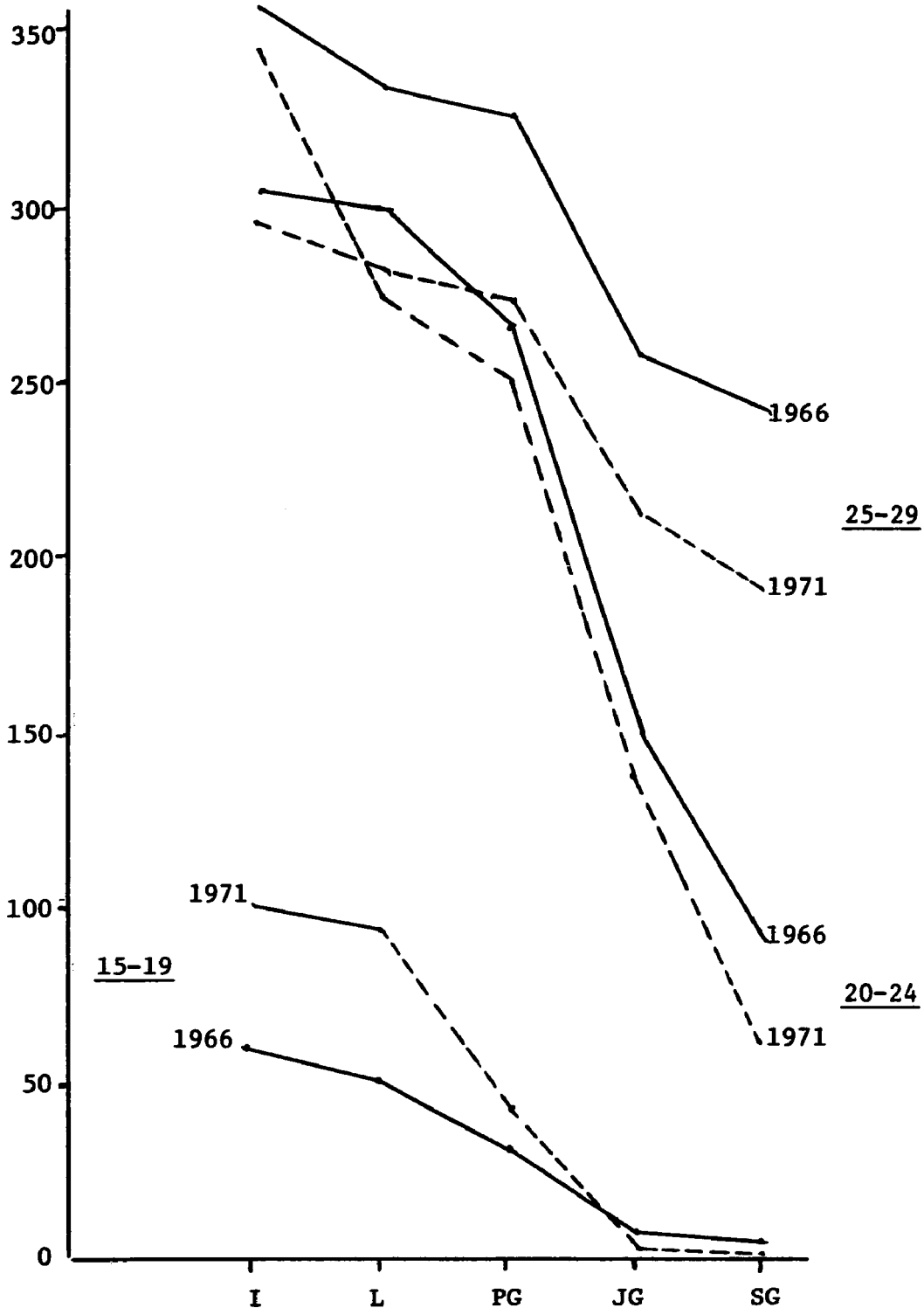


FIGURE 7-6: Taiwan: Age specific fertility, all women, 15-19, 20-24, 25-29, by education, 1966 and 1971.

TABLE 7-3. Components of 1966-1971 Change in Crude Birth Rate and Total Fertility Rate: Taiwan*

	Crude Birth Rate	Percent	Total Fertility Rate	Percent
1966	31.50		4779	
1971	24.27		3469	
Difference	7.23		1310	
Components due to:		100		100
Marital Fertility (<30 / 30+)	5.29 (1.01 / 4.28)	73 (14 / 59)	942 (170 / 772)	72 (13 / 59)
Proportion Married	.28	4	38	3
Education Distribution	1.96	27	273	21
Age Distribution	-.55	-8	-	-
Interaction	.25	3	58	5

*Negative component contributes toward increased fertility.

of the decline in both rates. A further decomoposition indicates that fully four-fifths of the marital fertility component can be attributed to women age 30 and over.

The trend toward later marriage adds only slightly toward the decline; this component absorbs the effects of decreasing proportions married below age 25 and increasing proportions above 30.

For total fertility rate and crude birth rate, the increasing educational attainment of the population has the second strongest net effect. Had marital fertility, proportions married, and the age distribution remained at 1966 levels and only the educational distribution changed, the crude birth rate would have declined 27% of the amount it actually did decline; total fertility rate would have fallen 21%.

Finally, it can be seen that the age distribution actually came to favor a higher crude birth rate in the 5 years as the "bulge" of young women born just after World War II entered the prime childbearing years.

Since, as Table 7-4 testifies, the effects of the three factors vary in both size and direction by age group, it is worthwhile to consider some age groups separately.

15-19. This is the only age group for which fertility for all women actually increased. There was an increase of about 6 births per thousand. However, had only marital fertility rates changed, the change would have been 14 points. The major reason the increase was not this great was the effect of the education distribution which by itself would have decreased fertility by 6 points.

