AN ECONOMETRIC ANALYSIS OF THE NUMBER AND TIMING OF BIRTHS: THE CASE OF VIETNAM

By

HUAN NGUYEN-DINH

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree

Doctor of Philosophy

McMaster University

AN ECONOMETRIC ANALYSIS OF THE NUMBER AND TIMING OF BIRTHS

DOCTOR OF PHILOSOPHY (1996) McMASTER UNIVERSITY

(Economics) Hamilton, Ontario

TITLE: An Econometric Analysis of the Number and Timing of Births: The Case of Vietnam

AUTHOR: Huan Nguyen-Dinh, B.Sc. (Hanoi National Economics University)
M.Sc. (University of London)

SUPERVISORY COMMITTEE: Professors B.G. Spencer (Chairman)
F.T. Denton
M.D. Dooley

NUMBER OF PAGES: xii, 284

ABSTRACT

This thesis represents an intensive econometric study of two important aspects of reproductive behavior -- namely the level of fertility and the intervals between births. The analysis is economics-based, but the standard microeconomic framework is extended to take into account the effects of social factors on reproduction. The estimation is based on data from the *1988 Vietnam Demographic and Health Survey.*

The initial analysis of the determinants of fertility (defined as the number of children ever born per woman) is conducted within a static framework, and three alternative statistical models (OLS, Poisson, and ordered-logit) are estimated and the results compared. Fertility decision-making is then modelled as a dynamic sequential-response process, with particular attention to the effects of sex preference and child mortality on subsequent fertility. The analysis of birth intervals is based on the estimation of both non-parametric life table methods and the (semi-parametric) proportional hazard model.

Among the main results of the study is the finding that individual and social characteristics generally have little effect on reproductive behavior in the first ten years or so of reproductive life, apparently reflecting the strong desire of typical couples to have at least two children. Such characteristics of the wife as education, knowledge of contraceptives, the industrial sector in which she works, and whether

she lives in an urban or rural area are found to have statistically significant effects on both the level and timing of completed reproductive behavior, although the magnitudes of the effects are generally moderate. Certain characteristics of the husband (notably, his educational attainment and the industrial sector in which he works) also affect the level and timing of births. However, no evidence is found to support an opportunity-cost effect of either the wife's or the husband's education on fertility. That finding is readily interpreted in the Vietnamese context and may explain why the estimated effects of education are considerably smaller in Vietnam than in other, more market-oriented countries. Finally, in Vietnam the preference for sons is strong and largely independent of socioeconomic variables; furthermore, the evidence indicates that parents, whatever their levels of education or other characteristics, wish to have *one* living son, not necessarily more.

ACKNOWLEDGMENT

I would like to express special thanks to my supervisor, Professor Byron G. Spencer, for his valuable advice, continuing encouragement and support, and various other kind help. I am grateful also to Professors Frank T. Denton and Martin D. Dooley, the two Supervisory Committee members, and Charles Hirschman, University of Washington, for their many valuable comments which have greatly inspired and encouraged me. Professor Hirschman served as advisor to the thesis committee, as proposed by the Population Council, which awarded me a fellowship. I wish to thank him for the warm welcome that he provided on my three visits to the University of Washington; his kind help and support are much appreciated. My Supervisory Committee and Professor Hirschman made my research not only fruitful but also pleasant.

I am grateful to all my earlier instructors, but wish to mention specially Professors Robert E. Wright and John F. Ermisch, who inspired my research interest in Population Economics and encouraged me to undertake further studies.

It would have been impossible for me to complete my work without the financial support provided by the McMaster Graduate Scholarship and the 1994-95 Population Council Fellowship in the Social Sciences and Demography. I wish to

express my respect and gratitude for that support.

Finally, I am grateful to my parents, my wife, and my two sons for their ongoing support and also for the sacrifices that they have made.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

Chapter 1 INTRODUCTION

The problem of global population growth has been on the world's agenda for many years. Although international organizations and governments of many countries have made considerable efforts to reduce population growth, the global population has increased at an average annual rate of 1.7% in the last two decades. According to the medium version of the three-level projection by United Nations experts, the world's population will be 8.3 billions by 2025. This moderate projected figure assumes the global population will continue to increase at an average annual rate of 1.3% in the next three decades, after taking into account the influence of the many family planning programs that are already in place. Although the volatile nature of fertility trends and lessons learned from early population projections might make experienced demographic observers cautious, everyone believes that the world's population will continue to increase quite rapidly in a foreseeable future.

In shaping population policy, two questions are central: (i) In what circumstances would a lower or higher rate of reproduction be desirable? and (ii) How can the rate of population change be altered? Unfortunately, the answers are not clear.

Regarding the first question, the arguments and the answers diverge strikingly. Standing at one extreme are the Neo-Malthusians with a pessimistic view about population growth. They argue that "if the present growth trends in world population, industrialization, pollution, food production, and resources depletion continue unchanged, the limits to growth on this planet will be reached within the next hundred years." (Meadow et al. 1972, p. 23) Others are more optimistic. They point to various potential adjustments or remedies to demographic pressure and also to certain positive effects of population growth on development (Simon 1976, 1977, 1993; Srinivasan 1989). Many people challenge the Neo-Malthusian view by emphasizing role of technological progress in solving problems of limited natural resources (Cole at el. 1973, Robert 1974). There is even an argument made that "population growth may be good for LDCs in the long run" (Simon 1976, 1993). Furthermore, the below replacement fertility in many industrial countries (David et al. 1987) and the recent rapid decline of fertility in some developing countries (Hirschman and Philip 1990, Leete and Alam 1993) also make pessimistic views about population growth more doubtful.

Dominating these extreme views is a more moderate approach. Although there are still disagreements about specific consequences of rapid population growth in developing countries (Kelley 1988a, 1988b; McNicoll 1984) and about the effects of the below replacement fertility in many developed countries (David et al. 1987), most analysts agree that current population growth in many developing countries is too high. That belief provides the basis for the implementation of vast family planning programs.

However, lower population growth is not desired by all nations. As said above, in many developed countries fertility has dropped below the replacement level. A few nations, like France and the former East Germany, have already taken steps to increase birth rates. In either case, the second question must be answered: What can be done to influence population growth?

Knowledge of the determinants of fertility is obviously important in designing population policies. Because fertility is thought to be influenced by many and diverse factors, a complete assessment of the determinants of fertility is difficult. Berelson (1975) provided a lucid and entertaining review of the controversies concerning the determinants of fertility and population policy at the time of the World Population Conference in Bucharest in 1974. Little progress has been made since, and those controversies have remained largely unresolved (Bongaarts 1993). While different theoretical models have been offered, none has gained sufficient empirical evidence to dominate others. In this situation, a better understanding of fertility determination is important. It is this reality that has motivated the present research.

Let us now turn to the objectives and methodology of the present study. This thesis is an empirical study of individual fertility behaviour in Vietnam. More specifically, it studies the effects of socioeconomic factors on the realized fertility of individual women (the number of children ever born) and on the timing of births. The first objective is to provide practical knowledge of fertility behaviour in Vietnam. Such knowledge would be helpful for framing population policies as well as policies for social and economic development. The second objective is to test certain fertility or fertility-related theories.

Knowledge of fertility behaviour, the first objective, is important. In common with most developing countries, population growth in Vietnam is a serious problem. The government has made an effort to reduce population growth since 1963 (Vu Quy Nhan 1993) but has done so without the benefit of comprehensive studies of fertility behaviour within the country. While some findings relating to other countries may be relevant for Vietnam, many distinctive features of its economy, customs, and traditions should be taken in to account. On these grounds alone, the present study should provide a useful contribution to the fertility literature. What hypotheses can be tested depends critically on data availability; a detailed discussion of that issue is reserved for later.

Vietnam was until recently a command economy. Hence, one may question whether Western economic theories of fertility should be tested at all. However, Zhang (1990) argues that the economic environment does not mean that the theories should be abandoned. Instead, it means that individuals face different constraints, and that they should be taken into account. As we shall see, the Vietnamese context in fact provides advantages for testing certain relationships.

A detailed statement of the methodology that is adopted is provided later. However, some general notes on the overall approach of the thesis at the onset may be helpful. In his criticism of Becker's (1960) economic theory of fertility, Duesenberry said

> "I used to tell my students that the difference between economics and sociology is very simple. Economics is

> all about how people make choices. Sociology is all about why they don't have any choices to make." (Duesenberry 1960, p. 233)

While it is difficult for a researcher not to confine himself/herself to one discipline, Duesenberry emphasizes the problems that result when too narrow a focus is taken. He stresses the importance of paying attention to the numerous constraints, including the social and moral constraints, on fertility faced by individuals (the economist's optimization problem) . We agree. Hence, while our methodology derives from economics, we pay attention to the many social factors that might affect fertility significantly. Qualitative factors are often difficult to take into account using regression and related techniques, but can be exploited to inform and guide the modelling and interpretation of quantitative results.

Micro studies can help to explain fertility trends (or macro relationships) by linking individual fertility to dynamic movements associated with economic development processes. For example, by viewing children as consumption goods and thereby identifying mothers' potential earnings from employment as the (shadow) price of children, economists tested and confirmed the hypotheses that the relative increases in wages and employment opportunities of women are important causes of fertility decline (Becker 1960, Butz and Ward 1979, Schultz 1990, Heckman and Walker 1991, Olsen 1994). But in some particular circumstances perhaps a reverse check would be helpful -- that is, to use macro trends as a crude test of micro theories of fertility. Consider the following. According to Becker's economic theory of fertility, the substitution of quality for quantity of children and the relative increase in the price of children are responsible for the decline in fertility (Becker 1960, Becker and Lewis 1973). Now if there exist countries where quality and price of children have remained constant but fertility has declined significantly, as we argue below was the case for Vietnam, then for those countries other determinants of fertility must have dominated for these.

The major concern of the thesis, though, is with individual fertility behaviour. The main data source is the *1988 Vietnam Demographic and Health Survey*. Very briefly, this was the first nationwide survey to collect information on individual fertility histories and family planning practices. The sample included 4712 women in the child bearing ages, defined as 15-49, selected randomly from 12 provinces across the country. It is considered to be the best currently available source of survey data relating to fertility in Vietnam.

The rest of the thesis is organized as follows. In Chapter 2 we discuss some key social and economic features of Vietnam. One would expect both the social environment (as represented by religious and political institutions and practices, kinship arrangements, etc.) and economic structure to affect significantly individuals' attitudes toward childbearing. Hence, knowledge of the social and economic context is indispensable in modelling and interpreting statistical relationships. To build defensible empirical models we need to draw also on theory. Fertility theories are discussed in Chapter 3. However, given the empirical interest of the thesis and the availability of extensive reviews of the current literature (Easterlin 1978, Handwerker 1986, Olsen 1994, Simmons 1985, and many others), our discussion will be selective and concentrated. Specifically, we will focus on the implications of the theoretical literature for modelling and interpreting the relationships. A number of empirical studies are also reviewed for guidance as to model specification, and to provide a basis for subsequent comparisons with our findings. In Chapter 4 data are discussed.

The approach to modelling is discussed in Chapter 5. A number of econometric models are potentially suitable for the estimation of fertility relationships. Our strategy is to estimate several alternative models and to evaluate them based on their empirical performance. For the determination of fertility we consider the conventional ordinary least squares model, the Poisson model, and the ordered logit model. (The ordered probit model is also tried and the results, as expected, are very close to those obtained from the ordered probit model). Two-stage least squares and sequential-response models are applied to study the replacement effect (of child mortality on fertility) and sex preferences. For modelling the timing of births we employ a duration model. Empirical estimates of these models are presented next in several chapters. In Chapter 6, general findings on the determinants of fertility from the OLS, Poisson, and ordered logit models are presented. Results relating to two special issues, the effects of child mortality on fertility and on sex preferences, are considered in Chapter 7. The findings on timing of births are dealt with in Chapter 8. Results are reconciled and summarized in Chapter 9.

Chapter 2 VIETNAM: SOCIAL, ECONOMIC AND DEMOGRAPHIC FEATURES

Vietnam is a country with a long history and a rich culture. Archaeologists have suggested that human beings have lived there for some hundreds of thousands of years, and the evidence of the Dong-Son culture (named after the village where relics were found) confirms that the nation's culture goes back no less than four thousand years (see UNESCO 1989). The low level of development and, until recently, relatively limited relations with the West have kept most traditions and customs intact or little changed. As a result, the traditional culture still has a profound influence on peoples's reproductive behaviour. To model and interpret fertility behaviour in Vietnam it is important also to understand its economic structure. Until the late 1980's Vietnam was a command economy. The ways in which a command economy influence fertility might differ from those in market economies. In this chapter, we discuss the social and economic background of Vietnam, after a very brief introduction to its geographic features. The last section describes fertility trends, the current overall demographic circumstances, and family planning practices.

2.1 A Summary of Geographic Features

Vietnam is located in southeast Asia. It has an area of 331,041 square kilometres (129,313 square miles) and a 1994 population of more than 72 million. On the world map its shape looks like a capital S, facing the China Sea in the east and south, China in the north, and Lao and Cambodia in the west. Mountain, high arid plateaus and forest account for nearly 80% of the country's territory. Stretching between latitudes of 24 and 9 degrees North, and influenced by sea and mountain, the climate and ecology vary greatly across the country. The weather is typically tropical in the south and sub-tropical in the north. However, the weather in the north is much more irregular: hot and humid in the summer (average 28°-29° C) and cold and dry in the winter (13°-14° C). The north also experiences floods and occasional damaging storms. The average rainfall in the country is 2000 millimetres per year.

Land in agricultural use occupies 21% of the total territory and another 5% is potentially arable. Nearly 80% of the country's population lives in the rural areas and 71% of the labour force relies on farming to earn a living. The population crowds into two fertile deltas: the Red River delta in the north and the Mekong River delta in the south. These two far-separated deltas account for less than 16% of the territory and 47% of agricultural land, but house 41% of the country's inhabitants and produce 68% of its traditionally most important product: rice.

What we can infer from the above in relation to demographic issues lies in the high population density and, especially, in the severe restriction of resources available for workers in the agricultural sector. With 69,500 km^2 of agricultural land and more than 71% of the labour force in agriculture, the average worker has only 3,100 square metres of land on which to work. With a population density of 217 people per square kilometre, Vietnam is a very crowded country. (Its population density is nearly double that of China, which has 127 persons per square kilometre.) Moreover, due to its uneven distribution, population density is extremely high in some areas. In some northern provinces, though production is agricultural, the population density is more than one thousand persons per square kilometre. While industrialization is the only long-run solution, controlling population is clearly critical in both short- and long-run terms.

2.2 Social and Economic Background

To understand the socioeconomic background of Vietnam a brief look at its history is necessary. For thousands of years this nation was dominated by, and struggled against, outside forces. The fact that it has been able to keep its own identity gives its people a mixed feeling of both pride and pain. Before being occupied by the French for a century since 1858, Vietnam was ruled by the Chinese for more than one thousand years, until 981 A.D. (see UNESCO 1989). After that Vietnam became a vassal state of the Chinese Empire. This subordination meant that Vietnam was continually influenced by the Chinese culture. Consequently, the culture and social structure of Vietnam have been markedly influenced by other powers, especially China. In the discussion below we review those aspects of the socioeconomic background of Vietnam that are thought to bear on the reproductive behaviour of Vietnamese people today. The discussion is organized under the following headings:

- Religion and other cultural factors;
- Ethnicity;
- Education and health care;
- Other social administrative policies;
- Economic mechanisms.

2.2.1 Religion and Other Cultural Factors

While the legacy of Western domination can be seen more materially in Vietnam -- for example, the French-style buildings in Hanoi and the infrastructure built by the U.S. in the south -- Vietnamese are closer to their northern neighbours, the Chinese, in customs, traditions, and even ideology. Many of the similarities can be explained by the long rule of China over Vietnam; the geographic proximity also made cultural transfer much easier.

An obvious and profound cultural transfer from China is Confucianism. In Vietnam, as in China, traditional beliefs, customs, family and social relationships, etc., reflect a co-existence and mixture of Buddhism and Confucianism. It should be noted here that while Confucianism is often mentioned as a religion, it is not really so. Confucius (551-479 B.C) was a great teacher and philosopher of ancient

China. His teaching was about societal, familial, and self governing. Regarding religious beliefs, since "he accepted ancestor worship and the state religious cult because they had been ordained by the sages, but did not place any superstitious trust in them" (Homer H. Dubs 1992, p.153), Confucianism and Buddhism have co-existed in China, Vietnam, and some other Oriental countries. This co-existence has also made many people confuse Buddhism with Confucianism.

Confucianism was important in feudalist education in Vietnam, even after the arrival of the French in 1858. This, in addition to the ancient popularity of Mandarin in Vietnam, made Confucianism popular even to people of lower classes, not only to elite groups (see Fforde and Dvylder 1988). Buddhism alone, whose main teaching includes charity and asceticism to ensure a good spiritual life after death, does not seem to affect reproductive behaviour significantly. However, Confucianism does, and needs to be discussed in some detail.

The aim of Confucianism was to build a rigid hierarchical society based on patriarchy. This explains why the feudalist authorities supported Confucianism: to retain power. The principles of Confucianism can be summarized simply as follows. First, unquestioned exercise of hierarchical and patriarchal rules. At the top, the King had absolute power, while at the bottom individuals were subordinated directly to the family head, the oldest male in the family.

Second, an absolute dominant role for males. This principle was also aimed at strengthening the centralized patriarchal power structure, so that in a family one person would have absolute command: the husband or the oldest male.

Male dominance took priority over the dependence of the wife on her husband. According to Confucian teaching, before getting married a woman must obey the father. After marriage she must obey and be faithful to her husband. If the husband dies she is subordinated to the son (see UNESCO 1989).

Finally, Confucianism is often taken by critics to be responsible for lineage and ancestor worship in countries under its influence (Williamson 1976, UNESCO 1989, Allen 1993). In countries like China, Vietnam, and Korea, it remains a popular belief that only sons, not daughters, can continue a family's lineage. Hence, having no son is a sad end for a family. Also, ancestor worship, normally involving up to three prior generations of ancestors, is a popular custom. The ceremony is often carried out at the home of a son or grandson (normally the oldest one) of the ancestor being worshipped, with other family members present. Offering foods with flowers and burning joysticks to the spirit of the dead person every year on the anniversary of the death (or perhaps on some other occasion) is the rite. However, such customs originated mainly from Buddhism. Confucius himself, as was indicated above, was a scholar, not an advocate of religious beliefs. However, his praise of men and discrimination against women in combination with Buddhist ideology made people think that only sons can continue the family's lineage.

This discussion has two direct implications for fertility. First, the dominant role of men in traditional Vietnamese society means that the husband has a strong role in making fertility decisions. Consequently, factors that influence husbands' attitudes toward fertility would have stronger effects in this society. Second, the male dominance principle of Confucianism, especially when combined with Buddhist beliefs, clearly created strong preferences for sons (see Williamson 1976). We discuss sex preferences in more detail in Chapter 7. It suffices here to say that it would be inappropriate to find explanations of sex preferences only in economic terms, i.e., cost differentials between boys and girls (see Ben-Porath and Welch 1976, Zhang 1990) in a country like Vietnam. Obviously, the influences of Confucianism on fertility behaviour depend also on other ideologies and social forces, and we need to continue our review of Vietnam's history.

The French came to Vietnam in 1858, and Vietnam remained a colony of France until the August Revolution in 1945. The French returned in 1946 and finally withdrew after a 9-year war which ended with the Dien-Bien-Phu battle in 1954. During French domination, the Catholic religion came to Vietnam but its influence has been very limited. In Vietnam today the Buddhist belief is still dominant, followed by about 80% of the population. Also, since the French colonial government paid little attention to education or local civilization (see discussion below), the traditions and customs, including sex discrimination, hardly changed, especially outside the tiny urban sector.

Two decades before 1975, Vietnam was divided into two regions, the North under the Communist regime, and the South with a government supported by the U.S. During this period the Christian religion gained increasing influence in the South, with Protestant sects as well as Catholic attracting some followers. However, as noted above, Buddhism remained dominant. Western life-styles certainly have had some effect on family concepts by opposing and weakening the feudalist ideology, especially in the urban areas. However, their influence on attitudes toward fertility, especially in the rural areas, seems to be limited. The evidence, which will be discussed later, lies in the very low divorce rates, the strong desire to have children, and the very strong preference for sons.

Communism has prevailed in the north of Vietnam since 1945 and throughout the whole country since 1975. Under the Communist regime religion has not been encouraged, and sometimes discouraged. This anti-religious attitude has been relaxed only recently. However, ancestor worship has always been respected. Marxism-Leninism has taken its place as the official ideology. One of the most radical policies of the Vietnamese government has been to legislate equality between men and women in all spheres. This legislation was enacted as soon as the Communist government assumed power (UNESCO 1989, Allen 1993). While this has obviously helped to weaken Confucian ideology, legislation can be enacted quickly, but traditional ideology, customs, and traditions change much more slowly. Consequently, while sexual equality has been legalized in Vietnam, and actually implemented in considerable degree in public administration, male dominance and male superiority still profoundly exist in people's ideology.

Our discussion allows us to draw the following conclusion: the domination of the French for a century and the two-decade intervention by the U.S. had only limited effects on people's traditional beliefs and customs. The activities of the Communist government against the feudalist ideology, especially the patriarchy and sexual discrimination, were more tangible and more successful. However, "the introduction of a rigid Confucius hierarchy by the Chinese rulers left an indelible mark on Vietnamese history and culture." (UNESCO 1989, p.1.) This profound influence of Confucianism has at least two important implications for the study of fertility in Vietnam, as noted before -- the dominant role of the husband in family decision-making and the strong preference for sons.

2.2.2 Ethnicity

Vietnam has nearly 60 ethnic groups. However, the Kinh, also called the Viet, is by far the largest, accounting for 87.1% of the country's total population. Table 1 shows the ethnic composition of Vietnam.

Table 1: Ethnic Composition, 1989

Ethnic group	Population	Percentage of total Population
Kinh	56,101,583	87.1
Tay	1,145,235	1.8
Thai	992,809	1.6
Chinese	961,702	1.5
Khome	872,373	1.4
Muong	874,195	1.4
Nung	696,305	1.1
Other	2,699,474	4.1
Total	64,411,713	100.0

Source: Banister 1992, Table 11; last column calculated by the author.

Ethnic groups aside from the Kinh, the Chinese, and the Khome live in the mountain and high plateaus. The cultures and traditions differ among the various ethnic groups. For example, the H'mong natives (not listed in the above table) have a tradition that daughters do not leave the parents' home after getting married, and also that the groom must pay a significant sum to the bride's parents. This certainly increases the value of daughters and hence the preference for daughters among the H'mong people, but the opposite holds for the Kinh -- the majority of population.

Fertility varies considerably across ethnic groups. The fertility of the minorities, except the Chinese, is higher than that of the Kinh (Dang Thu 1993, p.1-7); this is partly because they live in remote areas where fertility tends to be high anyway.

It is desirable that micro data include information on the ethnicity of individuals. (This information is not difficult to collect in a survey.) Unfortunately, the VNDHS-88 did not include a question on ethnicity. It appears that the provinces where most minority people live were not sampled in proportion to their population. The focus of the survey on high population density provinces seems to be consistent with the government's desire to control population in those areas. The difficulty and high costs of interviewing people in remote mountain and plateau areas seem to be another reason for the selection. We conclude that the proportion of minority people in the sample must be very small, ie., much less than 12.9% (the proportion of the minorities as a whole), and the consequence of leaving out the ethnic variable in our later analysis is therefore not a serious problem.

2.2.3 Education and Health Care

The influence of cultural and ethnic factors on fertility certainly depend on the social and economic environment. Education has a salient role (Cochran 1979, 1983; Caldwell 1980) and we review here general features of education in Vietnam to set the background for later discussion. Again, aspects relating to fertility issues are emphasized.

Traditionally Vietnam is a nation with great respect for learning. This is reflected in a popular proverb: "You couldn't possibly be a success without a teacher!" Literature Temple, the first Vietnamese university, was established in 1010. Before the arrival of the French in the middle of the nineteenth century, education consisted mainly of teaching Mandarin, Confucianism, and literature. Ethics, rites, and disciplines were emphasized: "Learning disciplines and rites must precede studying literature" was a strict principle, and scientific subjects got little attention. While there was no organized system of schools through out the country and only a few received any formal education, almost every villages had some small scholars who taught Mandarin and Confucianism. Furthermore, there was a system of organized examinations, which were open to everybody, and high ranked candidates could become mandarins. Fforde and de Vylder (1988) believe that these factors helped to "create the enormous popular respect for formal education that ensures today that almost all children go to school" (p. 20).

The presence of the French did little to improve the educational situation. Only a very small elite group could enter the schools that were established by the French, and which aimed to train workers for colonial administration. The French schools displaced only a portion of the ancient education system, and education during this period became a mixture of Western and traditional, and involved the use of three written languages -- Vietnamese, Chinese, and French. Consequently, when Vietnam became an independent state in 1945, after almost nine decades of domination by the French, there was little formal education. The illiteracy rate was about 90% (UNESCO 1989, UN 1990a); there existed only one medical and pharmaceutical college, one law faculty and some trade schools, all of which were located in Hanoi. Consequently, after a century of "civilization" only 600 people, of whom less than ten were women, were enrolled in higher education (UNESCO 1989). After independence the Communist government put high priority on the elimination of illiteracy and development of the educational system. An intensive campaign was carried out to build schools for children and to open complementary education classes for illiterate adults. After the country's reunification in 1975, the same strategy was applied in the South. As it might be expected, the problem of educational inequality was evident among the Southern population before 1975. While a small number of wealthy people could get access to qualified higher education, 50% of the population in urban areas and 75% of those who lived in rural were illiterate. The country has been recognized for its triumphs in the education field (UNESCO 1989, UNICEF 1990, UN 1990). Today Vietnam has primary schools in every village and secondary schools in most districts; in 1992 there were 109 universities and 271 vocational training schools throughout the country[1]. The literacy rate is 88%, regarded as high by the standards of developing countries.

Table 2 gives more details regarding literacy in Vietnam. It confirms the rapid improvements. The data suggest that by 1989 relatively little difference between generations remained in literacy rates in spite of the massive illiteracy in 1945. What has been the implication for fertility? Higher education is often associated with lower fertility, but the response time is uncertain, and there might be long lags (Becker and Barro 1988). Hence, we cannot conclude that education has not contributed significantly to the reduction of fertility in Vietnam in the last few decades because there has been little recent improvements in education, especially at the primary level. Also as is clear from the last column of Table 2, now that most of the population has primary education, that level has become more of a minimum requirement than a voluntary investment. Regarding male-female differentials in education, the literacy rates are similar for men and women, especially for younger generations.

The situation is somewhat different with regard to higher education. Table 3 provides some details. In general, educational attainment has been much lower for women than for men and for the rural sector than for the urban sector. The higher educational attainment in the urban sector reflects both the better services available in that sector and the greater pressure there of industrialization

Table 2: Literacy Rates and Years of Schooling

for the Population Aged 10 and Over, 1989

Age group	Literacy rate (%)					Average schooling years**
	Total	Male	Female	Urban*	Rural*	
10 - 14	92.9	93.4	92.5	97.3	91.8	5.8
15 - 19	93.3	93.5	93.2	97.2	92.2	9.5
20 - 24	94.2	94.8	93.6	98.1	93.1	9.6
25 - 29	94.6	95.7	93.5	98.7	93.4	9.7
30 - 34	94.4	96.1	92.9	98.6	93.1	9.5
35 - 39	93.1	95.8	90.8	98.1	91.5	9.1
40 - 44	91.4	95.7	87.7	97.5	89.4	8.9
45 - 49	87.6	94.4	82.0	95.6	85.2	8.1
50 - 54	83.7	93.5	75.8	91.0	81.3	7.4
55 - 59	78.1	91.1	66.6	88.9	75.5	7.1
60 +	54.9	78.4	38.0	68.5	51.7	6.7
Total	88	93	84	94	87	--

Source: GOS 1991, p.50-54, and calculations by the author.

* Obtained by adjusting the proportion of population who ever went to school. The coefficients for adjustment (same for urban and rural) were the ratios of the literacy rates to the percentages of population who ever went to school, by age group. These ratios were very close to 1 for the younger generations and up to 1.05 for the older ones. Hence the adjustments appear to be accurate.

** Calculated for the population who ever went to school.

Table 3: Percentage of the Population Attaining Specific Levels of Higher Education by Sex and Urban-Rural Sectors, 1989

Level completed	Total	By sex		By urban-rural	
		Male	Female	Urban	Rural
High school	6.9	8.3	5.2	12.6	4.2
Vocational school	2.7	2.5	2.9	5.4	1.4
College & university	1.6	2.1	1.1	4.5	0.7

Source: GOS 1991, p. 55.

educational requirements. The relatively low educational status of Vietnamese women reflects partly their traditional dependent roles, as discussed before. However, it also represents a major improvement in the status of women in Vietnam over the past half century.

In general, educational resources in Vietnam have been limited. Even today it is very difficult to get a place to study beyond the primary level is very difficult in Vietnam. To enter high schools (nowadays called secondary schools for consistency with world standards; we will use this term hereafter), students, beside other requirements, have had to take an admission examination, and the success rates are often less than 20%. The situation is similar for higher education, but the admission rates are much smaller. (As an example, the National Economics University of Hanoi had more than 9500 applicants in 1994, but only about 900 were admitted (see Far Eastern Economic Review, June 23, 1994, p.77); for some other universities the rates are even lower.) Before drawing implications from this, some other points should be noted. Under the Communist regime, education, including higher education, was basically free. Also until recently there were no private schools, colleges or universities in Vietnam. This means that most parents would have very little opportunity to invest in children's education even if they had money and wanted to do so. What are the implications of our discussion so far? First, the small chance of getting a place to study and the restricted opportunities for educational investment suggest that Becker's theory of quality and quantity of children would have little scope to operate in Vietnam. The argument is straight forward and simple: if parents plan to have fewer children while investing more in quality (i.e., in education) it will be difficult to do so. Also their investment would be risky since the probability that a student would be admitted to higher levels is low. Second, however, if the quality-quantity theory holds, then expansion of the education system in Vietnam to give parents more opportunity to invest in their children would have significant effects on fertility. To have a better understanding of this and the actual educational investment in Vietnam, let us look at the achievement of the country in this field.

Health Care

The availability of health care services is another important factor that might have a significant influence on fertility. The influence may be direct -- for example, fecundity may depend on women's health status (Easterlin 1980, p. 86) --

or indirect, through factors such as infant and child mortality (Olsen 1988, Preston 1978).

It has been acknowledged that health care is another area of relative success in Vietnam (UN 1990, UNESCO 1990). Like education, 50 years ago health care services were extremely poor. In 1945 the whole country had only 47 hospitals, 51 doctors, and about 1,000 nurses. However, substantial improvements have been made. Table 4 presents some basic information.

The improvements in health care have some implication for fertility trends in Vietnam. But before drawing such implication, let us comment briefly on the organization of the Vietnamese health care system (see also Fforde and Dvylder 1988). Vietnam has tried to build a comprehensive system. At the bottom are primary clinic units which operate within villages or organizations (schools, factories, etc.). These units are responsible for the first diagnosis and primary care. The cases which cannot be diagnosed or treated at this level are transferred to the next level -- the polyclinic centres or hospitals of the appropriate district. Provincial hospitals take care of more serious cases sent from the district polyclinic centres or hospitals. At the top are specialized central hospitals which, unfortunately, are all located in Hanoi or Ho Chi Minh City (formerly Saigon). This organization, in combination with poor transportation facilities, has created a serious urban bias in health services. Though the majority of the population has access to primary care, the urban population has much easier and better health services.

As in the rest of what used to be the Communist world, egalitarianism has been emphasized in health as well as in other social services. Until recently health services, including hospital care and physicians' services, were free of charge or substantially subsidized. However, the government was financially responsible only for clinic units in urban areas and for polyclinic centres and hospitals throughout

Table 4: Development of Health Care Resources

Resources	North				Whole country		U.K. 1974
	1960	1965	1970	1975	1986	1991	
Hospitals & polyclinic centres	65	252	440	645	1331	1550	-
Primary clinic units	3478	5813	6287	6212	10241	10558	-
Doctors per 10,000 population	1.4	5.1	10.2	12.1	10.5	11.0	12.5
Nurses per 10,000 population	18.5	20.7	22.8	17.3	13.8	10.1	35.1
Hospital beds per 10,000 pop.	8.3	10.3	15.4	16.5	20.1	17.4	111.4

Source: GSO 1978, GSO 1992, Andreopoulos 1975, p. 2, and calculations by the author.

the country. The primary clinic units in the rural areas were financed mainly by the cooperatives or local authorities. This means that primary health care in the rural sector varies across villages, depending on the attitude and commitment of the local authorities. This feature must be taken into account in modelling fertility.

Now let us look back at Table 4. Several features are noted. First, although the country has made great achievements in this field, health care conditions in Vietnam are still far behind the standards in the developed countries (comparisons are shown for the U.K.). Second, improvements in the health care system were rapid before 1965 and slow thereafter. This, with other socioeconomic improvements after independence, shows up in infant and child mortality, which dropped greatly from 1945 to 1960, but was rather stable thereafter. Formal data on infant and child mortality before 1975 are not available, but some estimates of infant mortality before 1945 are in the hundreds per thousand births. Table 5 shows infant and child mortality after 1975.

Table 5: Infant and Child Mortality (rates per 1000)

Year	1976	1980	1985	1987
Infant mortality	34.0	34.2	35.5	32.1
Child mortality	6.0	6.1	6.3	6.2

Source: VN 1990, p.97.

Note that the figures in Table 5 should be treated with caution. The infant mortality rate estimated from the 1989 census data was 44 per thousand (see GSO 1990, p.104). The Table 5 estimates appear to be based on death registrations, which tend to under-count the actual number of infant and child deaths. However, they are probably adequate for comparison purposes. These data have an interesting implication for the fertility transition in Vietnam: Infant and child mortality could not have contributed to the reduction of fertility over the past three decades (see below) unless there were long response lags.

2.2.4 Other Social Policies

Vietnam has other distinctive social and administrative policies which cannot be overlooked in a fertility study. The most relevant policies are those that affect women's status. We discuss briefly the legislation and social organizations in relation to Vietnamese women's status. For a more detailed discussion, see UNESCO (1989) and Allen (1993).

Legislation

The Vietnamese Communist party emphasized women's rights at the party's birth in 1930 (UNESCO, 1989). In part, this was a strategy to attract women into movements and activities led by the party. Indeed, the so called "long hair armies" became an important force in all spheres including that of fighting during the war. Sexual equality and women's rights were clearly granted in the 1946 constitution (the first constitution of Vietnam). We cite below two articles, as translated and quoted by Allen (1993).

Article 9: "All power in the country belongs to the Vietnamese people, regardless of race, sex, fortune, class or religion... Women are equal to men in all respects."

Article 21: "Women enjoy equal rights with men in all spheres, in political, economic, cultural, social and domestic life. For equal work she is entitled to equal pay..."

The second constitution in 1959 and the third in 1980 repeated, emphasized, and elaborated sexual equality and women's rights. The first (1959) and the second (1987) Marriage and Family Laws incorporated the relevant parts of the constitution and specified the rights of women in marriage and family life. For our purposes, it is sufficient to conclude that sexual equality and women's rights in Vietnam have been the law for the past half century.

Organizations

In Vietnam there is a comprehensive system of social organizations, called mass organizations. Technically, all these bodies are attached to a father organization, the Vietnam Fatherland Front. Practically, they are affiliates of, and led by, the Communist party. Vietnamese women have their own union, called the Vietnam Women's Union. This is a non-governmental organization, formally established in 1946, though its forebears existed since 1930 (UNESCO 1989, Allen 1993). Nowadays this union has between 10 and 11 million members. Also important is the Youth Union (formally called Ho Chi Minh Communist Youth Union). This social organization is for youths, both men and women, between the ages of 15 and 27. Until recently at least, members of these unions met quite frequently (monthly or at least several times a year) to listen to, and supposedly to discuss, the party's and government's policies, to engage in joint activities, and so on. There are also a Trade Union and many other social bodies, including professional clubs. Consequently, individuals in Vietnam -- men and women-- are exposed to public activities quite frequently. It is often joked, but it is true, that the

Communist regime is characterized by public meetings. There are all kinds of meetings in Vietnam: party meetings, youth union meetings, women's union meetings, cooperative meetings, team production meetings, and so on. We do not comment on the efficiency or politics of the system, but only on its one important implication for our fertility study: in Vietnam women are exposed to public discussions and activities much more frequently than in most other developing countries. This may have an important influence on fertility and child mortality (see Basu 1992).

Since both the legislation and the mass organizations discussed above have effected virtually all women in a similar way, these effects can not be studied using micro data. At the same time they are important for understanding fertility trends in Vietnam.

2.2.5 Economic Structure

Until the introduction of economic reform in the late 1980s, Vietnam had been a command economy which, in principle, operated under a system of top-to-bottom plans. Since the economic reform formally started only two years before the VNDHS-88, the old economic system is the relevant one for our analysis, and we therefore restrict our discussion to that. Also our discussion is confined to those features that relate to fertility behaviour. For a comprehensive discussion of the Vietnamese economy during the transition period, see Fforde and Dvylder (1988).

After assuming power in 1945, the Vietnamese government started a process of land reform (taking land from landlords and giving it to peasants) and nationalization of private firms in the industrial and service sectors. The processes were terminated when the French returned in 1946, but resumed in the north of Vietnam in 1954, when peace returned and the country was temporarily divided into two regions by the Geneva Treaty. After the land reform peasants were forcibly persuaded to join cooperatives, and the industrial and service sectors were managed by the government. By 1965 these reforms were essentially completed in the North. The economy then consisted of two major sectors: the government sector and the collective sector. The private sector accounted for only 10% of the national output and was dominated in all respects. After the country's reunion in 1975, the same procedures were imposed on the South to convert the South's economy to the Northern pattern. The reforms in the South were somewhat looser, however. Table 6 summarizes the composition of the Vietnamese economy by sector and industry.

Although the collective and public sectors were classified as belonging to the socialist sector, the administrative mechanisms were very different. For our purposes it is best to discuss each sector in turn.

The Public Sector

A very important feature of the public sector was the life-time job policy. Until recently, i.e., before the economic reform, lay-offs of public workers were extremely rare and someone who entered this sector was likely to stay until retirement. Students of vocational training schools, colleges, and universities, all of which were in the government sector, were automatically guaranteed employment

Table 6: Composition of the Economy's Output

by Sector and Industry, 1960-1987

Output	North			Whole country			
Composition	1960	1965	1975	1976	1980	1985	1987
By sector:							
Public	38.4	45.5	51.7	34.7	35.5	35.7	38.6
Cooperative	28.2	44.6	40.0	23.5	24.8	35.2	33.9
Private	33.4	9.9	8.3	41.8	39.7	29.1	27.5
	100	100	100	100	100	100	100
By industry:							
Agriculture	34.5	29.9	29.0	44.7	39.8	37.8	36.0
Industry	32.7	40.5	41.4	33.5	38.5	42.3	44.8
Others	32.8	29.6	29.6	21.8	21.7	19.9	19.2
Others	100	100	100	100	100	100	100

Source: GSO 1978, Table 20 and Fforde 1988, Table 2.2.

by the government after graduation. Job changing was very rare and was directed by the administrative boards. Although women were allowed paid maternity leaves (recently up to six months), they could not simply quit their employment without losing all benefits, including those for retirement. Furthermore, it would be very difficult to resume employment later. This mechanism discards one complicated issue in modelling fertility -- the endogeneity of women's labour supply (Cain and Dooley 1976, Schultz 1978, Hotz and Miller 1988, Heckman and Walker 1991). One may argue that the endogeneity still remains if either initial employment or educational decisions (which in turn affect a woman's employment status) depend on fertility. This may be true for other countries, but not for Vietnam or other command economies. Having employment in the public sector was privileged and desired by almost every one. Realized or planned fertility would not prevent a woman from taking employment in the public sector if she was fortunate enough to get an offer. For those who worked in the co-operative sector the concept of labour supply was not so straightforward. However, as discussed in the next section, the flexible working environment, the low time cost of raising children, and the significant role of family production mean that the mother's labour supply would be little affected by fertility. Fertility did not seem to affect female educational attainment either. The fact that more than 90% of females aged 10 and above had only primary education or less (GSO 1991, Table 6.6) means that most women stopped school long before 18, the legal age for marriage. There is also direct evidence (discussed in Chapter 5) that a few students over the age of 18 leave school to get married.

Another feature relates to the remuneration policy. As noted before, there was no discrimination again women in remuneration, legally or practically. The most important issue for us, however, is the uniform wage system which held until the late 1980's. The government set a rigid and uniform wage scale which applied to all workers in the public sector. The wage rates depended mainly on tenure and degrees. For example, all university graduates would get the same wage after their graduation, regardless of what they had studied and where they worked (there were negligible adjustments for regional expenses and job security); wage rises would be made to everyone after 4-5 working years. This remuneration policy and the life-time employment mechanism meant that workers could predict well their life-time income, and education was a good indicator.

Besides salary, rations of foods and other consumer goods were an important part of remuneration. In the 1980's, when economic hardship became intense, rations were actually worth more than cash salary. The rations also depended on salary level. Children and people outside the public sector, but living in the urban sector, also got lower, uniform rations.