20-24. A substantial decline was registered at this age--34.5 births per thousand women. The greatest net effect is for educational

TABLE 7-4. Components of 1966-1971 Change in Seven Age-Specific Fertility Rates for Women of Childbearing Age: Taiwan

	ASFR	Percent
Women, 15-19		
1966	32.62	
1971	38.56	
Difference	-5.93	100
Components:		
MF_e*	-14.18	-239
P_e**	-1.60	-27
R_e***	5.78	97
Interaction	4.08	69
Women, 20-24		
1966	247.5	
1971	213.0	
Difference	34.51	100
Components:		
MF_e	-9.14	-26
P_e	16.60	48
R_e	21.29	62
Interaction	5.76	17
Women, 25-29		
1966	342.9	
1971	262.4	
Difference	80.50	100
Components:		
MF_e	57.65	72
P_e	-2.58	-3
R_e	28.54	35
Interaction	-3.11	-4
Women, 30-34		
1966	202.8	
1971	120.6	
Difference	82.18	100
Components:		
MF_e	83.05	101
P_e	-1.67	-2
R_e	-3.21	-4
Interaction	4.02	5
Women, 35-39		
1966	88.03	
1971	43.80	
Difference	44.23	100
Components:		
MF_e	44.07	100
P_e	-1.47	-3
R_e	.36	1
Interaction	1.26	3
Women, 40-44		
1966	37.05	
1971	13.86	
Difference	23.19	100
Components:		
MF_e	23.52	101
P_e	-1.42	-6
R_e	1.63	7
Interaction	-.54	-2
Women, 45-49		
1966	4.88	
1971	1.61	
Difference	3.27	100
Components:		
MF_e	3.39	104
P_e	-.22	-7
R_e	.12	4
Interaction	-.02	-1

*MF_e = the set of birth rates to married women in each educational category.

**P_e = the proportion married in each educational category.

***R_e = the distribution of all women by educational category

distribution change, which accounted for two-thirds of the actual change. A substantial decrease would have occurred also if only proportions married had changed, but not as great as the educational effect. Marital fertility contributed toward an increase in fertility, but its effect was outweighed by the other factors.

25-29 and older. For all ages above age 25, change in marital fertility dominates as a cause of fertility declines. Education has an effect at age 25-29, equal to a third of the actual decline, but at older ages marital fertility change accounts for nearly all of the change.

Increased fertility at the earliest age groups is a consistent and puzzling finding in the Taiwanese data. A possible explanation is that as percent married declines, more of the married women are drawn from the low-education, high-fertility strata of society, less likely to use contraception. Decomposing marital fertility can help shed some light on this question.

Decomposing Age-Specific Marital Fertility Rates

Adjusting the equation used to compute components of change in fertility rates for all women, one can compute similar components for married women, assuming that illegitimacy is negligible. Marital fertility can be expressed as the product of two factors--proportion married (PM) and fertility to all women (F):

$$(1) \quad MF = (1/PM)(F)$$

F and PM can in turn be decomposed into education-specific factors yielding the second expression:

$$(2) \quad MF = \frac{\sum_e (MF_e)(P_e)(R_e)}{\sum_e (P_e)(R_e)}$$

Change in marital fertility, then, can be assigned to components due to change in the same three factors that were used in the earlier decompositions.

Table 7-5 presents such a decomposition of change in marital fertility using equation (2). For age groups 15-19 and 20-24 marital fertility increased between the two dates. Marital fertility would have increased in both these age groups had only the proportions married in educational groups (P_e) changed, lending support to the hypothesis that marital fertility increases are due to more low-education women among the married at the later date. However, the increase due to P_e is slight compared to the change brought about by increased fertility <u>within</u> educational categories.

The effect of changes in percent married in each education class is largely balanced by increased educational attainment in 1971. A third way of expressing marital fertility may shed some light on how this effects marital fertility:

$$(3) \quad MF = \sum_e (MR_e)(MF_e)$$

MR_e is the proportional distribution of <u>married</u> women by education. Marital fertility is a weighted sum of the education-specific marital fertility rates. The weights, MR_e, depend on both the educational distribution, R_e, and the education-specific proportions married, P_e:

$$(4) \quad MR_e = \frac{(R_e)(P_e)}{\sum_e (R_e)(P_e)}$$

TABLE 7-5. Components of 1966-1971 Change in Three Age-Specific Marital Fertility Rates: Taiwan

	ASMF	Percent
Women, 15-19		
1966	375	
1971	539	
Difference	-164	100
Components:		
MF_e	-162	99
P_e	-7	4
R_e	16	-10
Interaction	-11	7
Women, 20-24		
1966	431	
1971	444	
Difference	-13	100
Components:		
MF_e	-16	123
P_e	-1	8
R_e	1	-8
Interaction	3	-23
Women, 25-29		
1966	387	
1971	302	
Difference	85	100
Components:		
MF_e	65	76
P_e	0	0
R_e	24	28
Interaction	-4	-4

The distributions of MR_e are given in Table 7-6. The 1966-1971 change in education for married women is generally less than for all women as indicated by the dissimilarity indexes in the lower left-hand corner of Table 6-6. This is because highly educated women in 1971 are less likely to be married, but there are more highly educated women.

If married women are compared with all women, as in the lower right-hand corner of Table 7-6, it can be seen that in 1971 women who do marry are lower in education relative to all women than in 1966. In a sense, then, at the later date married women are, as a group, of lower relative status than in 1966.

Decomposing the Change in Proportion Married of All Women

Another approach to the same problem is to decompose the change in proportion married into components due to educational change, and within education group, change in proportion married using the formula for proportion married:

$$(5) \quad P = \sum_e (P_e)(R_e)$$

From Table 7-7 it is apparent that the changing educational composition of the population was the most important factor in all three of the age groups considered. Declines in marriage within educational categories were also important, but only for the age group 20-24.

It seems fair to conclude that the increasing age at marriage in Taiwan (as reflected by the proportions married) is due in large part to (1) the increasing educational attainment of women coupled with (2) the strong relationship between age at marriage and education.

TABLE 7-6. Distributions of Married Women, Ages 15-19, 20-24, 25-29 By Education, 1966 and 1971: Taiwan

Women's Education And Age	1966	1971	DIFFERENCE 1966-1971
15-19			
Illiterate	.149	.108	.041
Literate	.172	.184	-.012
Primary Graduate	.604	.629	-.025
Junior High Graduate	.061	.056	.005
Senior High Graduate and Above	.015	.016	-.001
20-24			
Illiterate	.204	.117	.087
Literate	.167	.164	-.003
Primary Graduate	.510	.567	-.057
Junior High Graduate	.075	.082	-.007
Senior High Graduate and Above	.045	.070	-.025
25-29			
Illiterate	.283	.182	.101
Literate	.209	.166	.043
Primary Graduate	.394	.452	-.058
Junior High Graduate	.059	.091	-.032
Senior High Graduate and Above	.053	.108	-.055

Women's Age	Indexes of Dissimilarity Between 1966 and 1971 For Married Women	All Women	Indexes of Dissimilarity Between All Women and Married Women For 1966	1971
15-19	4.2	16.3	13.5	26.8
20-24	8.8	10.5	9.3	16.1
25-29	14.4	14.6	2.2	3.5

TABLE 7-7. Components of 1966-1971 Change in Proportion Married for Three Age Groups of Women: Taiwan

	Women, 15-19	Percent	Women, 20-24	Percent	Women, 25-29	Percent
Proportion Married, 1966	.0871		.5747		.8849	
Proportion Married, 1971	.0716		.4800		.8694	
Difference	.0155	100	.0947	100	.0155	100
Components:						
Proportion Married	-.0025	-16	.0393	41	-.0068	-44
Education Distribution	.0123	79	.0482	51	.0210	135
Interaction	.0057	37	.0072	8	.0013	8

Urban-Rural Patterns

The tabulation of the data into two regions--five large cities and the 16 remaining hsiens--allows for some discussion of areal differentials and trends over the five year period. The data as reported in Tables 7-8 and 7-9 support a model of the cities leading a decline in fertility, with the outlying areas following at a later date. These facts are pertinent to this point:

1) At every age, group fertility is lower for the cities.

2) At every age over 20 the urban/non-urban difference in fertility is smaller in 1971 than in 1966.

3) At every age over 20 the 16 counties' fertility rates decline further than the cities' rates.

Table 7-8 presents the decomposition of 1966 and 1971 change in fertility rates separately for the cities and hsiens. The effects are generally in the same direction as the overall analysis in Table 7-4. One difference is the effect of marital fertility at age 20-24. For non-urban areas, change in MF_e's contributes toward an increase in fertility as in the island-wide case. For cities, the effect is to <u>decrease</u> fertility. The determinants of marital fertility, then, may be different within and outside of major cities at this point in time. This could be a sign that the adoption of contraception is beginning to be a factor at younger ages in urban areas.

The decomposition in Table 7-9 represents a different approach to the problem--a component of difference (rather than change) analysis. The analysis is exactly analogous to the one reported in Table 7-8 except that here the difference (D) is the urban/non-urban difference in each year (rather than the 1966-1971 change in each sector).

TABLE 7-8. Components of 1966-1971 Change in Seven Age-Specific Fertility Rates for Five Major Cities and Sixteen Hsiens: Taiwan

Five Major Cities

	ASFR 1966	ASFR 1971	Difference 1966-1971
Women, 15-19	30.65	31.69	-1.04
Components:			
Marital Fertility			-5.16
Proportion Married			-9.63
Education			8.10
Interaction			5.65
Women, 20-24	214.8	183.1	31.56
Components:			
Marital Fertility			3.56
Proportion Married			.59
Education			21.74
Interaction			5.79
Women, 25-29	263.2	217.1	
Components:			
Marital Fertility			33.09
Proportion Married			-6.37
Education			14.71
Interaction			4.64
Women, 30-34	140.6	109.2	
Components:			
Marital Fertility			41.45
Proportion Married			-11.90
Education			3.30
Interaction			-1.38
Women, 35-39	59.11	35.75	23.32
Components:			
Marital Fertility			23.65
Proportion Married			-1.63
Education			.44
Interaction			.86
Women, 40-44	20.46	9.02	
Components:			
Marital Fertility			11.67
Proportion Married			-1.09
Education			.93
Interaction			-.08
Women, 45-49	3.56	1.85	
Components:			
Marital Fertility			1.95
Proportion Married			-.27
Education			.16
Interaction			-.13

(Table Continued)

TABLE 7-8. (Continued)

Sixteen Hsiens

	1966	1971	Difference 1966-1971
Women, 15-19	33.40	40.03	-6.63
Components:			
Marital Fertility			-18.40
Proportion Married			1.12
Education			5.12
Interaction			5.53
Women, 20-24	257.5	223.5	34.01
Components:			
Marital Fertility			-15.17
Proportion Married			21.87
Education			19.54
Interaction			7.76
Women, 25-29	346.7	280.1	66.69
Components:			
Marital Fertility			63.55
Proportion Married			-1.44
Education			6.64
Interaction			-2.05
Women, 30-34	196.0	125.1	70.91
Components:			
Marital Fertility			70.84
Proportion Married			-1.07
Education			-1.84
Interaction			2.99
Women, 35-39	96.88	46.77	50.11
Components:			
Marital Fertility			49.75
Proportion Married			-1.47
Education			-.31
Interaction			2.14
Women, 40-44	42.34	15.55	26.79
Components:			
Marital Fertility			27.18
Proportion Married			-1.43
Education			1.47
Interaction			-.44
Women, 45-49	5.29	1.51	3.78
Components:			
Marital Fertility			3.88
Proportion Married			-.20
Education			-.05
Interaction			-.05

TABLE 7-9. Components of City-Hsien Difference in Seven Age-Specific Fertility Rates: Taiwan, 1966 and 1971

1966

	ASFR Cities	ASFR Hsiens	Difference City-Hsien
Women, 15-19	30.65	33.40	-2.75
Components:			
Marital Fertility			2.96
Proportion Married			-2.88
Education			-4.19
Interaction			2.09
Women, 20-24	214.8	257.5	-42.68
Components:			
Marital Fertility			-9.55
Proportion Married			-3.71
Education			-31.68
Interaction			2.26
Women, 25-29	263.2	346.7	-83.55
Components:			
Marital Fertility			-53.90
Proportion Married			-14.85
Education			-17.26
Interaction			2.46
Women, 30-34	140.6	196.0	-55.39
Components:			
Marital Fertility			-25.67
Proportion Married			-14.93
Education			-12.50
Interaction			-2.29
Women, 35-39	59.11	96.88	-37.77
Components:			
Marital Fertility			-22.60
Proportion Married			-2.52
Education			-8.55
Interaction			-4.10
Women, 40-44	20.46	42.34	-21.88
Components:			
Marital Fertility			-13.16
Proportion Married			-.92
Education			-4.62
Interaction			-3.19
Women, 45-49	3.57	5.29	-1.72
Components:			
Marital Fertility			-.92
Proportion Married			-.16
Education			-.30
Interaction			-.34