Workers in the public sector, including police officers and life-time army officers, were the only ones who got pensions. The pensions were up to about 80% of the main salary, depending on the employment tenure and age at retirement. Because there has been little by way of social security programmes in Vietnam, others have no source of old age security, except from relatives. This may strongly affect the demand for the children (Farooq and Simmons 1985, Nugent 1985, Vlassoff 1991, Cigno 1992, Jones 1993) in the non-public sector in Vietnam.

In general, most public workers and urban residents could get access to child care. Child care was essentially free; parents normally paid only for food expenses, which were also heavily subsidized.

Another point that should be noted is that child labour was rare in the urban sector under the Communist regime. One reason was the tiny role of the private sector, especially in urban areas, as seen before. The public sector certainly did not hire children.

The Collective System

While the public sector covered industrial production and services, the collective system was imposed in rural and small-scale urban industrial production. The collective system differed from the public sector in many respects. First, the assets of a cooperative were not national assets, as were those of the public sector, but were provided by its members and then became common properties of the cooperative. Members worked for the cooperative and their labour contribution was recorded on a labour-point system. Labour points were based on the time spent at work in the fields, or sometimes a measure of the work completed, as in the case of home production. They were paid (in kind) based on the productive outcome of the cooperative and their family's labour points. Because land and productive facilities belonged to the cooperative, parents in Vietnam did not need children to work the land or to inherit it, as it is argued is the case in other countries. Children, however, could work for co-operatives to gain labour points, which resulted in income, for their family. In this respect, the question that whether parents wanted to have more children to exploit the free access to the cooperative's assets is a possibly interesting question, but one that has not been studied and will not be pursued here. Since land and most productive equipment belonged to the cooperatives and families had equal access to them, they can be ignored in our modelling of individual fertility behaviour.

Second, though each cooperative typically had a welfare fund, it was very small. Only old people without relatives would normally get assistance, and that would be restricted to a small staples ration. No pension was available to cooperative members. This lack of social security certainly made children more valuable for parents in this sector than in the public sector.

Third, while many cooperatives organized child care services, such services were normally much poorer than in the urban sector and many parents relied on either relatives or older children to look after the younger ones (UNICEF 1990). Also, as in other developing countries, mothers often combined homework (housework or cooperative work) with child care. In general, the combination of low remuneration from the cooperatives, the possibilities of doing work at home while taking care of children, and the strong family sense made the time cost of children rather small in the Vietnamese rural sector. Strong family relationships and kinship are a salient feature of the Vietnamese society (Fforde and de Vylder 1988, Phan Dai Doan and Nguyen Quang Ngoc 1990, UNESCO 1988). Although they are often explained in terms of traditional customs or preferences, they are based also in the various social and economic benefits that flow from these relationships in low-income countries like Vietnam.

Finally, unlike the urban areas, child labour was quite common in

Vietnam's rural areas (UNICEF 1990). Children could help parents to do housework and certain kinds of cooperative jobs, such as looking after ploughing buffaloes and oxen, weeding, harvesting etc. -- the more backward the productive technology in the rural sector, the more employable the children. This child labour reduced further the net costs of children in rural areas.

Other Economic Features

The Vietnamese economy has another characteristic which relates directly to fertility: in about 15-30% of households women are de facto family heads (Allen 1993), often because their husbands are employed far away from home, normally in a city or industrial centre. This again has several explanations. First, the relatively favourable living conditions in the non-agricultural sectors and the government campaigns for industrialization induced people to "thoat ly" (a Vietnamese word for work away from the rural sector). However, the imbalance in education between men and women, the remaining male superiority, and, very importantly, the government policy aimed at giving soldiers who had completed their service employment in the public sector, all made it easier for men to move to the urban or industrial sectors. Second, the restrictions on household registration, which made the migration of wives and children to the urban sector for family union almost impossible, result in many couples having to live separately. Certainly this had direct effects on fertility. Husband's occupation, when included as an explanatory variable in fertility models for Vietnam, incorporates this kind of effect. More specifically, for those who work in the non-agricultural sector, the probability of being separated from the wife and family is much higher.

We have reviewed the social and economic environment of Vietnam in relation to the study of fertility. This discussion will inform our modelling and interpretation of estimation results which follow. In brief summary, we have noted the rapid improvement during the 1950's and 1960's in education, health care, women's status, and economic life. However, since the middle of 1960's in the north and the late 1970's in the south, the gains in primary education, health care, and living standards were modest at best, and in some cases there were reversals of previous gains. Only women's status, which has been strongly protected and promoted by Vietnamese legislation, has kept improving consistently. These movements must be related to fertility trends and the demographic situation in Vietnam, to which we now turn our attention.

2.3 A Demographic Picture

In this section we look at fertility trends in Vietnam, and then basic population features and family planning practices. The section forms part of the background for the analysis that follows; it also prepares the way for a micro-macro synthetic analysis in our concluding chapter. Thus some of the information provided here is not of immediate interest.

Fertility Trends in Vietnam

Time series fertility data in Vietnam are limited since there have been no regular estimates of national fertility. The major sources of information for use in constructing a picture of fertility trends have been the 1979 and 1989 censuses and the VNDHS-88 survey (see also Feeney and Xenos 1992). In addition, there were a few other surveys that focused on specific regions (see Dang Thu 1993, Nguyen Duc Hung 1991). Below we briefly discuss the estimates of fertility based on these sources and provide graphic presentations of the results.

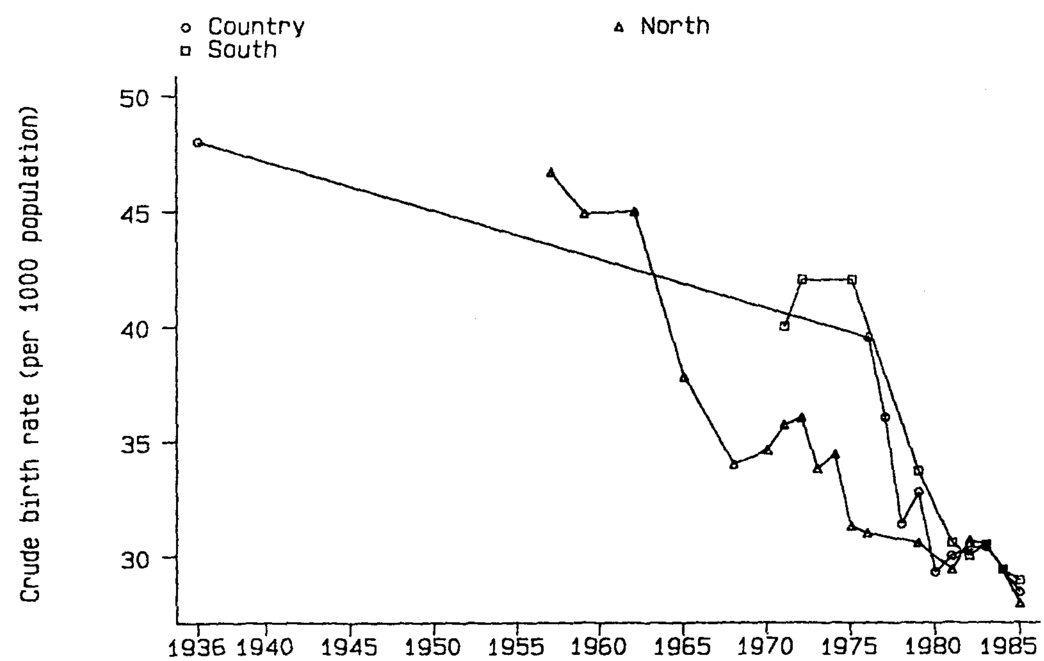

Figure 1. Movements of crude birth rates, 1936-1985

Source: Dang Thu (1993), Table 1.

Consider first the crude birth rate. Figure 1 shows the crude birth rates for selected years from 1936 to 1985 for the North, the South, and the country as a whole; data were taken from Dang Thu (1993), Table 1. Note that there are discrepancies between the estimates used here and others. For example, the 1989 census estimates of crude birth rates (see GSO 1991, P.95) for the 1980's are somewhat higher -- the differential is up to 17%. Also, within the data there are inconsistencies that can be detected easily from the figure. Specifically, there must have been errors or mistakes in the data for 1976 and 1980. For 1976 the author gives the crude birth rate as 39.5 per thousand for the whole country, 31 for the North, and no information for the South. But this implies that the measure for the South would be very large (about 50), and this is impossible, visually and logically. Another data source (see GSO 1991, P.95) estimated the country's crude birth rate in 1980-1983 as low as 33.5. Hence, 39.5 as the crude birth rate for the country in 1980 is improbably high. Similarly, the data for 1980 seem inconsistent. However, the declining trend in crude birth rates in Vietnam for the last three decades as seen in Figure 1 are consistent with other sources of information.

The 1979 and 1989 censuses allowed estimation of the total fertility rate. However, only the 1989 census collected information on the number of live births to women during the 12 months before the survey date (April 1, 1989). The sample consisted of about 5% of all women aged 15-49 and hence allowed direct estimation of the total fertility rate. However, based on information about age distribution and mortality, the reverse survival method was applied to estimate the total fertility rate indirectly (see GSO 1991, Chapter 9; Feeney and Xenos 1992). Data from each census were used to estimate the total fertility rate up to 20 years before the survey year. Figure 2 depicts the results. The nature of the reverse survival method means less accuracy is associated with estimates more distant from the survey dates (that is, the right ends of each curve), and that should be taken into account in the interpretation of the figure. The decline of fertility in the past 30 years is obvious from both figures. However, the deficiencies in these estimates makes further information desirable.

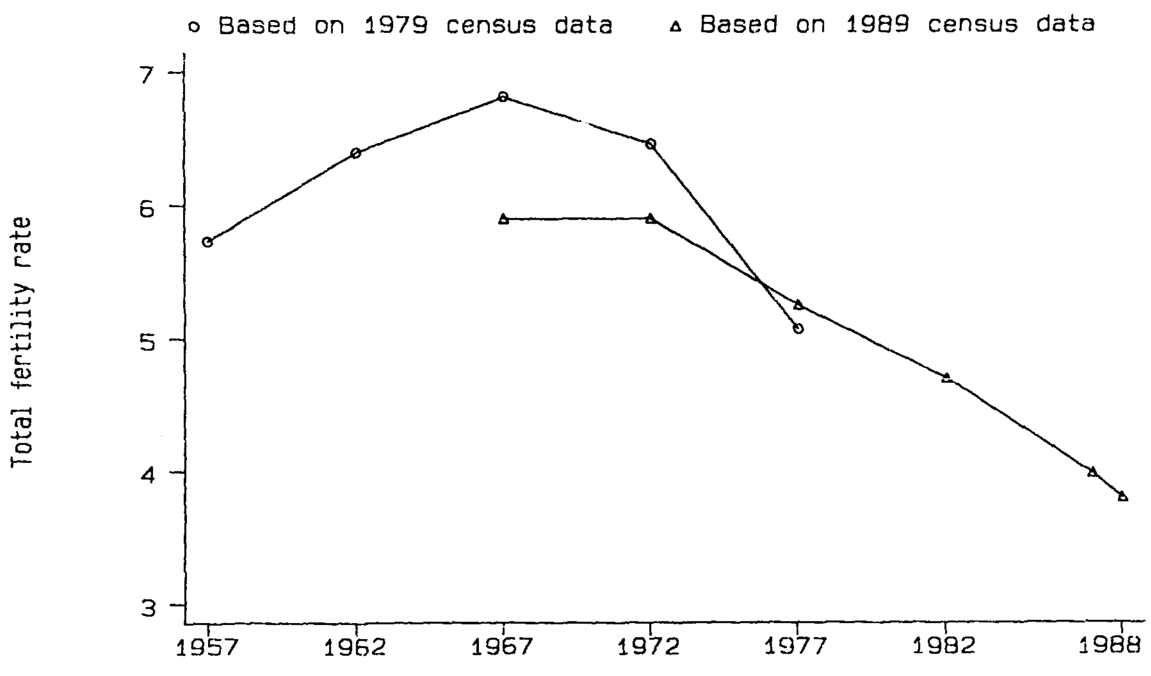

Figure 2. Movements of the total fertility rate, 1957-1988

Source: GSO (1991), Table 9.5, p. 95.

In 1990 the Centre for Population and Human Resource Studies of the Ministry of Labour and Social Affairs carried out a survey to study population and labour issues in the rural areas of the Red-River delta. The survey included information on women's birth histories in the previous ten years. Nguyen Duc Hung (1991) used this information for a sub-sample of 3,158 women aged 15-49 to estimate the age specific fertility rates for the ten-year period ending with 1989. Since women aged 49 in 1989 were 39 in 1979, age-specific fertility rates can be estimated up to age 39 in 1979, up to age 40 in 1980, and so on. The complete

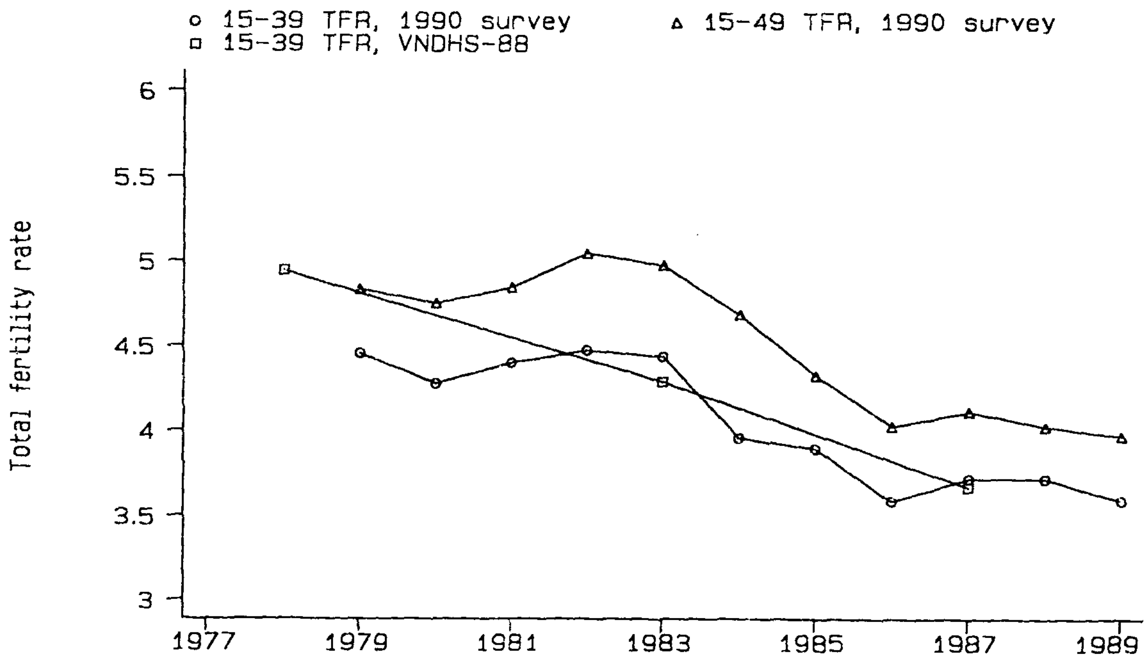

Figure 3. Movements of the total fertility rate, 1977-1989

Source: Nguyen Duc Hung (1991) and calculated by the author.

age-specific fertility profile can be obtained for 1989. In a similar way, he also calculated up-to-age-39 total fertility rates for the ten years starting with 1979. Since there is little fertility after the age of 39, this incomplete measure of the total fertility rate is helpful for studying fertility trends. He also made adjustments to obtain complete total fertility rates. Figure 3 reproduces his calculations and presents also our corresponding estimates based on VNDHS-88 data.

Since VNDHS-88 included information on birth histories of women up to the survey date, the method discussed above could be applied to study fertility trends for the ten years before 1988. Unfortunately, we do not have the household data for the VNDHS-88, which contains information on the age distribution of all women aged 15-49 who were in the survey, including never-married ones. Consequently, we could not calculate the annual age-specific fertility rates by single-year age groups as was done by Nguyen Duc Hung. However, the VNDHS-88 report gives the 5-year age distribution of all women (including never-married ones) in the sample. Combining this with data on the birth histories of ever-married women (or ever-lived with a partner), we were able to estimate the up-to-age-39 total fertility rate for 1983, or five years before the survey, and for 1978, or ten years before the survey. (The five-year interval estimates were determined from the 5-year age groups.) The estimate for 1987 is readily available from the VNDHS-88 report. All three estimates are depicted in Figure 3.

The closeness of the estimates from the 1990 Red-River delta and the VNDHS-88, despite the different coverage of the two samples, can be explained as follows. The 1990 survey covered only some rural areas in the Red-river delta, a region with moderate fertility. The VNDHS-88 included the urban sector, which has much lower fertility, as well as the mountain areas and the Mekong delta with their high fertility.

Even with the data discrepancies, the available information all confirms that fertility in Vietnam has declined rather quickly and uniformly in the last three decades. This evidence of fertility transition in Vietnam, taken in conjunction with the social developments discussed earlier, and the micro analysis that follows, provides a coherent explanation of fertility determination in Vietnam. Other general demographic indicators may also be helpful for such an assessment and are introduced in the next section.

Basic current demographic features

Some basic indicators of the current demographic situation in Vietnam are provided in Tables 7 and 8 below. Table 7 shows the distribution of the Vietnamese population by age and sex, based on the latest census data. Table 8 brings together other general demographic indicators.

The numbers in Tables 7 and 8 speak for themselves. Among the most salient features of the Vietnamese population are the following: (i) it is very young; (ii) the sex ratio (male/female) is low for the old generations (aged 35 and over in 1989), a consequence of 30 years of war; (iii) the divorce rate is very low; and (v) fertility remains high in rural areas, but in urban areas it is just above the replacement level.

Table 7: Age-Sex Distribution, 1989

Age group	Male (1000)	Female (1000)	Sex ratio (%)	% of total population (both sex)	Cumulated percentage
0 - 4	4646	4364	106.5	14.0	14.0
5 - 9	4404	4177	105.4	13.3	27.3
10 - 14	3876	3651	106.2	11.7	39.0
15 - 19	3377	3444	88.1	10.6	49.6
20 - 24	2880	3120	92.3	9.3	58.9
25 - 29	2696	2971	90.7	8.8	67.7
30 - 34	2264	2469	91.7	7.4	75.1
35 - 39	1551	1774	87.4	5.2	80.3
40 - 44	1039	1196	86.9	3.5	83.8
45 - 49	882	1083	81.4	3.1	86.9
50 - 54	865	1077	80.4	3.0	89.9
55 - 59	922	1045	88.2	3.0	92.9
60 - 64	714	861	83.0	2.4	95.3
65 - 69	537	701	76.6	1.9	97.2
70 +	680	1140	59.6	2.8	100
Total	31333	33072	94.7	100	x

Sources: GSO 1991, table 2.1, p.11; the last two columns were calculated by the author.

Table 8: General Demographic Indicators

Indicator	Year of estimation	Unit	Value
1) Total population (proximately)	1994	Million	72.4
2) Sex ratio (male/female)	1989 census	%	94.7
3) Urban population	1989 census	%	20.1
4) Dependency ratio:			
Population aged 0-14/pop. aged 15-	1989 census	%	71.8
Population aged 61+/pop. aged 15-	1989 census	%	12.3
Dependency ratio	1989 census	%	84.0
6) Life expectancy at birth:			
Male	1989 census	years	63.0
female	1989 census	years	67.5
7) Proportion of pop. aged 15-49			
who were: Single	1989 census	%	29.4
Currently married	1989 census	%	62.2
Widowed	1898 census	%	7.2
Divorced	1989 census	%	0.6
Separated	1989 census	%	0.7
8) Total fertility rate:			
Country	1989 census	Children	3.8
Urban	1989 census	Children	2.2
Rural	1989 census	Children	4.3
9) Crude birth rate	1985-1989	%	3.1
10) Crude death rate	1989 census	%	0.8
11) Rate of natural increase	1989 census	%	2.3
12) Infant Mortality:			
Country	1898 census	%	4.4
Urban	1989 census	%	3.2
Rural	1989 census	%	4.6

Sources: From and calculated based on GSO 1990, GSO 1991, GSO 1992.

Family Planning Policies and Practices

We have neither the intention nor the space to go into the details of family planning issues in Vietnam. However, knowledge of certain features of the programmes and related policies are important for an understanding of micro and macro variations in Vietnamese fertility. For a more complete discussion of the government's view and policies, see VN (1988), Vu Quy Nhan (1987, 1993); The VNDHS-88 report provides detailed evaluations of individuals' knowledge and use of contraceptive methods; assessments of accessibility to family planning services in rural areas can be found in UN (1992).

An interesting aspect of family planning programmes in Vietnam is the government's early concerns over population pressure and its consistent commitment to population control. Faced with high and uneven population density, the young government of the Democratic Republic of Vietnam (the North before 1975) soon realized that population problems had to be solved if living standards could be expected to increase. The governments's remedies included redistribution and family planning. To make the distribution of population more even across geographic regions, persuasion and assistance were used to encourage people to move from the crowded delta regions to the so called *new economic zones* in remote areas. With respect to family planning programmes, official promotion of population control had started by 1963 (Vu Quy Nhan 1993). After the country's reunion in 1975, family planning programmes designed in the North were implemented in the South. Before then, in the early 1970's, the South's government also had plans to promote family planning practices; however, both the policies and their implementation were less coherent (Vu Quy Nhan 1993). The end of war allowed the government to pay more attention to problems of economic reconstruction, including population problems. This, with support from international agencies, especially UNFPA, has increased the momentum of family planning programmes in Vietnam in the past two decades.

A distinctive feature of the programmes in Vietnam has been the consistent cooperation between the Communist party, the government, and other social bodies. The mechanisms of centralized planning and the fact that all governmental and social bodies are guided by the party mean that when a policy is endorsed by the party it can be implemented uniformly and quickly. The National Committee for Population and Family Planning is a ministry-equivalent body in charge of population and family planning issues; it works in close collaboration with the Ministry of Health, the Committee for Protection of Mothers and Newborns, and the Vietnam Women's Union, among others. This management mechanism, combined with individuals' frequent exposure to public discussion and activities, explains the extent of family planning knowledge among Vietnamese women.

The management and organization of family planning programmes in Vietnam have some similarities with those of its Communist neighbour, China. However, there is one important difference. China is well known for it harsh and ambitious policies to control population (see Larsen 1990, Zhang and Spencer 1992, and The New York Times, Sunday, April 25, 1993). By contrast, contraceptive practice in Vietnam has been left to individuals and families. The activities of the government and social organizations have been restricted to the followings: (i) educating people about the benefits of having fewer children; and (ii) popularizing knowledge of family planning methods (but this has been limited since Vietnamese leaders have favoured the IUD method, see Vu Quy Nhan (1993)); (iii) providing contraceptive devices to willing individuals. Only in 1988, with the issuance of the Decision number 162 of the Council of Ministers (see VN 1988), was family planning specified as a "duty" of all Vietnamese adults. According to this Decision, those who had more than the allowed number of children (two for most regions and occupations) would face financial and/or other penalties. However, economic deterioration and the transformation of the country into a more market-oriented economy have meant that those forceful measures have had little impact. Though the Decision has not been abolished formally, it was overridden by another legal act just one year after its issuance. Specifically, Act 4 of the 1989 Law on Protection of People's Health states: "All acts aimed at preventing or forcing use of contraception are prohibited." (See also Vu Quy Nhan 1993.) The voluntary nature of family planning in Vietnam thus leaves scope for the influence of social factors and makes meaningful the study of fertility determination.

Family planning services in Vietnam are provided either free of charge or for a negligible fee. Also some contraception methods, such as pills and condoms are quite inexpensive. The widespread knowledge about contraception (see below) and the low cost of the services mean that an inverse association between family income and the number of children, if that existed for Vietnam, could hardly be explained by Becker's (1960) suggestion that high income groups have better access to contraception. However, time cost and psychic or health costs are still relevant. But these costs are hard to model and the errors in measuring contraceptive use, as discussed below, discourage the introduction of it as a variable in fertility models applied to most data sets.

We now look at evidence of family planning knowledge and use in Vietnam. Table 9 provides information by age of woman, Table 10 makes comparisons across regions and educational levels, and Table 11 compares the popularity of different methods.

The evidence confirms our previous comments about wide knowledge of contraception in Vietnam: More than 93.6% of married women knew of at least one modern method of contraception. This is also shown in the widespread knowledge about contraception among women of all ages, regions, and educational levels. However, use of contraception was still rather limited: only 47.0% of ever-married women had ever used any modern method, and only 37.7% of currently married women were practising a modern method at the time of the survey. This level of contraceptive practice is below the average of the developing countries. But for the reasons discussed below, these numbers must be viewed with caution.

It is clear from the Table 11, and from other studies, that IUD is the most popular method of contraception in Vietnam. However, while it is acknowledged that abortion is also a common practice, Table 11 shows that only 3.5% ever-married

Table 9: Knowledge and Practices of Contraception

Age group	Ever-married women who know any		Ever-married women who ever used any		Currently married women who currently use any	
	method	modern method	method	modern method	method	modern method
15 - 19	82.8	82.8	14.1	9.4	5.3	5.3
20 - 24	90.9	90.1	36.4	23.7	31.7	19.7
25 - 29	94.8	94.6	61.6	46.4	52.2	36.4
30 - 34	95.2	94.7	68.4	54.5	59.8	42.5
35 - 39	94.9	94.6	71.7	58.6	68.8	49.9
40 - 44	96.5	96.5	67.8	56.2	65.4	46.8
45 - 49	92.4	91.5	55.0	46.5	47.1	36.6
Total	94.1	93.6	59.9	47.0	53.9	37.8

Source: VNDHS-88 (1990), tables 4.1, 4.5, 5.6

Table 10: Contraceptive Knowledge and Use by Sectors and Regions

Sector/region	Percentage of ever-married women knowing any method	Percentage of currently married women with current use of any method
Residence:		
Urban	98.6	67.2
Rural	94.0	50.2
Region:		
North	94.9	58.7
South	93.1	46.8
Education:		
Illiterate	81.0	28.6
Know to read & write	94.2	45.6
Primary	94.4	55.4
Secondary and higher	98.0	63.8

Source: VNDHS-88 (1990), tables 4.2 and 4.7.

Table 11: Popularity of Different Contraceptive Methods

Method	% of ever-married women knowing the method	% of ever-married women ever-using the method	% of currently married women with current use
IUD	91.8	40.3	33.1
Pill	46.4	3.1	0.4
Condom	44.5	4.1	1.2
Female sterilization	60.2	2.4	2.7
Male sterilization	49.2	0.5	0.3
Rhythm	43.0	16.9	8.1
Withdrawal	40.3	17.7	7.0
Abortion	68.1	3.5	X
Menstrual regulation	49.2	3.1	X
Others	6.7	0.6	0.3

Source: VNDHS-88 (1990).

Table 12: Trends in Abortion, 1976-1987

Year	Urban Areas		Rural Areas		Total	
	Cases	Index 1976=100	Cases	Index 1976=100	Cases	As % of births
1976	21084	100	49197	100	70281	4.3
1977	32345	153	71994	146	103339	-
1978	42192	200	89659	182	131851	-
1979	58432	277	108704	221	167236	-
1980	63352	300	103364	210	166716	9.6
1981	72276	343	108415	220	180691	10.2
1982	77257	366	120838	246	198095	11.5
1983	102674	487	167523	341	270197	15.5
1984	130290	618	231628	471	361918	20.6
1985	195015	925	318184	647	513199	28.9
1986	260061	1233	390092	793	650153	38.8
1987	373141	1770	338035	687	811176	44.0

Source: VN (1990), table 6.9 and 6.10; the 3rd, 5th and last columns were calculated by the author.

women have ever had an abortion. Since this figure seem doubtful, we looked for other sources of data. Table 12 helps to clarify the problem.

The abortion rate estimates based on table 12 are much higher than the estimates based on the VNDHS-88 data. If we divide the number of abortions in 1987 by the number of women aged 15-49 in the same year (about 15.3 million), we get 5.3% as the abortion rate among women aged 15-49 *in 1987 alone*. Our estimated abortion rate for ever-married women, ie., excluding single ones, for 1987 is 7.4%. Since abortion might be practised by single women, but rarely by single rural women, we assume that the true abortion rate of ever-married women in 1987 is higher than 5.3% and close to 7.4 %. As abortion has increased rapidly, the figure for 1989 must be higher still. Also note that these figures are annual rates, so the proportions of women who *ever had* abortions would be much higher. Hence, the differences between the abortion information from VNDHS-88 and that contained in table 12 are very substantial. Which source is more reliable? It is our understanding that the data in Table 12 are based on the abortion registrations recorded by the Ministry of Health, and hence should not be upward biased. We conjecture that many women did not report abortion in interview, and that this led to under-enumeration of abortions in the VNDHS-88. Studies for other countries also find that women are reluctant to talk about abortion (Schuler et al. 1994, p. 218). Hence underestimation of abortions seem to be a common problem.

While we had no other sources of data for the menstrual regulation method, which is used to terminate unwanted pregnancies at an early phase, and has become available in Vietnam only recently, we assume that it too results in a relatively low rate of reporting use of contraception. Due to the nature of this and abortion methods, a woman will use them only if she has an unwanted pregnancy. Hence an indicator such as the proportion of women who currently use any *modern* contraceptive method might not reflect appropriately the true level of commitment to family planning when abortion is common. This must be taken into account when comparisons are made. An example can make this explicit. Assume that there are two groups of women who want no more children. All women in the first group decide to rely on abortion, but everyone in the second group practises some modern non-abortion method, to attain the target. Then the widely-used indicator "proportion of women who currently practice a modern contraceptive method" is zero for the first group, but 100% for the second group. We suggest that the proportion of women who currently use (have used) any method, including the non-modern ones, is a more reliable indicator of family planning practices when abortion is common. This is shown for the case of Vietnam. 41.6% of the married women in urban areas currently used any (non-abortion) method, only 5% more than for such women in rural areas. This relatively small gap (compared to the fertility difference between urban and rural areas) was noted before: More urban women used non-modern methods and relied on abortion as a backup. As a result, the proportion of married women who used any method, including the non-modern ones, is 12% higher for urban areas than for rural areas. We conclude that the actual rate of birth control, including abortion, has been much higher in Vietnam than is suggested in the VNDHS-88 report, in the literal sense as well as based on a deeper interpretation.

While abortion (like the menstrual regulation method) certainly has negative effects on a woman's health, and has been considered by Vietnamese policy makers as a backup measure, its rate of increase has been rapid. By 1987 for every 2.3 births there was one abortion; we estimate that without this measure, fertility would have increased, not decreased. Unfortunately, there has been little attention to this problem. For two reasons we think that the growth in the use of this method has not been caused by the absence of alternatives. First, while the supply of alternative methods clearly has increased over time, abortion has increased 11-fold between 1976 and 1987. Second, although the urban population has access to most alternative methods, abortion in urban areas has increased at an above average rate. The relatively high abortion rate in the urban sector seems to relate to the knowledge about non-modern contraceptive methods (calendar rhythm and withdrawal): More than 60% of the ever-married urban women knew about these methods, while only a little over 30% of such women in rural areas had such knowledge. This "wisdom" of the urban population, in combination with easier access to clinic services, tends to induce urban couples to choose these unreliable but less costly (not just in monetary terms) methods, and to use abortion as a backup measure. (One could question whether this is really a wise strategy.) Among the married women who lived in urban areas and were using any contraceptive method in 1987, 38% chose the non-modern methods; the corresponding figure for married rural women is only 26.5%. The high abortion rates in both rural and urban areas may also be caused by a limited knowledge of family planning practices. Note that a woman who knows of the existence of a contraceptive method does not necessarily have sufficient knowledge to use that method. We suggest that educating people about the advantages of methods other than abortion and about early family planning strategies so that they do not have to rely on abortion, is especially important for Vietnam now. Also, as UNFPA and the Vietnamese government are planning to shift the costs of family planning services to individuals, it is very important that they should plan price schedules to help move women away from abortion rather than remain with this undesirable family planning method.

2.4 Chapter Summary

In this chapter we have reviewed selected aspects of Vietnamese society in relation to fertility issues. Many of its distinctive features would seem to have the potential to influence fertility behaviour.

First, in common with other developing countries, "the calculus of marginal utility" is not the only factor that affects individual attitudes toward child bearing. Traditional beliefs, customs, social norms, and religious rites are important in moulding these attitudes. Among such factors, male superiority has obvious and important consequences: among other things it creates a strong preference for sons and it suggests that husbands may have an important role in fertility decision-making. Whether these influences transfer to fertility behaviour is a question whose answer requires quantitative analysis.

Second, during the late 1950's and 1960's there was rapid and continued improvement in living conditions in the north, especially in education, health care, social and economic equality, and women's status. However, subsequent gains have been small. In the south, the situation before 1975 was rather different, but after unification conditions there were similar to those in the north. In particular, economic hardship has increased throughout the country over the last two decades, as living conditions deteriorated. There has been no evidence of improvements in the health status of children.

Third, family planning programs, which have been in effect in Vietnam for the last three decades, have been voluntary in nature, which means that there is more scope for the analysis of fertility determination. We note that at 38%, the proportion of currently married women who are using a modern contraceptive method, is somewhat below the average for developing countries (which is about 50%). However, abortion is popular in Vietnam and has been considerably under-estimated in the surveys.

Fourth, fertility in Vietnam has gradually but steadily decreased since the late 1960's. This, when contrasted with movements of socioeconomic conditions and child quality, raises interesting questions about some of the previous explanations of fertility determination in general and fertility transition in particular. A micro analysis of fertility behaviour is necessary before a comprehensive explanation can be provided.

Chapter 3 ECONOMIC THEORIES OF FERTILITY: A REVIEW

Theoretical underpinnings are important for empirical models. However, discussing theories of fertility is a difficult task because they come from many disciplines and are marked by their diversity and complexity. While our analysis is largely economics based, a brief consideration of theoretical issues raised in the broader fertility literature will inform our discussion of economic theories. Hence, we begin with a review of the broader literature in section 3.1 before moving to a more detailed discussion of economic theories of fertility in section 3.2.

3.1 An Overview of the Major Theoretical Approaches to Fertility Determination

The complexity of fertility determination is obvious to everyone. Apart from the role of biological factors, a claim can be made relating to the influence of almost every social variable on reproductive behaviour. This section provides an overview of the fertility literature defined broadly. The purpose of this section is to highlight both the main advantages and disadvantages of the economic approach to fertility. No theory is all-encompassing, and realization of the limitations of theory is necessary to improve empirical research. With this in mind, we start with discussion of the "technical" mechanism of fertility determination due to Davis and Blake (1956). We then sketch briefly the economic approach in order to contrast it with three other major approaches: sociological, psychological, and anthropological.

Davis and Blake's framework is summarized by Figure 4. All variables that influence individual fertility are divided into two groups. The first group, *intermediate variables*, includes those factors, such as fecundity and frequency of intercourse, which directly determine human reproduction. The term *intermediate variables* has become standard and is used interchangeably with *proximate* variables. The variables in the second group, *indirect variables*, influence fertility through one or more of the intermediate variables. (These were named *conditioning* variables by Davis and Blake, but the terminology has changed.)

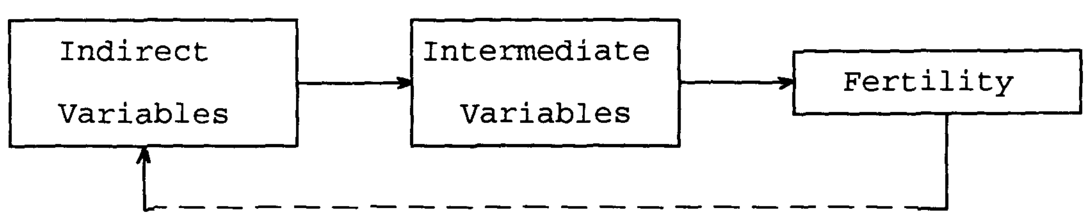

Figure 4. Determination of fertility, David and Blake's framework

This framework can be used to describe fertility determination at either an individual or an aggregate level (Bongaarts 1978). At the aggregate level, and especially in a dynamic context, there may be feed-back effects of fertility on the indirect determinants. For example, by affecting the relative sizes of age cohorts over time, changes in fertility may influence the education, earnings, and other socioeconomic outcomes of these cohorts, as well as the macroeconomy (Denton and Spencer 1975, 1988, 1989; Dooley and Gottschalk 1984; Easterlin 1980; Ermisch 1988; Welch 1979). We have therefore supplemented the conventional diagram with the dashed line indicating the feed-back effects of fertility on the indirect variables at the societal level.

Davis and Blake identified eleven intermediate variables which they divided into three groups: (i) the factors affecting exposure to intercourse, (ii) the factors affecting exposure to contraception, and (iii) the factors affecting gestation and successful parturition. Bongaarts (1978) modified the Davis and Blake model by proposing eight intermediate variables classified into three groups as follows.

A. Exposure factors

1. Proportion married

B. Deliberate marital fertility factors

2. Contraception
3. Induced abortion

C. Natural marital fertility factors

4. Lactational infecundity
5. Frequency of intercourse
6. Sterility
7. Spontaneous intrauterine mortality
8. Duration of the fertility period

Davis and Blake's framework and Bongaarts' revised version are important in emphasizing that socioeconomic variables affect fertility only through one or more intermediate variables. Knowledge of the indirect socioeconomic determinants of fertility is thus very important since government policies can influence them in many ways. The scope for direct interventions with the intermediate variables is more limited and often deemed less desirable. However, theoretical and empirical study of the indirect determinants of fertility is fraught with difficulties. Davis (1959) predicted correctly that advances in demographic theory would be scattered as researchers pursued particular problems. There are many, often conflicting, theories of fertility. Evaluating and testing these theories is complicated by the fact that some variables are not observable, others are not easy to measure accurately, and many are highly correlated.

The Microeconomic Approach

The "standard" economic model of fertility concentrates on the demand for children[2]. While macro relationships between economic and demographic variables are also studied by economists, the basis in microeconomic theory is what is both fundamental and distinctive about the economists' approach to fertility determination.

In the microeconomic approach to fertility (or, more precisely, demand for children), individuals are rational actors (Pollak and Watkins 1993) in the sense that they consciously make optimal choices among the attainable alternatives so as to maximize utility (or satisfaction), given preferences. The choices available are the set of affordable bundles (or combinations) of consumption goods, services, and children. Which bundles are affordable depends on individual income and market prices, which together determine the budget constraint. For the "child" good, the price is the cost of rearing children net of any economic benefits (e.g., children's labour income). A change in the budget constraint, due to changes in income or market prices, will lead to a different optimal consumption bundle. This is the simplest version of the new home economics theory of fertility. Figure 5 provides a graphic illustration.

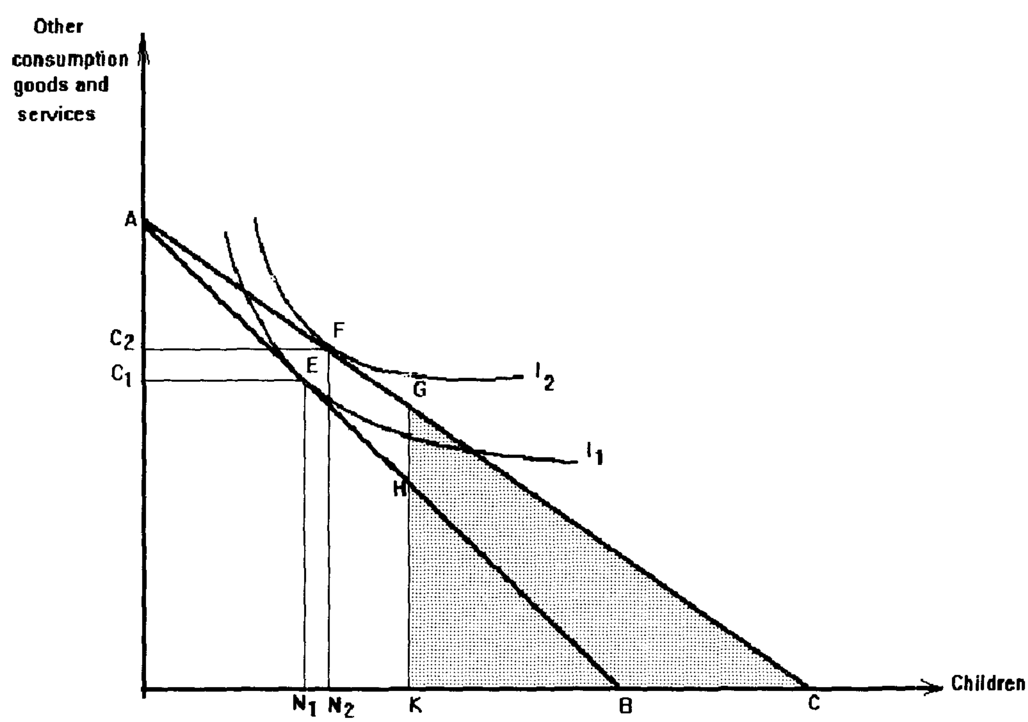

Figure 5. Microeconomic approach to the demand for children

In Figure 5 (ignoring the shaded area for the moment), all consumption goods and services (other than children) are represented on the vertical axis and the number of children is on the horizontal axis. At the initial budget constraint, AB, the couple would choose to have N_1 children and consume C_1 of other consumption goods since that would yield the maximum attainable level of satisfaction, represented by the indifference curve I_1. If the price of children were to decrease, due, for example, to the introduction of a subsidy from the government in the form of child tax benefit, the budget constraint would rotate outward to AC. As a result, it would be optimal for the couple to have N_2 children and consume C_2 of other goods. A change in the price of children or the price of other goods would change both real income (i.e., purchasing power) and the price of children relative to other goods. A problem pursued by economists is to separate the income and substitution effects on fertility.

Empirical estimation of the above model is usually based on individual cross-sectional data. So, in terms of Figure 5 we observe a couple who has the budget constraint AB and chooses the combination (C_1,N_1), and a second couple who perhaps at a different time has the budget constraint AC and chooses the bundle (C_2,N_2). This highlights an important problem: the choice points between E and F may be related to differences in references of the two couples as well as differences in incomes or prices. The "standard" model assumes that preferences are exogenous. However, some economists argue that preferences are endogenous (Easterlin et al. 1980, Pollak and Terence 1992, Pollak and Watkins 1993). The issue here is that if a model assumes fixed, exogenous preferences while they are actually endogenous, then all parameter estimates will be biased (Pollak and Watkins 1994, p. 491). For example, if education influences the taste for children, then the estimated coefficient for the educational variable would not reflect only opportunities effects (i.e. effects on fertility though the choice set, see Pollak and Watkins (1993, p. 474)) as interpreted by the new home economists. We consider extensions of this simple model in the next section. Let us turn now to non-economic approaches.

The Psychological Approach

The psychological approach is closer to the microeconomic approach than are the other non-economic theories of fertility. Psychological theories of fertility have developed only recently, since the 1970's, and owe much to microeconomics (Beckman 1978, p. 59; Crosbie 1986, p. 35). There have been several social-psychological models of fertility determination. Crosbie (1986) identifies and reviews three models offered by psychologists: the value of children theory, the subjective expected utility theory, and the theory of reasoned action. Beckman (1978) discusses a general psychological framework of fertility determination.

Psychological models of fertility determination share some fundamental assumptions with economic theory. In particular, the psychological approach emphasizes the role of individual decision-making. As Robinson and Harbison (1980, p. 216) observe: "Many psychologists argue that rational, purposeful human actions must be assumed." However, the decision may relate to either fertility intention or behaviour. This approach thus diverges from the sociological and anthropological ones, which, as discussed below, emphasize the roles of social factors such as norms and culture.

The psychological approach differs in that it takes psychological as well as economic costs and benefits of parenthood into consideration. The introduction of subjective (psychic) factors leads to methodological differences: the well-defined utility functions assumed by economic theory are discarded, and the concept of subjective utility is introduced (Beach et al. 1979, Beckman 1978, Townes et al. 1980). Questions have been raised about the usefulness of the psychological approach (Robinson and Harbison 1980, p. 212). The introduction of psychological factors make the models less suitable for studying the roles of socioeconomic variables, which are of more interest to policy makers. Furthermore, the approach is not concerned with changes in fertility at aggregate levels. Attempts have been made to model psychological factors as mediating forces between structural factors and the reproductive outcome, but little success has been reported.

The Sociological Approach

Sociologists have been interested in demographic issues for a long time. They have contributed numerous studies, especially of issues relating to the demographic transition, often by combining demographic methods and sociological ideas. However, Ford and De Jong (1970) commented that while there were many theoretical propositions by sociologists, they had not been "brought together in any single organized schema or theoretical system." The situation has changed little since then.

The emphasis of almost all sociological theories of fertility is on social factors, such as social norms and other social and cultural variables; that is the main difference between the sociological approach, on one hand, and the economic (and psychological) approach, on the other. As quoted in Robinson and Harbison (1980, p. 211), Blake (1968) argued that "economic issues are secondary to normative ones." This view, as seen below, is extreme and does not represent the contemporary views of many sociologists. Freedman (1970) extends the Davis and Blake framework (discussed above) into a more general and complex model in which intermediate variables mediate influences of numerous social and cultural variables on fertility. However, in the view of Freedman and most sociologists, social norms have a dominant role in reproductive theory (Freedman 1970, Robinson and Harbison 1980).

Sociological work often focuses on explaining variations of fertility over time or across social groups. However, while nobody rejects the roles of social and cultural factors or the need to explain fertility at the aggregate level, ignoring the determination of fertility at the individual level makes the approach incomplete. It is obvious that even within social groups whose members are socially and culturally homogeneous, there are still substantial fertility variations. That alone implies the need for more comprehensive approaches.

Ignoring individual behaviour also gives rise to a methodological problem. In the opening chapter of his radical book on social theory, Coleman (1990, p. 1) states: "A central problem in social science is that of accounting for the functioning of some kind of social system. Yet in most social research, observations are not made on the system as a whole, but on some part of it. In fact, a natural unit of observation is the individual person....This focus on individual behaviour as the thing to explain is not completely misplaced in social science. Much of contemporary social research focuses on explaining individual behaviour." Many researchers (e.g., Greenhalgh 1994, Hirschman 1994, Mason 1992, Pollak and Watkins 1993) now provide complementary, synthetic approaches to fertility determination.

The Anthropological Approach

Anthropological theories of fertility remain little known even though interest in anthropological explanations of demographic issues has been increasing since the 1970's (Handwerker 1986a, Greenhalgh 1994), largely in consequence of the findings of the well-known Princeton European Fertility Project which started in 1963 and lasted for nearly two decades (Coale and Watkins 1986). The project produced abundant and convincing evidence to challenge the famous demographic transition theory. While questioning the "multiphasic response" explanation of the demographic transition theory (i.e., that people adapt their demographic behaviour in response to modernization, see Davis (1970)) , the new findings pointed to the important role of diffusion of contraceptive technology and, in relation to that, of cultural factors (Watkins 1986). Culture, of course, is a major field of anthropological study.

In studying fertility most anthropologists emphasize the role of cultural factors (Greenhalgh 1994; Handwerker 1986a, 1986b; Robinson and Harbison 1980), although some pay attention also to the roles of history, power, and gender (Greenhalgh 1994, Mason 1987). Handwerker (1986b, p. 10), for example, claims that "Fertility transition reflects a **cultural** transition" [emphasis in original]." But the meaning of culture is itself controversial (Mason 1992, Hammel 1990). The concept was formally defined for the first time in 1871 by Edward B. Tylor as "the complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society." (Academic American Encyclopedia, 1991 ed., s.v. "Culture," by Charles Wagley) To study the determinants of fertility, such a broad concept is of little use. Anthropologists have tried to refine the concept of culture to make it more explicit (Hammel 1990), while other social researchers have simply adopted operating definitions in empirical studies (Coale and Watkins 1986). The use of a very broad concept of culture has led to some contradictions. For example, while claiming a dominant role for culture in the demographic transition, Handwerker (1986, p. 11) argues: "when used as an independent variable, culture turns out not merely as all those factors *other* than economic, political, social, religious, and psychological; *culture is not distinct from these phenomena*" [italic letters are original] In our view, application of such a theoretically complete but all-encompassing concept of culture is of little use, and hinders the task of studying fertility determination through the evaluation and estimation of the effects of various factors on fertility.

Traditionally, anthropology, like sociology, paid less attention to individual behaviour, but stressed the homogeneous patterns of behaviour among groups in a culture. In the last twenty years this has changed, and anthropologist have started to pay attention to variations in individual behaviour within a culture and to the individual decision-making process (Barlett 1980, Robinson and Harbison 1980, and Greenhalgh 1994). With this development, anthropologists now criticize social demographers who, while emphasizing the roles of culture, envision people as "mindlessly adhering to cultural rules." Contemporary anthropologists assume the co-existence of cultural influence and human agency, understood as the ability of individuals to "shape their own lives through monitoring and rationalization of a continuous flow of conduct." They, therefore, also model individuals as "conscious decision makers"; however, individuals choose fertility levels through "abstract rationality" rather than through explicit utility-maximization as proposed by economists (Greenhalgh 1994, p. 23).

We draw two main conclusions from the discussion so far. First, theories of fertility produced within the framework of a single discipline can hardly be complete. These "partial" theories focus on only sub-sets of numerous explanatory variables or examine only certain aspects of a complex system of socioeconomic relations. Second, although it is very difficult to establish a single integrated theory of fertility determination, if that can be done at all, a broad and synthetic approach to the problem is likely to be more fruitful.[3] Note how social and cultural factors could be incorporated into the microeconomic model depicted in Figure 5. If, for example, a culture dictates that couples should have at least K children, then the choice set (perhaps before and after the introduction of a child tax benefit) will be restricted to the shaded areas of the triangles HKB and GKC. In either case the utility maximizing agent depicted will choose to have K children; the introduction of a child benefit allowance would not affect fertility in this case.

In studying fertility some researchers emphasize the role of the supply of births, while others focus exclusively on demand. Still others prefer complementary explanations. We turn now to examine theories of fertility from this vantage point.

Demand, Supply, and Combined Demand/Supply Theories of Fertility

Disagreements among scientists about the roles of factors which affect the demand for children and of those which influence the supply of children are striking. (Following Simmons (1985), we will use the terms "demand side" factors and "supply side" factors; this should not be confused with other use of the same terminology in economics.) Berelson (1975) provides an excellent review of the widely differing implications of different approaches for policy. Since the controversy has been largely unresolved, policy makers are left in a quandary.

The demand theories assume that children are born because they are wanted (i.e., "demanded") by their parents. The new home economics approach to fertility, for example, presents a sophisticated demand-for-children model according to which couples choose the quantity and quality of children so as to maximize utility, taking into account their income and time constraints, the prices of goods, the wage rates, and the costs and benefits of children (Becker 1960, 1991). While the demand approach is often associated with microeconomic theories of fertility (Olsen 1994), the three social-psychological models discussed above also adopt the demand view. The differences among demand theories, as pointed out before, are in the ways in which demand is formed. The supply theories emphasize the role of supply side factors, an approach often adopted by demographers with a sociological perspective. Since intermediate variables are almost always part of the story, and are used to argue for effects on fertility of various social factors, the Davis and Blake (1956) framework and Bongaarts' (1978) revised version of it suit this approach. (By assuming perfect fertility control and leaving out the biological constraints, the demand models often neglect the relationships between intermediate variables and fertility (Becker 1960, T.P. Schultz 1976)). The family-planning-gap view (Robey et al. 1993) is an example of the supply approach.

One test, due to Pritchett (1994), compares the explanatory power of the supply and demand approaches by examining the relationships between actual fertility and fertility preferences. The greater the gap between desired and actual fertility, the less perfect is fertility control and hence the larger the role of supply factors in determining actual fertility. At an aggregate level, the total fertility rate is a measure of realized fertility. To quantify fertility preferences, three measures have been proposed: the average ideal number of children (AINC), the desired total fertility rate (DTFR), and the wanted total fertility rate (WTFR). There is potential for terminological confusion because the differences among the three measures are of a technical nature and all three are measures of desired fertility (see Pritchett 1994, note 4, p. 46). The first measure of fertility preferences, AINC, is based entirely on women's answers to a question about desired fertility. That is, it is the simple average of desired family sizes, as reported. This measure has several problems and is considered the least accurate of the three. In particular, it is sensitive to age composition of the sample. Also, some factors lead women to understate their desired fertility, while others cause an overstatement. For example, ex post rationalization of fertility preferences may cause desired fertility to be overstated, while government campaigns relating to family size may have it understated (see Bongaarts 1990 and Pritchett 1994, p. 8 for other sources of bias).

The other measures are designed to overcome such limitations by adjusting reported fertility preferences, taking into account the actual number of births. Both measures first deduct, for each woman in the sample, those births that are "not wanted" and then apply conventional procedures to calculate the total fertility rate (with some further adjustments for minor issues). The main difference between the two measures is the way in which they distinguish wanted births from unwanted ones. The DTFR measure relies on women's responses to the question about the desired family size to identify unwanted births: if a woman reports three children as her desired family size but she has already had five children, then the fourth and fifth children are not wanted and would be deleted for the calculation purposes (Pritchett 1994, Westoff 1991).

Instead of using the desired number of children, the WTFR measure (Bongaarts 1990) uses information about a woman's preferences for a birth in the future to identify wanted births. More specifically, if a woman wants another birth then previous births are wanted also. This helps to identify only a portion of the wanted total fertility rate, which Bongaarts called the "want-more total fertility". Some adjustments then follow to account for the wanted births to women who say "want no more" in order to derive the overall wanted total fertility rate. The ratio of WTFR to TFR reflects the relative magnitude of wanted fertility. A closely related indicator is the proportion of all births that are wanted. It is worth noting that this proportion is not independent of the sample age distribution and tends to be somewhat larger than the ratio of WTFR to TFR. The estimates obtained by Bongaarts confirm this, although the differences are small (see Bongaarts 1990, pp. 498-99).

Bongaarts (1990) calculated TFR, WTFR, the ratio of WTFR to TFR, and the proportion of all births that are wanted using 35 World Fertility Surveys and 13 Demographic and Health Surveys. On average the total wanted fertility rate is 26% lower than the TFR and the proportion of unwanted births among all the births is 22%. He concluded that "a substantial portion of births is unwanted." We note that unwanted births are not an issue for the developing world alone: even in the U.S. "27 per cent of the couples reported that they had experienced one or more unwanted children by 1975" (Rosenzweig and T. P. Schultz 1985, p. 1013).

Pritchett (1994) assembled estimates of the total fertility rate, the above three measures of desired fertility, and the proportion of wanted births for 75 national surveys conducted in 55 countries. (A few countries had more than one survey.) Table 13 summarizes selected information for 47 national surveys in 39 countries. (28 surveys for which relevant measures are not available are excluded; for detailed national measures, see Pritchett 1994, the Appendix, p. 43-45.)

The numbers should be treated with caution because of the well-known problems with the simple arithmetic mean. Nonetheless, the evidence of unwanted births is clear: in 30 of 47 national surveys the ratio of WTFR to TFR is less than 80%. Furthermore, without the family planning programs that have been in effect, unwanted fertility would have been much higher. This evidence appears to support the "supply side" approach to fertility. However, it is not sufficient to reject the "demand side" alone approach: if demand side factors had no effect, we would expect that nations with high ratios of wanted to total fertility and better fertility control would have lower fertility. But TFR and desired fertility are positively correlated. Note that this is true regardless of which measure is used to represent fertility preferences. The positive correlation between realized fertility and fertility preferences is used by Pritchett (1994) to defend the demand view.

Bongaarts (1993), Easterlin (1978), Rosenzweig and T.P. Schultz (1985), and Turchi (1975a) have called for a compromise approach which pays attention to both the supply and demand sides. Some major economic models using such an approach will be discussed in the next section, but we note also that some

Table 13: Actual and Desired Total Fertility Rates

Ratio of WTFR to TFR (%)	Number of national surveys	Simple average of national measures of			
		TFR (births)	AINC (births)	DTFR (births)	PWB (%)
<60	4	4.6	3.5	3.0	59.7
60 - 70	15	4.8	3.6	3.6	70.9
70 - 80	11	4.7	4.4	4.0	75.8
80 - 90	11	5.1	5.1	4.5	87.6
90 - 100	6	6.0	6.5	5.8	92.3
Total	47	5.0	4.5	4.1	77.7

Source: Author's recalculation based on Pritchett (1994, Appendix, pp. 43-45)
Note: TFR is total fertility rate; AINC is average ideal number of children; DTFR is desired total fertility rate; WTFR is wanted total fertility rate; PWB is proportion of wanted births among all births.

proponents of cultural theories of fertility have included not just supply factors but also demand ones (Caldwell 1982; Handwerker 1986a, 1986b; Mason 1992).

To close this section we cite a concluding remark from Mason's recent paper reviewing theories of fertility decline:

> It is time to stop fighting about an either-or scenario and to recognize that there is likely to be a complex interplay among several factors involved in any fertility decline -- with a different mix involved in each decline."
> (Mason 1994, p. 12)

Our discussion not only leads to the same conclusion but also makes that conclusion valid for fertility theories other than the theories of fertility decline, that is, for all theories of fertility determination.

3.2 Microeconomic and Related Theories of Fertility

We now focus our discussion on what are often called *microeconomic* theories of fertility (see, for example, Crosbie 1986, Simmons 1985, Zhang 1990), even though this use of the term may be somewhat misleading, given the hybrid nature of some of the models to which it refers.

There are many models of fertility determination which rely in one way or another on microeconomic theory. Hence the classification of these theories is important for our discussion. Classification of microeconomic and related theories vary with authors, often due to the level of aggregation; see, for example, Burch (1980), Fulop (1977), Gulati (1988) Simmons (1985), Zhang (1990). We find Simmons' (1985) scheme to be helpful. He divides the theories into three groups. The first includes the new home economics models of fertility determination, which emphasize the demand for children and focus on the economic aspect of that demand. The second group is the social-determinants school which adopts a broader framework including both supply and demand side factors, and brings social as well as economic variables into consideration. The third group includes all other (and less popular) microeconomic-oriented models of fertility. We focus discussion on the first two; a review of the excluded models can be found in

Simmons (1985).

3.2.1 The New Home Economics Approach to Fertility

The new home economics approach to fertility has also been called the Chicago model (Zhang 1990), the Chicago-Columbia approach (Easterlin et al. 1980, Leibenstein 1975), and Chicago-NBER theories (Turchi 1975b). The approach has its origins in the work of Becker and his colleagues working at Columbia University, the University of Chicago, and the National Bureau of Economic Research.[4] Some associate the beginnings of the new home economics with the frequently cited papers by Becker (1965) and Mincer (1963), which emphasize the role of household production and incorporate it in the microeconomic model of decision-making. However, certain radical ideas on fertility which are now considered part of the new home economics approach -- a microeconomic model of the demand for children and the introduction of the concepts of quality and quantity of children -- were established earlier in Becker (1960). Perhaps it was this fact that prompted Gulati (1988) to distinguish "Becker's theory of fertility", by which he meant Becker's (1960) model, from the "new home economics theory of fertility", by which he meant the household production model of fertility. However, this distinction may cause confusion because Becker's full-fledged theory of fertility incorporates both the quality/quantity of children concept and household production (Becker 1991). In our discussion below the new home economics approach to fertility includes the theory of the demand for quality and quantity of children. We outline the development of this approach before commenting on its strengths and weaknesses.

Becker was not the first person to apply microeconomic theory to fertility behaviour. Leibenstein (1957) used such reasoning to explain changes in fertility when there is a persistent increase in income per capita. However, Leibenstein's model diverges significantly from standard economic theory, and it was not until Becker's first paper on fertility that such theory was applied to the field of human reproduction.

The following statement is a good summary of Becker's approach.

> "I will try to show that the theory of the demand for consumer durables is a useful framework in analyzing demand for children" (Becker 1960, p. 211)

Becker argued that, in the sense that children were a source of satisfaction to their parents, they could be regarded as a consumption good. Further, he suggested that children were like durable goods because they might generate income and because their costs and benefits varied with age. With these fundamental assumptions, standard microeconomic theory can be applied to model fertility behaviour with only minimum modifications. In section 3.2 we presented an elementary model of the new home economics theory of fertility. In that simple model parents choose a fertility level and a bundle of other goods so as to maximize utility, given their income constraint, the prices of goods, and the price of children. (The price of children is their rearing costs net of such benefits as children's labour income; the opportunity costs of parents' time was not introduced in the 1960 paper).

By treating children as a (normal) consumption good, the theory predicts that fertility is positively related to income and negatively to the price (cost) of children. However, this implication is challenged by the common observation that high income people often have fewer children than low income people, and rich countries have lower fertility than poor ones. Becker argued that the income elasticity of the demand for children was positive and offered two main explanations for the observed negative relationship between income and fertility. His first explanation was that low income people had poorer knowledge of and access to contraception, so that their high fertility did not mean a higher demand for children but instead an uncontrolled supply of births. Becker pointed out that in the absence of effective contraception, due to limited knowledge or taboos against its implementation, "chance would bulk large in determining the distribution of births...(and)... actual fertility may diverge significantly from desired fertility." (Becker 1960, pp. 210 and 231) This shows clearly that Becker, while emphasizing the demand for children, did not reject the role of the supply of births in actual fertility. A relevant question, then, is whether this separation is legitimate. We discuss this problem later.

Becker's second explanation is more innovative and controversial. The argument relies on the introduction of the concepts of quality and quantity of children, which play an important part in Becker's theory of fertility. Becker argues that the demand for children consists of the demand for quantity and for quality and that, to some degree, the quantity and the quality of children are substitutes. This early model of fertility by Becker can be presented as follows.

$$\text{Maximize} \quad U = u(N, Q, Z) \qquad (1)$$

$$\text{Subject to} \quad P_N N + N_Q Q + P_Z Z = I \qquad (2)$$

where N, Q, Z represent the number (quantity) of children, the quality of children, and a composite of other goods, respectively; I is money income and P's indicate the prices of the factors indexed. Becker postulates that both the quantity and quality income elasticities of demand for children are positive, but that the quality income elasticity is "relatively large." This provides an alternative to Leibenstein's explanation of the negative income-fertility relationship, which says that since rich people are obligated by social pressure to spend more on children than do poor people, their cost of children (or the disutility of children, in Leibenstein's language) was high, and hence they are better off choosing to have fewer of them. (Leibenstein's theory is discussed further in the next section.) Becker, however, argued that while high income people had a higher demand for children's services, that demand could be more effectively fulfilled by spending more on each child in order to increase child quality.

In the same paper Becker mentioned potential interactions between the quality and the quantity of children. That view was elaborated in later work with Lewis (Becker and Lewis, 1963). This model of the interaction between the quality and the quantity of children differs from Becker's (1960) model in its budget constraint. The model is

$$\text{Maximize} \quad U = u(N, Q, Z) \qquad (3)$$

$$\text{Subject to} \quad P_{Q|N} NQ + P_Z Z = I \qquad (4)$$

where $P_{Q|N}$ is the price of a unit of the quantity of children given the child quality, and the other notation is as before. With this specification of the budget constraint, it turns out that the shadow price of the quantity of children (π_N) depends positively on the quality of children (Q), and the shadow price of the quality of children (π_Q) depends positively on the quantity of children (N). The budget constraint is therefore a non-linear function of N and Q. An important implication of this model is the prediction that a once-and-for-all change in the shadow price of either the quantity or the quality of children would cause a series of long lasting effects on the demand for both. For example, an increase in the shadow price of quality will first reduce the demand for quality itself. But the resulting reduction in quality will cause a decline in the shadow price of quantity which, in turn, will negatively affect the demand for quantity, and so on. Hence the cumulative effect of a program that affects fertility may be much larger than its initial effect.

Mincer (1963) and Becker (1965) established important ground work for further development of the new home economics theory of fertility and, more generally, of microeconomic theory, leading to a number of studies that emphasized the roles of human capital, household production, and the opportunity costs of time. In turn, these concepts were applied to model fertility behaviour, as extensions to Becker's first model, but the quality of children was often left out to avoid complication. The basic resulting model can be compared to Becker's (1960) model as follows:

i) The utility function is

$$U = u(N,Z) \qquad (5)$$

where N and Z are defined as before except that to become consumable they must be produced by household production, specified by functions n(.) and z(.); the inputs into these production functions are purchased market goods and the time of household members.

(ii) As with other household production models, the budget constraint must include the time resource. This is because a household's time can be used as an input in household production to generate final output. A "full" budget constraint thus replaces the conventional one, and is defined as

$$wT + Y = P_N N + P_Z Z \qquad (6)$$

where w is the wage rate, T the total time resource, Y non-labour income, and (wT +Y) "full income".

The basic ideas discussed above have been greatly extended and elaborated by Ben-Porath (1974), De Tray (1974), T. P. Schultz (1976), Willis (1973, 1974), and Becker (1991), among others. Although many aspects of these studies are interesting, the major criticisms have concentrated on the fundamental issues already summarized. We, therefore, will not go into the details of them. Let us now turn to comment on the basic theory itself.

The new home economics approach to fertility has faced many criticisms by both non-economists and economists. The most important arguments can be summarized as follows.

First, some scholars questioned whether it was legitimate to adopt the microeconomic approach to reproductive behaviour at all. As seen in section 3.1, researchers with an extreme sociological view argued that fertility behaviour was shaped and influenced more by psychological and social forces than by economic factors. In his comment on Willis's (1974) paper, which well represents the new home economics approach, Ryder (1974) argued that Willis built his model by "systematically destroying the idea of a family." Certainly, other microeconomic theories of fertility also face this criticism, but the direct application of microeconomic theory to fertility behaviour by the new home economics approach made it the first target. These criticisms seem too extreme. As we saw in the last section, there has been recent attention paid to individual rational behaviour by researchers other than economists.

Second, others who did not reject the application of economic theory disapproved of the "pure" demand framework (Easterlin 1978, Easterlin et al. 1980, Leibenstein 1981, Turchi 1975a, 1975b). As noted above, the evidence of significant levels of unwanted births was clear and Becker recognized it; others also acknowledged the influence of the supply of births on actual fertility (T. P. Schultz 1976, Rosenzweig and T. P. Schultz 1985). However, the first problem of the "pure" demand approach is that it leaves a significant part of fertility variation unexplained. But more seriously, ignoring the supply of births may cause bias in empirical estimation of the elasticities of demand, even though the theory itself can be defended by imposing appropriate assumptions. Thus while defending his postulate of a positive income elasticity of demand for children, Becker explained that the observed negative relationship might be caused by an influence of income on contraception. To control for the effect of income on the supply of births through the access to contraception, Becker selected data for populations which could control the supply of births. In empirical studies, researchers often do not have that option.

Third, there are many scholars who argue that the theory ignored the normative side of the demand for children. Caldwell (1982), Duesenberry (1960), Easterlin (1978), Easterlin et al. (1980), Leibenstein (1974, 1981), Okun (1960), Ryder (1974), and Turchi (1975a, 1975b) were among many who thought that psychological, social, and even biological factors were important. They argued that such factors could limit the choice set of individuals, could influence reproductive attitude, and could even affect the costs of producing a birth. (For the cost effect of social and biological factors, see Turchi's model discussed below.) Others strongly attacked the new home economics assumption of exogenous preferences in modelling fertility behaviour (Easterlin et al. 1980, Pollak and Watkins 1993). They argued that such an assumption leaves the theory incomplete and cause bias in empirical estimation.

Fourth, the assumption of the substitutability of the quality and quantity of children was questioned. It has been argued that the quality of children is determined mainly by the social status of parents (Leibenstein 1957, 1974), social pressure, morality and family obligations (Duesenberry 1960, Caldwell 1982). Furthermore, it has been noted that the definition of quality of children is ambiguous and its measurement difficult, and that treatment of the quality of children as an output of household production is not possible without measurement (Polak and Watcher 1973, Turchi 1975b). Others also questioned the testability of the quality/quantity of children theory.

Fifth, the new home economics interpretation of the opportunity cost of a mother's time has also been criticized. Leibenstein (1974, pp. 4-5) argues that the time cost of children is not the value of the mother's time as measured by her potential wage. Instead, the appropriate measure is the substitute child care costs of family members or servants, and the prices or costs of these people are the same for high and low income groups. He also points to the possibly small reproductive effect of the opportunity cost of women's time in societies where the use of their time is highly culture bound.

Sixth, a well-recognized weakness of the theory is its static nature. Children, however, are "produced" in sequence. This feature, in combination with the uncertainty of the sex and survival of children, and the existence of sex preferences, makes fertility decision-making a dynamic process (Namboodiri 1983). However, traditional new home economics models assume that parents make once-and-for-all decisions. Recent work has tried to address this limitation (Heckman and Walker 1991). The theory has also been criticized for it "sexless" treatment of fertility decision-making, that is, it ignores the husband/wife interaction in making fertility decisions.

Finally, many hypothetical results of the theory have not been supported with reliable empirical evidence. T. W. Schultz (1974) concluded that its findings remained analytical and should not be used for deriving policy implications. In addition, the theory, with its narrow framework, has difficulty in explaining the recent rapid declines in fertility rates in developing countries where economic conditions have hardly changed (Freedman 1995).

Even with these limitations, the new home economics theory of fertility represents a great contribution to the fertility literature. No theory is without limitations, and the new home economists started and promoted a movement of radical studies of human reproductive behaviour. That alone is a very important contribution. Even more important is that it has laid stepping stones for others to travel forward.

3.2.2 The Social-Determinants School

The discussion in section 3.1 and the criticisms of the new home economics theory clearly indicate the weakness of too narrow a framework. But an important question is whether broader frameworks have more benefits than costs. Those who favour a broader approach to fertility determination consistently say yes:

> "It should be stressed that there is nothing in the theory of consumer behaviour which excludes the insight of other disciplines such as sociology or psychology. Indeed, I suspect rather strongly that the direct transfer of consumer theory to fertility analysis will prove to be totally inappropriate." (Turchi, 1975a, p. 121)

> "It seems reasonable to suppose that a model which

> integrates approaches of both sociologists and economists might clarify their relationship and help foster beneficial exchanges between scholars in the two disciplines. It might also have wider empirical applicability than either approach taken alone." (Easterlin, 1978, p. 59)

> "If economists stick to economics and sociologists stick to sociology, then neither will do very well in theorizing about phenomena in which both economic and social factors play significant roles. Put somewhat differently, economists bring to any problem sharply honed modelling skills that can be used to build models capturing some aspects of social reality. These skills, however, tell us little about which aspects of social reality are most important to model." (Pollak and Watkins 1993, p.491)

Within this approach, Leibenstein, Easterlin, and Turchi are prominent. (Other researchers who have adopted broader frameworks have emphasized the empirical aspect; see Simmons 1985.) Although they agree on the need for a broader model of fertility determination, their models differ considerably. We review the three models in turn. To make our discussion concise, we focus on how social factors were introduced and modelled, and leave out familiar economic elements.

Leibenstein's Theory

Leibenstein offered two models of fertility. His first, which constitutes part of his 1957 book, is a micro/macro linked model. In it, he was concerned to explain fertility in the context of a persistent increase in income per capita. Briefly, his argument runs as follow. (1) Fertility decisions, like other decisions, are made at the margin. Think of a "fixed" demand function for children with the marginal children as **n-1** and **n**. (2) Individuals make rational decisions by comparing the sum of utilities and that of disutilities of marginal children, that is of the **n-1**th child and **n**th child. (3) Utility of a child consists of consumption utility (in a sense that the child is wanted for itself rather than for material benefits it provides), work or income (from children) utility, and security utility; disutility comes from direct and indirect costs. (4) It is assumed that consumption utility is independent of income but the other types of utility (work/income and security utility) decrease with income. Hence, the overall utility associated with the marginal children presumably declines as income increases. The author accepted that things were not so clear for disutility but assumed that it did not decline with income. (5) At each income level utility was assumed to be higher for the **n-1**th child than for the **n**th child, *but the reverse was assumed for disutility.* (6) The observed negative income-fertility relationship can then be explained if an increase in income makes the total disutility of the **n**th child higher than its total utility. Parents would then rationally choose to have **n-1**, not **n**, children. Figure 6 reproduces his graphic illustration.

In this model, by introducing the concept of disutility, Leibenstein made his arguments diverge considerably from standard microeconomic theory. Furthermore, he himself acknowledged that "it is somewhat more difficult to say anything clear-cut about the disutility." (Leibenstein, 1974, p. 460) In addition, the model does not predict or postulate the sign of the income-fertility relationship, but only explains it after the fact.

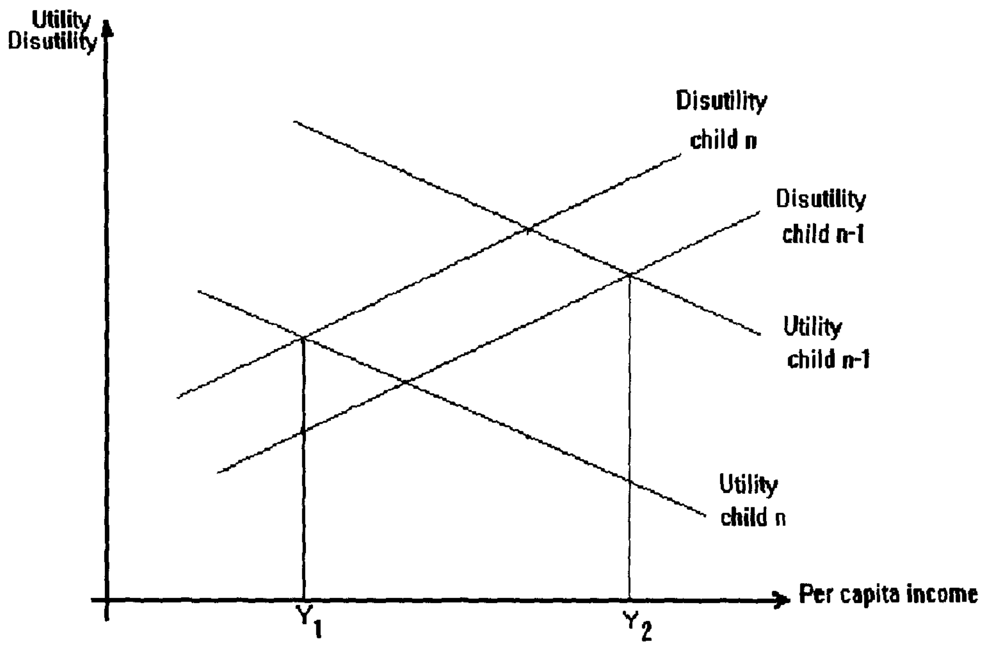

Figure 6. Leibenstein's micro/macro linked model of fertility

Source: Leibenstein (1974, p. 461).

Leibenstein's later model (Leibenstein, 1974) is also microeconomics oriented but once again diverges considerably from standard microeconomic theory. He assumes the existence of increasing marginal utility (IMU) of consumption (expenditure) for some segment of consumption and also introduces a new concept of Social Influence Groups (SIG) which plays a central role in his theory. His argument goes though seven steps, but can be reorganized into three, as follows. First, population is divided into socio-cultural groups; these groups are called

Social Influence Groups to emphasize their influence on group members, especially on members' target family size and living standard. Second, commitments of individuals to family members or outsiders are associated with the group's standards and targets. Thus, if a group's standards and targets are higher, so are the committed targets made by the group's members to their family members. Third, the introduction of the increasing marginal utility of expenditure (IMUE) then explains why a higher SIG would have fewer children than a lower SIG.

Although Leibenstein tried to model social influences on fertility, his approach has faced strong criticism. The theory was attacked for its ad hoc assumptions which make generalization difficult. In addition, since the theory was not formulated in a specific and testable form, it is not very useful for empirical study. Also, the assumptions and concepts are so general that their interpretation is uncertain; even the central concept of the SIG is not explicitly defined. Finally, the theory is weak in its predictive power with no clearly postulated relationships. For example, concerning the income-fertility relationship, he stated: "It is impossible to deduce that children should necessarily be fewer as income grows." (Leibenstein 1974, p. 460)

Easterlin's Theory

Easterlin has provided us with two theories. The first is often referred to as the relative income hypothesis while the second is based on a synthetic micro framework of fertility determination. Like Leibenstein, Easterlin sought a broader model of fertility determination. However, Easterlin's models, especially the second one, are more formal and closer to standard microeconomic theory.

The Relative Income Hypothesis

Easterlin established and developed his relative income hypothesis in a series of publications (Easterlin 1966, 1968, 1969) prompted by the major swings in U.S. fertility since the middle of the 20th century. His model, which links human psychology with the socioeconomic environment, can be summarized as follows. First, the living environment of an individual during his/her childhood significantly influences his/her expectations about the future. Second, the relative size of each cohort or generation (compared to other generations) significantly affects the earnings opportunities of its members: the smaller the relative size the more favourable its opportunities. Third, individual actions depend on how closely expectations are realized. Since members of small cohorts tend to experience living conditions that are better than they had expected, they tend to be more optimistic and hence to marry earlier and have more children. The reverse applies to large cohorts. The theory thus predicts long run swings in fertility.

The formulation of the hypothesis makes empirical testing difficult. Some have suggested that the hypothesis fits the U.S. data, but that evidence from other countries gives little support (see Wright 1989). Even in the U.S. context the absence of a recent upswing in fertility as predicted by the hypothesis is another objection to it. However, Butz and Ward (1979) offered a different explanation to the movements of fertility in the U.S. and other industrial countries based on new home economics, attributing fertility movements largely to changes in women's earnings opportunities.

Easterlin's second model of fertility determination (Easterlin 1975, 1978; Easterlin and Crimins 1985; Easterlin et al. 1980) has more explicit microeconomic foundations. Easterlin's treatment of the demand for children is much simpler than that of the new home economics and, unlike the new home economics approach, the supply of births is explicitly included. Easterlin takes the framework of Davis and Blake (1956) as his starting point. His diagram (Easterlin 1985, p. 13) is reproduced in Figure 7. The diagram was constructed to emphasize that any

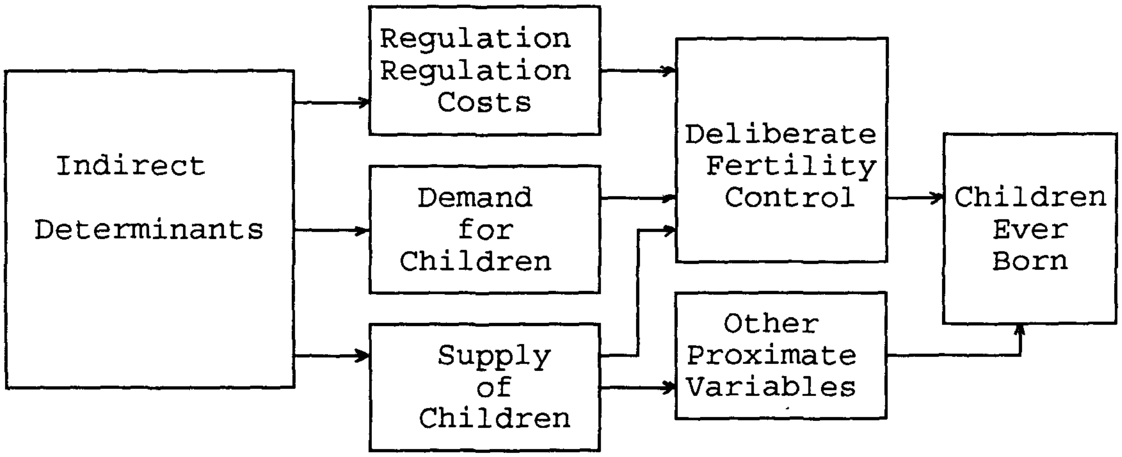

Figure 7. Easterlin's supply/demand combined model of fertility
Source: Easterlin (1985, p.13).

influence from social or economic variables must be channelled through at least one of: the demand for children, the supply of children, and the costs of fertility control.

The formulation of the model can be summarized by the following basic equations (for details see Easterlin 1978, pp. 79-98).

$$\text{Maximize} \quad U = u(\alpha Z, N) \qquad 0<\alpha<1 \qquad (7)$$

$$\text{Subject to } I = P_Z Z + P_N N + P_R(sF - N) + \Phi \qquad (8)$$

where α is a summary measure reflecting the disutility of fertility regulation, Z consumption goods, N the number of children surviving into adulthood, P_R the cost of fertility regulation per child averted, s the probability of a live birth's survival to adulthood, F the natural fertility, and Φ the fixed cost of fertility regulation.

The introduction of the supply of births and regulation costs into the decision-making problem is shown in the presence of α in the utility function (equation 7) and the budget constraint (equation 8). Assume, for example, that two couples are identical except for their fecundity. Since it would be more costly for the more fecund couple to limit its fertility to the same realized level, more fecund couples would tend to have more children. Easterlin and Crimmins (1985) offered a method to estimate individual natural fertility using information from World Fertility Surveys, but due to the limited information, the accuracy of such a crude method is clearly limited.

In Easterlin's view, tastes are important in explaining fertility differences. Since tastes are not easy to measure, he formulated tastes as a function of such social and cultural factors as religion, colour, place of residence, education, and family background (Easterlin 1978, p. 67). (As we see below, an alternative approach assumes that these factors influence fertility by affecting the costs of children, not tastes.) In later work with Pollak and Wachter (Easterlin at al. 1980), the above framework was extended to introduce endogenous preferences and to include a household production function.

A major advantage of Easterlin's model is its inclusion of the supply of births and the costs of fertility regulation. This and the author's emphasis on a broader set of social and economic determinants of fertility make the model more defensible and more attractive to researchers working on developing countries. A limitation of the model is its lack of specificity in the formulation of the demand for children. Consequently, the model provides few testable relationships.

Turchi's Model

Turchi's model (Turchi 1975a, 1975b) is less well-known than those discussed above. This is perhaps due to two reasons. First, his work is concerned mainly to reformulate and improve earlier approaches. Second, it was focused particularly on the context of the U.S., and hence is less applicable to the developing world. However, his model has certain attractions, as noted below.

Turchi, like other authors of the social-determinants school, tried to incorporate normative aspects of reproductive behaviour into the standard microeconomic framework. He relied on the new home economics for an extension in that direction. The basic formulation of his model is presented in equations (9)-(13) below.

i) Utility function:

$$U = u(N, Z) \qquad (9)$$

where N is the number of children, Z is the present value of the couple's resources that are spent in activities other than child rearing (or, simply, consumption goods).

It is assumed that the couple behaves rationally in order to maximize this joint utility function subject to the conditions specified in equations (10)-(13).

ii) The production function of births in implicit form:

$$g^{\alpha}(Z, X, T_N) = 0 \qquad (10)$$

where α is a vector of parameters indexing biological, psychological, and other normative factors, X a vector of market goods used in child rearing, Z a vector of goods consumed by the parents, and T_N the time input needed for child rearing.

iii) The (total) cost function of births:

$$C = P_X X + wT_N \qquad (11)$$

where C is the total cost of rearing children, P_X is a vector of prices of goods and services that are represented by X, and w is the wage rate. The couple minimizes the cost of producing a given number of children subject to the production function.

iv) The market budget constraint:

$$N(P_X X) + P_Z Z = V + wT_L \qquad (12)$$

where P_Z is a vector of prices of goods and services that are represented by Z, V is non-labour income, and T_L is the time spent in labour market activities, and $(P_X X)$ is a scalar representing the monetary cost of a child.

v) The time constraint:

$$T_N + T_L + T_O = T \qquad (13)$$

where T_N, T_L, and T_O are time spent rearing children, working, and in other activities, respectively; T is the total time resource. (12) and (13) can easily be combined into an overall (full) budget constraint (by using (13) to substitute for T_L in (12) and rearranging the resulting equation).