(Table Continued)

TABLE 7-9. (Continued)

1971

	ASFR Cities	ASFR Hsiens	Difference City-Hsien
Women, 15-19	31.69	40.03	-8.34
Components:			
Marital Fertility			-1.12
Proportion Married			7.05
Education			-11.40
Interaction			7.19
Women, 20-24	183.1	223.5	-40.36
Components:			
Marital Fertility			-34.09
Proportion Married			18.58
Education			-35.42
Interaction			10.56
Women, 25-29	217.1	280.1	-62.93
Components:			
Marital Fertility			-45.43
Proportion Married			-7.74
Education			-26.42
Interaction			16.66
Women, 30-34	109.2	125.1	-15.93
Components:			
Marital Fertility			-8.60
Proportion Married			-3.37
Education			-3.21
Interaction			-.76
Women, 35-39	35.79	46.77	-10.98
Components:			
Marital Fertility			-7.00
Proportion Married			-1.50
Education			1.36
Interaction			-3.84
Women, 40-44	9.02	15.55	-6.53
Components:			
Marital Fertility			-4.51
Proportion Married			-.37
Education			-.05
Interaction			-1.60
Women, 45-49	1.85	1.50	.34
Components:			
Marital Fertility			.37
Proportion Married			.01
Education			.08
Interaction			-.12

This type of analysis can help answer questions about how much of the fertility differential between cities and hsiesn is due to (1) different proportions married, (2) different distributions of women by educational status, and (3) differences in marital fertility at each educational status. In crude fashion, this speaks to the issue of whether socioeconomic development (measured by education) can account for rural-urban fertility differentials.

Table 7-9 indicates that areal differentials are less in 1971 than 1966 for every age except 15-19. However, this general finding masks considerable variation in the size and direction of components in the two years.

From Table 7-9 it can be seen that the education variable contributes substantially to differences in fertility below age 30, education having the single strongest effect at the 2 youngest age groups, in both years. Further, city-hsien differentials in educational attainment contribute to greater fertility differences in 1971 than in 1966. This is because in cities, educational attainment increased more rapidly. Differences in educational distributions presented in Table 7-10 are greater at the second date. Thus, on the basis of educational trends, one would not project the complete convergence of fertility rates.

Below age 25, marital distributions favored higher fertility in rural areas in 1966, but the opposite was true in 1971. In Table 11, it can be seen that the city-hsien differentials in P_e's reversed direction between the two years. By 1971, there were smaller proportions married within each education class, outside the five major cities, even though proportions married declined in both sectors.

TABLE 7-10. Distributions of Women for Three Age Groups by Education for Five Major Cities and Sixteen Hsiens: Taiwan, 1966 and 1971

Education and Age	1966 Five Major Cities	1966 Sixteen Hsiens	1966 Difference Cities-Hsiens	1971 Five Major Cities	1971 Sixteen Hsiens	1971 Difference Cities-Hsiens
15-19						
Illiterate	.040	.086	-.046	.023	.046	-.023
Literate	.116	.108	.008	.054	.083	-.029
Primary Graduate	.588	.646	-.058	.435	.570	-.135
Junior High Graduate	.204	.134	.070	.276	.246	.030
Senior High Graduate & Above	.053	.027	.026	.212	.055	.157
Total	1.00	1.00		1.00	1.00	
Index of Dissimilarity			10.4			18.7
20-24						
Illiterate	.097	.176	-.079	.042	.088	-.046
Literate	.112	.142	-.030	.094	.118	-.024
Primary Graduate	.449	.508	-.059	.421	.527	-.106
Junior High Graduate	.155	.094	.061	.158	.102	.056
Senior High Graduate & Above	.187	.080	.107	.284	.165	.119
Total	1.00	1.00		1.00	1.00	
Index of Dissimilarity			16.8			17.6
25-29						
Illiterate	.184	.301	-.117	.088	.204	-.116
Literate	.153	.214	-.061	.095	.181	-.086
Primary Graduate	.426	.388	.038	.441	.442	-.001
Junior High Graduate	.102	.053	.049	.157	.072	.085
Senior High Graduate & Above	.135	.044	.091	.220	.100	.120
Total	1.00	1.00		1.00	1.00	
Index of Dissimilarity			17.8			20.4

TABLE 7-11. Proportions of Women Married, Ages 15-19 and 20-24, by Education, For Five Major Cities and Sixteen Hsiens: Taiwan, 1966 and 1971

Education and Age	1966			1971		
	Five Major Cities	Sixteen Hsiens	Difference Cities-Hsiens	Five Major Cities	Sixteen Hsiens	Difference Cities-Hsiens
15-19						
Illiterate	.245	.160	.085	.242	.184	.058
Literate	.104	.147	-.043	.124	.185	.061
Primary Graduate	.078	.085	-.007	.115	.075	.040
Junior High Graduate	.036	.036	0	.030	.012	.018
Senior High Graduate & Above	.034	.043	-.009	.017	.009	.008
All Women	.077	.090	-.013	.074	.071	.003
20-24						
Illiterate	.745	.740	.005	.814	.725	.089
Literate	.675	.717	-.042	.738	.694	.044
Primary Graduate	.590	.594	-.004	.554	.542	.012
Junior High Graduate	.389	.406	-.017	.409	.299	.110
Senior High Graduate & Above	.245	.246	-.001	.228	.137	.091
All Women	.519	.590	-.071	.467	.484	-.017

Why the stronger reduction of marital proportions in rural areas? One possibility is that postponement of marriage is a "response" that is not resorted to quite as often in cities where contraception is employed by some proportion of the young married population.

Finally, in Table 7-9, below age 25 within education class, marital fertility contributes toward larger differentials in 1971 than in 1966. Figures 7-7 and 7-8 illustrate the relation of fertility and education for two age groups. The greater difference in city-hsien marital fertility for women age 20-24 in 1971 appears to be due to increased fertility in rural areas, particularly at the higher educational strata. Decreases at the highest strata in cities also contributed.