The five equations taken together say that a couple tries to maximize its utility while taking into account its own birth production function, the wage rate, markets prices, and time resources. With specific forms assigned to the utility function and the birth production function, explicit relationships can be derived.

Turchi's model is essentially a variant of the new home economics framework. This is clearly expressed in the author's emphasis on household production of births and the assumption of perfect birth control. Note how normative factors enter the model. Turchi argued that "normative influences play an important role in influencing the cost of child rearing, and thereby have a powerful indirect effect on the demand for children." (Turchi 1975a, p. 14) In the above formulation, normative variables affect productivity in the production of births. A couple's efficiency in birth production, in turn, affects the cost (or price) of the "output of births," which then influences the demand for children. Hence, this model also suggests that biological, psychological, and other normative factors should be included as explanatory variables. However, Turchi's explanation of their influence differs from that of Easterlin. For Easterlin, psychological and other social variables affect the demand for children by influencing tastes, and not through costs. In our view the two channels of influence are rarely if ever distinguishable in practice. For example, an increase in respect for education may press couples to spend more on children's education, but it is not clear whether the cost of children or preferences of parents is influenced by this social pressure; perhaps both are affected. Also, for Easterlin, biological factors affect the supply of births, which is modelled in parallel to the demand. Turchi's model is basically demand-determined; biological and social factors influence fertility only through the demand side.

Turchi's model was built specifically to study reproductive behaviour in the U.S. He defended the assumption of perfect fertility control, by arguing that "family limitation is almost universally practiced and approved." He also argued that there has been "an impressive decline in the rate of unwanted fertility among all groups of the population," but gave no measure of this decline. The evidence given above suggests that the magnitude of unwanted births in the U.S. was still considerable when he wrote. The assumption of perfect control of fertility is clearly less plausible for developing countries. In this respect, Easterlin's model is more credible.

Apart from limitations discussed above, the social-determinants approach has other weaknesses in common with the new home economics approach. (1) It works with basically static models and ignores the sequential nature of fertility decision-making. (2) Uncertainty of the sex and survival of children are not dealt with in these models (except for a simple incorporation of child mortality in Easterlin's framework). (3) The measurement of certain variables is either very difficult or impossible, and this impedes empirical testing.

3.3 Concluding Remarks

The discussion in this chapter provides important guidelines for the study of fertility behaviour. The most important lesson drawn from the discussion is the need to avoid too narrow a view when modelling fertility behaviour or when interpreting empirical results. In particular, preferences and the supply of births should not be neglected.

Regarding the matter of modelling preferences, the following conclusion by Pollak and Watkins is supported by our discussion:

> "Because estimation presupposes a correctly specified model, empirical investigators cannot ignore preference changes. If an investigator assumes fixed preferences when in fact they are changing, then all the coefficient estimates, even those of the narrowly specified economic variables, are inconsistent. Thus if preference change is taking place, economists cannot ignore it unless they are prepared to abandon empirical analysis and reconstitute economics as a purely deductive enterprise." (Pollak and Watkins 1993, p. 491)

Regarding the role of the supply of births in fertility behaviour, few would disagree that fertility is influenced by many factors including supply factors. The new home economics theory, which adopts a partial framework, focuses exclusively on the demand for children. That approach is defensible, and indeed, partial models are especially useful for deriving hypothetical relationships. However, partial models do not seem appropriate for most empirical studies, especially in the field of human reproduction. Correlations among independent variables and the interactive nature of social and economic relationships can lead to large estimation bias, and this may result in misleading interpretations of statistical results. Another consequence of the partial approach is that it leaves a significant part of fertility variation unexplained.

It is, therefore, quite convincing to argue that broader models of fertility determination are more appropriate, especially for empirical estimation. Even more convincing is the fact that some prominent advocates of the new home economics theory of fertility have recently endorsed a broader approach. Rosenzweig and T. P. Schultz in a recent study adopted a model in which exogenous variation in the household supply of births affected fertility behaviour and the allocation of time. They stated

> "Fertility within a household is determined by the dynamic interaction between its supply of and demand for births, and variations in births across households reflect exogenous intercouple variation in both the supply of births and prices, income, and preferences for children, or demand." (Rosenzweig and T. P. Schultz 1985, p. 993)

As is well known, T. P. Schultz has been a prominent advocate of the new home economics theory of fertility. Although the new home economists have not allowed endogenous preferences in their fertility models, as Pollak and Watkins (1993, p. 479) point out, Becker and his colleagues have recently recognized the importance of the preference formation and have introduced endogenous preferences for some types of consumption. Those facts and the discussion in this chapter have a clear message for the construction of an appropriate empirical framework.

Chapter 4 DATA

The available data inevitably limit any empirical analysis. In particular, when regression is a main tool of analysis, as in this study, the specification of equations to be estimated cannot go beyond what is feasible with the available information. For this reason, data are discussed before we deal with modelling in the next chapter. As mentioned earlier, the data used for our empirical study are from the *1988 Vietnam Demographic and Health Survey* (VNDHS-88). Our description of the survey is brief; detailed information about the survey can be found in VNDHS-88 (1990). However, we think it helpful to report in detail the problems that we encountered in dealing with this data set as well as the solutions that were adopted.

4.1 The 1988 Vietnam Demographic and Health Survey

The *1988 Vietnam Demographic and Health Survey* was conducted in May-June 1988 by the National Committee for Population and Family Planning of Vietnam (NCPFP). The survey was supported financially by the United Nations Population Fund (UNFPA). The Population Division of the United Nations Economic and Social Commission for Asia and Pacific (ESCAP) provided technical assistance. In carrying out this survey, NCPFP collaborated closely with four

Vietnamese national organizations: the Institute of Computer Sciences, the Committee for Protection of Mothers and Newborns, the Institute of Sociology, and the Institute of Statistical Sciences. The survey was the first nationwide demographic survey in Vietnam.

The VNDHS-88 was not a part of the Demographic and Health Survey Program of the Institute for Resource Development (based in the U.S.A.). However, NCPFP acknowledged that in carrying out this survey it relied on that Institute's documentation and experience in order to make the survey comparable with other Demographic and Health Surveys (DHS's) in the world. As explained below, though, fewer questions were asked in the VNDHS-88 than in the standard DHS questionnaire.

The survey was designed to assess knowledge and use of contraception and to provide basic demographic and health information. Such information is important for evaluating and planning population policy in Vietnam. We noted above that the Vietnamese government had implemented family planning programs in the North as early as the 1960's, and has long considered population control a national strategic task. However, it has done so without information about many practical issues.

The VNDHS-88, as other DHS's, used two types of observational units -- households and eligible women -- those between the ages of 15 and 49 who were ever-married or currently living with a partner. (Cohabitation without marriage is still very rare in Vietnam.) Separate questionnaires were applied to each type of unit. As with other DHS's, the VNDHS-88 focused on ever-married women in the child-bearing ages. Only a few questions related to the household.

A three-stage sampling procedure was applied to select households and eligible women. It was designed so that every eligible woman living outside of the provinces of Hanoi and Ho-Chi-Minh City had an equal probability of being interviewed. Women in these two large city provinces had a somewhat higher probability of being sampled than those living elsewhere.

In the first stage, 12 of the provinces were selected from the 40 provinces. The provinces of Hanoi and Ho-Chi-Minh City were deliberately included because of their important roles in the country. Ten other provinces were selected randomly from the remaining 38; for each the probability of being chosen was proportional to its number of households. (The ones chosen in this way were Cao bang, Ha bac, Hai hung, Ha nam ninh, Nghe tinh, Binh tri thien, Phu khanh, Tien giang, Dong nai, and Hau giang.)

In the second stage, 151 clusters (communes or urban sub-districts) were selected from the first 12 provinces. The number of clusters for each province was proportional to it population size. Within each province, clusters were randomly chosen so that for each cluster the probability of being selected was proportional to its number of households. In the third stage, households were selected randomly according to the designed probability. It was not clear from the survey report precisely how selection probabilities were determined in the third stage (see VNDHS-88 1990, p. 63). It is likely that they were determined for each (selected) cluster by taking into account both the number of households in the cluster and the selection probabilities in the first two stages in order to give all households except those in Hanoi and Ho Chi Minh City equal chances of being selected. As noted, since Hanoi and Ho Chi Minh City were deliberately included in the first stage, households in these two cities had a disproportionate chance of selection; the reported sampling fractions were 0.000612 for Hanoi and Ho-Chi-Minh City, and 0.000350 for the other provinces. Consequently, to make sample estimates nationally representative, each observation must be weighted by the inverse of its sampling fraction.

Women satisfying the following conditions were selected for interview: (i) they were members of a selected household and present in that household during the survey period, or were visitors who were present in a selected household the night before the first visit or before any subsequent visit by an interviewer; (ii) they were in the age range 15 to 49 ; (iii) they were ever-married or currently living with a partner.

A total of 4807 households were randomly selected, of which 4746 were successfully interviewed. Within these 4746 households, 4179 eligible women were identified and asked to complete individual questionnaires. (Some households had no eligible women while other might have more than one.) The rule for the interviewers was to call back at least three times if a woman had not been contacted or the interview had not been completed. In the end 4172 responded. Thus the response rates were very high: 98.7% of the selected households and 99.8% of eligible women.

As noted above, the household questionnaire gathered only limited information relating to the household. Specifically, it asked the name, sex, age, marital status, and residence of every person in a household (including visitors staying in the household the night before the first interview). It was designed largely to identify eligible women for individual interviews in the next step.

The individual questionnaire applied in VNDHS-88 had seven sections:

- respondent's background;
- reproductive history;
- contraception and abortion;
- health and breastfeeding;
- marriage;
- fertility preferences;
- husband's background and woman's work.

Compared with the standard DHS questionnaire, the VNDHS-88 concentrated on basic information, and dropped most questions on health and others deemed not relevant or essential for Vietnam. Thus, the individual questionnaire in the VNDHS-88 had only 72 questions, while the standard DHS model A questionnaire (applying to high contraceptive prevalence countries) has 190. In general, the VNDHS-88 provided detailed information about reproductive history, child survival, and knowledge and use of contraception. A disadvantage of this survey for our study is that it did not provide information on economic indicators such as wages and household income. However, this lack of coverage is quite common for surveys conducted in developing countries because of difficulties in collecting accurate information on such indicators. Also, as discussed in Chapter 2, distorted prices and a system of rationing, as well as the in-kind payment in collective farms, imply that prices and money income provide little information that is useful for our analysis. Perhaps it was for these reasons that in the VNDHS-88 women were asked only if their husbands had a stable source of income rather than the income or wage levels.

There are often concerns that, in surveys of this type in developing countries, respondents may not know when certain events occurred, for example, dates of births of children and adults. In Vietnam, the lunar calendar is still in common use for farming practices and in connection with traditional customs and beliefs, even though the solar calendar has been used officially for a long time. For example, the date of birth according the lunar calendar is used for fortune telling and the death of a relative is remembered by the lunar calendar for worshipping practices. As a result, many women who would not remember important events by the solar calendar would know the lunar calendar dates. To exploit this feature, a special table (see VNDHS-88 1990, Appendix F, p. 97) was constructed to help interviewers to convert time from the lunar calendar to the solar one when necessary.

Overall, the VNDHS-88 was well prepared and conducted (see VNDHS-88 1990). As noted above, in carrying out the survey, the principal organizer, NCPFP, got technical assistance and consultation from ESCAP and four national institutes. It got support also from local authorities. The individuals who were selected for the field work seemed to be well qualified. All were staff members of either the Provincial Committees for Population and Family Planning or the Family Planning Offices from the selected provinces, and all were university graduates. Seminars and field practice were organized for the interviewers. The quality of the survey can be assessed in part by comparing it with the 1989 Census. It appears that, in general, comparable estimates from these two sources are consistent when available (see VHDHS-88 1990, GSO 1990, 1991). However, there are still some minor problems, as discussed below.

4.2 Problems With the Data

In processing the VNDHS-88 data we encountered several problems. In this section we report the problems and discuss how we dealt with them.

Missing supplementary documents

We obtained a computer-readable file of the VNDHS-88 data in August 1993 from the National Committee for Population and Family Planning in Hanoi. Unfortunately, the codes used for a few of the variables that would be useful in our analysis were not provided, the reported reason being that the relevant documents could not be located at that time. Specifically, we had no information on how the "province" and "cluster" variables were coded. This information was needed to define key residential variables (rural versus urban and North versus South).

Fortunately, we were able to rely on previous work to decode the province variable. Swenson et al. (1993) reports the number of child deaths *by province* for children born between 1983 and 1988. (Several co-authors of the paper were involved in the survey, and thus had access to information.) We reproduced part of their work in order to decode the province variable. A copy of the codebook for the survey was later provided by a member of NCPFP, which confirmed our decoding.

Also, we were not provided with information on which of the 151 clusters were in rural areas so as to define a rural-urban residential variable. However, there was a simple solution to this problem based on the number of individuals who worked in the agricultural sector. We found 22 clusters with at most one woman working in the agricultural sector. Hence, those clusters were assigned to urban areas. Of the remaining 129, we classified 8 with the smallest proportions of women working in the agricultural sector (ranging from 10% to 30%) as urban. This resulted in 21.5% of all observations falling in the urban category, similar to the estimate given in VNDHS-88 (1990) which, we assume, was based on the territorial division for administrative purposes. Even though our urban-rural classification does not match that scheme exactly (the discrepancies likely relate to a few clusters in suburban areas), the difference is likely to be of little consequence for our analysis. Indeed, we see no reason to believe that the administrative classification is better than ours.

Problems Relating to Data Entry

For each woman interviewed, the resources provide basic vital statistics for each child, in birth order. However, we detected 104 women for whom the order of births was not consistent with the recorded dates of births (i.e., a birth of a higher order turned out to have a recorded date of birth earlier than a birth of a lower order). We assumed that the recorded date of birth was correct, and used the birth dates of children to correct the order of births, and rearranged the related variables accordingly.[5] Such errors would affect any analysis that uses the information on the order of births.[6] Our analysis of the timing of birth in Chapter 8 is based on this information, and hence correcting these errors is important.

Chapter 5 ECONOMETRIC MODELLING OF FERTILITY DETERMINATION

The main concern of this chapter is to discuss statistical issues that arise in modelling the determinants of individual fertility using the linear ordinary least squares (OLS), Poisson, and ordered-logit models, the three statistical models on which our empirical analysis is based. First, however, we note the implications for empirical modelling that are suggested by our review of theories of fertility in chapter 3 and the discussion of data in chapter 4.

5.1 Implications of the Theory and Data Restrictions for Empirical Modelling

The discussion so far has several implications for our empirical models. Let us at this point reconcile them and specify an empirical model in general form.

The literature suggests, as noted towards the end of chapter 3, a preference for broader models, especially in the context of developing countries. By "broader" we mean models that take into account factors other than "the effects of parents' income and the cost of rearing children," which have been emphasized in the new home economics (see Becker and Barro 1988, p. 1). Most empirical models used to study the determinants of fertility in developing countries have taken a broader approach (see numerous studies in Bulatao and Lee 1983, Farooq and Simmons 1985, and many others). However, data constraints must also be taken into account.

As with other economics-based studies of reproductive behavior, we focus on the impacts of parental socioeconomic characteristics. Given this concentration and the available data, our first aim is to estimate a reduced-form equation for the number of children ever born, which we specify in general form as

$$N = g(\Omega, P_N, P_Z, Y) \qquad (14)$$

where Ω is a vector of parameters and exogenous variables (including child survival probabilities) that determine a couple's preferences. The remaining notation is as defined previously (N is the number of children, P_N the cost (net of possible monetary benefits) of rearing a child, P_Z a vector of prices of other consumption goods and services, and Y lifetime income).

Without Ω, the above equation is consistent with the new home economics model, which assumes exogenous preferences for children. It is not easy to measure preferences; however, we follow Easterlin (1978, p. 67) by formulating them as a function of such variables as education, residence, family background, and religion. This is justified by the discussion in chapter 3. Empirically, the treatment of preference formation may not change equation (14) substantially, partly because of data availability. However, the interpretation of estimation results may differ significantly (Pollak and Watkins 1993). For example, if education influences the preferences for children, and is included as an independent variable in the reduced-form equation for the number of children (N), then it is inappropriate to attribute all the fertility effects of education to income and/or substitution effects (as is often done in the new home economics; see Yen and Yen, 1992).

We discuss specific independent variables included in equation (14) in a later section. It is well known that if a variable on the right hand side of equation (14) is treated as exogenous but is actually endogenous, then the estimator would be inconsistent. As is often the case, our data do not allow estimation of a complete system of structural equations. However, when possible, we perform the Durbin-Wu-Hausman exogeneity test on variables suspected to be endogenous. Variables that are deemed endogenous but cannot be tested (due to data availability) are omitted.

We do not attempt to specify a functional form for (14); that would require specifying a utility and, perhaps, other functions. Wolfe and Behrman (1982) argue reasonably against such a procedure of specification and derivation for three reasons: i) the choice of the functional form would be arbitrary in the absence of prior information; ii) for an empirical study involving many variables, and based on a nonlinear utility function, the resulting derivatives would be complex, so that it would be difficult or impossible to predict theoretically the sign of a coefficient without prior information on the *magnitudes* of other coefficients; and iii) only rarely do available data permit estimation of the theoretically complete model. Nonetheless, there are important statistical problems relating to the estimation of equation (14), and they will be discussed below.

Equation (14) implicitly assumes that couples make once-and-for-all decisions, after which there is no adjustment to unexpected changes in their economic or demographic status. As pointed out in chapter 3, this is a weakness of mainstream economic theories of fertility: static models are not suitable for analyzing the impacts of factors such as the sex and mortality of children, known to be important determinants of fertility but the future course of which cannot be predicted by an individual family. That is, the sex of a child is not known at least until some time after conception, and parents may condition their future reproduction on the sexes of children.[7] There is evidence of sex preference and its effect on fertility (Becker 1993, Ben-Porath and Welch 1976, Behrman 1988, Pong 1994, Williamson 1976, Wolfe and Behrman 1982, Zhang 1990). However, since sex preference and its consequences vary greatly across countries and ethnic groups (Williamson 1976), an analysis for Vietnam is an important part of our study.

In dealing with child mortality, it has been suggested that parents may follow either a "replacement" or an "insurance" (hoarding) strategy, or even both (Preston 1978). The "replacement" strategy, which is put into practice after a child death, is likely to be more important because (i) information about the future mortality of one's own children is obviously limited, making the insurance strategy difficult, and (ii) it is impossible to have only a fraction of a child, as would be suggested by the "insurance" strategy. We note also that with lower child mortality, the insurance strategy is less attractive and the replacement strategy more appealing. With infant and under-five mortality rates of about 4 and 5 percent respectively in the late 1980's, Vietnam is among the group of developing countries that have relatively low infant and child mortality rates; see GSO (1991) for mortality rates in Vietnam and World Bank (1993, Table A.3, pp. 200-1) for the rates in other countries.

It follows from the above argument that a sequential fertility decision-making model (Namboodiri 1983) would be a suitable vehicle for a study of the fertility effects of sex preference and child mortality. The model is summarized graphically by Figure 8.

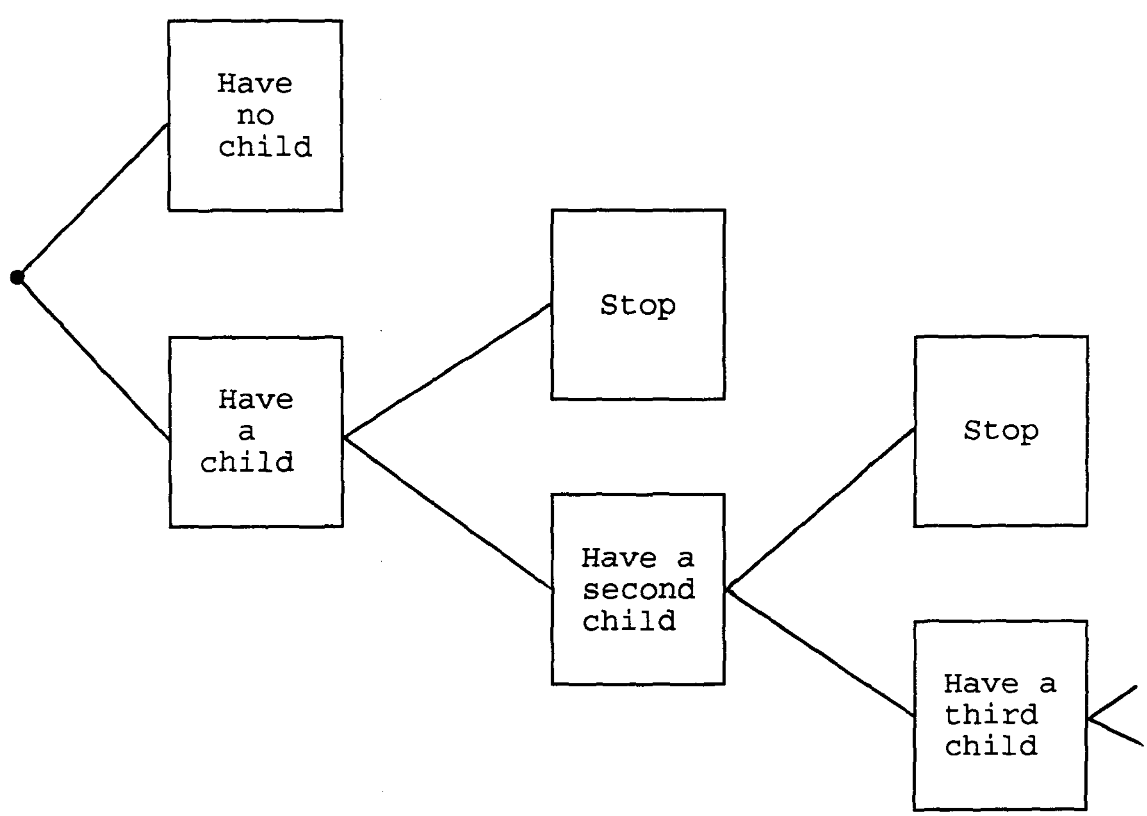

Figure 8. Sequential fertility decision-making

In the first stage of a sequential fertility decision-making process, couples decide whether to have children at all. For those who choose to have at least one child, a second stage follows after the first birth, in which couples decide whether to stop or to have more children, taking into account the sex and mortality of the first child, any change in socioeconomic status, and so on. It has been argued that the choice is meaningful only beyond certain non-zero parity (Leibenstein 1981, Simmons 1985). The sequential decision-making model can be used to test such a hypothesis. For example, if all couples wish to have at least two children, then parental socioeconomic characteristics would have no impact on the choice in the first two stages of the decision-making process, and the sex and survival of the first child might have little influence on an occurrence of a second birth (because couples would not stop after the first birth anyway, given their "minimum" demand for two children).

There is another kind of dynamic models of fertility decision-making that concentrates on explaining the timing of births. As noted above, the timing of births is studied in Chapter 8. Let us move now to consider some important statistical issues as they relate both to the estimation of equation (14) and to the sequential fertility decision-making model.

5.2 Statistical Issues

5.2.1 The Number of Children Ever born (Equation 14)

The Ordinary Least Square Model

Let us denote the right-hand-side variables of equation (14) (excluding the constant term) by vector X and their coefficients by vector A. The least squares method has been used widely to estimate fertility models, such as equation (14); for example, see dozens of studies reviewed in Cochrane (1983). In this case we have a regression equation of the form

$$N_i = a_0 + X_i A + \epsilon_i \qquad (15)$$

where N_i is the number of live births to woman i, a_0 a scalar constant, ϵ_i an error term.

In this model the standard assumption that the error term has a normal distribution is clearly unrealistic since the dependent variable is not continuous. In consequence, as is well known, the least squares estimator is inefficient for finite samples and standard tests are invalid (see, for example, Judge et al., 1985, Ch. 5). Under standard assumptions this estimator is asymptotically consistent and the central limit theorem implies that conventional tests are asymptotically valid (see Johnston 1984, pp. 279-81, Judge et al. 1985, Ch.5, and references cited there). However, in practice it is not clear how large a sample should be to justify the asymptotic properties. We therefore look for alternative models with more suitable probability distribution assumptions for small samples. Two limited-dependent variable models are selected: the Poisson and ordered-response models. Our strategy is to estimate and compare results of three models, including the linear OLS one. Similar results would strengthen our conclusions and support the application of the linear model in earlier studies.

The Poisson Model

Inasmuch as the number of children ever born has only non-negative integer values, the Poisson distribution is suitable, and has been used by a few researchers in modelling fertility. Broström (1985) uses the Poisson distribution to estimate the Coale-Trussell model of marital fertility. Rodríguez and Cleland (1985) and Cleland and Rodríguez (1985) also assume that "the birth counts for different women are independent Poisson random variables." They combine this statistical assumption with Page's (1977) model of marital fertility to derive a generalized linear model of birth counts. In this model, the dependent variable is the logarithm of the number of births and the error term has a Poisson distribution (see Rodríguez and Cleland 1985, pp. 241-44). An advantage of this model is that prior information on natural fertility, if available, can be taken into account. However, the only explanatory variables in the model are age and marital duration (exposure). To study the impact of socioeconomic variables, the two coefficients are allowed to vary across different categories (Cleland and Rodríguez 1985, p. 424-25), an approach that is not convenient for an analysis involving many socioeconomic variables or interactions between them. Note also that because the dependent variable is the logarithm of the number of births, which is not defined if a woman has no children, the model is not applicable when the observational units are individual women, some of whom have no children.

In our specification of the Poisson model for the number of children ever born, the probability that N_i equals n is given by

$$Prob\ (N_i = n) = \frac{e^{-\lambda_i}\ \lambda_i^{\ n}}{n!} \qquad (16)$$

where n is a non-negative integer, and λ_i is the expectation (and also the variance) of the random variable N_i. To introduce regressors, λ_i is specified in a conventional way:

$$\lambda_i = e^{\ b_0 + X_i\ B} \qquad (17)$$

where B is a coefficient vector and b_0 a constant term. B and b_0 can be estimated by substituting for λ_i in (17) and applying the MLE method.

The Poisson model assumes independence among events. Note that even if events are not independent, the uncorrelated count (the Poisson) model still gives consistent estimates, but ones that are inefficient (King 1989b, p. 128).[8] Positively correlated events result in over-dispersion (the variance is greater than the mean), and negatively correlated ones in under-dispersion (King 1989b, pp. 121-30). It has been observed that over-dispersion, which can be modeled with the negative binomial probability distribution, is common, but under-dispersion is rare (see King 1989a, p. 769-70). It is not easy to say whether births are negatively or positively correlated, however. It is likely that in the absence of fertility control births are positively correlated, and vice versa. However, in practice the ability to control births varies across individuals as well as across populations. As a check, we divided each woman's exposure (i.e., the period in which she was married or living with a partner) into 5-year intervals, using the ages of 19, 24, 29, 34, 39, 44, and 49 as end ages. We then regressed the number of births in each interval on the number of births in the previous intervals and on other explanatory variables.[9] We found that births were negatively correlated before age 34 but positively correlated after. (This implies that births at older ages are mainly determined by biological factors.) Thus, there is no simple patterns of correlation. Furthermore, we used the tests suggested by Cameron and Trevidi (1990) and found no evidence of over-dispersion in our case. To our knowledge, there are no simple tests for under-dispersion. However, the conventional goodness-of-fit test in the case of the (uncorrelated) Poisson model (see Agresti 1984, Computing Resource Center 1992) indicates that the hypothesis that the number of children ever born follows the Poisson distribution cannot be rejected at any conventional level of significance with our data.

Winkelmann (1995) found that there is evidence of underdispersion in data from the second wave of the *German Socio-Economic Panel* and that the Poisson model was rejected in favour of his gamma count model. Since fertility control is more complete in developed countries than developing ones, the influence of biological factors (a possible source of overdispersion) tends to have a smaller influence. However, Winkelmann remarks that "the estimated coefficients are very stable for the two specifications [the Poisson and gamma count models] both in sign and in order of magnitude" (p. 472). As noted above, the Poisson model gives consistent estimates even if data are underdispered or overdispered.

The Ordered-Response Model

The ordered-response model in the present context can be described simply.

Let a latent (unobserved) variable V_i^* be specified as

$$V_i^* = X_i \Gamma + u_i \qquad (18)$$

where Γ is a vector of coefficients and u_i an error term. V_i^* can be interpreted as the ith woman's indirect utility function (Hoffman and Duncan 1988). In our specification, Γ does not include the constant term. (As seen below, the inclusion or exclusion of the constant term does not affect the results, but the number of ancillary parameters, also called cutting points, must be chosen appropriately. This means that there is no "real" choice between the inclusion and exclusion of the constant term as with, for example, the OLS model.) Applied to our case, the ordered-response model is

$$\begin{aligned}
&\text{Prob}(N_i = 0) = \text{Prob}(V_i^* < c_0) = \text{Prob}(u_i < c_0 - X_i \Gamma) \\
&\text{Prob}(N_i = 1) = \text{Prob}(c_0 \leq V_i^* \leq c_1) = \text{Prob}(c_0 - X_i \Gamma \leq u_i \leq c_1 - X_i \Gamma) \\
&\ldots\ldots\ldots\ldots\ldots\ldots \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (19) \\
&\text{Prob}(N_i = m\text{-}1) = \text{Prob}(c_{m-2} \leq V_i^* \leq c_{m-1}) = \text{Prob}(c_{m-2} - X_i \Gamma \leq u_i \leq c_{m-1} - X_i \Gamma) \\
&\text{Prob}(N_i = m) = \text{Prob}(V_i^* > c_{m-1}) = \text{Prob}(u_i > c_{m-1} - X_i \Gamma)
\end{aligned}$$

where the c_j (j=0,1,..., m-1) are ancillary parameters and m equals the maximum number of children in the sample if grouping is not allowed (hence, m is random if grouping is not applied). Note that if a constant term is included in (18), normalization is necessary. (To see this, consider the first inequality in (19) as an example. Without normalization, there would be the constant term on the left hand side and an ancillary parameter (another constant), c_0, on the right hand side of the inequality, with the result that an identification problem occurs.) The normalization is often done by setting c_0 equal to zero, see Greene (1993, pp. 672-76).

Figure 9 illustrates the specification in equation (19) for the case in which there are only three ordered categories (representing, for example, three levels of fertility). The figure is interpreted as follows (ignoring for the moment the dashed lines and letters with a prime). As specified in the first equation in (19), the probability that couple i will fall in the first ordered category is the probability of having $V_i^* < c_0$. The same equation implies that that is equivalent to the probability of having $u_i < c_0 - X_i\Gamma$, which is represented by the left shaded area. Similarly, the

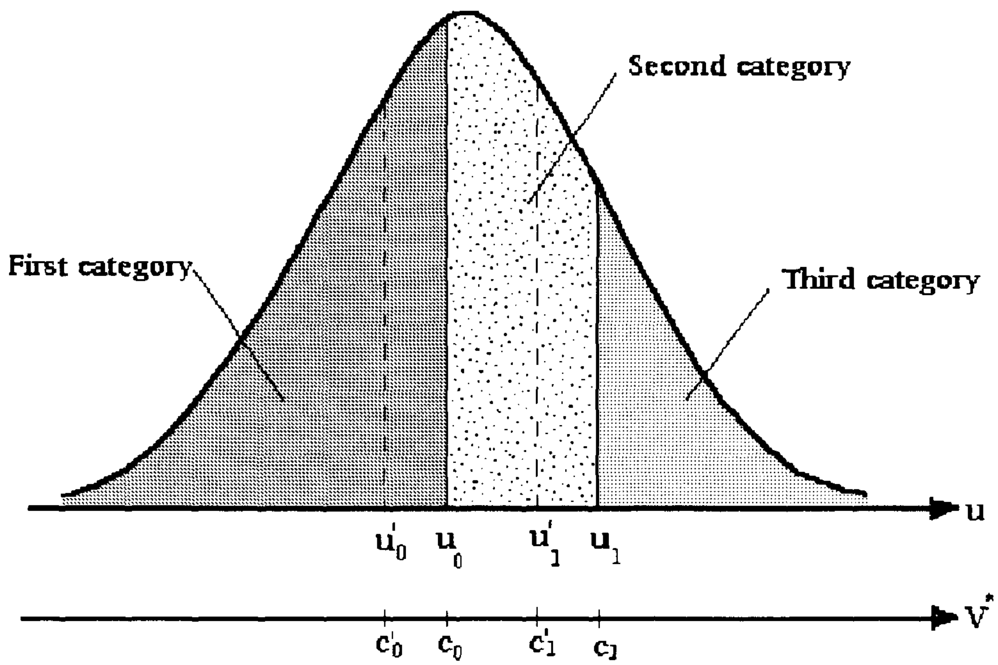

Figure 9. An illustration of the ordered-response model

middle (dotted) area corresponds to the second equation in (19), and the right shaded area to the last equation.

By substituting (18) for V^* in (19) and assuming a specific distribution for u_i, we can estimate c_0, Γ and the c_i parameters using the MLE method. The standard normal or logistic distribution is often employed, resulting in the ordered-probit or ordered-logit model. Since the two distributions converge asymptotically, the results may differ little with large samples. However, we tried both and found that for our data the ordered-logit model performed a little better than the ordered-probit one (in terms of the goodness-of-fit measures that we discuss below).

A disadvantage of the ordered-response model is the difficulty in the interpretation of its coefficients. More specifically, the coefficient of a variable does not tell us specifically the magnitude, and even the sign, of the impact of a unit increase in that variable on the predicted probabilities for each number of children as well as on the expectation of the (total) number of children ever born. Assume that the estimated coefficient of an independent variable, x_1, is +0.5. Then a unit increase in this variable is equivalent to shifting c_0 and c_1 in Figure 9 to the left by a distance of 0.5, which in turn would shift u_0 and u_1 to the left by the same distance, to u'_0 and u'_1. Consequently, the probability for the first category decreases and that for the last (third) category increases; however, the change in the probability for the second category is uncertain, depending on the initial state and the magnitude of the coefficient. Green (1993, p. 674) comments that "this is the least obvious of all of the models we have considered. Indeed, without a fair amount of extra calculation, it is quite unclear how the coefficients in the ordered probit model should be interpreted." However, because the number of children ever born is not only ordinal but also cardinal, its predicted values can be calculated. We are able to provide a measure that explicitly reflects the impact of unit increases in explanatory variables on the predicted number of children ever born (see chapter 6).

5.2.2 The Sequential-Response Model

The sequential-response model is suitable for modelling decisions that are made in sequence (Amemiya 1975, Maddala 1983). Zhang (1990) uses this model to analyze fertility behaviour in China. As seen below, this model is easy to apply. Yet it can capture some important dynamic elements in fertility behaviour.

As depicted in Figure 8, in the first stage (parity zero) of the decision-making process, couples decide whether to have a (first) child or not. Hence, such decision-making can be formulated as a model of binary choice (dichotomous dependent variables). Let X_{1i} be a set of demographic and socioeconomic variables (a constant term included) that influence woman i's choice in this stage, θ_1 a vector of coefficients; the dichotomous dependent variable, denoted N_{1i}, is coded 1 if a woman chooses to have a child and zero otherwise; F(.) stands for a cumulative probability function. The probabilities for woman i to have a first child or to bear no child are, respectively

$$\begin{aligned} Prob(N_{1i} = 1) &= F(X_{1i}\theta_1) \\ Prob(N_{1i} = 0) &= 1 - Prob(N_{1i} = 1) = 1 - F(X_{1i}\theta_1) \end{aligned} \tag{20a}$$

Only those women who choose to have a first child proceed to the second stage of decision-making, in which they decide whether to stop or to have a second child. The probabilities are specified in a similar way (note that the subscript digit denotes the stage in the decision-making process):

$$\begin{aligned} Prob(N_{2i} = 1) &= F(X_{2i}\theta_2) \\ Prob(N_{2i} = 0) &= 1 - Prob(N_{2i} = 1) = 1 - F(X_{2i}\theta_2) \end{aligned} \tag{20b}$$

The formulation is similar for later stages (higher parities):

$$\begin{aligned} Prob(N_{3i} = 1) &= F(X_{3i}\theta_3) \\ Prob(N_{3i} = 0) &= 1 - Prob(N_{3i} = 1) = 1 - F(X_{3i}\theta_3) \end{aligned} \tag{20c}$$

$$\begin{aligned} Prob(N_{4i} = 1) &= F(X_{4i}\theta_4) \\ Prob(N_{4i} = 0) &= 1 - Prob(N_{4i} = 1) = 1 - F(X_{4i}\theta_4) \end{aligned} \tag{20d}$$

....

The probability that a woman will have each specified number of births by the end of her reproductive period can be found by multiplying relevant "conditional" probabilities defined above. For example, the probability for woman i to have two births in her life, $Prob(N_i = 2)$, is

$$\begin{aligned} Prob(N_i = 2) &= Prob(N_{1i} = 1) \times Prob(N_{2i} = 1) \times Prob(N_{3i} = 0) \\ &= F(X_{1i}\theta_1) \times F(X_{2i}\theta_2) \times [1 - F(X_{3i}\theta_3)] \end{aligned} \tag{21}$$

The specification in (21) corresponds to the assumption that the choices at various stages are independent (Maddala 1983, p.50). To estimate θ_1, the whole sample is divided into two groups, women with at least one child and women with no children; with a specification of the probability distribution (discussed below), the MLE method can be applied to estimate θ_1. Similarly, to estimate θ_2 women with no children are omitted, and the remaining women are divided in two groups, one that includes women with only one child and the other women with at least two children. And so on.

Note that vectors of independent variables need not be the same for different parities. This allows the sequential-response model to captures dynamic factors, and is an important advantage of this model. However, difficulties may arise in the interpretation of results since the estimated effects of some variables at the several stages may not be consistent. For example, we might find that maternal education has a negative impact on the probability of having a second child but a positive impact on the probability of having a third.

In practice the standard normal or logistic probability distribution is often assumed for F(.). Since the estimators for these two models converge asymptotically and our sample is large, the choice of probability distribution is of little consequence. The logistic form is assumed here. As a result, the probabilities can be written more concisely as (j indicates the stage of the decision-making process):

$$
\begin{aligned}
Prob(N_{ji} = 1) &= F(X_{ji}\theta_j) = \frac{e^{X_{ji}\theta_j}}{1 + e^{X_{ji}\theta_j}} \\
Prob(N_{ji} = 0) &= 1 - Prob(N_{ji} = 1) = 1 - \frac{e^{X_{ji}\theta_j}}{1 + e^{X_{ji}\theta_j}}
\end{aligned}
\qquad (22)
$$

The ratio of the first to the second probability, called the *odds ratio*, is

$$\frac{Prob\ (N_{ji} = 1)}{Prob\ (N_{ji} = 0)} = e^{X_{ji}\theta_j} \qquad (23)$$

It is more convenient to use the natural logarithm of this ratio, commonly called the *log odds ratio*, which simply is $X_{ji}\theta_j$. Thus, if the coefficient of a variable is 0.2, for example, a unit increment in this variable increases the probability of proceeding to the next parity and decreases the probability of stopping so that the log odds ratio increases by 0.2 folds (and the new odds ratio equals exp(0.2)=1.221 folds of the initial odds ratio).

5.3 Concluding Remarks

Because of the complexity of socioeconomic relationships and data restrictions, it is impossible to estimate a single complete model. This is summarized well by Feldstein (1982) who commented:

> "...in practice all econometric specifications are necessarily "false" models. They are false not only in the innocuous sense that the omissions and other misspecifications make it impossible to obtain unbiased or consistent estimates of the parameters even by sophisticated transformations of the data.
>
> ...As a practical matter, we often need different studies to learn about different aspects of any problem. The idea of estimating a single complete model that tells about all the parameters of interest and tests all implicit restrictions is generally not feasible with the available data. Instead, judgements must be formed by studying several different studies, each of which focuses on part of the problem and makes false assumptions about other parts." (Feldstein, 1982, p. 829-30)

These remarks apply well to empirical research in the reproductive field. In addition, the choice of model specification could relate the problem of data mining; see Lovell (1983) and Denton (1985) for discussion about data mining. Denton (1985, footnote No. 7, p. 127) suggests that, as a measure to deal with data mining, authors should be required to demonstrate that their estimates are not sensitive to minor changes in model specification as well as to the inclusion or exclusion of variables which are supposed to reflect "nuisance" effects. With these in mind let us turn to a discussion of the empirical results.

Chapter 6 EMPIRICAL FINDINGS: DETERMINANTS OF THE NUMBER OF CHILDREN EVER BORN

In this chapter we apply the (linear) OLS, Poisson, and ordered-logit specifications to the VNDHS-88 data to estimate equation (14). Estimation of the sequential-response model is reported in the next chapter, due to the large amount of empirical findings and the relative independence of the issues. The variables are discussed in section 6.1, followed by the basic estimation results in section 6.2. Section 6.3 further analyzes selected relationships. The last section, section 6.4, summarizes the findings.

6.1 Variable Definitions

As already noted, the dependent variable of equation (14) is the number of children ever born. That is, it is the total number of live births reported by each woman who was interviewed in the survey.

The independent variables consist of four groups. In the first are variables that control for demographic factors. The second includes variables that reflect individual socioeconomic characteristics and the third community differences in socioeconomic environment. The final group includes interaction terms. We discuss the four groups of variables in turn. Variables that are constructed to extend the analysis of specific issues are discussed later.

Demographic Variables

As seen in Chapter 4, women who were interviewed in the VNDHS-88, as in other demographic and health surveys, come from a number of age cohorts. This, and the fact that women were married at varying ages, means that their exposure to conception varied greatly. Marital duration, *Mardur*, measured as the number of years from the woman's first marriage to the time of the survey, and its square, *Mardur2*, are included to control for differences in exposure. *Mardur2* is included to account for the non-linearity in cumulative fertility. Some women might, at some stage, have been divorced, separated, widowed, and hence have experienced an interruption in their exposure. Unfortunately, the data do not provide sufficient information to measure the timing of changes in marital status. However, we drop all 253 women who were not married at the time of the survey and introduce *Marrno*, a dummy variable, coded 1 if a woman married more than once and zero otherwise.[10] (Among the retained women, 4% had remarried.)

By definition, *Mardur* and *Mardur2* are closely related to *Age*. However, they do not fully account for the age-cohort effect. For example, with these two variables alone, a woman who was 25 years old in 1988 and got married at age 20 would be treated the same as a 40-year-old woman who had also been married for five years. Thus, *Age*, the woman's age at the time of the survey, and its square, *Age2*, are also included in our regression. Note that the variables *Age* and *Age2* incorporate both the age-specific effect (i.e., the effect of age on the cumulative fertility when there are no changes in fertility profiles of different age cohorts) and the age-cohort effect (i.e., the effect of age on fertility due to changes in fertility profiles of different age cohorts). The inclusion of four variables *Age*, *Age2*, *Mardur*, and *Mardur2* is equivalent to the inclusion of the variables *Age*, *Age2*, *Marrage* (age at the first marriage), *Marrage2* (the square of *Marrage*), and the interaction between *Age* and *Marrage* and at the same time imposing a linear restriction on the coefficients of these variable. This can be shown easily by starting with the inclusion of *Age*, *Age2*, *Mardur*, and *Mardur2*, then substituting the difference between *Age* and *Marrage* (i.e., *Age* - *Marrage*) for *Mardur* and performing relevant grouping and cancelling.

The end of the war in 1975 might have affected the expectations of younger generations and that, in turn, might have affected their fertility, as suggested by Easterlin's relative income hypothesis (Easterlin 1966, 1968). An age-spline variable, *Agespline*, is included to account for possible additional non-linearity introduced by such an effect (see Zhang 1990). There is one knot, the position of which corresponds to age 31 in 1988 or age 18 (the legal minimum age of marriage for women in Vietnam) in 1975. Since the effects of this variable on reproductive behaviour among the populations of the South and the North may be different, an interaction between it and a regional variable is included, as discussed below.

We do not include other proximate variables such as the length of breastfeeding in our models. Our aim is to study the effects of socioeconomic variables. However, Davis and Blake's (1956) framework discussed in Chapter 3 implies that, because the influence of any socioeconomic variables must be through one or more proximate variables, if all proximate variables were included and there were no statistical errors, the coefficients of socioeconomic variables would all be zero; see also Cochrane (1983). This, however, raises a question: Why do we (and others) not exclude the variable marital duration as we do other proximate variables? There are at least two reasons for its inclusion, in our view. First, since the survey included women who had not completed their reproductive life, the variables *Mardur* and *Age* are responsible for much of the variation in the number of children ever born. Second, *Mardur* can be measured accurately and is less endogenous than other proximate variables such as contraceptive use and breastfeeding. We note that when *Mardur* is included as an independent variable, the estimated coefficients of other socioeconomic variables that are also included will not reflect any effect that *Mardur* may have on fertility. Thus, for example, while maternal education might affect fertility by influencing a woman's age at marriage, the estimated coefficients of the maternal education variables do not include such an effect when *Mardur* is included as an independent variable. However, that effect could be estimated with a supplementary regression that estimates directly the effect of such a variable on *Mardur*. Note also that the inclusion of the variable *Age* is justified not only because our sample includes women who had not reached the end of the reproductive period but also because it is not affected by other independent variables.

Parental Socioeconomic Characteristics

The effect of maternal education is captured by five dummy variables corresponding to five specific educational levels. *Wed1* is coded 1 if a woman was illiterate and zero otherwise. *Wed2* is coded 1 if a woman was literate but had no formal education and zero otherwise. *Wed3* is coded 1 if a woman had primary education and zero otherwise.[11] *This is the base case* (and, hence, is not included in our regressions). *Wed4* is coded 1 if a woman had secondary education and zero otherwise. *Wed5* is coded 1 if a woman had post-secondary education and zero otherwise.

For paternal education, five dummy variables, *Hed1*, *Hed2*, *Hed3*, *Hed4*, and *Hed5*, are similarly defined, with *Hed3* taken as the base case (omitted categories). The use of the dummy variables (rather than "continuous" variables, such as the number of years of school attended) to model parental education is due partly to data availability. However, the wage rate (and hence the opportunity cost of parents' time) and social status are likely to be well approximated as step functions of education. In this respect, dummy variables are suitable.

Five dummy variables, *Wind1*, *Wind2*, *Wind3*, *Wind4*, and *Wind5*, are constructed to specify the sectors in which women were employed. *Wind1* equals 1 if a woman was employed in the agricultural sector and zero otherwise. This is the base case. *Wind2* equals 1 if a woman was employed in the industrial sector and zero otherwise. *Wind3* equals 1 if a woman was employed in the services sector and zero otherwise. *Wind4* equals 1 if a woman was employed in the armed forces, police, or other sectors and zero otherwise. *Wind5* equals 1 if a woman was not formally employed and zero otherwise. It may be argued that the variable *Wind5* is endogenous (see Cain and Dooley 1976, Hotz and Miller 1988), and the data do not allow us to perform an exogeneity test. We note, however, that Vietnam is a poor country with little non-labour income, and that most adults have to work for sustenance. A person who is not formally employed may still have to work hard in one or other kind of informal job. We note also that when we dropped from the sample the 4% of women who were not employed and re-ran the regressions, we found little change in the estimates of the coefficients of the other variables.

Sectors where husbands were employed are similarly specified by five other dummy variables, *Hind1*, *Hind2*, *Hind3*, *Hind4*, and *Hind5*. The variable Hind1 is the base case. Perhaps, it would have been better to use some other occupational classification which reflects more closely the socioeconomic status of individuals (for example, individuals might be classified as farmer, blue-collar public worker, or white-collar public worker, etc.), but necessary information for such a classification was not available. However, the sector in which an individual works reflects social status and living conditions. As seen in Chapter 2, non-agricultural production and services have been generally dominated by the public sector. With the exception of military service, work in the public (non-agricultural) sectors is preferred by most to work in the agricultural sector, in part because only workers in the public sector are eligible for pensions.

Women' residence is identified by two dummy variables, *Rural* and *North*. The variable *Rural* is coded 1 if a woman lived in a rural area and zero otherwise. It has commonly been found that fertility is higher for rural women even when the effects of other basic parental characteristics have been controlled for. Two different social systems prevailed in the North and the South until 1975, which may have caused a difference in reproductive behaviour. This is accounted for by the variable *North*, which is coded 1 if a woman lived in the North and zero otherwise.

A dummy variable indicating whether a husband had stable income is included. This variable, denoted *Instab*, is coded 1 if a woman's husband had a stable source of income and zero otherwise. One might expect couples with stable income to have fewer children since their security motives for having children may not be as strong as those of couples with unstable income. As noted in Chapter 4, information relating to money income was not collected in VNDHS-88 nor, if it had been, would the information likely have been useful in the context of Vietnam.

Community Features

Individuals' real incomes and the relative prices they face, as well as their preferences for children, may depend on the socioeconomic environment in which they live. It has been shown that contextual variables (i.e., variables reflecting the local socioeconomic environment) are responsible for part of the cross-sectional variation in individual fertility (Cleland and Rodríguez 1988, Hirschman and Guest 1990). In Vietnam the well-being of rural families depended significantly on the performance of the farming collective to which they belonged. Unfortunately, the data do not contain variables that reflect directly the community socioeconomic environment. However, based on available information about individuals, we construct two contextual variables which are intended to capture part of the diversity in the socioeconomic environments of different communities. The first variable, denoted *Cominform*, reflects for each community the knowledge about contraception among women. It is defined as the average number of contraceptive methods known by those women in the same commune or urban block who were interviewed. We do not include an indicator of individual contraceptive knowledge/practice or other proximate variables because, as noted above, we focus on the effects of parental socioeconomic characteristics. However, the variable *Cominform* may be considered a contextual variable reflecting "the presence of organized family planning programs" as discussed above. The presence of family planning programs may influence demand for children by affecting the costs of fertility regulation (Easterlin and Crimmins 1985).

The second contextual variable, *Commort*, is a measure of child mortality in the community. This variable is constructed as follows. First, child mortality is calculated for individual women. In this calculation, we do not follow the conventional method of dividing the number of child deaths by the number of children ever born. Such a measure is endogenous (and inappropriate) because it ignores the age (exposure to risk) of children. Instead, we divide the number of child deaths for each woman by the potential number of child-years. The latter is the sum of ages of a woman's children, assuming that all of her children ever born were still alive at the time of the survey. (Some may not have been.)[12] Second, we do not include the individual woman's child mortality as a regressor because of its endogeneity. Instead, we calculate average child mortality for women living in the same community. Community child mortality reflects the general physical and socioeconomic environment, and we use it as an encompassing contextual variable. In particular, couples may condition their fertility decision-making on the observed rates of child survival in their neighbourhood. As noted above, the effects of sex preference and child mortality on fertility are the subject of the next chapter.

Interaction Terms

Interaction terms among several of the variables discussed above are included in our regressions. We argued above for the inclusion of the variable *North* to account for a possible North-South difference in fertility. Such a difference, however, may have varied with age cohorts. Specifically, the existence of the different social regimes in the North and the South before 1975 implies that the North-South differences in reproductive behaviour might be larger for older women. Therefore, three interaction terms between *North* and each of *Age*, *Age2*, and *Agespline* are included in our regressions, and are denoted *NAge*, *NAge2*, and *NAgespline*, respectively. In addition, since our discussion in Chapter 3 implies that the North-South difference in fertility behaviour might not have been the same for the rural and urban populations, an interaction between *Rural* and *North*, denoted as *RurNorth*, is included.

Table 14 is designed to provide the reader with a quick reference for all variables used in our empirical analysis. It provides brief definitions of all variables in alphabetical order (including ones to be discussed later), together with some summary statistics. We do not report the variances of dummy variables, since they can be inferred easily from their means. The dummy variables are consistently coded 1 for the category indicated, zero otherwise. Unless explicitly indicated, the variables refer to the wife. Take the variable *Wind5* as an example. Since the word "husband" does not appear in the second column, it refers to wives, and since its standard deviation is not reported, it is a dummy variable. It is coded 1 if a woman belongs to the indicated category (not employed) and zero otherwise.

Table 14: Summary of Variables' Definitions and Statistics

(Independent variables listed in alphabetical order)

Variables	Definitions	Mean	Min, Max
Dependent	The number of children ever born	3.20 (2.2)	1 13
Independent			
Age	Age of the woman (years) at the time of the survey	32.2 (7.8)	16 49
Age2	Square of Age	1097 (532)	256 2401
Agespline	$= 0$ if $Age>31$, $=(31\text{-}Age)^2$ if $Age\leq 31$	18.6 (33.4)	0 225
Cominform	Community's knowledge of contraception (see text discussion)	3.2 (1.7)	.5 7.6
Commort	Community's child mortality (see text discussion)	.01 (.01)	0 .08
Dh	Husband employed in a non-agricultural sector	.35	0 1
Dw	Employed in a non-agricultural sector (wife)	.23	0 1
Hed1	Husband is illiterate	.02	0 1
Hed2	Husband has no formal education	.13	0 1
Hed3	Husband has primary education	.54	0 1
Hed4	Husband has secondary education	.23	0 1
Hed5	Husband has post-secondary education	.08	0 1
Hind1	Husband employed in the agricultural sector	.60	0 1
Hind2	Husband employed in the industrial sector	.18	0 1
Hind3	Husband employed in the services sector	.12	0 1
Hind4	Husband employed in other sectors (police, armed forces,...)	.05	0 1
Hind5	Husband not working	.05	0 1
Instab	Husband has stable income	.72	0 1
Marage	Age at the first marriage	20.6 (3.4)	
Mardur	Marital duration (years)	12 (8)	0 38

Table 14 (continued)

Variables	Definitions	Mean	Min, Max
Mardur2	Square of Mardur	198 (237)	0 1296
Marrno	Married more than once	.04	0 1
NAge	Product of North and Age	16.6 (16.8)	0 49
NAge2	Product of North and Age2	558 (654)	0 2401
NAgespline	Product of North and Agespline	10.5 (26.9)	0 225
North	Lives in the North	.52	0 1
Rural	Lives in a rural area	.79	0 1
RurNorth	Product of Rural and North	.46	0 1
South	Lived in the South (=1-North)	.48	0 1
South35	Lived in the South and aged 35 or more in 1988	.17	0 1
Wed1	Illiterate	.06	0 1
Wed2	Literate but has no formal education	.21	0 1
Wed3	Primary education	.56	0 1
Wed4	Secondary education	.13	0 1
Wed5	Post-secondary education	.04	0 1
Wind1	Employed in the agricultural sector	.71	0 1
Wind2	Employed in the industrial sector	.12	0 1
Wind3	Employed in the services sector	.10	0 1
Wind4	Employed in other sectors (police, armed forces,...)	.01	0 1
Wind5	Not working	.06	0 1

Note: Figures in parentheses are standard deviations.

In the regressions reported in this chapter we excluded 253 previously married women who were not currently married at the time of the survey. We also excluded 31 women who, at the time of the survey, had not given birth, although they reported that they desired children and had been married for more than seven years. We consider these women infertile. Finally, 239 other observations with information missing on one or more variables were also dropped.

6.2 Empirical Findings

In this section we first tabulate the estimation results. Goodness-of-fit measures for the three models are then evaluated. That is followed by our interpretation of the estimated relationships. Finally, we give further attention to North-South differences and to the effects of parental education.

6.2.1 Estimation Results

The estimated coefficients for the three models together with several measures of goodness of fit and statistics for hypothesis testing are reported in Table 15. Their calculation and meanings are familiar in the econometric literature, with the exception of the measures which we call "pseudo-OLS coefficients."

The pseudo-OLS coefficients are calculated to facilitate the interpretation of the coefficients of the Poisson and ordered-logit models. They are similar to the coefficients of the OLS model in that they reflect the effects of unit increases in

Table 15: Summary of Regression Results

Variable	OLS Coefficient		Poisson Coefficient (B)		Poisson Pseudo-OLS coefficient	Ordered-Logit[a] Coefficient (Γ)		Ordered-Logit[a] Pseudo-OLS coefficient
Mardur	0.239	(18.6)	1.252	(19.0)		0.659	(26.8)	
Mardur2	0.0003	(0.79)	-0.002	(9.23)		-0.009	(11.3)	
Age	0.372	(4.66)	0.015	(0.44)		0.148	(1.19)	
Age2	-0.005	(4.96)	-0.0004	(0.91)		-0.003	(1.71)	
Agespline	0.005	(1.73)	-0.005	(3.42)		-0.011	(2.57)	
North	1.091	(0.59)	0.790	(0.96)		4.542	(1.62)	
NAge	-0.008	(0.08)	-0.032	(0.74)		-0.185	(1.21)	
NAge2	-0.0008	(0.60)	0.0003	(0.46)		0.001	(0.69)	
NAgespline	-0.004	(1.26)	-0.003	(1.37)		-0.013	(2.36)	
Marrno	-0.960	(8.59)	-0.224	(5.00)	-0.532	-1.341	(7.56)	-0.667
Rural	0.475	(5.19)	0.146	(3.37)	0.369	0.660	(4.63)	0.349
RurNorth	-0.371	(3.26)	-0.091	(1.61)	-0.238	-0.500	(2.87)	-0.271
Instab	-0.165	(3.47)	-0.049	(2.34)	-0.131	-0.188	(2.62)	-0.103
Cominform	-0.036	(2.56)	-0.012	(1.84)	-0.031	-0.601	(2.81)	-0.033
Commort	6.687	(4.19)	2.224	(3.11)	5.760	9.887	(4.17)	5.300
Wed1 vs Wed3	0.310	(3.00)	0.051	(1.29)	0.140	0.248	(1.57)	0.136
Wed2 vs Wed3	0.141	(2.30)	0.027	(1.05)	0.073	0.189	(2.06)	0.104
Wed4 vs Wed3	-0.115	(1.64)	-0.091	(2.43)	-0.232	-0.305	(2.80)	-0.162
Wed5 vs Wed3	-0.175	(1.32)	-0.116	(1.65)	-0.290	-0.503	(2.46)	-0.264
Hed1 vs Hed3	0.103	(0.72)	0.041	(0.72)	0.115	0.290	(1.35)	0.162
Hed2 vs Hed3	0.005	(0.06)	-0.004	(0.15)	-0.012	0.082	(0.77)	0.045
Hed4 vs Hed3	-0.124	(2.22)	-0.038	(1.40)	-0.099	-0.128	(1.51)	-0.069
Hed5 vs Hed3	-0.349	(3.74)	-0.118	(2.57)	-0.299	-0.569	(4.01)	-0.299
Wind2 vs Wind1	-0.077	(0.85)	-0.031	(0.74)	-0.081	-0.137	(0.98)	-0.074

Table 15 (continued)

Variable	OLS Coefficient		Poisson Coefficient (B)		Poisson Pseudo-OLS coefficient	Ordered-Logit[a] Coefficient (Γ)		Ordered-Logit[a] Pseudo-OLS coefficient
Wind3 vs Wind1	-0.103	(1.17)	-0.036	(0.87)	-0.095	-0.254	(1.89)	-0.136
Wind4 vs Wind1	-0.247	(1.07)	-0.115	(0.93)	-0.287	-0.556	(1.60)	-0.292
Wind5 vs Wind1	0.153	(1.29)	0.058	(1.06)	0.159	0.216	(1.17)	0.119
Hind2 vs Hind1	-0.139	(2.06)	-0.450	(1.43)	-0.119	-0.341	(3.33)	-0.185
Hind3 vs Hind1	-0.234	(3.07)	-0.080	(2.25)	-0.210	-0.472	(4.05)	-0.254
Hind4 vs Hind1	-0.465	(4.74)	-0.179	(3.42)	-0.445	-0.836	(5.52)	-0.440
Hind5 vs Hind1	-0.403	(3.80)	-0.100	(2.14)	-0.255	-0.583	(3.60)	-0.312
Constant	-5.618	(3.96)	-0.024	(0.04)				
Number of observations	3649		3649			3649		
R^2	0.699							
McFadden Pseudo-R^2	0.270		0.255			0.314		
Maddala Pseudo-R^2	0.699		0.669			0.735		
Aldrich and Nelson Pseudo-R^2	0.545		0.525			0.570		
Cragg and Uhler Pseudo-R^2			0.697			0.735		

Tests of Hypotheses[b]	OLS		Poisson		Ordered-Logit	
Wife's education	16.0	[0.003]	10.3	[0.036]	18.0	[0.001]
Husband's education	16.3	[0.003]	8.0	[0.091]	19.2	[0.001]
Wife's sector of employment	7.4	[0.118]	4.9	[0.300]	10.5	[0.033]
Husband's sector of employment	34.8	[0.000]	17.0	[0.002]	45.2	[0.000]

Notes: Figures in parentheses are t-ratios.

a. For the ordered-logit model there are 12 cutting points: 1.18, 4.11, 6.54, 8.35, 9.80, 10.89, 11.88, 12.86, 13.59, 14.27, 15.28, 16.57. (Women having 12 or 13 children are grouped in the same category.)

b. Likelihood-ratio tests; figures in square brackets are P-values.

explanatory variables on the expected number of children ever born. In the case of the Poisson model such effects could be estimated by deriving corresponding derivatives, but that procedure is not appropriate for dummy variables. Furthermore, as noted above, in the case of the ordered-logit model (or ordered-response models in general) there are no closed-form formulae for the corresponding derivatives. Appendix A gives the details of the calculations.

We note that the pseudo-OLS coefficients are not independent of the values of explanatory variables, given the assumed non-linear nature of the relationships; the values reported were calculated at the mean values of the explanatory variables (but see Appendix A for modifications when pseudo-OLS coefficients are calculated for the dummy variables). We note that no measure are reported for the first nine variables in Table 15 since such measures would not be meaningful if calculated *separately*, ignoring interactions. As an example, the effect of marital duration must be estimated by allowing both *Mardur* and *Mardur2* to vary simultaneously. Using this method we estimate that an one-year decrease in marital duration due to an one-year increase in age at marriage would reduce the number of children ever born by 0.42 in the Poisson and 0.45 in the order-logit model. The North-South differences in fertility could be estimated similarly; further discussion is provided below.

Table 15 shows that the pseudo-OLS coefficients in the Poisson and ordered-logit models are similar (some are very close), but they differ substantially from the coefficients in the OLS model. For example, the pseudo-OLS coefficients for the variable *Wed1* (versus *Wed3*) are 0.140 and 0.136 in the Poisson and ordered-logit models, whereas the coefficient is 0.310 in the OLS model.

We observe also significant differences among the three models in the t-ratios relating to certain variables. For example, the coefficients of the variables *Wed1* and *Hed4* are significantly different from zero at the five-percent level in the linear OLS model, but not in the Poisson and ordered-logit models; however, at the same level of significance the coefficient of the variable *Wed4* is significant in the Poisson and ordered-logit models, but not in the OLS model. To summarize the extent of agreement among the three models we use the five-percent level of significance as a rule of thumb. For the 31 independent variables included in our models (the constant term and the ordered-logit model's ancillary parameters are excluded) we find that all three models agree in the rejection or acceptance of the null hypothesis for 18 variables, that the linear OLS model agrees with the Poisson model for 20 variables and with the ordered-logit model for 22 variables, and that the Poisson and ordered-logit models are most consistent in this respect with testing outcomes coinciding for 25 variables. These findings, together with the problems relating to the linear OLS model's assumption of the probability distribution discussed above, bring into question the use of the linear OLS model. Comparisons of goodness of fit provide further information.

6.2.2 Evaluating Goodness of Fit

Table 15 provides three pseudo-R^2 measures; see Greene (1993, p. 651), Maddala (1983, p. 39), and Veall and Zimmermann (1994, p. 8) for discussion of these measures. They indicate that the ordered-logit model gives the best fit, but measures for the OLS and Poisson models are close. Another common indicator of goodness of fit is the prediction/success ratio, the proportion of observations whose outcomes are predicted successfully (see Maddala 1983, pp. 76-77). We detail our calculation of this measure below.

We first of all construct prediction success tables. *A woman is predicted to have k children if at k the predicted probability is largest.* Details for the Poisson and ordered-logit models are provided in Table 16. (This method is not applicable to the OLS model because of its assumption of continuity for the dependent variable.)

Based on the prediction success tables we calculated the (overall) prediction/success ratio, S_1, as

$$S_1 = \frac{\sum_{i=1}^{N} N_{ii}}{N} \qquad (25)$$

where N_{ii} is the number of women correctly predicted by the model to have i children and N is the total women in the sample.

The conventional prediction/success ratio has two limitations when applied to the Poisson model. First, if the expectation of a Poisson-distributed random variable x is a non-zero integer n, then there are two possible values, n and n-1, at which the probability would have reached its maximum, and it is not clear how predicted counts should be determined. The problem is not critical since it rarely arises; not a single case occurred with our data. Second, when the expectation is "close" to an integer (for example, 2.05) then the probabilities of x=n and x=n-1 are close and the S_1 ratio tends to understate the goodness of fit when compared to other models. We therefore constructed a similar prediction success table for the *second* choice in which a woman is predicted to have k children if k is her second choice (that is, the probability that she has k children is ranked second). A "second choice" prediction/success ratio, S_2, is calculated by applying (25) to this new prediction success table. S, the arithmetic average of S_1 and S_2, is a more accurate prediction/success ratio. This method has been suggested for other models (see Maddala 1983, p. 77), but it appears relevant also when the Poisson model is applied. Our estimates of S_1, S_2, and S are shown in Table 17. We can see that S_1 understates the goodness of fit for the Poisson model, as expected, and also that the ordered-logit model dominates on both the S_1 and S measures.

As noted above, the prediction/success ratio does not apply to the OLS model. We therefore used an alternative method to calculate the prediction/success ratio which is less standard but can be applied to the OLS model as well as the others. This method differs in that it is based on the predicted expectation, not the predicted probability, of the number of children ever born to a woman. More specifically, a woman is predicted to have k children, where k is a non-negative integer, if the expected number is between k-0.5 and k+0.5. We then apply the same procedures as above to calculate S_1, S_2, and S. The results are given in the lower panel of Table 17.

It is interesting to see that for the Poisson model the success ratio based on the predicted expectation is more accurate than the one based on the predicted probability.[13] (Appendix B provides two prediction success tables for the Poisson

Table 16: Prediction Success Table for the Number of Children Ever Born (CEB) for the Ordered-Logit and Poisson Models

(First line for the ordered-logit model, second line for the Poisson model)

Actual CEB	Predicted CEB													Actual count	Pred. index 2
	0	1	2	3	4	5	6	7	8	9	10	11	12		
0	**102** **172**	123 64	13 4	15 0										240 240	42.5 71.1
1	44 174	**379** **346**	140 61	30 16	8 5	4 4	6 5							611 611	62.0 56.5
2	0 9	149 373	**403** **246**	152 93	45 28	6 8	4 3	6 5						765 765	52.0 32.2
3	0 0	12 69	202 257	**270** **203**	139 93	25 32	15 9	1 1						664 664	40.7 30.6
4	0 1	1 5	34 88	191 191	**212** **157**	44 50	23 16	14 8	0 3					519 519	40.8 30.3
5		0 1	6 16	66 83	146 118	**58** **69**	28 20	9 6						313 313	18.5 22.0
6			0 1	11 19	72 64	46 60	**55** **49**	27 16	0 2	0 1	1 0			212 212	25.9 23.1
7				3 7	29 25	36 48	39 37	**38** **21**	0 7	0 1	2 1	0 0	1 1	148 148	25.7 14.2
8					8 8	11 15	21 25	33 16	**0** **9**	0 1	1 0			74 74	0 12.2
9					3 3	8 11	12 16	20 8	1 6	**0** **0**				44 44	0 0
10					0 0	4 5	11 13	16 9	0 6	0 1	**4** **1**			35 35	11.4 0
11						1 1	3 4	13 8	0 4					17 17	0 2.9
12							1 1	5 3	0 2	0 1	1 0			7 7	0 0
Predicted count	146 356	664 858	785 673	738 612	662 501	243 303	218 198	182 101	1 39	0 5	9 2	0 0	1 1		
Pred. index 1	69.9 48.3	57.1 40.3	51.3 36.6	36.6 33.2	32.0 31.3	23.9 22.8	25.2 24.8	20.9 20.8	0.0 23.1	0 0	44.4 50.0	0 0	0 0		

Table 17: Summary of Prediction Success Ratios

Models and Criteria	S_1	S_2	$(S_1+S_2)/2$
Based on the predicted probability			
- Poisson	34.9	28.7	31.8
- Ordered-Logit	41.7	27.7	34.7
Based on the predicted expectation			
- Poisson	39.8	28.8	34.3
- Ordered-Logit	41.5	27.7	34.6
- OLS	40.5	27.2	33.8

model, one based on the predicted probability and the other on the predicted expectation.) The two methods, however, give similar results for the ordered-logit model, which dominates the others on both S_1 and S measures.

The several measures of goodness of fit thus all point to the same conclusion: The ordered-logit model fits the data better than the linear OLS and Poisson models. While this suggests that we should weight the results from the ordered-logit model more heavily, it does not mean that we should ignore the other two, for at least two reasons. First, better goodness of fit does not necessarily mean the model is better specified; spuriously high measures of R^2 in un-detrended time series models illustrate the argument. Second, and most important, is the inevitable misspecification and, hence, the need to consider sensitivity of estimates and hypothesis tests to model specification, as discussed above. With this in mind we turn to a discussion of the estimated relationships themselves.

6.2.3 Interpretation of the Estimated Relationships

All three models indicate a statistically significant effect of a community's child mortality on individual fertility. The estimated coefficient of the variable *Commort* implies that doubling of that variable, from its mean of 0.01, causes the number of children ever born to increase by only 0.053 in the ordered-logit, 0.058 in the Poisson, and 0.067 in the OLS model. Thus, the quantitative effect is small.

The community's knowledge of contraception has the expected negative effect on fertility and is statistically significant (at the five-percent level) except in the Poisson model. However, the magnitude of the effect is small, perhaps reflecting the fact that contraceptive knowledge is already widespread in Vietnam (see VNDHS-88 1990). On the other hand, such knowledge may not reflect women's access to family planning services. Thus, while further provision of information about contraception may no longer be important the provision of services may.

A stable source of income has a statistically significant, although small, negative effect on fertility; that is consistent with the security motive for children.

After taking other factors into account, women working in non-agricultural sectors are predicted by all three models to have fewer children than those working in agriculture, while those who are not employed have the highest fertility.

However, the magnitudes of the differences are small and none of the t-ratios is statistically significant. Joint tests for the effect of wife's sector of employment indicate no significance, except in the ordered-logit model.

The husband's sector of employment does have a statistically significant effect on fertility. This is confirmed both by the single and joint tests, and by all three models. In general, women with husbands employed in the non-agricultural sectors have lower fertility than those with husbands working in agriculture. The magnitudes of the effects are moderate but much larger than for the wife's sector of employment. The effect of husband's sector of employment on fertility can be explained. First, in Vietnam a significant number of men leave their wives behind in rural areas in order to find employment in urban areas. Such separation would reduce a woman's risk of getting pregnant as long as contraception is imperfect. However, the discussion in Chapters 2 and 3 indicated that birth control has been far from perfect in Vietnam and, indeed, most other countries; another evidence of imperfect birth control is the existence of unwanted fertility -- among the women who reported their desired number of children, 21% said they had more children than they wanted. Second, husbands play an important role in Vietnamese family decision-making, as discussed above, and their employment status may affect their preferences for children. In particular, people working in non-agricultural sectors are often deemed to have higher social status than peasants. As a result, they may pay more attention to the "quality" of children, as opposed to "quantity."

All three models indicate that location of residence matters. Residence in rural areas has a positive influence on the number of children; the difference is about half a child in the OLS model and about one-third in the others. Also, rural women in the North tend to have fewer children than rural women in the South (see the *RurNorth* coefficient). For urban women, there are no statistically significant North-South differences in fertility. However, the signs of the coefficients suggest that women in urban areas in the South tend to have more children than those in the North. Note that the magnitudes of the differences depend on women's ages because of the interaction terms of *North* with *Age*, *Age2*, and *Agespline*, but the differences are very small in general. We shall extend our analysis of these relationships in the next section.

A comparison of the coefficients for educational levels shows that, in general, higher maternal and paternal education both have negative effects on fertility, a pattern that holds in all three models. Comparing their magnitudes, we see that higher maternal education has a somewhat larger impact on fertility than does higher paternal education. The joint tests (see bottom of Table 15) indicate that the effect of maternal education is statistically significant at the five-percent level; this is true for all model specifications. Similarly, the null hypothesis that paternal education has no effect is rejected in the OLS and ordered-logit models. However, the effects are quite moderate, compared with findings for other countries (see Cleland and Rodríguez 1988, Cochrane 1983). More specifically, after controlling for other characteristics of the husband and wife, our estimates suggest a fertility difference between illiterate women and those who had secondary or higher levels of education of about 0.3 to 0.5 births, depending on which model is selected. The estimated gaps obtained by Cleland and Rodriguez were 1.3 births for Africa, 1.0 for Asia (Vietnam was not included), 1.8 for Latin America, and 2.3 for Arab countries. perhaps because the opportunity cost of the mother's time varies little with education in Vietnam, as discussed above. The availability of child care services at relatively low cost and the existence of mass organizations may further reduce the influence of parental education.

6.2.4 Further Exploration

This section provides further investigation into the North-South differences in fertility and, especially, the effects of parental education.

Further Analysis of North-South Differences in Fertility

We saw above that rural women in the North have more children than their counterparts in the South, other things equal, but the opposite holds for the urban population. To assist our interpretation of North-South differences in fertility we calculate and graph the predicted number of children ever born by age of woman, based on the Poisson model estimates for the urban and rural samples separately; see Appendix C.[14] The estimates take account of interactions of educational variables with each of the age variables, *Age*, *Age2*, *Agespline*, and *NAgespline*, in order to account for possible differences across age cohorts in the impact of education on fertility; see Zhang (1990). Another reason for the inclusion of these interactive terms is to analyze the effect of education across age cohorts.

To calculate the predicted number of children ever born, the variable *Age* and, hence, those variables that *by definition* are functions of *Age* (including the interactive terms) vary. Age at marriage is arbitrarily assumed to be 18 for all women, while all the other independent variables are held constant at their mean levels. (We avoid the mean age at marriage because it would imply negative marital durations for younger cohorts; the use of age 18 makes predicted fertility too high but does not affect the conclusions drawn below.)

Figure 10 summarizes the results. Note that the curves need not increase monotonically since they incorporate both age and cohort effects. We observe that after about age 40 they tend to decline slightly. That may reflect the fact that many couples were separated for a long time during the war when it was common in the North for husbands in the army not to visit their families until the war ended or they became disabled.

Figure 10 indicates, consistent with the results in Table 15, that urban women in the South have fewer children than those in the North, but rural women in the South have more than rural women in the North. (We emphasize, however, that each plot in Figure 10 is based on a separate regression with a subset of the data, while Table 15 results are based on the entire sample.) Figure 10 provides further insights. For rural women the North-South differences are small for young cohorts but substantial for old cohorts. Note that all women in the younger cohorts started family life under the communist regime while some women in older cohorts

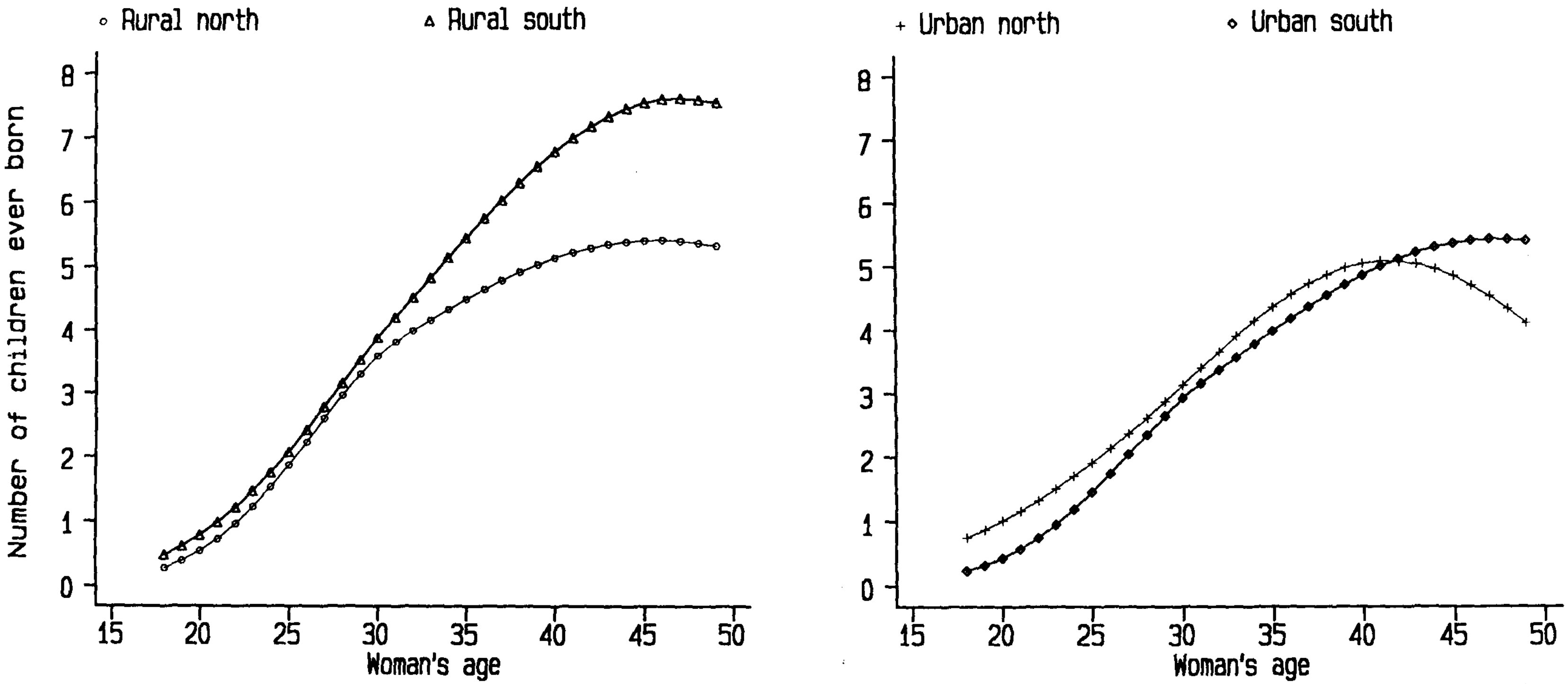

Figure 10: Predicted number of children ever born

were in their main years of reproduction when the South had a different social system. Thus the plots in the left panel might reflect, in part, the influence of social change on fertility. In particular, fertility of younger generations in southern rural areas might have been reduced by the installation of the communist regime in the South in 1975. First, as suggested by Easterlin's "relative income hypothesis" (Easterlin 1966, 1968), such social change may have depressed expectations about the future, and hence reduced fertility. Second, the change to public ownership of all land may have had a negative impact on the fertility of southern farmers. (As discussed above, when peasants work their own land, they may need children to help with the work.) Third, the communist regime brought better social services to southern rural areas (health care, family planning programs, education for adults and children, etc.). Such improvements, in turn, may have helped to reduce fertility.

For urban residents, both Table 15 and Figure 10 suggest that women in the South have fewer children than their counterparts in the North, although the difference is not statistically significant. Cities and towns in the South have been more industrialized and market-oriented, and that may have increased the opportunity cost of children, and hence reduced fertility relative to northern urban areas.

Further Analysis of the Effects of Education

We extend our analysis of the effects of education in two directions. First, we examine the effects of the interactions between the educational variables and age variables. Second, as discussed in Chapter 3, we wish to test the attitudinal versus opportunity-cost effect of parental education.

As noted above, the models in Appendix C (which include interactions between educational variables and each of the age variables, *Age*, *Age2*, *Agespline*, and *NAgespline*) are estimated partly to analyze the effects of education across age cohorts. Based on these estimates we calculate the predicted number of children ever born by age for each of five educational levels. Fertility differences by age of women between different levels of maternal education are then derived. The analysis is done for the rural and urban samples separately. Similar comparisons are made for paternal education. Figure 11 graphs the results for maternal education, and Figure 12 for paternal education. The plots present fertility differences compared to the base case which, to be consistent with estimates presented elsewhere in this thesis, is chosen to be the primary education level. We note two reasons for which comparisons are not made for younger cohorts (women aged less than 25 in 1988). First, since very few people would have post-secondary education degrees before age 22, the comparisons would be unrealistic. Second, in calculating the predicted number of children ever born we fix the age at the first marriage at its mean, and thus the assumed marital duration would be negative for younger cohorts.