At age 30-34 and above, the pattern is one of convergence--both between the two segments and among educational classes similar to the island-wide pattern in Figure 7-4

Summary of Main Findings

1) The pattern of association and change in marital fertility rates strongly suggests that contraception is a factor only at older ages, above 25. Increases in marital fertility below 25 are somewhat mystifying and may be due to shifts in marital durations and increases in pre-marital pregnancy.

2) The convergence of fertility differentials by education above age 30 invites the conclusion that contraception has completed a process of "diffusion" from high to low education strata. Since the family planning program reached a large number of women during this period, some of the convergence may be due to its efforts.

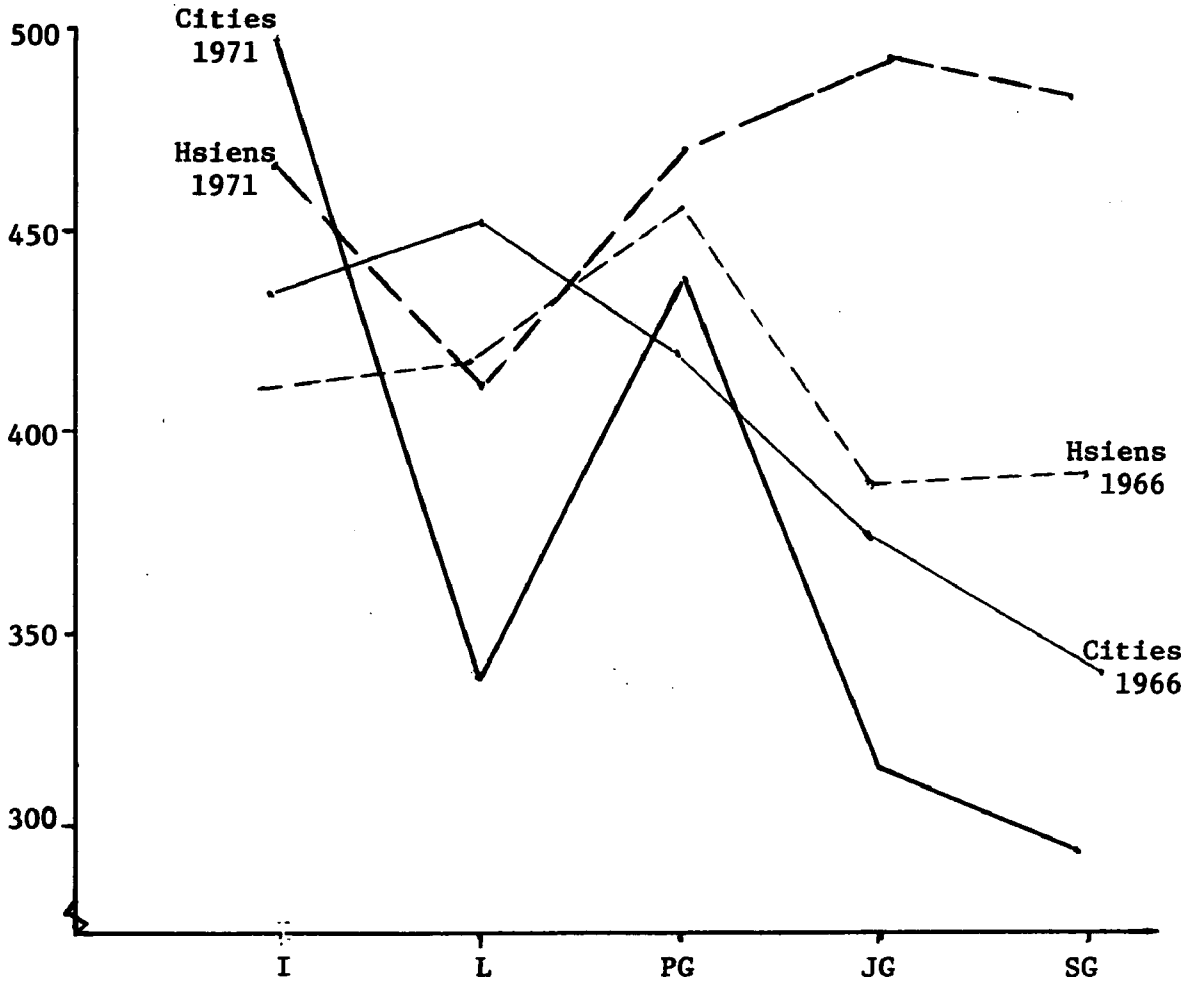


FIGURE 7-7: Marital fertility, women 20-24, by education, 1966 and 1971, for two subregions: Taiwan.

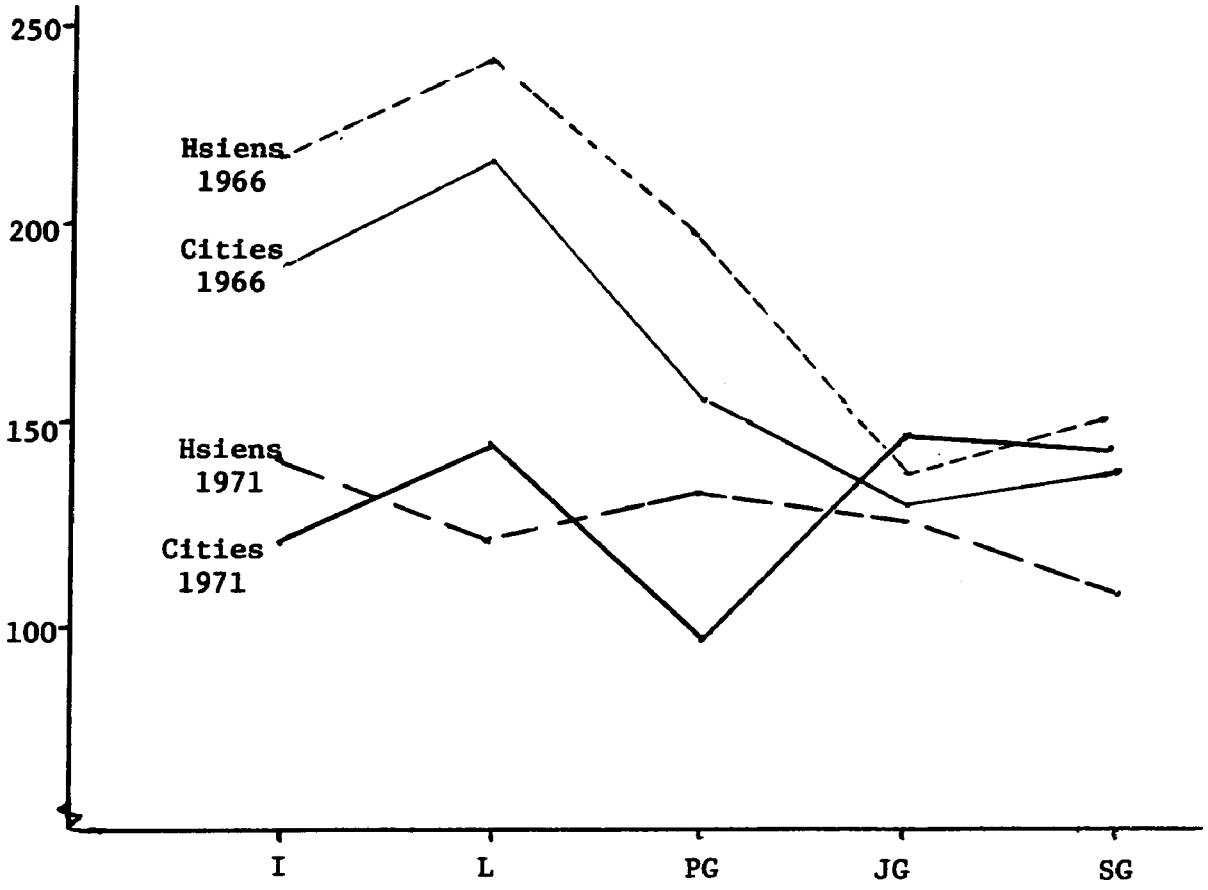


FIGURE 7-8: Marital fertility, women 30-34, by education, 1966 and 1971, for two subregions: Taiwan.

3) The components analysis proves that a factor such as educational composition can have considerable effect on fertility in a country where educational attainment is increasing rapidly between cohorts, and where education is associated with marriage and fertility. For Taiwan, the education component was important for each age under 30. Not surprisingly, declines in marital fertility were the most important factor for fertility rates above 30, and for crude birth rate and total fertility rate. At younger ages there are more development effects. How modern women are in an area (in terms of education) can effect the fertility rate in that area, particularly through nuptiality differences. Above age 30 where there is very little educational variation in marriage rates, and control of fertility within marriage is the primary factor in change, a diffusion model fits the pattern of decline observed. Thus, the process of change in fertility rates can be seen to vary by age group.

4) Results of the decomposition of change in marital fertility indicate that change in proportions married by education had only a slight effect toward increasing marital fertility in the two youngest age groups. It could be that other dimensions of population composition besides education are important. Perhaps those who postpone marriage are also the ones most likely to adopt contraception so that the remainder of the women, who do marry, have higher fertility.

5) Across the two regions there was a decline in fertility differentials at every age. However, the education component contributed to larger differentials in 1971, indicating that the cities and outlying areas were diverging with respect to this indicator of modernization. This may be due in part to migration of educated women to cities. For

the two youngest age groups, cities had larger proportions married in 1971 than rural areas. This may suggest the end of the period of increasing age at marriage, once some degree of control has been gained over fertility within marriage. The areal differences in 1966 and 1971 analyzed here correspond to the annual differences observed for the years 1952-70 interpreted to suggest a spread of low fertility outward from major cities. While there may indeed be areas that lead and others that follow in the fertility decline, this analysis points out that the lagging sector does not have to duplicate exactly the experience of the leading sector, but may exhibit a unique combination of the factors underlying fertility, even while fertility levels themselves converge.

6) Finally, the analysis in this chapter represents one of the simplest possible decompositions of a country's fertility--only one dimension of modernization and only 2 areal subregions. The analysis serves, if nothing else, to underscore the complexity of the forces involved in the transition from high to low fertility, even when viewed in terms of a limited number of factors.

CHAPTER 8

SUMMARY AND CONCLUSIONS

Although this study employs data measured on several levels of analysis, a certain consistent picture emerges of the process of fertility change in Taiwan between 1952 and 1970. It is a picture of fertility change sweeping like a "wave of innovation" across the country beginning in the mid to late 1950's with urban areas entering the decline first and rural areas following a few years later on the average. Areas that began declining later were able to move toward controlled fertility more rapidly. Among individual women in the mid 1960's more modern women were more likely to be experienced contraceptors, but the trend above age 30 was toward a convergence of social and urban-rural differentials in contraceptive experience. It is probably not surprising, then, that there should be a marked convergence of marital fertility (over age 30) across educational strata and level of urbanization. The picture is one of a "trickle down" pattern of spread of fertility consistent with the interpretation that the knowledge of contraceptive techniques, the general set of attitudes required for efficient use, and the supply of contraceptive material are important factors bearing on the pattern of decline. In short, the data on the balance suggest that the diffusion model, rather than the development model, best describe Taiwan's fertility decline. A more detailed look at the findings of the various substantive chapters can help confirm this.

Chapter 3: The Longer Demographic Record of Taiwan

(1) While there was some fluctuation in fertility levels prior to the 1950's, the downturn beginning in the last half of that decade appears to mark a genuine departure from previous levels.

(2) Areal differences in fertility existed prior to the onset of decline; fertility was, on the average, lower in the major cities than the other area, but there was wide variation within both categories. The pattern and magnitude of areal differences in the early 1950's is very similar to the pattern evident in the 1930's. These differences apparently are long standing and do not reflect the initiation of change on the part of some sectors.

Chapter 4: Rural-Urban and Regional Differences in Fertility Trends, 1952-1970

(1) In a series of yearly cross-sections of 22 areal units the urban-rural dichotomy (UR) explains an increasing and then decreasing proportion of variance, suggesting a diverging and converging of fertility levels as urban areas lead the decline and rural areas catch-up. Urban-rural differences are important through most of the series, but regional differences become unimportant fairly soon after rates begin falling.