The plots in both Figure 11 and Figures 12 indicate, consistent with estimates in Table 15, that both maternal and paternal education have negative effects on fertility, that the magnitudes of the effects are moderate in general, and

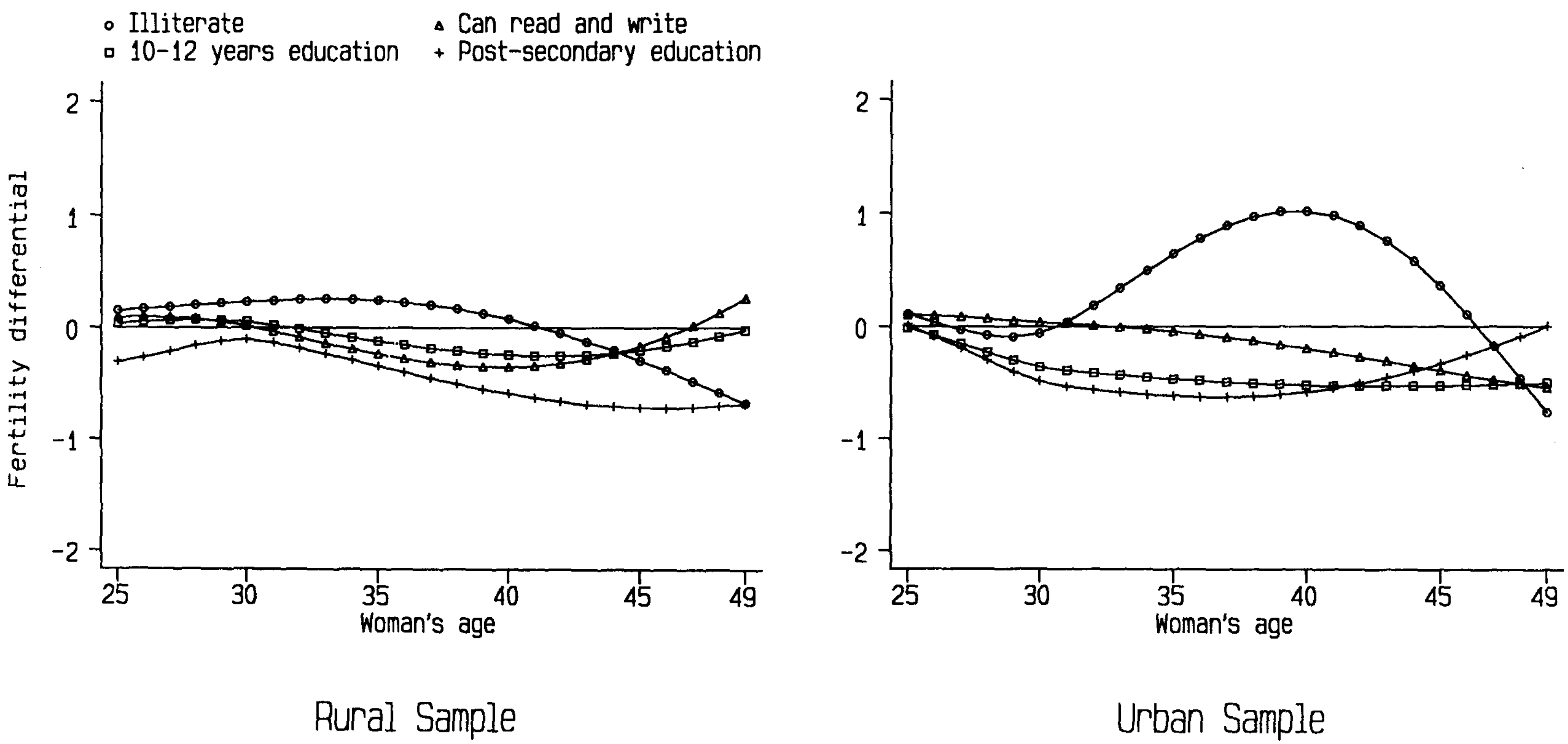

Figure 11. Effect of maternal education on fertility
Note: The base (omitted) category is primary education (Wed3).

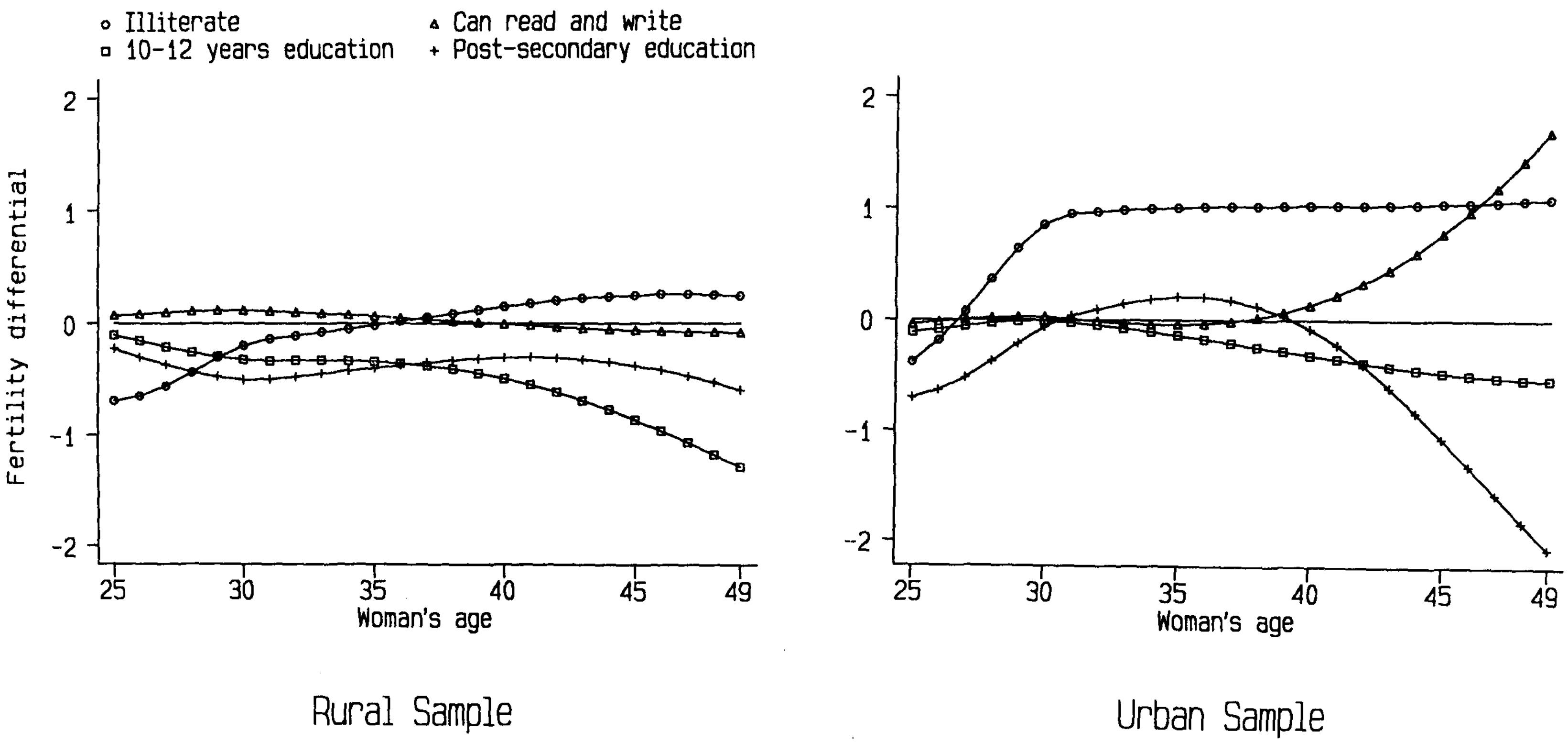

Figure 12. Effect of paternal education on fertility
Note: The base (omitted) category is primary education (Hed3).

that the effect of maternal education is a little larger than that of paternal education. (As noted above, these plots are based on estimates for the rural and urban samples taken separately while the Table 15 estimates are for the whole sample.) The figures show that the effects of both maternal and paternal education are somewhat larger in urban than in rural areas. This seems to be consistent with our argument below that for Vietnam the opportunity cost of mother's time in the agricultural sector depended little on education. In each panel the plots tend to be closer to the zero line in the early phase of reproductive life but the spread increases with age. One possible explanation is that socioeconomic variables influence fertility only after parents have had a minimum desired number of children (Leibenstein 1981, Simmons 1985). (In this survey only 4 women reported that they did not want to have any children.) Additionally, the divergence of the plots at older ages might reflect differences in the opportunity cost of mothers' time among women in different age cohorts. (The gaps in earnings potential might have been greater for older women since few of them had higher levels of education.) Also, the absence of alternatives (such as mass organizations and well-organized family planning programs) to formal education in the South before 1975 might have increased the effect of education for older women there. However, we note also that the non-linear specification of the relationships may have exaggerated the estimated effects of education at older ages.

To test for the attitudinal versus opportunity-cost effect of education, the approach of Yen and Yen (1992) can be applied. They argued that for non-working women education had only an attitudinal effect on fertility while for working women the opportunity-cost effect would have an influence also. Using data for Taiwan they found that the estimated effects of maternal education for the two groups were close and that there was no evidence of a structural difference in the effect of maternal education between the working and non-working women (the F-test statistic was only 1.668, less than the critical value at the five-percent level of significance). They concluded that "the view that the wife's education not only represents a mere proxy for wife's wage but also exerts attitudinal effect cannot be rejected." (Yen and Yen op. cit., p. 104)

There is a problem with the above approach. While having children is a lifetime matter, a woman may or may not have been working at the time of the survey. However, the proportion of women who are not working is very small in poor countries. (Only 4% of women interviewed in the VNDHS-88 reported that they were not working.) With slight modification, the context of Vietnam makes the approach more suitable. In Vietnam, education had little or no effect on individual income in the agricultural sector at the time of the survey, since production on collective farms was distributed solely on the basis of time worked. (We note also that education had little impact on individual incomes though migration since migration across collective farms, as well as from rural to urban areas, was controlled and restricted. In addition, the migration programs that were organized by the government to move people from crowded regions to "new economic zones" were not based on the educational attainment of individuals.) Thus we can assume that for those who worked in agriculture, as well as for non-working people, education had mainly an attitudinal effect on fertility.[15]

The test involves introducing, for each of the woman and her husband, a dummy variable coded 1 if that person worked in the agricultural sector or was not employed, and zero otherwise. The two dummy variables (denoted Dw and Dh for the wife and her husband, respectively) interact with the appropriate education variables, and the estimated interaction terms reflect the opportunity-cost effect of education on fertility. While it is often assumed that the opportunity-cost effect applies mainly to women, since they spend more time on child-rearing, we test also for men.

Table 18: Attitudinal Versus Opportunity-Cost Effects of Parental Education

Variables	OLS		Poisson		Ordered-Logit	
Wed1*Dw	0.920	(2.95)	0.215	(1.94)	1.288	(2.49)
Wed2*Dw	0.142	(0.95)	0.079	(1.23)	0.298	(1.31)
Wed4*Dw	0.281	(2.03)	0.084	(1.12)	0.357	(1.67)
Wed5*Dw	-0.083	(0.27)	-0.072	(0.45)	-0.085	(0.17)
Hed1*Dh	0.680	(1.83)	0.213	(1.45)	0.942	(1.59)
Hed2*Dh	0.236	(1.51)	0.060	(0.94)	0.338	(1.41)
Hed4*Dh	-0.064	(0.59)	-0.053	(1.01)	-0.256	(1.55)
Hed5*Dh	0.009	(0.05)	-0.010	(0.10)	-0.083	(0.28)
Likelihood-Ratio Tests[a]:						
- First four variables	12.2	[0.016]	5.2	[0.267]	8.0	[0.091]
- Last four variables	6.4	[0.171]	6.0	[0.199]	8.8	[0.066]
- All (8) variables	21.76	[0.005]	12.3	[0.138]	20.0	[0.001]

Note: Figures in parentheses are t-ratios, figures in square brackets are P-values.
a. Tests of whether coefficients of variables are all equal to zero.

Table 18 reports the estimates and test-statistics relating to these variables. While the relative magnitudes of the coefficients suggest that the effect of parental education is larger for those working in non-agricultural sectors (where wages are more dependent on education), the individual and joint tests show that the opportunity-cost effect is not statistically significant. One might think that this argument would be less applicable in the South, where agricultural collectives were not established until the latter part of the 1970's, and even then had little impact. Thus, one might have anticipated that education would have had more of an opportunity-cost effect on the fertility of rural women in the South. We tested for that possibility using equations estimated separately for the North and South and found the results to be consistent with those for the sample as a whole. We conclude that our data provide evidence of an attitudinal effect alone of parental education in Vietnam.

For two reasons own education might have had a greater impact on the fertility of older women in the South. First, the opportunity cost of women's time might have been greater under the pre-1975 capitalist regime. Second, they were less influenced by the communist mass organizations and propaganda, which, as noted above, may partly substitute for formal education (for example, in providing information and influencing preferences for children). Parts of the socioeconomic environment change only gradually even after a change in the political system. Thus education might have had a larger effect for younger women in the South than for both younger and older women in the North. To summarize, the hypothesis is that education had the largest effect for older women in the South, a smaller effect for younger women in the South, and the smallest effect of all for women in the North.

We test for this relationship, using a technique similar to the one applied in the above test. Two dummy variables are defined; the first, denoted *South*, is coded 1 if a woman lived in the South and zero otherwise (i.e., *South* = *1* - *North*); the second, denoted *South35*, is coded 1 if a woman lived in the South and was aged 35 or more in 1988 and zero otherwise. We then extend the basic models (in Table 15) by including interactions between each of *South* and *South35* with the educational variables and test for those interactions. Table 19 provides the estimates of these interaction terms and testing results.

Table 19 shows no disagreement in the signs of estimated coefficients for Poisson and ordered-logit models. However, the signs for the OLS model differ for several variables. This is consistent with what we found above (Tables 15 and 18). Differences in the effect of maternal education for older women in the South are captured by the first four interaction terms. However, only the first term in all three models and the third term in the OLS model are statistically significant with the expected signs; other terms are not significant and/or have estimated effects with signs that are presumably incorrect. The joint test of significance for the coefficients of these terms is sensitive to model specification, and that, combined with the differences in signs of the estimates, indicates that there is no reliable evidence that education had a larger effect on fertility of older women in the South.

Table 19: Effects of Education for Different Groups of Women

Variables	OLS		Poisson		Ordered-Logit	
Wed1*South35	0.803	(3.39)	0.531	(2.32)	3.179	(4.30)
Wed2*South35	-0.067	(0.43)	0.041	(0.49)	0.211	(0.75)
Wed4*South35	-0.733	(3.17)	0.060	(0.51)	0.081	(0.22)
Wed5*South35	-0.909	(1.96)	0.113	(0.71)	0.136	(0.30)
Wed1*South	-0.035	(0.13)	0.481	(2.25)	2.647	(4.08)
Wed2*South	-0.017	(0.12)	0.035	(0.47)	0.261	(1.12)
Wed4*South	-0.027	(0.18)	-0.061	(0.76)	-0.232	(1.04)
Wed5*South	-0.029	(0.10)	-0.140	(0.77)	-0.525	(1.10)
Hed1*South	0.460	(1.28)	0.047	(0.22)	0.465	(0.74)
Hed2*South	-0.121	(0.74)	-0.048	(0.54)	-0.245	(0.89)
Hed4*South	-0.126	(1.06)	-0.080	(1.32)	-0.436	(2.42)
Hed5*South	0.164	(0.76)	-0.036	(0.32)	-0.253	(0.77)
Hed1*South35	-0.190	(0.57)	0.019	(0.07)	0.056	(0.06)
Hed2*South35	0.157	(0.84)	-0.059	(0.60)	-0.131	(0.39)
Hed4*South35	0.139	(0.83)	-0.135	(1.76)	-0.817	(3.23)
Hed5*South35	-0.159	(0.51)	-0.125	(1.16)	-0.883	(2.69)
Likelihood-Ratio Tests[a]:						
First four variables	26.84	[0.000]	6.48	[0.166]	18.12	[0.001]
Wed1*South - Wed5*South	0.06	[1.000]	6.92	[0.140]	19.24	[0.001]
Hed1*South - Hed5*South	4.84	[0.304]	2.02	[0.732]	7.20	[0.126]
Last four variables	2.44	[0.655]	4.03	[0.402]	14.60	[0.006]

Note: Figures in parentheses are t-ratios, figures in square brackets are P-values.
a. Testing whether coefficients of variables are all equal to zero.

Based on the signs of the estimates, the Poisson and ordered-logit models suggest that maternal education tends to have had a larger effect for women in the South (see the four interactions of maternal education and *South*) while there are mixed signals for the OLS model. However, the test that coefficients of all four variables are equal to zero is rejected only in the ordered-logit model. Furthermore, we find no evidence of differences across the groups in the effect of paternal education (see the last eight interaction terms).

6.4 Chapter Summary

We have analyzed the determinants of individual fertility using three statistical models. Based on goodness-of-fit measures, the ordered-logit model performs better than either the OLS or the Poisson model. The Poisson and ordered-logit models give similar estimated effects of variables on the number of children ever born, and the estimates from these models differ quite significantly from those of the OLS model.

We find that both paternal and maternal education have statistically significant effects on the number of births. However, the magnitudes of the effects are relatively small compared with estimates for other countries. Of particular interest, the hypothesis of opportunity-cost effects of parental education on fertility is rejected by our tests, and this suggests that, at least in Vietnam, parental education exercises its impact on fertility mainly through its influence on preferences for children. However, the lack of evidence of an opportunity-cost effect in the Vietnamese data may have resulted from the distinctive socioeconomic environment of Vietnam and, hence, not be typical. Our results show, further, that the employment status and income stability of the husband have important effects on fertility. This, together with the effect of paternal education, is consistent with the important role of the husband in family decision-making in Vietnam. It is also consistent with the view that, although the status of Vietnamese women has improved considerably, especially in public life, husbands still have the dominant role in family life. Male dominance creates a preference for boys. Whether sex preference and child mortality influence reproductive behaviour is the topic of the next chapter.

Chapter 7: EFFECTS OF SEX PREFERENCE AND CHILD MORTALITY ON FERTILITY

This chapter analyzes the effects of sex preference and child mortality on fertility, using a sequential-response model. The modelling which was introduced in Chapter 5 is extended to include a discussion of the stages involved in the fertility decision-making process. The relationships are estimated and the estimates discussed.

At this point we note that the concept of child mortality used in this study refers to the mortality of a woman's ever-born children; thus, for example, the death of a child at age 20 is included, and its effect on her fertility is relevant for our study. This, however, does not mean that the effect of a child's death on its mother's future fertility is independent of the age at which the child dies, as we shall see.

7.1 The Variables

The Stages of the Decision-Making Process

Maddala (1983, pp. 49-51) gives examples of simple sequential-response models in which the values of all independent variables remain the same throughout the decision-making process. However, as noted in Chapter 5, an advantage of the model is that the independent variables can change. In order to define variables associated with the decision-making process, we must first identify the points at which couples make their fertility decisions. Let us illustrate this important point with an example: The death of a first child that happened after the couple had already decided to have a second (perhaps the first child died even after the woman had conceived a second child) would have no impact on the probability of a second birth. However, to define mortality variables to reflect such information we need to know not only the timing of child deaths but also the timing of fertility decisions.

Of course we do not know when decisions are made at each stage in a sequential decision-making process. In an analysis featuring educational choices (Maddala 1983, pp. 49-50, Amemiya 1975), for example, one may assume that individuals decide whether to proceed to the next level of education when the present level is completed. But in reproductive decision-making, and even in the case of education, couples might not make decisions immediately after an event occurs. In particular, since mortality is very high during the early years of life, a couple may wish to postpone final decisions about further fertility at least until the youngest of their desired number of children has passed that high risk period. Because we do not observe when each couple makes such decisions, we adopt a "search" method in our estimation. That is, we estimate the model assuming alternative decision-making points, and base our conclusions on log-likelihood values. Figure 13 illustrates the cases in which, with the exception discussed below, decisions are assumed to be made one year after marriage and, after that, one year after every birth. (For the first stage, we also tried the possibility that couples made fertility decisions as soon as they got married.) The first stage of decision-making, then, relates to the choice after marriage of whether to have a first birth, the second stage corresponds to the choice between having only one child and having a second, and so on.

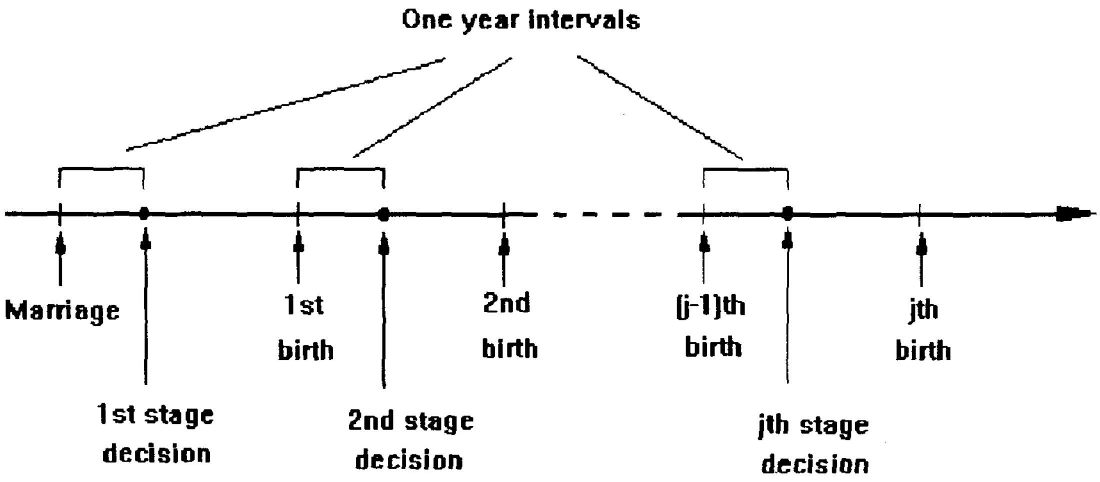

Figure 13. An assumed pattern of decision-making points

However, if a woman's k^{th} birth occurred less than 22 months after the preceding birth (or after her marriage, if the birth was the first one), the decision relating to that birth was made earlier than is depicted in Figure 13. In such a case we shift the decision-making point back to one month before conception (that is, the decision was assumed to be made approximately 10 months before the child was born).

There is an exception to the rule presented in Figure 13, and it relates to the problem of censoring. A woman who had k births with the latest less than one year before the survey date had not yet reached the date at which the next decision would be made -- i.e., the decision for the $(k+1)^{th}$ stage. We tested two alternatives. In the first we assumed that the decision for the $(k+1)^{th}$ stage had been made by the survey date. In the second we dropped such incomplete observations from the estimation. We found that the results were largely independent of which alternative was used.

Given the assumed decision-making points, stage variables can be defined accordingly.

Variable Definitions

Most variables that were introduced in earlier chapters continue to play a role here, so it is convenient to refer back to Table 15 as a starting point.

Since only women who were continuously married are included in the empirical analysis, the variable *Marrno* is dropped. Otherwise we retain all variables. In practice, few of these variables would remain unchanged throughout reproductive life for all women. (For example, some women might have had higher educational attainment at the time of the survey than at the times when their first children were born.) We treat them as static (fixed) variables, largely for reasons of data availability. However, the resulting measurement errors are likely to be small.

We now add a number of stage variables, variables whose values vary over the course of decision-making. A woman's age at decision-making point j, Age_j , and its square, $Age2_j$, are added both because a woman's fecundity varies with her age (and that influences whether she has more children) and because the probability that a woman will have another birth depends on her exposure. An example might help. Consider two women who are identical except that one had a first birth at age 25 and the other at age 35. As a result, the periods during which they were exposed to the risk of having a second birth were not the same; for one who gave birth at age 35 the exposure was less. To control for exposure, all previously defined age variables, *Age*, *Age2*, and *Agespline*, as well as their interactions with other variables, are retained.

Three dummy variables are defined to capture the effect of sex preference. The first, denoted B_j, equals 1 if a woman had only one boy alive at decision-making point j and zero otherwise. Obviously, this variable is not defined for the first stage of decision-making, i.e., the stage following (first) marriage. The second, denoted BB_j, equals 1 if a woman had at least two boys alive at decision-making point j and zero otherwise. This variable is not defined for the first and second stages. The third, denoted BBB_j, equals 1 if a woman had at least three boys alive at the decision-making point j and zero otherwise. This variable is defined only for the fourth and later stages. The review of the Vietnamese context in Chapter 2 suggests that what matters to Vietnamese families is perhaps to have at least one boy, not to have a predominance of boys as it tends to be in some other countries (Williamson 1976). The above dummy variables are designed to test such a relationship.

Several stage dummy variables are defined to analyze the effects of child mortality, and are denoted $Dead_j$ (j=2,3,...). For j=k, $Dead_k$ equals 1 if a child (in any birth order) died in the period between the decision-making point k-1 and k and zero otherwise. In the regression for stage k, in which a woman chooses either to stop after having k-1 births or to have a k^{th} birth, we include not only $Dead_k$ but also $Dead_{k-1}$, $Dead_{k-2}$,..., $Dead_2$. A woman's fertility decision at each stage might be affected by child deaths that happened in earlier stages. In particular, if a couple wishes to have at least n surviving children, the death of the first child, for example, would influence their fertility decision only after n children had survived. In other words, each death increases desired pregnancies by one as long as the desired number of surviving children is unchanged.[16]

Table 20 provides a summary of definitions and statistics for the newly defined variables. Note that because the sample size becomes smaller for later stages, the sample means and variances for static variables will also vary across stages of decision-making. (The definitions as well as summary statistics for the whole sample are given in Table 14.) The organization of Table 20 is similar to that of Table 14.

Table 20: Summary of Variables' Definitions and Statistics

Variable	Definitions	Mean[1]		Min, Max	
	Dependent Variables:				
N_1	Had at least one child versus no child [n=3492]	0.932		0	1
N_2	Had at least two children versus only one child [n=3253]	0.816		0	1
N_3	Had at least three versus only two children [n=2656]	0.722		0	1
N_4	Had at least four versus only three children [n=1917]	0.666		0	1
N_5	Had at least five versus only four children [n=1277]	0.616		0	1
N_6	Had at least six versus only five children [n=787]	0.617		0	1
	Independent Variables:				
Age_1	Age of the woman (years) at first stage decision-making	21.6	(3.3)	13	40
Age_2	- at second stage decision-making	23.6	(3.5)	15	41
Age_3	- at third stage of decision-making	26.0	(3.6)	17	45
Age_4	- at fourth stage of decision-making	28.3	(3.8)	20	46
Age_5	- at fifth stage of decision-making	30.5	(3.9)	21	49
Age_6	- at sixth stage of decision-making	32.5	(3.7)	22	43
$Age2_1$	Square of Age_1	478.0	(156.2)	169	1600
$Age2_2$	Square of Age_2	570.8	(174.7)	225	1681
$Age2_3$	Square of Age_3	688.2	(196.1)	289	2025
$Age2_4$	Square of Age_4	817.4	(225.5)	400	2116
$Age2_5$	Square of Age_5	945.3	(252.6)	441	2401
$Age2_6$	Square of Age_6	1068.	(246.9)	484	1849

Table 20 (continued)

Variable	Definitions	Mean		Min, Max	
B_2	One boy alive at 2nd stage decision-making	0.509	(0.500)	0	1
B_3	At least a boy alive at 3rd stage decision-making	0.742	(0.438)	0	1
B_4	- at 4th stage decision-making	0.859	(0.348)	0	1
B_5	- at 5th stage decision-making	0.912	(0.284)	0	1
B_6	- at 6th stage decision-making	0.936	(0.244)	0	1
BB_3	Two boys alive at 3rd stage decision-making	0.257	(0.438)	0	1
BB_4	At least two boys alive at 4th stage decision-making	0.481	(0.500)	0	1
BB_5	- at 5th stage decision-making	0.637	(0.481)	0	1
BB_6	- at 6th stage decision-making	0.760	(0.427)	0	1
BBB_4	Three boys alive at 4th stage decision-making	0.112	(0.316)	0	1
BBB_5	At least three boys alive at 5th stage decision-making	0.280	(0.449)	0	1
BBB_6	- at 6th stage decision-making	0.400	(0.490)	0	1
$Dead_2$	At least one child died before 2nd stage decision-making	0.030	(0.172)	0	1
$Dead_3$	At least one child died between 2nd & 3rd decision-making stages	0.037	(0.188)	0	1
$Dead_4$	- 3rd & 4th decision-making stages	0.064	(0.244)	0	1
$Dead_5$	- 4th & 5th decision-making stages	0.078	(0.268)	0	1
$Dead_6$	- 5th & 6th decision-making stages	0.062	(0.242)	0	1

Note: 1. Figures in parentheses are standard deviations

7.2 Results

The procedures used to estimate the model were discussed in Chapter 5. As a summary, one binary-logit regression is estimated for each stage of decision-making. In the regression for stage j, in which a woman chooses whether to have a j^{th} birth, only those who had at least j-1 births are included in the sample. The binary dependent variable, again taking stage j as an example, is coded 1 if a woman had a j^{th} birth and zero otherwise.

7.2.1 Searching for the Decision-Making Points

Table 21 summarizes the results of searching for the decision-making points that give the model the best fit, based on, as noted above, log likelihood values. In addition to the log likelihood values, which are used as an indicator of goodness of fit, the table provides estimates for key variables. We alternatively assume decision-making points to be one, two, three, four, or five years after a woman had each birth (with the exceptions discussed above). Since we focus on the effects of sex preference and child mortality, the first stage is not relevant and results for it are not presented.

We discuss the estimated relationships later. For now we note the following results. First, the model fits best, in terms of the log likelihood values, when couples' decisions are assumed to be made one year after every birth.

Second, however, different assumptions about the timing of fertility decision-making cause only little change in the estimated coefficients of the key variables.

Table 21: Alternative Decision-Making Points and Key Estimation Results

Estimates and Statistics	Time of Decision since the Previous Birth									
	One Year		Two Years		Three Years		Four Years		Five Years	
Stage 2: Stop or Have a Second Child										
B_2	-0.315	(2.23)	-0.328	(2.37)	-0.334	(2.46)	-0.335	(2.49)	-0.340	(2.54)
$Dead_2$	-0.117	(0.29)	-0.030	(0.08)	-0.021	(0.06)	0.063	(0.17)	0.136	(0.38)
No. of observations	3253		3253		3253		3253		3253	
Log likelihood	-687.9		-721.7		-748.5		-764.0		-771.5	
Stage 3: Stop or Have a Third Child										
B_3	-0.711	(4.34)	-0.699	(4.38)	-0.664	(4.27)	-0.640	(4.18)	-0.622	(4.11)
BB_3	0.079	(0.50)	0.341	(0.22)	-0.005	(0.04)	0.011	(0.08)	-0.019	(0.13)
$Dead_2$	0.681	(1.54)	0.837	(2.08)	0.947	(2.39)	1.038	(2.62)	1.107	(2.79)
$Dead_3$	1.017	(2.33)	0.930	(2.15)	0.742	(1.81)	0.741	(1.84)	0.751	(1.87)
No. of observations	2656		2656		2656		2656		2656	
Log likelihood	-774.5		-805.6		-841.54		-866.2		-866.2	

Table 21 (continued)

Estimates and Statistics	Time of Decision since the Previous Birth									
	One Year		Two Years		Three Years		Four Years		Five Years	
Stage 4: Stop or Have a Fourth Birth										
B_4	-0.673	(3.07)	-0.739	(3.42)	-0.762	(3.59)	-0.737	(3.54)	-0.719	(3.50)
BB_4	-0.248	(1.55)	-0.176	(1.12)	-0.127	(0.82)	-0.115	(0.76)	-0.096	(0.65)
BBB_4	0.841	(3.63)	0.748	(3.29)	0.685	(3.07)	0.649	(2.96)	0.613	(2.83)
$Dead_2$	0.316	(0.78)	0.319	(0.83)	0.375	(0.98)	0.438	(1.16)	0.518	(1.38)
$Dead_3$	-0.110	(0.30)	0.041	(0.11)	0.007	(0.02)	-0.003	(0.01)	0.157	(0.05)
$Dead_4$	0.987	(2.89)	0.973	(2.91)	0.927	(2.79)	0.792	(2.48)	0.757	(2.35)
No. of observations	1917		1917		1917		1917		1917	
Log likelihood	-697.1		-713.8		-736.4		-758.0		-775.8	
Stage 5: Stop or Have a Fifth Birth										
B_5	-0.656	(2.10)	-0.676	(2.19)	-0.617	(2.05)	-0.585	(1.98)	-0.578	(1.98)
BB_5	-0.347	(1.71)	-0.304	(1.53)	-0.306	(1.56)	-0.300	(1.55)	-0.296	(1.56)
BBB_5	0.017	(0.09)	-0.050	(0.26)	-0.056	(0.29)	-0.073	(0.39)	-0.081	(0.44)
$Dead_2$	-0.079	(0.16)	0.122	(0.26)	0.178	(0.39)	0.221	(0.49)	0.272	(0.61)
$Dead_3$	-0.001	(0.00)	-0.192	(0.52)	-0.170	(0.47)	-0.160	(0.44)	-0.159	(0.44)
$Dead_4$	0.281	(0.91)	0.170	(0.57)	0.188	(0.64)	0.228	(0.79)	0.265	(0.93)

Table 21 (continued)

Estimates and Statistics	Time of Decision since the Previous Birth									
	One Year		Two Years		Three Years		Four Years		Five Years	
$Dead_3$	-0.001	(0.00)	-0.192	(0.52)	-0.170	(0.47)	-0.160	(0.44)	-0.159	(0.44)
$Dead_4$	0.281	(0.91)	0.170	(0.57)	0.188	(0.64)	0.228	(0.79)	0.265	(0.93)
$Dead_5$	0.453	(1.44)	0.438	(1.36)	0.456	(1.47)	0.428	(1.40)	0.406	(1.34)
No. of observations	1277		1277		1277		1277		1277	
Log likelihood	-521.3		-532.3		-546.7		-559.6		-571.4	
Stage 6: Stop or Have a Sixth Birth										
B_6	-0.729	(1.44)	-0.711	(1.43)	-0.760	(1.54)	-0.809	(1.67)	-0.865	(1.80)
BB_6	-0.200	(0.67)	-0.184	(0.61)	-0.168	(0.57)	-0.144	(0.49)	-0.110	(0.38)
BBB_6	-0.211	(0.88)	-0.180	(0.76)	-0.177	(0.76)	-0.217	(0.93)	-0.253	(1.10)
$Dead_2$	-0.647	(1.09)	-0.508	(0.88)	-0.465	(0.83)	-0.362	(0.66)	-0.298	(0.55)
$Dead_3$	-1.034	(2.04)	-0.532	(1.14)	-0.571	(1.26)	-0.588	(1.30)	-0.604	(1.35)
$Dead_4$	-0.373	(0.95)	-0.212	(0.56)	-0.110	(0.29)	-0.053	(0.14)	-0.017	(0.04)
$Dead_5$	0.533	(1.31)	0.609	(1.44)	0.485	(1.20)	0.505	(1.27)	0.550	(1.40)
$Dead_6$	0.798	(1.77)	0.735	(1.65)	0.745	(1.66)	0.500	(1.14)	0.427	(1.01)
No. of observations	787		787		787		787		787	
Log likelihood	-313.2		-318.7		-324.4		-329.1		-333.4	

The explanation is straightforward: Because child mortality rates are low after infancy (in Vietnam, about 70% to 80% of all child deaths under age 5 happened within infancy; see VNDHS-88 1990, p. 55), assuming different decision-making points as we have done causes little change in the sex and mortality variables.[17]

7.2.2 Interpretation of Estimated Relationships

Since the model fits best when couples' decisions are assumed to be made one year after each birth, we base our discussion on this case.

Table 22 provides estimation results in detail. In addition to the conventional coefficients for the binary logit model, which show the effects of unit increases in explanatory variables *on the log odds ratios* (see section 5.2.2), the table gives, in shaded cells, the estimated effects of unit increases *on the probabilities* for key explanatory variables. These estimates are dependent on the values of explanatory variables, which determine the initial (base) values of the odds ratios; the reported figures assume the sample odds ratios as the base cases. (An alternative would be to use, for each stage, a base case that has explanatory variables set equal to their means. However, the results would be similar). An example might help. Since among women with at least two children, 72.2% went on to have three or more children, the odds ratio for this sample (which is used for regression for stage 3) is 2.60. Since the coefficient of the variable B_3 (in Table 22, it is B_j with $j=3$) is -0.711, a unit increase in this variable (i.e., a switch from having no living boy to having at least one living boy) would decrease the log odds ratio

Table 22: Regression Results for the Sequential-Response Model

Variables	Stages of Decision-Making (j)									
	Second		Third		Fourth		Fifth		Sixth	
B_j	-0.315	(2.23)	-0.711	(3.43)	-0.673	(3.08)	-0.656	(2.10)	-0.729	(1.44)
	-5.20		-16.11		-16.22		-16.17		-17.97	
BB_j			0.079	(0.50)	-0.248	(1.55)	-0.347	(1.71)	-0.200	(0.67)
			1.57		-5.77		-8.47		-4.82	
BBB_j					0.841	(3.63)	0.017	(0.09)	-0.211	(0.89)
					15.59		0.004		-5.09	
$Dead_2$	-0.117	(0.29)	0.681	(1.54)	0.316	(0.78)	-0.079	(0.16)	-0.647	(1.09)
	-1.82		11.50		6.59		-1.88		-15.94	
$Dead_3$			1.017	(2.33)	-0.110	(0.30)	-0.001	(0.00)	-1.034	(2.04)
			15.59		-2.54		0.000		-25.28	
$Dead_4$					0.987	(2.89)	0.281	(0.91)	-0.373	(0.95)
					17.63		6.40		-9.10	
$Dead_5$							0.453	(1.44)	0.533	(1.31)
							10.02		11.60	
$Dead_6$									0.798	(1.77)
									16.46	
Age_j	-1.780	(6.92)	-1.650	(6.69)	-1.255	(5.08)	-0.611	(1.97)	-1.235	(2.40)
$Age2_j$	0.022	(4.69)	0.018	(4.34)	0.012	(3.07)	0.002	(0.32)	0.012	(1.58)
Mardur	0.257	(4.45)	0.155	(2.52)	0.142	(1.89)	0.012	(0.13)	0.273	(1.75)
Mardur2	-0.010	(4.56)	-0.007	(3.43)	-0.005	(2.42)	-0.003	(1.01)	-0.005	(1.44)

Table 22 (continued)

Variables	Stages of Decision-Making (j)									
	Second		Third		Fourth		Fifth		Sixth	
Age	0.865	(2.26)	1.681	(4.84)	0.866	(2.62)	1.336	(3.97)	2.135	(4.36)
Age2	-0.008	(1.45)	-0.017	(3.63)	-0.007	(1.52)	-0.012	(2.75)	-0.023	(3.73)
Agespline	-0.030	(2.60)	-0.003	(0.22)	-0.035	(2.08)	-0.011	(0.41)	0.019	(0.30)
North	-5.318	(0.61)	9.046	(1.23)	-8.566	(1.20)	2.340	(0.29)	27.948	(2.39)
NAge	0.392	(0.79)	-0.509	(1.26)	0.396	(1.03)	-0.200	(0.47)	-1.395	(2.34)
NAge2	-0.006	(0.84)	0.007	(1.23)	-0.005	(0.98)	0.003	(0.60)	0.017	(2.24)
NAgespline	0.004	(0.24)	-0.024	(1.44)	0.021	(0.84)	0.039	(0.99)	-0.250	(1.25)
Rural	1.033	(3.27)	0.679	(2.14)	0.502	(1.56)	0.280	(0.77)	0.497	(1.03)
RurNorth	-0.975	(2.58)	0.283	(0.73)	-0.034	(0.08)	0.085	(0.16)	-0.129	(0.19)
Instab	-0.059	(0.35)	0.157	(0.99)	-0.095	(0.57)	-0.517	(2.86)	-0.357	(1.59)
Cominform	0.043	(0.86)	-0.067	(1.46)	-0.117	(2.42)	-0.196	(3.56)	-0.214	(3.10)
Commort	7.674	(1.45)	2.339	(0.44)	10.818	(1.96)	8.378	(1.34)	5.783	(0.72)
Wed1 vs Wed3	-0.375	(0.81)	-0.353	(0.91)	0.373	(0.99)	0.183	(0.51)	0.373	(0.86)
Wed2 vs Wed3	0.293	(1.20)	0.216	(1.01)	0.150	(0.79)	0.040	(0.20)	0.261	(1.04)
Wed4 vs Wed3	-0.023	(0.12)	-0.628	(2.94)	-0.014	(0.05)	-0.665	(1.73)	0.256	(0.45)
Wed5 vs Wed3	-0.666	(1.62)	-0.821	(2.14)	-0.896	(1.82)	-1.200	(1.68)	0.514	(0.44)
Hed1 vs Hed3	0.361	(0.65)	0.644	(1.42)	-0.360	(0.74)	0.020	(0.04)	1.222	(1.70)

Table 22 (continued)

Variables	Stages of Decision-Making (j)									
	Second		Third		Fourth		Fifth		Sixth	
Hed2 vs Hed3	-0.086	(0.29)	0.648	(2.44)	-0.097	(0.42)	-0.102	(0.42)	-0.049	(0.17)
Hed4 vs Hed3	-0.222	(1.26)	-0.010	(0.06)	-0.248	(1.32)	-0.516	(2.24)	-0.063	(0.20)
Hed5 vs Hed3	-0.437	(1.41)	-0.034	(0.12)	0.054	(0.18)	-1.078	(2.80)	-1.527	(2.47)
Wind2 vs Wind1	-0.509	(1.63)	-0.431	(1.46)	-0.737	(2.27)	-0.748	(2.05)	-0.329	(0.67)
Wind3 vs Wind1	-0.380	(1.31)	-0.678	(2.39)	-0.769	(2.57)	-0.392	(1.09)	0.182	(0.36)
Wind4 vs Wind1	-1.602	(2.57)	-0.818	(1.44)	-0.956	(1.06)	0.766	(0.54)	-1.029	(0.24)
Wind5 vs Wind1	0.529	(1.28)	-0.154	(0.37)	-0.752	(1.90)	-0.116	(0.24)	-0.055	(0.09)
Hind2 vs Hind1	-0.570	(2.50)	-0.200	(0.93)	-0.201	(0.91)	0.522	(1.94)	0.044	(0.12)
Hind3 vs Hind1	-0.425	(1.63)	-0.546	(2.19)	-0.668	(2.59)	0.122	(0.38)	0.167	(0.39)
Hind4 vs Hind1	-0.501	(1.64)	-0.404	(1.44)	-0.706	(1.88)	-0.519	(0.93)	-3.082	(2.62)
Hind5 vs Hind1	0.204	(0.45)	0.208	(0.59)	-0.281	(0.91)	-0.593	(1.63)	-1.101	(2.25)
Constant	12.76	(1.75)	-3.667	(0.58)	6.027	(1.00)	-11.94	(1.80)	-20.56	(2.01)
No. of observations	3253		2656		1917		1277		787	
Log likelihood	-687.9		-774.5		-697.1		-521.3		-313.2	
Pseudo-R^2	0.666		0.651		0.589		0.553		0.563	

Note: Figures in parentheses are t-ratios; figures on shaded background are estimated effects of unit increases on the probability of proceeding to the next parity.
The Pseudo-R^2 is the one suggested by Cragg and Uhler (1970).

by 0.711. The new odds ratio (after a unit increase in B_3) would be 0.491 (calculated as exp(-0.711)) times the initial odds ratio of 2.60. Thus, the new odds ratio would be 1.277, and the new probability of proceeding to have a third birth would be 0.561. Consequently, the probability of having a third birth would decrease by 16.1 percentage points, from 72.2% to 56.1%.