(2) The parameters of fertility trends exhibit a distinct pattern when estimated by the logistic function for age groups 30-34 and 35-39. There are pre-decline differences related to both region and UR. However, only UR is related to the date of initiation of decline, urban areas entering the decline phase 3 or 4 years earlier than rural areas on the average, depending on the criteria used. The rate of decline is faster in the outlying areas. The pattern that emerges is one in which timing is important in a way consistent with the diffusion hypothesis; the timing

of the areas' fertility trends also has considerable bearing on cross-sectional variation in fertility at a given point in the series.

Chapter 5: Multivariate Analysis of Fertility Trend Parameters

(1) Differences in pre-decline fertility levels of fertility between urban and non-urban places can be accounted for by educational differences in an analysis of covariance model. This may indicate that the long term differences noted in Chapter 3 are the result of long term difference in development as measured by education levels. It suggests that there was greater use of the means of contraception in highly educated urban areas prior to decline whether this was due to differential access to and knowledge of the means of family limitation, or to normative differences. It is argued that long term differences probably reflect norms, or other fairly stable differences in the family building process, since differences in the spread of knowledge would be manifested in the parameters of fertility change.

(2) Remoteness of areas, measured by the distance to the nearest urban center of 25,000 or greater is the variable best able to account for the initiation of decline, a finding consonant with the diffusion model. Measures of mortality are of next greatest importance suggesting the interrelation of the vital processes in the period of demographic transition. Educational levels are not able to account for the urban-rural differences in the initiation date in the covariance analysis.

(3) Areas with late dates of initiation of decline and low levels of education tended to decline fastest. Apparently, these areas were able to move at a faster pace toward controlled fertility because they had a relatively small proportion using contraception at the beginning of the

decline, and by the time they entered the decline contraception was more generally available.

Chapter 6: Changes in Family Size Norms and Contraceptive Experience, 1965-1970

(1) It is evident from this review of individual level data that normative differences exist across areas with smaller numbers of children desired in more urban settings. There is considerably more variation across non-areal categories, particularly education. At this period norms are declining but not rapidly.

(2) In 1965 80% of all married women age 30-39 wanted no more children, but, only 38% had ever used some means of contraception; by 1970, 72% had contraceptive experience. Thus, even well after change was underway in fertility there was rapid change in the contraceptive behavior of women.

(3) The pattern of change in contraceptive experience 1965-1970 is very much like the pattern of change in fertility over the longer period: the use of contraception spread from urban to rural residents, from modern to least modern women. Among married women over age 30 there is a convergence of differences in contraceptive use as the least modern, more rural women catch up to the leading sector.

(4) Half or more of the difference in contraceptive experience between major cities and rural townships can be accounted for by only a few selected variables in a multiple classification analysis. Measures of individual linkage to communication networks (e.g., newspaper readership) do as well as or better than education in accounting for areal differences, suggesting a process of innovation diffusion may be working on an individual level.

Chapter 7: Effects of Education, Nuptiality and Marital Fertility on Fertility Change and Rural-Urban Differences, 1966-1971

(1) Increases in educational attainment between cohorts apparently has a fairly important effect on fertility changes below age 30 during the period studied.

(2) There is a convergence of differentials in marital fertility rates across educational groups above age 30; in both urban and rural areas in 1966 women in lower educational categories had higher marital fertility. In 1971 there was much less variation by education.

(3) At every age group above 20 there was a smaller difference in age specific fertility rate between urban and rural areas in 1971 than in 1966. Examining the components of these differences indicates that this general finding masks considerable movement in different directions in the components, particularly below age 30. Different areal sectors may be taking different pathways toward controlled fertility.

Conclusions

In the data reviewed in this study timing differences in the spread of controlled fertility, and in the spread of contraceptive experience as well, are very distinct, consistent with the hypothesis that controlled fertility was an innovation. Further, it is difficult to appeal to the alternative development model since in the 1960's change was most rapid in the least developed areas and strata.

Insofar as the process of fertility decline has been one of innovation, the argument for family planning program effect, net of social change, gains some support. Program variables are not introduced here and this interpretation must remain tentative. It is possible to have had a very effective program during a fertility decline set off by

development factors, and likewise, given a diffusion process of change, women could substitute program contraceptives for those obtained elsewhere. It has been argued here that it is most likely for the program to be effective where lowered fertility appears to be an innovation that took time to permeate all areas of a country, where the program can work to overcome the resistance to contraceptive adoption caused be remoteness and the lack of necessary knowledge, attitudes and materials.

Finally, an important lesson of this analysis is that neither of the contrasted models is adequate to fully describe the process of fertility decline in Taiwan. The process is much too complex. At different age groups and in different areal sectors fertility change results from change in different factors underlying fertility. At older ages an innovation pattern may describe the fertility declines fairly well. For younger women there may be development effects working through nuptiality in a pattern that is more difficult to sort out. The analysis presented here may not answer all the questions concerning the decline of fertility in Taiwan, but at least it has shown that the analysis of areal variation in fertility trends can be a profitable approach to studying fertility in transition.

APPENDICES

APPENDIX I

Data Sources

Chapter 4

A. Age specific fertility rates for hsiens and major cities

1952-1960	Demographic Reference, Taiwan, Vol. II, Taiwan Population Studies Center, 1965.
1961-1970	Taiwan Demographic Fact Books, 1961-1970, Ministry of the Interior, Republic of China.

Chapter 5 (See Table 5-1 for full definitions of variables)

A. AF_{53}, ED_{53}	Household Registration Statistics of Taiwan, 1946-1958, Department of Civil Affairs, Taiwan Provincial Government, 1959 (Chinese).
B. AF_{60}, ED_{60}, PM	Household Registration Statistics of Taiwan, 1958-1961, Department of Civil Affairs, Taiwan Provincial Government, 1962.
C. CDR_{52}, CDR_{60}	Annual Reports, Taiwan Provincial Health Commission, 1951-1960; Taiwan Demographic Fact Books, 1961-1970.
D. CM_{52}, CM_{60}	Unpublished data at University of Michigan, Population Studies Center, supplied by the Division of Population Statistics and Census, Ministry of the Interior, Taiwan.
E. DEN, DTT, DTC	Unpublished data at The University of Michigan, Population Studies Center.
F. FU, HAK, ML, ABO	Distribution of Family Names in Taiwan, Chen Sha-hsing and Morton H. Fried, Chinese Materials and Research Aids Service Center, Taipei: 1968.
G. MIG	Speare, Aldin, Jr. The Determinants of Rural To Urban Migration in Taiwan, Unpublished Ph.D. Dissertation in Sociology, The University of Michigan, 1969, p. 27.

Chapter 6	Unpublished data at University of Michigan Population Studies Center from three island-wide surveys taken in Taiwan in 1965, 1967 and 1970 under the auspices of the Taiwan Population Studies Center in the first two years and the Taiwan Provincial Committee on Family Planning in 1970.
Chapter 7	1966 data published in the Taiwan Demographic Factbook, 1966 and were recombined at the Division of Population Statistics and Census Ministry of the Interior. 1971 data were collected from the records local areas, in a study also carried out by the Division of Population Statistics and Census. The data were made available at The University of Michigan Population Studies Center.

APPENDIX II

Use of the Logistic Function

The function used is a standard logistics function subtracted from a constant. Such a function having four parameters ($P_{(1)}$, $P_{(2)}$, $P_{(3)}$ and $P_{(4)}$) was fit to each area's trend in fertility rate using least squares criteria, yielding a non-linear regression equation (Griliches, 1957).

A. $$\hat{F}_t = P_{(1)} - \frac{P_{(2)}}{1 + e^{-(P_{(3)}+P_{(4)}t)}}$$

F_t: fertility rate at year 't'

t: year

$P_{(1)}$, $P_{(2)}$, $P_{(3)}$, and $P_{(4)}$: parameters determined by each area's fertility trend

$P_{(1)}$: pre-decline level of fertility rate

$P_{(2)}$: total amount of decline in fertility rate

$P_{(1)}-P_{(2)}$: final level of fertility rate.

B. To get initiation date, each area's equation must be solved for the year 't' when fertility has fallen some minimum amount.

Given M: minimum amount

Find t where $P_{(1)} - \hat{F}_t = M$

$$M = \frac{P_{(2)}}{1 + e^{-(P_{(3)}+P_{(4)}t)}}$$

$$t = -\frac{P_{(3)}+\ln(\frac{P_{(2)}}{M} - 1)}{P_{(4)}}$$

C. To get the point of inflection

Let $f_t = F_t - P_{(1)}$

f_t: amount of decline below pre-decline level of fertility rate.

Logistic function is symmetric, so

$f_t = \frac{P_{(2)}}{2}$ at inflection point.

Find t where

$$\frac{P_{(2)}}{2} = \frac{P_{(2)}}{1 + e^{-(P_{(3)}+P_{(4)}t)}}$$

$$1 + e^{-(P_{(3)}+P_{(4)}t)} = 2$$

$$P_{(3)} + P_{(4)}t = 0$$

$$t = -\frac{P_{(3)}}{P_{(4)}}$$

D. Find rate of change at inflection point.

$$f_t' = P_{(4)} f_t - \frac{P_{(4)}}{P_{(2)}} f_t^2 \text{ , rate of change in } f_t$$

$$f_t = \frac{P_{(2)}}{2} \text{ at point of inflection so}$$

$$f_t' = P_{(4)} \left(\frac{P_{(2)}}{2}\right) - \left(\frac{P_{(4)}}{P_{(2)}}\right) \left(\frac{P_{(2)}}{2}\right)^2$$

$$f_t' = \frac{P_{(4)} P_{(2)}}{4}$$

APPENDIX III

Components of Difference Methodology for Chapter 7

Definitions of terms:

F_a : Age specific fertility, all women, age a.

$$= \frac{\text{births to women age a}}{\text{number of women age a}}$$

MF_a: Age specific fertility, married women, age a.

$$= \frac{\text{births to married women age a}}{\text{number of married women age a}}$$

P_a : Proportion of married women age a

$$= \frac{\text{number of married women age a}}{\text{number of women age a}}$$

R_{ea}: Proportion of women age a in "e^{th}" educational class.

$$= \frac{\text{number of women in "e}^{th}\text{" class age a}}{\text{number of women age a}}$$

$$\sum_e R_{ea} = 1.0$$

(1) $$F_a = \sum_e (MF_{ea})(P_{ea})(R_{ea})$$

$$F_a = \frac{b_a}{W_a} = \sum_e \left(\frac{b_{ea}}{mw_{ea}}\right)\left(\frac{mw_{ea}}{W_{ea}}\right)\left(\frac{W_{ea}}{\sum_e W_{ea}}\right) = \frac{\sum_e b_{ea}}{\sum_e W_{ea}}$$

(2) $$MF_a = \left(\frac{1}{PM_a}\right)F_a = \left(\frac{\sum_e b_{ea}}{\sum_e W_{ea}}\right)\left(\frac{\sum_e W_{ea}}{\sum_e mw_{ea}}\right)$$

(3) $$TFR = 5\sum_a F_a$$

(4) $$CBR = \sum_a (F_a)(D_a), \text{ where } D_a = \frac{\text{number of women age a}}{\text{total population}}$$

Method: Components for F. were derived using equation (1) and the values of F_e, P_e, and R_e for 1966 and 1971, which are subscripted as 1 and 2 respectively in the formulas below:

D = the difference in age specific fertility rates between 1966 and 1971, and therefore,

$$D = F_1 - F_2$$

The components of this difference are as follows:

C_1 = Component of difference in age specific fertility rate (F.) 1966-1971 due to change in the marital fertility rate (MF.) for each education group (F_e).

$$C_1 = F_1 - \sum_e (MF_{e2})\ (P_{e1})\ (R_{e1})$$

C_2 = Component of difference in F. 1966-1971 due to the change in proportion married (P.) for each education group (P_e).

$$C_2 = F_1 - \sum_e (MF_{e1})\ (P_{e2})\ (R_{e1})$$

C_3 = Component of difference in F. 1966-1971 due to the change in the distribution of women for each education group (R_e).

$$C_3 = F_1 - \sum_e (MF_{e1})\ (P_{e1})\ (R_{e2})$$

and

$$I = \text{Interaction term} = D - (C_1 + C_2 + C_3)$$

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