Below we consider estimates of the effect of sex preference and child mortality in turn. Interpretation of other variables is limited to reconciling results from the present model with findings from the static models in the previous chapter.

Effects of Sex Preferences

The coefficients of the variables B_j (j=2,3,...,6) indicate that at each stage after the second birth, the probability of stopping is greater for couples who had had at least one living boy. The differences are about 5% in the second stage (following the first birth) and between 16% and 18% in the later stages. The effect of the presence of a boy is statistically significant at the 5% or higher level of significance in all stages before the sixth stage. That suggests that many couples would continue to try to have a boy by having more births until they reached a high level of fertility. The small estimated effect at the second stage (i.e., the small effect of the sex of the first child on the probability of a second birth) is consistent with the preference of most couples to have at least two children (the survey showed that 98.5% of couples who reported a desired number of children wished to have at least two). Thus most couples would have a second birth regardless of the sex of the first. However, once the preferred number of children had been born, sex preference and other factors would be expected to have a greater influence on reproductive behaviour.

With the exception of BBB_4 (to be discussed below), none of the BB_j or BBB_j variables ($j=2,3,...,6$) is significant. Thus our results suggest that what matters to parents is to have at least one boy, not necessarily many.

The above results are consistent with other evidence. For example, Vu Manh Loi (1990) reported a survey conducted in a village which showed that 64% of women and 60% of men who were interviewed said that "it is necessary to have a boy" and that they would "continue with reproduction until a boy comes." Applying the proportional hazard model to the 1992 Vietnam Living Standards Survey to study sex preference, Haughton and Haughton (1995) found evidence of "a preference for a boy but not necessarily many boys". The desire to have a boy is consistent also with the discussion in Chapter 2 about Vietnamese culture.

The finding of a strong, positive and statistically significant effect for BBB_4 is interesting. It suggests that couples whose first three children were all male and alive when the decision whether to have a fourth birth was made were much less likely to stop than those with fewer living sons. Can this be interpreted as evidence of a preference for having children of both sexes? To answer that question we need to consider also the behaviour of parents who had two boys but no girls. We note that the estimated coefficient for BB_3 is very small and its t-ratio is only 0.5. Thus, among couples with two children those with two boys are no more likely to have a third child than those with only girls. However, the negative and statistically significant B_3 coefficient suggests that such parents are less likely to stop than parents with one boy and one daughter. Thus, there is some evidence of a preference for having children of both sexes. We note, however, that the estimates indicate that having three daughters and no sons has a much larger effect on the probability of another birth than having two daughters and no sons (the effect for the former is about twice that for the latter). This might reflect a cultural effect. There is a popular proverb in Vietnam that "having three sons [and no daughters] would not lead to prosperity, but having four daughters [and no sons] would not lead to impoverishment." Some people interpret this proverb as a remark about the high costs of raising boys and the economic benefits derived from daughters. However, others might be superstitious, and try to bear another child if the first three children were all male.

We compared (in results not shown here) sex preference among different groups of people. We tested for differences in sex preference between rural and urban residents and among groups of women differing in educational attainment, using methods described in Chapter 6. In the case of education, we consider only two levels, with and without post-secondary education, in order to make the results more transparent. Although the estimates indicate that the effects are stronger for rural residents, the differences are not statistically significant. Among groups of women with different educational attainment, the estimates do not show a consistent pattern of differences, nor are the differences statistically significant. Thus male preference seems to be true for all groups.

It may be helpful to compare our findings to empirical evidence from elsewhere. There is no doubt about the existence of son preference in many developing countries (Becker 1992, East-West Center 1995, Suet-ling Pong 1994, Williamson 1976, Ben-Porath and Welch 1976, Behrman 1988, and many others). Moreover, researchers have found evidence of the effect of sex preference on fertility. (Sex preference also influences certain behavioral variables, such as the distribution of health inputs (Behrman 1988) and, recently, even the sex ratios in a number of countries (East-West Center 1995).) However, it is not easy to compare our results with findings for other countries. One reason is that, due to cultural diversity and socioeconomic differences, the degrees and even the types of sex preference differ greatly across countries and ethnic groups (Williamson 1976). Another reason is that comparisons of results from different studies are complicated because researchers have used a variety of methods.

Although there are difficulties, we can make some comparisons and comments. The first relates to the fertility consequences of sex preference. Two decades ago Ben-Porath and Welch concluded that "we have no evidence to suggest that sex preferences are important determinants of aggregate fertility, although we cannot rule it out as a possibility." (Ben-Porath and Welch 1976, p. 302) Our work provides clear evidence of a strong effect of sex preference on fertility. Other researchers have also come to a similar conclusion; indeed, Gulati (1988, p. 55) comments that "only Rapetto (1972) suggested that decisions on family size are derived from economic considerations rather than son-preference motivations."

The second observation relates to explanations for sex preference. Some researchers regard son preference in developing countries as rational, arguing that in those countries sons give parents higher economic benefits than girls (Becker 1992, Vlassoff 1990, Wolfe and Behrman 1982). Becker, for example, states "I believe that most of the desire to have sons stems not from any intrinsic preference for sons, but that sons have greater value to parents in undeveloped economies." (Becker 1992, p. 194) However, he does not include non-economic roles of males in the "value" of children. It was shown in Chapter 2 that religious belief and traditional custom give men "intangible" values that are important to Vietnamese family life. It is obvious that Vietnam is not an exceptional case (Williamson 1976). This cultural explanation is consistent with our quantitative result that parents are more likely to stop childbearing when they have had a boy (i.e., what matters to parents is to have a son, not necessarily many sons). On the other hand, the view that emphasizes the economic reasons for boy preference cannot explain this empirical result. More specifically, given that the probability that a newborn will be male is very close to 0.5 and that couples cannot control the sex of children (this is true until recently, see East-West Center 1995 and Park and Cho 1995), that view would anticipate either no relationship between sex composition of ever-born children and future fertility or a positive effect of the proportion of ever-born children who are male on future fertility.[18] Using simple OLS regressions, Repetto

(1972) showed that in Morocco and Bangladesh family size was positively related to the proportion of living children who were boys. It was concluded that since rearing boys was less costly than rearing girls, families with more boys could afford to have more children (see also Ben-Porath and Welch 1976, p. 293). That implies that for couples with the same number of ever-born children, those with more boys would be more likely to proceed with childbearing, the opposite of our findings. However, our findings are consistent with recent studies for other countries; see Pong (1995) and dozens of references cited therein.

Our final comment concerns the issue of specification. We note that some specifications intended to detect the effect of sex preference on fertility are not appropriate. In particular, Repetto (1972) estimated the relationship between the number of male children in the first three births and the number of subsequent births, and found no consistent results (see also Ben-Porath and Welch 1976). However, if sex preference is restricted to the desire to have at least one boy, such a method would not be suitable. The specification adopted in this study is more general and can be applied to any type of sex preference.

Child Mortality and Fertility

The estimated effect of child mortality on subsequent reproductive behaviour is reflected in the coefficients of the variables $Dead_j$ (j=2,3,...,6). In the second stage $Dead_2$ is not statistically significant and its estimated coefficient is small with a perverse sign, indicating that the death of the first child has little impact on the probability that a couple would have a second birth. This result is consistent with the estimated small effect that the sex of the first child has on the probability that childbearing will stop after the first birth. However, this does not mean that parents do not increase fertility to compensate the lost child. As noted above, almost all couples want to have at least two children, and would proceed to have a second birth regardless of the sex and survival status of the first child. However, the death of the first child would affect the couple's decision at later stages. More specifically, for a couple with a two-child target, the death of the first child would affect the probability of having a third birth, not a second birth; for a couple who have set a three-child target, the death of the first child would influence the probability of having a fourth birth, not the second or third, and so on. (This explains again why in the regression for stage j we include not only $Dead_j$ but also $Dead_2$, $Dead_3$,..., $Dead_{j-1}$.) We note that in the regression for the third stage, the coefficient of $Dead_2$ is positive and nearly statistically significant at the ten-percent level, indicating that the death of the first child increases somewhat the probability that the woman would have a third birth.

The estimated coefficients of the variable $Dead_3$ for different stages imply that the death of the first or second child that occurred between the second and third decision-making points increases the probability that a couple would have a third birth but has no impact on the probabilities associated with later births. Similarly, the death of a first, second or third child that occurred between the third and fourth decision-making points has a positive and statistically significant effect on the probability of proceeding to a fourth birth but not on the probabilities associated with higher-order births (see the estimates for the variable $Dead_4$). However, in the fifth and sixth stages, none of the mortality variables ($Dead_j$) have significant effects on fertility. That is, after a woman has had four births, child mortality appears to have no significant impact on future fertility.

In sum, we find that the death of either a first or a second child affects only the probability of a third birth while the death of a third child affects the probability of a fourth. That suggests, again, that couples typically want at least two children; it suggests, furthermore that few want more than four.

While the death of the second or third child appears to increase the probabilities of having another birth, that effect might include a biological component. Since child deaths that occur in infancy (the first year of life) would often shorten the length of breastfeeding (the mean length of breastfeeding is 14 months for Vietnam) and that, in turn, would allow an early return to ovulation and speed the arrival of the next birth (Preston 1978, p.7). Thus the statistically significant effects of the variables $Dead_3$ in the third stage and $Dead_4$ in the fourth stage may reflect not only a replacement effect but also a supply effect of child deaths.

We performed simple tests for the supply effect of child deaths on fertility. Specifically, we added a dummy variable, S_j, as a regressor in the regression for stage j. S_j is coded 1 if a child in birth order j-1 died during infancy and zero otherwise. Although the t-ratio was significant at the 5% level only for stage 5, we found that the estimated coefficients for the variable S_j were positive in all stages, thereby indicating some support for a supply effect of infant deaths on fertility.[19]

Our results suggest that the impact of a child death on fertility, including both the supply and behavioral effects (increase in fertility caused by the implementation of a replacement and/or insurance strategy) was moderate. For example, the death of a child that happened after a couple had a third birth but before it made a decision whether to have a fourth birth would, according to the estimated effect of the variable $Dead_4$, increase the probability of having a fourth birth by 17.6%. The effect of such a death on the probability of proceeding to a fifth birth is small and not statistically significant. The sign of this variable even becomes negative in the regression for stage 6, in which the choice is between five and more than five births. Thus, in general a child death would increase the couple's fertility by about a sixth of a child if we ignore its lagged effect. The magnitudes of the effect are similar for different stages of decision-making.

There are other methods to estimate the effect of child mortality on fertility. A simple technique is due to Olsen (1980). He shows that an OLS model with the number of children ever born as the dependent variable and the number of child deaths as an independent variable would give a biased estimate of the effect of child mortality. He offers methods to obtain unbiased estimates. One method is to use the child mortality rate for individual women, defined as the ratio of the number of child deaths to the number of children ever born, as an instrument (for the number of child deaths). He argues that while the number of child deaths is correlated with the error term in the OLS model, the child mortality rate as defined above "can be used as an excellent instrumental variable which avoids the least squares bias provided certain conditions hold." (Olsen 1980, p.432) However, we think that the required conditions might not hold in practice. It is well known that a good instrumental variable must not be correlated with the error term (and must be correlated with the variable it instruments for). Child mortality for individual women might depend on their fertility levels since the more children could reduce the health inputs available each one. We note, however, that Swenson et al. (1993), using the VNDHS-88 data, found no statistically significant relationship between infant mortality and birth order. In addition, the child mortality rate for individual women, as defined by Olsen, tends to be dependent on fertility for another reason. As explained in Chapter 6, for samples that include women of various ages, as in our case, such a child mortality rate depends on the number of children ever born because of the differences in exposure. (The number of children ever born is fewer for young women, who have yet to complete their reproduction. However, exposure to death for children of these women was in general shorter than for children of older women.) In his empirical work, Olsen ran regressions for different groups of women, stratified by age; thus the problem of differences in exposure was partly dealt with. In any event, that approach is not appealing unless the sample size is much larger than is available not in our case. However, the standardized child mortality rate for individual women that we constructed in Chapter 6 (and that was based on to measure community child mortality) is independent of the exposure factor. We note, in addition, that the correlation coefficient between the number of child deaths and the standardized child mortality rate is 0.623. Thus the standardized child mortality rate seems to be a good instrumental variable for the number of child deaths, and is used in the estimation that follows.

Since child mortality is not defined for women with no children, we dropped those women from the sample. We then added the number of child deaths for individual women to the set of right hand side variables in the linear model for the number of children ever born (see Table 15), and estimated the model by the instrumental variable method. The exogenous variables, i.e., the right hand side variables other than the number of child deaths, *and* the standardized child mortality rate were used as the set of instruments. (Technically, this is the same as using the two stage-least squares method to estimate the equation for number of children ever-born while treating the number of child deaths as an endogenous variable and the standardized child mortality rate as an exogenous variable that is not included in the equation.) This method resulted in 0.257 as the estimated coefficient for the number of child deaths, which is very similar to Olsen's estimates for Colombia. (His estimates for different age groups differ and are dependent on specific statistical assumptions. However, his results tend to suggest that "the replacement rate is around 0.25.")

To justify the use of the instrumental variable method we tested for endogeneity of the number of child deaths variable using the Durbin-Wu-Hausman test. The resulting Chi-square statistic was 33.0 (with 1 degree of freedom). Thus, we could not reject endogeneity of that variable at any conventional level of significance. We note that if the OLS model was used, the estimated coefficient of the number of child deaths was 0.897. Thus, if the result from the instrumental variable method is reliable, the bias in the OLS model is large.

As noted, in the above regression we dropped from the sample women with no children so that the child mortality could be defined for all women included. This implies that the sample was truncated at a level of the dependent variable, which might cause the estimates to be biased. As an alternative, we first dropped women who were less than 31 years old at the time of the survey, so that the majority of women with no children would be excluded by a truncation of the sample based on an independent variable; a few remaining women with no children were then also dropped. We then repeated the above procedures to estimate the effect of the number of child deaths on fertility. The estimated coefficient of the number of child deaths became 0.484 by the two-stage least squares method, 0.925 by OLS; endogeneity in the number of child deaths still cannot be rejected by the Durbin-Wu-Hausman exogeneity test at any conventional level of significance.

Thus, the estimated effects of the number of child deaths using the instrumental variable method are sensitive to the age composition of the sample. One possible explanation relates to our earlier finding that child deaths would significantly affect future fertility only after women had had two children. Consequently, the exclusion of younger women from the sample tends to increase the estimated effect of child mortality. Also, as noted above, the truncation of the sample by excluding women with no children (in the first two-stage least squares regression) might cause the estimates to be biased.

We conclude that the effect of chid mortality on individual completed fertility is moderate for Vietnam, a result that seems to be consistent with findings for other developing countries (Chowdhury et al. 1978, Olsen 1980, Zhang 1990). In addition, our results show that child mortality has both behavioral and biological (supply) effects on fertility. We also find that the death of a child of birth order one would not affect the couple's decision to have a second birth -- a result consistent with the desire of the majority of Vietnamese parents to have at least two children.

Results Reconciled

Although in this model we focus on the effects of sex preference and child mortality, estimates for other factors are also given in Table 22. For a few variables, the signs of the coefficients in the regressions for different stages may not be consistent; for example, the estimated effect of the variable *Hed1* is positive in the regressions for the second and third stages, but negative for the fourth stage, and then once again positive for the fifth and sixth stages. However, the results from this model and those from the static models in Chapter 6 can be partly reconciled. In our analysis of the effect of education in Chapter 6, we pointed out that education tends to have little impact on fertility in the early part of reproductive life. The estimates from the sequential-response model are consistent with that: none of the educational variables, for either the husband or the wife, is statistically significant at the five-percent level in the regressions for either the first (not presented) or second stages of decision-making. However, some are significant, and bear the expected signs, in regressions for later stages. The findings regarding the effects of sex preference and child mortality provide further evidence of the narrow scope for the impact of still other variables on reproductive behaviour before a certain desired level of fertility is met.

We find, consistent with the results for the static models, that at all stages of decision-making the probabilities of stopping are smaller for rural residents. At every stage of decision-making, the variable *Commort* has a positive impact on the probability of proceeding; this too is also consistent with what we found in Chapter 6. Also, at each stage except the third, the probability of stopping is greater for women whose husbands had a stable source of income, as expected. Most of the estimated coefficients for the variables *Wind2...Wind5* and *Hind2...Hind5* have negative signs; thus for both husbands and wives, being employed in a non-agricultural sector is associated with having fewer children, a finding consistent with earlier results. The effect of the *Cominform* variable is interesting: it is statistically significant (at the five-percent or higher level of significance) in the regressions for the fourth and later stages of decision-making, but not in the regressions for the first, second, and third stages. That suggests that couples were likely to start practicing birth control only after they had had their preferred numbers of children. The pattern of this effect is again consistent with what found for the effects of sex preference, child mortality, and even parental education, as discussed above.

Measuring Goodness of Fit

Table 22 reports the pseudo-R^2 measure suggested by Cragg and Uhler (1970); see also Maddala (1983) and Veall and Zimmermann (1994). The goodness of fit of the model, as reflected by this measure, appears to be satisfactory for cross-sectional data. Note, however, that the inclusion of women who had not completed reproductive life tends to exaggerate the model's goodness of fit, since the age variables alone are responsible for much of the variation in the number of children ever born. In addition to this pseudo-R^2 measure, we construct prediction/success tables for the six stages of decision-making, including the first stage in which couples choose whether to have a (first) birth. The principles of these prediction/success tables are similar to those of Table 16 in Chapter 6, although for each of these six prediction/success tables there are only two possible outcomes (stopping or proceeding with childbearing). Tables 23a through 23f give details. Let us take a specific case, Table 23b, to illustrate the calculation and interpretation. Among the 3253 women who had at least one child and were included in the second stage regression, 597 women had only one child, and of those, 441 cases correctly predicted by the model (the estimated probabilities of stopping childbearing after the first birth for these women are less than 0.5); for the remaining 2656 women with more than one child, 2548 of the cases are correctly predicted and 156 are incorrectly predicted. The last cell at the bottom right corner gives the overall success ratio, which is 91.9 for this stage.

Tables 23a through 23f show relatively higher success ratios for earlier stages of decision-making; that again relates to the desire of almost all couples to have

Table 23a: Prediction Success Table -- First Stage

Observed	Predicted ceb=0	Predicted ceb>0	Prediction index 2
ceb=0	140	99	58.6
ceb>0	39	3214	98.8
Prediction success index 1	78.2	97.0	Overall index =96.0

Table 23b: Prediction Success Table -- Second Stage

Observed	Predicted ceb=1	Predicted ceb>1	Prediction index 2
ceb=1	441	156	73.9
ceb>1	108	2548	96.0
Prediction success index 1	80.3	94.2	Overall index =91.9

Table 23c: Prediction Success Table -- Third Stage

Observed	Predicted ceb=2	Predicted ceb>2	Prediction index 2
ceb=2	569	170	77.0
ceb>2	134	1783	93.0
Prediction success index 1	80.5	91.1	Overall index =88.6

Table 23d: Prediction Success Table -- Fourth Stage

Observed	Predicted ceb=3	Predicted ceb>3	Prediction index 2
ceb=3	475	165	74.2
ceb>3	133	1144	89.6
Prediction success index 1	78.1	87.4	Overall index =84.4

Table 23e: Prediction Success Table -- Fifth Stage

Observed	Predicted ceb=4	Predicted ceb>4	Prediction index 2
ceb=4	366	124	74.7
ceb>4	117	670	85.1
Prediction success index 1	75.8	84.4	Overall index =80.1

Table 23f: Prediction Success Table -- Sixth Stage

Observed	Predicted ceb=5	Predicted ceb>5	Prediction index 2
ceb=5	226	75	75.1
ceb>5	70	416	85.6
Prediction success index 1	76.4	84.7	Overall index =81.6

some children (often two). Although the prediction success ratios are high in general, one must again take into account the exaggeration of goodness of fit caused by the inclusion of women who had not completed reproductive life, as noted above.

7.3 Chapter Summary

In this chapter we have analyzed the effects of sex preference and child mortality on fertility, using a sequential-response model. The available information on the timing of births and, for those children who died, the time when death occurred, meant that we could identify those child deaths that could not have influenced fertility specific decisions and thereby allowed us to avoid important measurement errors in estimating the effect of child mortality and sex preference.[20] Our results show clear evidence of the effects of sex preference and child mortality on fertility behaviour. With regard to son preference, we find that what matters to Vietnamese parents is to have (at least) one son, not necessarily many sons.[21] In terms of the magnitudes of the effects, while the effect of son preference on fertility is strong, the effect of child mortality is moderate (in the sense that only a small proportion of dead children is replaced). The death of the first child does not influence the probability of having a second but it does increase the probability of a third birth. The effect on future fertility of the first child being male is very small, although statistically significant. These results, taken together, reflect the strong desire of Vietnamese parents to have at least two children, and are consistent with the findings in Chapter 6. It is difficult to estimate the effects of variables on total (lifetime) fertility in this model. However, the signs of the estimates are in general consistent with the results for the static models in Chapter 6.

Limitations inherent in the data demand that our results be interpreted with qualification. As with other surveys of this type, VNDHS-88 included women who had not completed their reproductive life. The inclusion of such censored observations in regression analysis may cause the estimates to be biased. For example, sex preference in combination with the sex composition of ever-born children might lead couples to adjust the timing of future births. Such adjustments in the timing of births would be appropriately included in the estimates of variables' effects on the level of fertility when there are no censored observations (aside from biological factors). However, when observations are censored, these adjustments would inappropriately influence the estimates of the effects of those variables on fertility. We think, though, that taking account of this problem would not reverse the conclusions drawn above. Our study of the timing of births in the next chapter will provide, among other things, further clarification.

Chapter 8 AN ANALYSIS OF THE TIMING OF BIRTHS

The sequential-response model of fertility decision-making considered in the last chapter extends the static model of fertility in a simple but appealing way: couples make decisions (or alter earlier ones) on future reproduction as time passes so as to take into account unpredicted changes in their demographic and socioeconomic status. That model, however, does not address the timing of births. The rationality approach favored by economists suggests that, as with other "commodities", couples would choose not only the number of children but also the timing of their births in order to maximize (expected) lifetime utility. Thus recent developments in microeconomic models of the timing of births can be seen as a natural evolution of static models of reproduction of the new home economics. Demographers, too, have paid increasing attention to the determinants of the time between births, although their theoretical approach differs from that adopted by economists (Montgomery and Trussell 1986, p. 226).

In this chapter we use available data on the birth histories of individual women as collected in VNDHS-88 to analyze the patterns and determinants of the timing of births. Such an analysis complements the findings of previous chapters. For example, we found in Chapter 6 that in Vietnam, as in other countries, women who had high education or who resided in urban areas had fewer children. A further question is whether or not those women had longer birth intervals when they reduced their fertility. An analysis using a duration model helps to answer such a question. Analysis of the determinants of the timing of births also has direct policy implications. As noted in Chapter 2, the Council of Ministers' Decision No. 162 not only restricts the number of children a couple may have, but also sets a minimum three-year interval between the first and second birth as a legal requirement. That raises questions about how the timing of births is determined and about whether restriction on their timing, which would constrain individual optimization, is socially efficient. Only determination of timing is considered here.

The rest of this chapter is organized as follows. In section 8.1 we review briefly the theoretical underpinnings of economic models of the timing of births. Methods used in developing life tables are used in a nonparametric analysis of birth intervals in section 8.2. Section 8.3 provides a regression analysis of the determinants of birth intervals based on a proportional hazard model with time-varying variables. The chapter concludes in section 8.4.

8.1 An Overview of Microeconomic Approaches to Modelling the Timing of Births

Economists have started only recently to develop microeconomic models of the timing of births. It was pointed out in Razin (1980, p. 280) that there had been "no theory of birth spacing." It seems that Butz and Ward's (1979) findings that birth rates moved countercyclically in response to women's earning opportunities increased the interest of economists in the matter.

As Newman (1988) pointed out, two approaches have been developed. In the first (see Razin 1980, Wolpin 1984), parents choose the timing of births directly. In the second account is taken of the uncertainty in conception caused by biological factors and couples choose a probability of conception by altering the efficiency of contraception (see Heckman and Willis 1976, Newman 1988). We discuss both these models briefly.

Razin (1980) offered a simple extension of the new home economics static framework to include the spacing of births in the optimization problem. His model has the same utility function as the new home economics model discussed in section 3.2.1 (i.e., it includes parents' consumption, the number of children, and the quality of children as arguments) but differs in its specification of the budget constraint and the number of variables whose levels must be chosen by parents to maximize utility. The revised budget constraint involves, among other variables, age of mother at the first birth and at the last birth, the length of time between births, and the proportion of time that the mother works at home during the childrearing period. The couple chooses the levels of these four variables as well as the number and quality of children and the consumption of other goods in order to maximize lifetime utility.

The model predicts that during the childrearing period the amount of time the mother spends in the labor market is negatively related to birth spacing as well as to family income and that the mother's age at the first birth increases as family income increases. With regard to empirical estimation, the approach implies the possibility of estimating a system of simultaneous equations that involves, among the endogenous variables, the time between births and the mother's ages at the first and last births.

Wolpin (1984) developed a dynamic stochastic model of fertility in which the household's life cycle evolves through a finite number of periods. The household's utility in each period depends on its stock of children and its consumption of other goods. It is assumed that the household cannot save or dissave. Thus, the budget constraint requires the equality of income and total expenditure within each time period. Income, specified as a random variable, is made a function of age and a disturbance term while expenditure consists of three elements: the cost of maintaining surviving children, the cost of a birth if it occurs, and all other consumption. The decision problem for the household in each period is whether to have a child in any subsequent period. The model, which was formulated as a dynamic programming problem, must be solved numerically and Wolpin admitted that "significant computation issues must be resolved if extensions are to be pursued" (p. 872).

The model developed by Heckman and Willis (1976) is also a stochastic model of fertility framed in discrete time over a finite horizon in which the couple chooses each month a probability of having a birth by altering the efficiency of contraception. The decision for the household therefore becomes a problem of optimization under uncertainty.

Newman's (1988) model is similar to the model of Heckman and Willis in that couples are assumed to choose a probability of conception through the control of contraception. However, his model is built in continuous time, includes uncertainty in the survival of children as well as in their contraception, and yields an analytic solution (made possible by assuming a specific quadratic utility function).

The above two models, which take into account the biological constraints that make conception at any time uncertain come closer to reality. However, they are difficult to test empirically. In particular, as pointed out by Wolpin (1984, footnote 2, p. 853), these studies do not "develop the econometric methodology necessary to provide estimates of "structural" parameters." Heckman (1990) also acknowledged that " recent theoretical models of fertility dynamics... have not yet produced a consensus about an appropriate empirical specification of life cycle fertility" (p.1412). We note, in addition, that even though it is appealing to replace the choice of birth timing by the choice of contraceptive use, it is not often feasible to estimate even a reduced-form model of contraceptive use with available data. It is well known that information on individual history of contraception is unreliable, especially in developing countries. For those reasons, and given our empirical interest, we do not consider these theoretical models any further. We turn now to analysis of the data.

8.2 A Nonparametric Analysis of the Timing of Births

8.2.1 Methodology

In duration analysis, it is often useful to start with a nonparametric approach; as is illustrated below, that approach may suggest appropriate functional forms of duration dependence and provide useful information such as non-parametric estimates of means of intervals and graphic comparisons of survival and hazard curves relating do those intervals. Methods used to develop life tables are a popular nonparametric estimation technique in survival (duration) analysis of the effects of variables on the hazard rate when few variables are involved. Below we use such methods to analyze the data. Since the methodology is familiar, we discuss it only briefly.

We must first decide how to define duration. There are three elements (Kiefer 1988, pp. 649-50): a time origin (the beginning of a duration), a time scale, and the event that ends the duration. In the present study, the origin is the (first) marriage in the transition from marriage to a first birth (first transition), the first live birth is the origin in the transition from a first to a second birth (second transition), and so on. As durations are measured in months, the time scale is the month. As in other studies of the timing of births (Heckman 1990, 1991 and Trussell et al. 1985), conception leading to a live birth is chosen as the event that ends a duration. Thus each duration is measured as the time from the origin to the conception of the next birth for closed intervals (i.e., for women with a next birth). In practice, durations are measured by subtracting nine months from the intervals between births (or between marriage and the first birth). For censored observations, intervals are open, and are measured in an analogous manner by subtracting nine months from the intervals between the appropriate origin and the time of the survey.[23] Even with these definitions, for convenience, we shall refer to the dependent variables as intervals between "births" and use the terms *birth interval*, *interval between births*, *birth space*, and *transition* interchangeably.

We could instead have used "real" birth intervals (i.e., intervals between births rather than intervals between births and subsequent conceptions) as durations. However, if time-varying variables are included in the analysis, they must be specified appropriately. For example, as noted in Chapter 7, the death of a child that happened after its mother had already become pregnant with the next child would normally have had no effect on the birth from that pregnancy.[24] Thus child mortality must be lagged 9 months if "real" birth intervals were used as dependent variables.

Let the time horizon, τ, be divided into L segments (or time intervals) as follows: $0<\tau\leq\tau_1$, $\tau_1<\tau\leq\tau_2$, ..., $\tau_{L-1}<\tau\leq+\infty$ corresponding to interval before the first birth, the interval between the first and second birth, and so on. Let N_j be the number of women at the beginning of time segment j (j=1, 2, 3,..., L), let b_j be the number who gave births during time segment j (in the standard terminology for life tables, b_j would correspond to the number of "deaths" or "failures"), and let m_j be the number who did not (i.e., the number of observations that are censored).

The survival and hazard functions are defined as follows (see Kalbfleisch and Prentice 1980, pp. 10-15, Greene 1989, p. 287 which provide also expressions for the variances of these functions):

$$S_j = \prod_{k=1}^{j}\left(1 - \frac{b_k}{N_k - 0.5m_k}\right) \tag{26}$$

$$\lambda_j = \frac{\frac{2b_j}{N_j - 0.5m_j}}{\left(2 - \frac{b_j}{N_j - 0.5m_j}\right)(t_{j+1} - t_j)} \tag{27}$$

The survival function, S_j, indicates the probability that a woman will not have become pregnant by the end of interval j. This interpretation can be seen from equation (26). Note first in $(N_j\text{-}0.5m_j)$ the adjustment that assumes that each censored observation contributes only half of what an uncensored observation contributes to the risk set. Thus $(1\text{-}b_j/(N_j\text{-}0.5m_j))$ is the probability of not conceiving a child during time segment j given that a child had not been conceived by the end of time segment j-1 and S_j, the probability of not conceiving a child by the end of time segment j, is the product of the conditional probabilities of not conceiving in each of the first j time segments. The complement of the survival function is the cumulative failure rate function, $F_j=1\text{-}S_j$, the probability of having conceived a child by the end of time segment j. (The terminologies "failure" and "survival", which originated in the study of mortality, are awkward in the reproduction context; however, they have become standard terminologies for all duration analysis.)

The hazard function, λ_j, shows the conditional probability of conceiving a child, per a unit of time between t_j and t_{j+1}, given that the woman had not conceived by time t_j. (It is assumed in this formula that the probability of getting pregnant is equally distributed between t_j and t_{j+1}.) To see the meaning of the hazard rate (27), consider that case in which $t_{j+1} - t_j = 1$ and $m_j = 0$ (i.e., there are no censored observations) and that b_j is very small compared to N_j. Then equation (27) is close to b_j/N_j, the ratio of the number of pregnancies (events) to the risk set. (In hazard functions defined for continuous durations this would correspond to the ratio of the density function to the survival function; see our discussion below.)

8.2.2 Estimation

Consistent with our practice in the last chapter, and for the same reasons, our nonparametric estimation (as well as the regression analysis in the next section) is based only on women who had married only once and were currently married at the time of the survey. Figure 14 plots the survival functions for the first six birth intervals and Figure 15 plots the corresponding hazard functions. In our case, plotting six survival functions in the same quadrant does not cause visual difficulties and it makes comparisons easier. However, that is not true of the hazard functions, which therefore are plotted separately. Numeric estimates of the survival and hazard functions, including standard errors and other related measures, are provided in Appendix D.

Let us look at the plots of the hazard functions first. In general the hazard rates are very low, because of the use of the month as the unit of time. The hazard functions have an inverted U-shape: a woman's conditional probability of getting

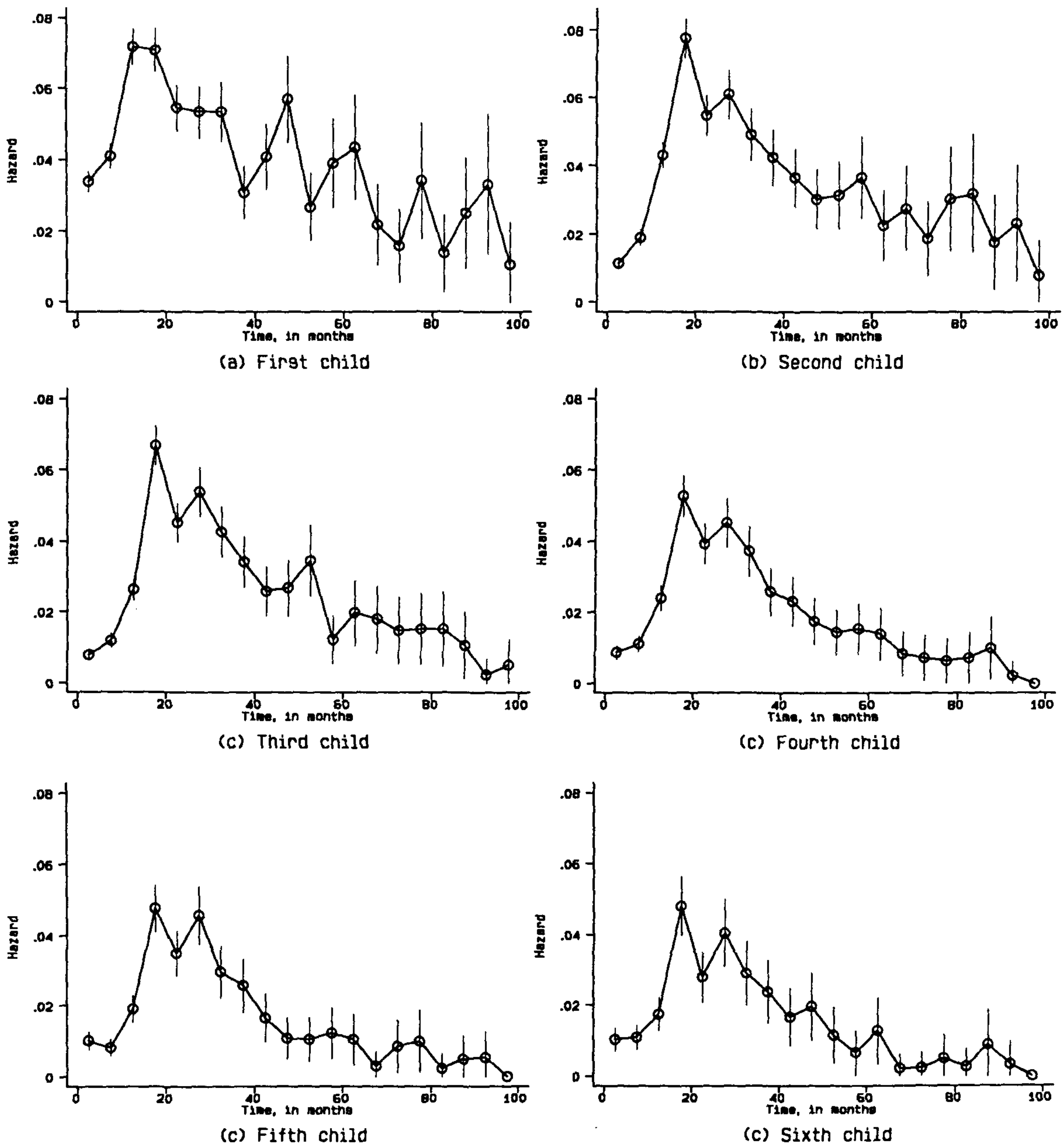

Figure 14: Plots of estimated hazard functions, first through the sixth birth

Note:
- For the jth birth time is the number of months from the (j-1)th birth (marriage in the case of the first birth).
- The hazard is measured by the proportion of (qualified) women who became pregnant at each time.
- Vertical lines are 95 percent confidence intervals.

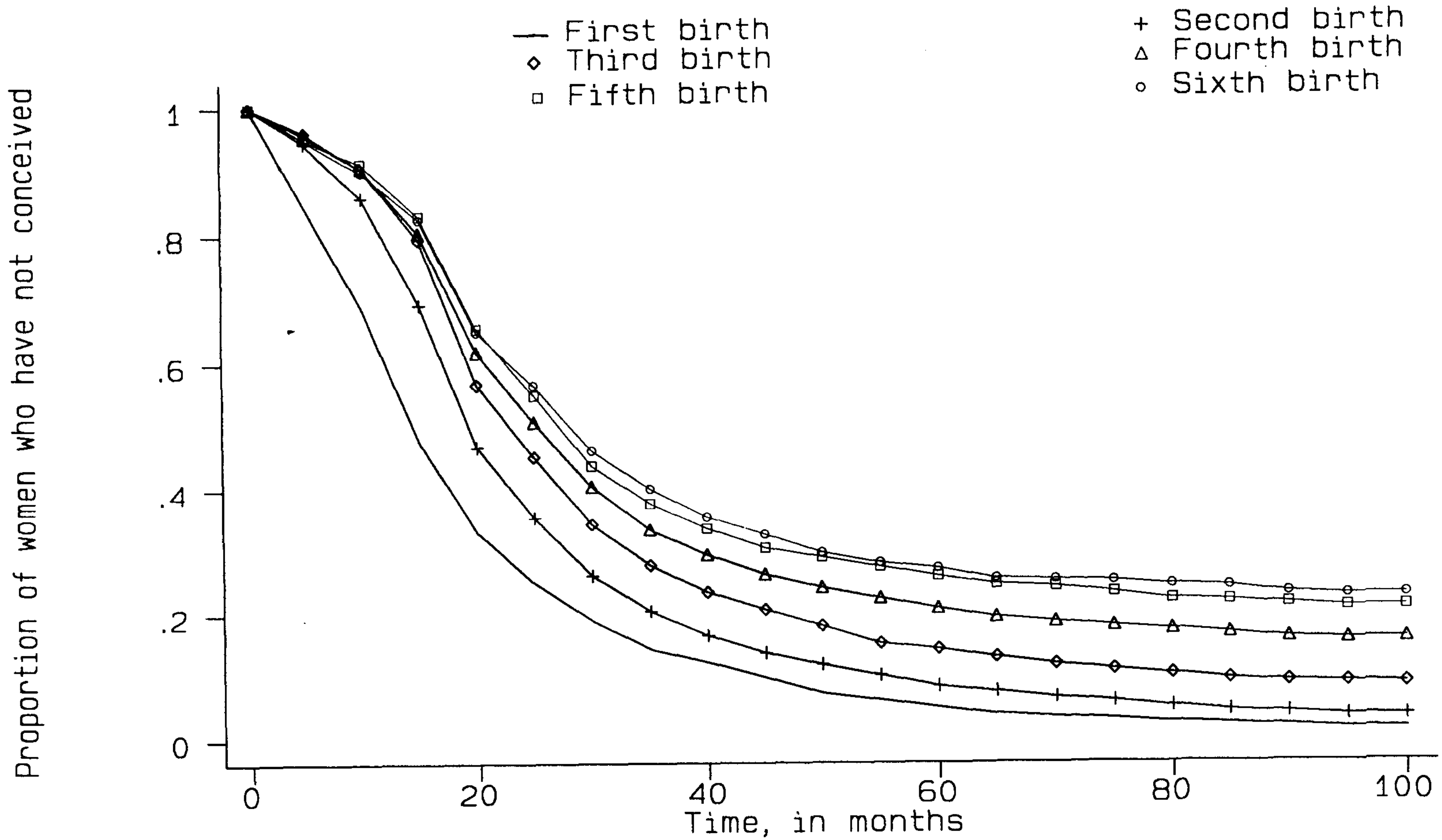

Figure 15: Plots of estimated survival functions, first through the sixth birth

Note: - For the jth birth time is the number of months from the (j-1)th birth (marriage in the case of the first birth).
- Survival is measured by the proportion of women who have not conceived within the specific number of months.

pregnant increases for about 20 months after marriage and after each birth and then decreases steadily. One factor that causes the hazard functions to increase in the early period relates to beastfeeding. That is supported by the fact, shown in Figure 14, that the hazard curve for the first birth starts at a rate that is much higher than for subsequent births. The inverted U-shape may reflect, in part, planning by households to increase or decrease the waiting time. In any event, the finding suggests that in parametric models of duration dependence, it would be best to use a nonmonotonic specification

The time pattern of duration dependence reported here is consistent with the findings based on regression analyses reported by Newman and McCulloch (1984) for Costa Rica and by Trussell et al. (1985) for Malaysia, Indonesia, and the Philippines. It differs from the findings by Heckman and Walker (1991) who, using the 1981 Swedish fertility survey, report that "in all models in which nonzero duration dependence is permitted, we find positive duration dependence" (p. 27). As Trussell et al. (1985) noted earlier the estimates might reflect systematic differences in reproductive behavior between developed and developing countries. We note, however, that Heckman's and Walker's result is inconsistent with what they and Hotz had found earlier based on the same data (Heckman, Hotz, and Walker 1985). Although the earlier paper does not discuss the estimates in relation to duration dependence, the estimated effect of duration, which enters the model in a quadratic form, implies inverted U-shaped relationships between hazard rates and duration. For example, in the regressions that are based only on ever-married women and take account of heterogeneity, the hazard rate peaks at the 27th month after marriage in the first transition, at the 39th month after in the second transition, and at the 51st month in the third transition; see Heckman, Hotz, and Walker (1985, Table 1, p. 182).

Our findings and those of others help to clarify the underdispersion/overdispersion issue discussed in Chapter 6. We argued there that birth counts might not be "purely" underdispersed or overdispersed. The analysis here supports that point. Winkelmann (1995) shows that positive duration dependence causes underdispersion and vice versa. However, the evidence of a nonmonotonic effect of duration on the hazard function indicates that the birth process involves both underdispersion and overdispersion, at least in developing countries.

Figure 14 shows that for the first birth the hazard tends to move cyclically with time since marriage. The first cycle is relatively long and ends about three years after marriage; later cycles last for a year. The first cycle might reflect deliberate planning by couples who typically do not proceed to childbearing immediately after marriage. The subsequent cycles of shorter duration might reflect the result of at least three factors. First, it is well known that a woman's probability of conceiving a child depends on the frequency of sexual intercourse, other things equal. That might be important for couples who are less fertile. As is shown in Figure 15, the survival curve for the first transition indicates that about 80% of married women had a first birth within 3 years of marriage; thus the shorter cycles in the hazard of the first birth apply only to a small proportion of couples who, it appears, were less fecund.

Second, it is possible that sexual activity is relatively more intensive during certain parts of the year in Vietnam. In particular, extremely hot and humid whether in the summer might discourage sexual activity. As discussed below, in Vietnam few marry in the summer. In addition, we noted above that it is common for married men to leave their families in the countryside to go to work in industrial centres. However, they always return for lunar new year celebrations. A Vietnamese proverb says that "January (on lunar calendar) is the month for pleasure," but that is partly because agricultural work then is relatively less intensive than in other periods.

Note that since birth intervals are measured as times from marriage, the above two factors alone would not lead to a cyclical hazard function unless marriages were seasonal. That is our third factor: in Vietnam many more marriages take place in the winter and spring, especially around the lunar new year, than in the summer. The data from VNDHS-88 showed that 37% of ever-married women who were interviewed got married in either December, January, or February (on the solar calendar) and only 19% in June, July, or August.

Now let us look at the plots of the survival functions in Figure 15. The figure is consistent with our earlier finding that couples want to have at least two children: about seven years after marriage, almost all couples would have had a first birth, and after seven years more most of them would have had a second birth.

At this point it is helpful to consider one aspect of the interpretation of estimates from duration models. Consider the survival function for the second birth interval depicted in Figure 15. An increase in the hazard rate for a second birth would move the corresponding survival curve inward, implying a decrease in the mean interval between the first and second birth. However, that does not mean that the probability of having a second birth by the end of reproductive life would necessarily decrease. Figure 15 suggests that for a "typical" woman, having a second birth by the end of her reproductive life is almost certain. Thus an increase in the hazard function might have no effect on the probability of having a second birth, just on its timing. That is important for interpreting the estimated effects of explanatory variables not only in birth space analysis but also in other duration models.

Figure 15 shows again, consistent with the hazard functions, that couples proceed to childbearing relatively quickly after marriage. However, for births of second and higher orders the speed of conceiving is lower in the first 15-20 months (reflecting the effect of breastfeeding as noted above) and then starts to diverge. The survival curves for the fifth and sixth births are very close; this might indicate that births of order five and higher are determined mainly by biological factors, as suggested by the sequential-response model.

It is informative to consider the mean lengths of the birth intervals. Estimates can be based on the (discrete) probability density functions which, in turn, can be derived from the corresponding survival functions. Since the data generally do not permit us to work with complete survival functions, truncated distributions must be used. Our estimates assume that intervals are closed 100 months from the origins. The resulting estimated means of "real" birth intervals (i.e., the end of an interval is a birth, not conception) increase from 27.9 months for the first transition to 32.7 months for the second transition, and then to between 35.0 and 35.5 months for subsequent transitions. Note, however, that the survival curves become approximately horizontal before the 100^{th} month. Thus few births are excluded with the arbitrary truncation and the mean birth intervals would increase very little if births after the month 100 were included. (Median intervals would not be affected at all by births beyond the 100 month bound.)

Life table methods could be applied to analyze the effects of variables on the hazard or survival functions by constructing different life tables for different categories. However, this approach is not suitable when many variables are involved, as in our case. We turn, therefore, to regression analysis.

8.3 Regression Analysis of the Timing of Births

8.3.1 An Overview of Regression Models for Failure Time

At this point let us treat the time to conception, T, as a continuous variable and redefine the survival and hazard functions. Let the probability density function of T at $T=t$ be $f(t)$ and let the survival and hazard rates at $T=t$ be $S(t)$ and $h(t)$, respectively. The survival function is now defined as

$$S(t) \equiv S(T=t) = 1 - F(t) \tag{28}$$

where $F(t)$ is the cumulative probability at $T=t$, and is defined as

$$F(t) = Prob(t \leq T) \tag{29}$$

The hazard function is then

$$h(t) \equiv h(T=t) = f(t)/S(t) \tag{30}$$

Although the four functions, $f(t)$, $F(t)$, $S(t)$, and $h(t)$, are equivalent ways of presenting the same "system of probabilities", it is the hazard function that is most often used in regression modelling. The reason, as explained by Kiefer (1988), is that "if we are thinking in terms of conditional probabilities, it makes sense to choose a parameterization that allows the estimated sequence of conditional probabilities to behave as we think it should" (p. 649). We think that there is another justification for the use of the hazard function in model specification. Researchers typically know little about the characteristics of the hazard, probability density, and survival functions. Consequently, some preliminary graphical analysis of data is often useful and, at that stage, differences are recognized most readily when working with the hazard function. For example, the survival function must be nonincreasing, but the hazard function can be increasing, constant, decreasing, or have some other shape. Also, as seen below, even when the natural logarithm of duration is used as the dependent variable, instead of the hazard rate, different assumptions about the hazard function lead to different log-linear models.

Two general models (or, more precisely, classes of models) are commonly used in duration analysis, the proportional hazard and accelerated failure-time models. Below we discuss these models briefly; see Cox (1972), Cox and Oaks (1994), Kalbfleisch and Prentice (1980), and Kiefer (1988) for further details.

The Proportional Hazard Model

Let X be a vector of regressors (a constant term is not included) and let α be a vector of corresponding coefficients. In the proportional hazard model the hazard function is specified as

$$h(t;X) = h_0(t)e^{X\alpha} \qquad (31)$$

where $h_0(t)$ is a "baseline" hazard which is an unspecified function of time. The effect of the regressors is to increase or decrease the baseline hazard multiplicatively. Note that this model does not include an estimate for the constant term, since it is absorbed into the baseline hazard. Equation (31) implies that the ratio of the hazards for any two individuals is independent of time. Furthermore, for any two individuals, the ratios are constant over time if there are no time-varying variables. Those features explain the model's name (Allison 1984, p.34).

The important contribution of Cox's (1972) paper is his derivation of a conditional likelihood method that gives consistent estimates of the coefficients, α, without knowing the functional form of duration dependence. The proportional hazard model is therefore semiparametric. If the functional form of duration dependence is known, a fully parametric model can be applied, and the gain is an increase in efficiency of estimates. However, as noted above, we rarely know with certainty the functional form of duration dependence.

Researchers have extended the above model by specifying the baseline hazard as a parametric function of duration. An approach, which was noted by Cox (1972, p. 190) and has been applied by Trussell and Bloom (1983) and Trussell et al. (1985) to study the timing of marriage and birth space, is to assume the baseline hazard to be a step function of duration. Newman and McCulloch (1984) extended the original proportional hazard model to study the timing of births by specifying the baseline hazard as a two-knot spline function of duration. When a functional form is specified for the baseline hazard the standard maximum likelihood method can be used.

The Accelerated Failure-Time Model

In this general model, linear relationships between regressors and lnT are specified. More specifically, the regression equation is specified as

$$lnT = \beta_0 + X\beta + u \qquad (32)$$

where u is an error term independent of regressors X, β_0 is a scalar constant, and β is a vector of coefficients. Thus the regressors affect lnT additively or T multiplicatively. The model is referred to as the accelerated-time model since the effect of the regressors is to rescale the failure time (time to conception in our case) directly. A probability distribution function for the error term u can be derived if the distribution of T is known (or assumed). The model is often illustrated for the case in which T follows an exponential or Weibull distribution, in which case equation (32) can be conveniently written as

$$lnT = \beta_0 + X\beta + \sigma v \qquad (32')$$

where σ is a scalar parameter (to be estimated) and v follows an extreme value distribution. The exponential model is a special case of the Weibull model, where σ equals one.[25]

Other common accelerated failure-time models include the Gompertz-Makeham, log-normal, and log-logistic models. The Gompertz model assumes that T has a Gompertz-Makeham distribution while the log-normal model assumes that lnT has a normal distribution and the log-logistic model that it has a logistic distribution. Thus the log-normal and log-logistic models make assumptions about the distribution of lnT rather than T, as in earlier models; the probability density and hazard functions for T are then derived. The hazard function is constant in the exponential model, monotonic in the Weibull and Gompertz models, and nonmonotonic in the log-normal and log-logistic models. Note that, unlike Cox's proportional hazard model, a constant term must be included in the accelerated failure-time model even when the regressors are measured in deviations to account for the nonzero mean of the error term (Kiefer 1988, p. 665).

It has been pointed out that the proportional hazard and accelerated failure-time specifications are flexible in different ways; one or other of them provides an accurate description of most duration data (Kalbfleisch and Prentice 1980, p. 35, Kiefer 1988, p. 669).[26] Each specification also has its own advantages and disadvantages. The advantages of the semiparametric proportional hazard model are especially important in the present context, and the estimates presented below are based on that model. The model provides consistent estimates of the effects of independent variables (other than duration) on the hazard rate, even when the form of duration dependence is unknown. Also, it is much simpler to estimate with time-varying variables than the (fully parametric) accelerated failure-time model. However, it is not suitable for determining how the hazard function varies over time. Nor can it take unobserved heterogeneity into account. (Note, however, that the extended (parametric) proportional hazard model discussed above can overcome these limitations.) Finally, as noted above, if the functional form of duration dependence is known, a fully parametric model provides more efficient estimates.

8.3.2 Model Selection and Specification

Model Selection

In this section the effects of variables on the hazard function for each birth interval (between marriage and the first birth as well as between subsequent births) are estimated using a semiparametric proportional hazard model, as in equation (31). The vector of regressors, X, includes time-varying variables. We start with a brief defense of this model selection in relation to other empirical studies.

It is possible to estimate a proportional hazard model with equality restrictions on coefficients for different transitions (for example, estimates of the effects of maternal education on the hazards of a first birth and of a second birth could be restricted to be equal). This approach was adopted, without testing, by

Newman and McCulloch (1984) and Trussell et al (1985).[27] However, Heckman et al. (1985) tested for such restrictions using Swedish data, and found that they were strongly rejected (page 183). Our results from the sequential-response model in the previous chapter also gave clear evidence of structural differences in the effects of certain variables. Another reason for adopting an unrestricted model is our wish to contrast and reconcile results found here with the results found in the sequential-response model. However, analyzing each birth interval separately has limitations that are rooted in the problem of unobserved heterogeneity.

Heckman and Walker (1991) argued that if there are unobservables that are correlated over spells (heterogeneity), analyzing each transition in isolation from other transitions would produce inconsistent estimates in general. They developed a sophisticated semiparametric multistage duration model that accounted for heterogeneity and applied it to study the timing of births in Sweden. They found "little evidence that unobservables correlated across spells ("heterogeneity") that are a main focus of the demographic literature are empirically important in explaining life-cycle fertility once account is made of parity-specific stopping behavior. This finding justifies application of low-cost piecemeal estimation strategies that estimate birth transitions in isolation of each other" (Heckman and Walker, 1991, p. 70).

We point out that incorporating heterogeneity in duration models is still very controversial; see Heckman and Singer (1982, 1984), Heckman and Walker (1987), Montgomery and Trussell (1986), Trussell at al. (1985), and other references listed therein. The following quotations summarize the problem.

> "Procedures accounting for unobserved heterogeneity in duration models have been questioned because of the sensitivity of the estimated parameters to model specification..., these sensitivity results are widely cited as discouraging evidence about the value of incorporating unobserved heterogeneity into duration analysis." (Heckman and Walker 1987, p. 249)

> "This sensitivity to the choice of functional form of the distribution of unobservables leaves us profoundly depressed about where next to proceed." (Montgomery and Trussell 1985, p. 231)

However, in interpreting the coefficients of certain variables we must take into account possible influences of heterogeneity. In particular, previous birth intervals are often included as independent variables in the regression for the current interval. As has been pointed out, the coefficients of such variables might incorporate the effect of unobserved heterogeneity.

Most empirical work on duration analysis has been based on reduced-form models.[28] So is ours. The reasons are essentially the same as for models relating to the number of children ever born, which were discussed in Chapter 5.

Variable Definition

Equation (31) indicates that the hazard rate, $h(t;X)$, is the "dependent" variable. However, it is a latent (unobserved) random variable with the failure time as its support. (Otherwise the equation would represent a deterministic relationship rather than a regression equation.) Thus the "real" dependent variable is the failure time, as can be seen more easily if the accelerated failure-time specification, equation (32), is used. Thus, for our analysis, the dependent variable in each transition is the length of the corresponding birth interval, as defined in section 8.2.1. Except for the changes noted below, the independent variables are the same as in the sequential-response model. Note that stage j in the sequential-response model corresponds to transition j here.

First, there are changes in the definition of child mortality and sex variables. Since the model allows values of independent variables to vary with duration (see, for example, Kalbfleisch and Prentice 1980, pp. 122-27), the child mortality and sex variables are redefined to take advantage of this flexibility. In the regression for transition j, $FixDead_j$ denotes for each woman the number of children who had died by the time she conceived birth (j-1), which is not a time-varying variable. $TivDead_j$ denotes a time-varying variable that records child deaths that occurred after the conception of birth (j-1). At the beginning of birth interval j (i.e., at the time of birth (j-1)) this variable equals the number of child deaths that occurred during the preceding nine-month period. A death that occurred after birth (j-1) would increase this variable by one unit at the time of the death. (As noted in the last chapter, upwards of 80% of all deaths before age five occur in infancy. Thus, $TivDead_j$ would be influenced mostly by the deaths of infants of birth order j-1.) The variables $TivB_j$, $TivBB_j$, and $TivBBB_j$ replace B_j, BB_j, and BBB_j, which were defined in the last chapter to study the effects of sex preference. The two sets of variables are similar except that the new ones are time-varying (to account for any change in the number of living sons), with their starting values measured at the beginning of the birth interval, while the old ones were time-invariant, with their values fixed at the decision-making point. Thus, at any time $TivB_j$ equals one if a woman had at least one living son at that time, and zero otherwise. Similarly, $TivBB_j$ identifies women with at least two living sons and $TivBBB_j$ identifies women with at least three living sons.

Second, the variables Age_j and $Age2_j$ are also redefined. In the sequential-response model, Age_j was the woman's age at the decision-making point j, and its square was $Age2_j$. In this model, Age_j is redefined as the woman's age at the beginning of birth interval j. Our definitions of decision-making points and of birth intervals mean that for most women the new measure of Age_j is less than the old measure by one year.

Finally, following previous studies (Heckman and Walker 1985, Heckman and Walker 1991, and Trussell et al. 1985) we have included previous birth intervals (lagged dependent variables) as regressors in the model. Because there is perfect multicollinearity between *Mardur*, Age_j and the set of birth intervals (T_1, T_2,..., T_{j-1}), the first birth interval, T_1, is excluded in estimation. The reasons for the inclusion of lagged dependent variables will become clear later, when we discuss the estimation results.[29]

As with the sequential-response model, the sample becomes smaller for later transitions. Consequently, all conditional sample means and variances change with the birth interval.

8.3.3 Results and Discussion

As specified in equation (31), regressors increase/decrease the baseline hazard by a multiplicative factor. For example, the effect of a one unit increase in regressor x_1 with a coefficient $\alpha_1=0.2$ is to increase the baseline hazard by a multiplicative factor of $exp(\alpha_1)=exp(0.2)=1.22$ (i.e., to increase the baseline hazard by 22%). This index, $exp(\alpha_1)$, is call *relative risk* (since it equals the ratio of the hazard after a unit-increase in x_1 to the initial hazard). Of course, positive coefficients (α) result in greater-than-unity relative risks, and vice versa; zero coefficients result in relative risks of one, and the baseline hazard is not affected. We report the estimation results in Table 24, in the form of relative risks.

The figures in the table are easy to interpret. We discuss selected relationships and focus on reconciling the results with the findings reported in Chapters 6 and 7. We note that the regression for each transition involves the same sample of women included in the corresponding regression in the sequential-response model. However, the number of observations reported in Table 24 includes also the "new" observations that are generated whenever a time-varying variable changes its value.

The estimated coefficients of previous intervals, except that of T_2 in the fourth transition, are less than unity. Thus longer previous birth intervals decrease the hazard rate in the current interval (and increase the length of the current interval). This result is consistent with previous findings (Heckman et al. 1985, Rodriguez et al. 1984, Trussell et al. 1985). The explanation remains controversial.

Table 24: Estimated Effects of Variables on Hazard Rates

Independent Variables	Transition 1 (T_1)	Transition 2 (T_2)	Transition 3 (T_3)	Transition 4 (T_4)	Transition 5 (T_5)	Transition 6 (T_6)
T_2			0.9545 (2.325)	1.0119 (0.576)	0.9636 (1.166)	0.9778 (0.540)
T_3				0.9219 (2.744)	0.9322 (1.785)	0.9893 (0.207)
T_4					0.9280 (1.981)	0.9345 (1.298)
T_5						0.9067 (1.874)
Age_j		1.1929 (4.905)	1.2162 (2.700)	1.1519 (1.590)	1.2904 (2.001)	1.3315 (1.659)
$Age2_j$		0.9965 (2.267)	0.9952 (3.529)	0.9961 (2.509)	0.9944 (2.638)	0.9945 (2.032)
Mardur	0.9775 (2.028)	1.0279 (1.553)	1.0686 (2.775)	1.0074 (0.236)	1.0666 (1.428)	1.0107 (0.176)
Mardur2	0.9987 (3.319)	0.9999 (0.096)	0.9979 (3.638)	0.9993 (0.918)	0.9978 (2.254)	1.0001 (0.150)
Age	1.1138 (1.354)	1.1968 (2.340)	1.1775 (1.792)	1.2004 (1.630)	1.1508 (0.930)	1.1492 (0.650)
Age2	1.002 (2.261)	0.9973 (2.639)	0.9984 (1.345)	0.9984 (1.119)	0.9992 (0.439)	0.9988 (0.457)
North	62.944 (2.387)	15.9375 (1.555)	11.8103 (1.146)	0.9185 (0.031)	20.638 (0.774)	1978.6 (1.221)
NAge	0.7789 (2.631)	0.8829 (1.297)	0.8744 (1.178)	0.9964 (0.025)	0.8215 (0.992)	0.6764 (1.273)
NAge2	1.0038 (2.951)	1.0014 (1.113)	1.0015 (1.007)	1.0000 (0.022)	1.0027 (1.079)	1.0048 (1.263)
Agespline	0.9924 (2.732)	1.0050 (1.528)	1.0072 (1.397)	1.0158 (1.754)	1.0151 (0.742)	1.0260 (0.929)

Table 24 (continued)

Independent Variables	Transition 1 (T_1)	Transition 2 (T_2)	Transition 3 (T_3)	Transition 4 (T_4)	Transition 5 (T_5)	Transition 6 (T_6)
NAgespline	0.9951 (1.391)	0.9954 (1.024)	0.9933 (0.927)	1.0026 (0.195)	1.0163 (0.566)	0.9153 (0.613)
Rural	1.0764 (0.870)	1.3181 (3.025)	1.2068 (1.749)	1.3876 (2.471)	1.0903 (0.475)	1.1722 (0.696)
RurNorth	0.8759 (1.315)	0.7740 (2.278)	1.3527 (2.118)	0.9005 (0.561)	1.3889 (1.278)	0.9484 (0.143)
Instab	1.1842 (3.887)	0.9813 (0.414)	0.8992 (2.020)	0.9127 (1.475)	0.7966 (2.984)	0.8183 (2.040)
Cominform	1.0210 (1.690)	1.0044 (0.329)	0.9863 (0.855)	0.9794 (1.110)	0.9546 (1.918)	0.9367 (1.947)
Commort	0.3633 (0.682)	41.7871 (2.468)	2.0206 (0.389)	497.91 (2.945)	659.55 (2.382)	69517.8 (3.209)
Wed1 vs Wed3	1.3762 (3.333)	0.9019 (1.064)	1.1575 (1.418)	0.9459 (0.481)	1.1066 (0.758)	1.3212 (1.771)
Wed2 vs Wed3	1.0262 (0.489)	1.0158 (0.279)	1.0730 (1.133)	1.1191 (1.555)	1.0018 (0.020)	1.1911 (1.513)
Wed4 vs Wed3	0.9162 (1.390)	0.8752 (1.855)	0.7218 (3.291)	0.8820 (0.964)	0.5919 (2.520)	0.9023 (0.358)
Wed 5 vs Wed4	1.1334 (1.078)	0.7700 (1.964)	0.5842 (2.999)	0.6569 (1.710)	0.4970 (1.683)	1.9284 (1.237)
Hed1 vs Hed3	1.0178 (0.135)	0.8570 (1.150)	1.0435 (0.286)	1.0580 (0.321)	0.9108 (0.424)	1.2883 (0.996)
Hed2 vs Hed3	1.1737 (2.555)	0.9070 (1.476)	0.9363 (0.915)	1.0315 (0.372)	1.0048 (0.049)	0.8688 (1.183)
Hed4 vs Hed3	1.0058 (0.116)	0.9594 (0.759)	0.9589 (0.630)	0.9623 (0.461)	0.9043 (0.921)	0.9198 (0.544)
Hed5 vs Hed3	0.8812 (1.512)	0.8409 (1.912)	1.0001 (0.001)	1.0408 (0.304)	0.5310 (3.081)	0.5083 (2.084)
Wind2 vs Wind1	1.176 (2.000)	0.9413 (0.682)	1.0627 (0.600)	0.8386 (1.361)	0.9394 (0.360)	0.7778 (1.136)

Table 24: (continued)

Independent Variables	Transition 1 (T_1)	Transition 2 (T_2)	Transition 3 (T_3)	Transition (T_4)	Transition (T_5)	Transition (T_6)
Wind3 vs Wind1	1.2220 (2.588)	0.9447 (0.673)	0.8605 (1.424)	0.9190 (0.629)	0.8420 (1.024)	0.9706 (0.130)
Wind4 vs Wind1	1.3527 (1.541)	0.7060 (1.411)	1.0860 (0.051)	0.7717 (0.620)	1.6402 (0.957)	0.7078 (0.471)
Wind5 vs Wind1	0.9948 (0.048)	1.2651 (2.049)	1.0528 (0.3592)	1.0128 (0.076)	0.9553 (0.213)	0.8750 (0.472)
Hind2 vs Hind1	0.9930 (0.117)	0.8208 (3.079)	0.9520 (0.656)	0.9793 (0.224)	0.9831 (0.143)	1.1613 (0.872)
Hind3 vs Hind1	0.8974 (1.597)	0.8578 (2.080)	0.8512 (1.849)	0.8300 (1.707)	1.2712 (1.660)	0.9937 (0.033)
Hind4 vs Hind1	0.8881 (1.363)	0.6677 (4.131)	0.7498 (2.164)	0.7240 (1.640)	0.5878 (1.764)	0.0900 (2.380)
Hind5 vs Hind1	0.9793 (0.222)	0.7931 (2.412)	0.9903 (0.092)	0.9015 (0.774)	0.9759 (0.137)	0.6818 (1.626)
$FixDead_j$			1.1708 (1.297)	1.2140 (2.051)	1.0143 (0.163)	1.0784 (0.850)
$TivDead_j$		1.4751 (3.505)	1.3258 (2.259)	1.6959 (4.349)	1.9403 (4.866)	1.5434 (1.891)
$TivB_j$		0.9190 (2.124)	0.8057 (3.899)	0.8291 (2.240)	0.6959 (2.896)	0.6275 (2.243)
$TivBB_j$			1.0432 (0.758)	0.8936 (1.691)	0.8242 (2.123)	1.0985 (0.671)
$TivBBB_j$				1.2040 (1.996)	1.0567 (0.603)	1.0380 (0.346)
Log likelihood	-20887.80	-19046.53	-13652.57	-8994.91	-5283.60	-2972.62
Number of obs.	3509	3301	2732	2020	1344	834

Note: Figures in parentheses are t-ratios

Rodriguez et al. (1984) argued that this observed relationship indicates that the reproductive process is "an engine with its own built-in momentum," and variables that determine the start of the reproductive process are also important for explaining subsequent reproduction. (They, thus, suggest a concentration on explaining the determinants of age at marriage and age at the first birth.) However, Heckman et al. (1985) argued that the estimated effects of previous birth intervals incorporated the effect of unobserved heterogeneity.

The coefficients of Age_j and $Age2_j$ suggest that in each transition the hazard rate decreases with the age of the woman. That is consistent with the finding in the last chapter that in each stage of decision- making the probability of having another child decreases with the age of the woman at the decision-making point. To see the relationship from the estimated coefficients, note that a unit-increase in Age_j is generally accompanied by an increase in $Age2_j$ by more than one unit, depending on the initial value of Age_j. Thus, based on the estimated coefficient of Age_j and $Age2_j$ for the second transition, we can infer that a unit increase in the age of the woman at the beginning of the second birth interval from 30 to 31 would reduce the baseline hazard of a second birth by 0.037 ($=1-1.1929 \times 0.9965^{61}$) times.[30] Using the same procedure, it can be shown that hazard rates are generally higher for older cohorts. For example, the predicted hazard rate for a third birth for women in the South who married at age 21 but were 40 years old in 1988 is 64% higher than the corresponding rate for women who were 35 in 1988.

Note that the estimated coefficients of *North* are generally large, but to calculate the North-South differences in hazard rates we must take into account the interaction terms involving *North* and other variables. When that is done, the predicted hazard of a first child for a 35-year-old rural woman in the North, for example, was 91.4% of that for a rural woman in the South. This pattern of differences in the hazard also holds for later transitions, with hazard ratios of 87.6% in the second transition, 91.3% in the third transition, 72.9% in the fourth transition, 80.0% in the fifth transition, and 75.5% in the sixth transition. For urban women, the North-South differences in the hazards are mixed: again for women of age 35, for example, the hazards were higher for women in the North in the first and second transitions, but lower for later ones.

In each transition the hazard is consistently higher for women in rural areas; that agrees with our finding that such women have more children. The estimate for the variable *Instab* suggests that those with a stable source of income had a first child sooner, but increased birth spacing thereafter.

The variable *Cominform* has statistically significant negative effects (at the five-percent level) only in the fifth and sixth transitions. That is consistent with the result reported in the last chapter that this variable has a statistically significant effect only after the third birth. Also, lending support is our non-parametric estimation in section 8.2 which indicates that the means of the first and second intervals were considerably shorter than those for later intervals. These findings consistently indicate that Vietnamese women do not practice contraception until they have had their desired number of children. Such behavior also accords with the widespread use of abortion to control (subsequent) unwanted births, as discussed in Chapter 2. These results suggest that without successful measures to help women practice contraceptives earlier and increase birth intervals, the legal restriction on birth space by the Council of Ministers' Decision No. 162 would force many women to undergo abortions earlier.

The estimated relative risks for the variable *Commort* exceed one in all transitions and are statistically significant in transitions 2,4,5, and 6. That is consistent with the findings in Chapters 6 and 7 about the effect of this variable on the fertility of individual women. (In the three static models in Chapter 6, we found that this variable negatively affected the number of children ever born while in the sequential-response model in Chapter 7 we found it to have a negative effect on the probability of having another birth, given the existing number of children.) We note that, although the magnitude of the coefficients is large, especially for higher-order transitions, the whole-sample mean of this variable is only 0.01. Thus in transition six, for example, doubling the variable to 0.02 would increase the hazard by only 11.8%.

The estimated coefficients of the variables Wed_4 and Wed_5 are less than one in all transitions, with the exception of Wed_5 in the first transition. Thus women with higher education generally have longer birth intervals (and fewer children). The effect of husband's education on hazard rates is less clear, although the estimates indicate that higher education of the husband generally tends to increase the lengths of birth intervals.

The effect of the wife's sector of employment on the timing of births is mixed. However, the effect of the husband's sector of employment is clear: In each transition the hazard is lower (and hence the birth interval longer) for women whose husbands worked in non-agricultural sectors. This is consistent with the findings in the last two chapters, and reflects the fact, noted above, that many Vietnamese men left their families in the countryside to seek work in industrial or urban areas.

The pattern of the effect of child mortality on the timing of births is also clear: child deaths affect hazard rates positively (and thus birth spacing negatively). However, the estimates for $FixDead_j$ are not statistically significant, except in the fourth transition. Thus the death of a child that happened before the woman conceived birth (j-1) would have little impact on the timing of a j^{th} birth. At the same time the estimated coefficients of $TivDead_j$ are large and strongly significant. The explanation is the same as for the sequential-response model: Only child deaths that happened after the woman conceived birth (j-1) are counted by $TivDead_j$, but such deaths might have a replacement effect on the reproductive process after birth (j-1). In addition, our discussion in Chapter 7 suggested that deaths of infants of birth order (j-1) constituted most counts for $TivDead_j$, but such deaths would shorten breastfeeding and hence would also have a supply effect in addition to a replacement effect.

It is helpful to compare the estimated effect of the death of a first child on the probability of a second birth from the sequential-response model with the estimated effect of the same child death on the timing of a second birth from this model. In the last chapter we found that the death of a first child did not appear to influence the probability of having a second birth (the t-ratio was only 0.29). The result here shows that such a death has an important effect on the hazard of a second birth (and hence decreases birth space). Thus it appears that the death of a child affects the timing of the next birth, even though it has no impact on the occurrence. Our findings also show that the sequential-response model does not wrongly translate the pure timing effect of child deaths into a spurious effect on the level of fertility.

Regarding the effects of sex prerference, the results in general are consistent with the findings from the sequential response model. In each transition the relative risk for $TivB_j$ is less than one and statistically significant. Thus, in each transition having at least one living son consistently decreases the probability of a next birth while having more than one does not. Also, comparisons of the magnitudes of the relative risks relating to the variable $TivB_j$ indicate that in the second transition having a male first child has a relatively small effect on the probability of a second birth, a further result consistent with the intentions of most couples to have at least two children. The relative risk is less than one and statistically significant for $TivB_3$, but not statistically significant for $TivBB_3$; it suggests that among parents with two children those with two sons or two daughters are more likely to have a third birth than those with one of each. The relative risk for $TivBBB_3$ is greater than one and statistically significant, suggesting that risk of a fourth birth is greater for parents with three sons and no daughters than for those with fewer sons. Thus, the model also gives some evidence of a preference for having children of both sexes.

8.4 Chapter Summary

This chapter has studied the reproductive process from the perspective of the timing of births. The analysis was designed so that the results could be contrasted and, one hopes, reconciled with the findings reported in Chapters 6 and 7. While the main purpose of this chapter was to identify the determinants of the timing of births, it appears that the results, when comparable, are in general consistent with findings reported in the previous two chapters.

Our nonparametric analysis of the timing of births shows a consistent inverted U-shape for hazard functions (which represent the conditional probabilities of having a next birth). That shape has been found for other developing countries but differs from the results for developed countries.

Our analysis shows that certain variables appear to influence the timing of births, especially lower order ones, but to have no effect on their ultimate occurrences. That suggests that duration models may not be suitable when the main concern is the level of fertility. As a dynamic model of the fertility process, the sequential-response model seems to be suitable for studying the level of fertility. An important question is whether the application of the sequential-response model to samples of women who had not completed reproductive life would wrongly interpret the pure timing effect as an effect on the level of fertility. Our results suggest that the answer is "no". In particular, the estimates from the proportional hazard model suggest an important role of certain variables (for example, the death of a child) for the timing of births and, consistent with that, the sequential-response model correctly predicts that those variables have little effect on the occurrence of births.

The analysis has direct implication for the government's policy on birth spacing. We find convincing evidence that most Vietnamese women control births only after they have had their desired number of children: Parental characteristics, including their knowledge about contraceptives and their preference for sons as well as any deaths of their own children, have no or little impact on reproductive behavior until the desired number of children have been born. In addition, they have often relied on abortion to terminate subsequent unwanted pregnancies. Hence, the regulation that stipulates that couples should have no more than two children and that they "must be spaced 3 to 5 years apart" would force many women to undergo abortion before having two children. This predicted outcome, and the fact that the regulation on birth spacing restricts household choice of timing, with probable little effect on the society's long-term birth rate, makes the policy questionable.

Chapter 9 CONCLUSION

This thesis has provided a comprehensive empirical analysis of individual reproductive behavior in Vietnam, based on data from the Vietnam Demographic and Health Survey that was conducted in 1988. The context of Vietnam makes the study of reproductive behavior in Vietnam interesting and useful. Unlike most countries that are very poor, its total fertility rate has declined steadily since the late 1960's. We note that it was not until December 1988, or eight months after the survey was conducted, that Vietnam introduced legal restrictions on the number of births a woman might have. In order to understand fertility behavior in Vietnam a number of important and, in some cases, distinctive features of its society must be recognized. The key features, in our view, are that: the opportunity cost of women's time varies little with educational attainment, that active mass organizations complement the formal educational system, and that Confucianism has profoundly influenced customs and beliefs.

The theoretical underpinnings of our empirical models are based on the microeconomic theory of fertility. However, this does not mean that social and cultural factors are unimportant, or that they should be excluded from the analysis. Our empirical findings about the effects of maternal education and sex preference, for example, show that social and cultural variables systematically influence preferences for children.

It is often impossible to derive statistical models (regression equations) directly and explicitly from theoretical models. Assumptions must be made and several candidates may be possible (for example, the distribution of the error term). Limitations of available data also restrict the models that can be estimated. Consequently, several competing models often emerge. Our solution to this problem was to examine reproductive behavior from different perspectives, to test alternative statistical specifications, and to compare, contrast and reconcile the results.

In analyzing the determinants of the number of children ever born, we first made use of a static framework. Within that framework three alternative statistical models -- the OLS, Poisson, and ordered logit -- were estimated and the results, including estimated effects and goodness of fit, were compared. We found that the ordered logit model fitted best, but that the estimated effects, as well as the test statistics for that model, and for the Poisson model, were similar. Then, to allow for the dynamic nature of fertility, two dynamic models were estimated -- the sequential-response model and the proportional hazard model. The sequential-response model was the basis for estimates of the effects of included variables on a woman's conditional probability of having another child; our particular focus was on the effects of sex preference and child mortality. The proportional hazard model was used to analyze the timing of births.

The empirical results are varied and interesting. We summarize below the main findings based on our estimation of the several models noted above.

(i) Available survey information regarding the desired number of children suggests that almost all Vietnamese couples wish to have children and that a majority wish to have at least two. That information is consistent with observed reproductive behavior and, in particular, with our finding that individual demographic and socioeconomic characteristics have little effect on fertility decisions until the minimum desired number of children, two as noted above, have been born.

(ii) The estimated mean length of the first birth interval (from the marriage to the first birth) is 28 months and the second (between the first and second birth) is 33 months. About 70% of women with a first child had a second one within 36 months. That, in combination with the low levels of contraceptive practices, but widespread use of abortion, raises a concern about the recent policy that couples must let three years pass before the birth of their second child. Strict implementation of that regulation would force many women to have abortions when they would prefer to carry the child to birth and thereby run counter to the government's objective that abortion would be used only in a quite limited way in family planning.

(iii) As has been found for other countries, whether a woman resides in an urban or a rural area affects both the number of children ever born and the spacing of births. However, we find that the differences are considerably larger for women living in the South than for those living in the North. (The rural-urban differences in the number of children ever born is about 0.4 in the South but only about 0.1 in the North.) It appears that public ownership of land, which was introduced much earlier in the North, and the limited land resources in the North, have made the influence of residence on fertility less in the North.

(iv) As in other developing countries, we find that the education of parents, especially of the mother, is important for both the life-time level of fertility and the timing of births. A more controversial question concerns the nature of the effect of parental education; that is, whether education influences fertility through the opportunity cost of children, through an effect on parents' preference, or both. We were able to test for these effects, based on an assumption that in Vietnam, education had both opportunity-cost and attitudinal effects for those working in non-agricultural sectors, but only an attitudinal effect for those who were either working in agriculture or not working. Our tests indicate that the null hypothesis that there is no opportunity cost effect of maternal education on fertility cannot be rejected. That maternal education is important, but that there is no evidence of an opportunity cost effect on fertility, can be considered as evidence of an attitudinal effect (or an effect on preferences for children). However, our estimated effects of maternal education are considerably smaller than those obtained by other researchers for developing countries with more market-oriented economies. Thus the lack of an opportunity cost effect is consistent with the Vietnamese context, but not inconsistent with existing evidence of such an effect in other countries.

(v) We have found that several characteristics of the husband, including education, sector of employment and a stable source of income, are also important determinants of fertility. That may reflect the still dominant role of husbands in family life in Vietnam, where the influence of Confucianism has been profound. The finding suggests too that family planning programs should pay attention to men as well as to women.

(vi) The preference for sons is very strong in Vietnam. However, what matters is to have (at least) one son, not necessarily many. Such a preference is easily explained in the context of Vietnamese culture but is at odds with the argument made by some economists that in developing countries sons are preferred to daughters either because they give parents more economic benefits, or because they are less expensive to raise. Our findings also suggest that some previous specifications of sex composition, such as the proportion of living children who are male, were not well designed to detect the effect of sex preference on fertility. First, it is clear that such specifications are not appropriate if parents prefer to have one living son but not necessarily more. Second, while the effect of sex preference tends to vary with the number of children (it has little impact until the desired number of children have been born), the specifications used in previous work do not allow for that possibility.

(vii) Child mortality is found to have statistically significant effects on both the timing and the level of fertility. However, the effect on timing is more important; that can be explained by the fact that infant deaths, which generally shorten the length of breastfeeding, account for about 70 to 80 percent of the mortality of children under five in Vietnam. The effect of child mortality on the level of fertility is small, as found in other countries. Comparisons of the estimates from the sequential-response model with those from the proportional hazard model suggest that it is acceptable to apply the sequential-response model to samples of women with incomplete reproductive life. Specifically, we have found no evidence that the sequential-response model has identified an effect on the level of fertility when, in fact, a pure timing effect had occurred.

(viii) Concerning the indirect effects of socioeconomic characteristics on fertility, a general conclusion from our analysis is that reproductive behavior in Vietnam is influenced by several variables, none of which seem to have a dominant role.

These major conclusions have been reached after analyzing the fertility process from a variety of perspectives and checking the sensitivity of estimated relationships to alternative statistical specifications. Thus they are reliable and merit our confidence.

We note that with changes in Vietnamese society as the country moves toward a market economy, the roles of individual characteristics in reproductive behavior may change significantly. For example, in recent years wages and employment opportunities have come to vary considerably with educational attainment. As a result, the effect of maternal education on fertility may increase. While such changes do not diminish the contribution of this study, they do suggest the need for continuing investigation of reproductive behavior.

NOTES

1. Until the educational reform in the 1980's, Vietnam had a ten-year pre-university educational system; elementary school lasted for four years, middle school for three years, and high school for three years.

2. However, as seen in the next section, more complete models also bring the supply of births into consideration.

3. Caldwell's (1982) wealth flow theory and Easterlin's (1969, 1978) synthetic model provide examples of advancement in this direction. Although problems remain in these (Hirschman 1994, Simmons 1985), the synthesis approach makes them agreeable to many researchers of different disciplines.

4. The idea of home economics, which recognizes the household as a production and consumption unit, existed since the beginning of the century (see Keeley 1975, p. 461). The term "new home economics" was adopted by the authors of the new approach presumably to recognize this historical fact and to distinguish their view.

5. We did not think that these women could not remember their children's birth order. They might not have listed their children in such order, but interviewers might have taken it for granted that they did and, thus, entered related information incorrectly. This seems to be consistent with the fact that the problem tended to happen more frequenly among women with many children, and when it happened it often involved several or all children.

6. The study by Swenson et al. (1993) uses the same data and uses information on the order of births from this survey, but there is no mention of this problem.

the order of births from this survey, but there is no mention of this problem.

7. In China and some other Asian countries, son preference in combination with newly available technologies to determine the sex of unborn fetuses has led to sex-selective abortion (see East-West Center 1995), and provided parents with the means to control the sexes of their children. However, this method is not common in Vietnam.

8. In specific contexts, independence among Poisson-distributed events is also referred to as *time independence* (Hausman et al. 1984, p. 911) or *independence over time* (Cameron and Trivedi 1986, p. 29). However, in a broader context, independence among events needs not be over time. For example, the numbers of visits to medical doctors made by different individuals within a certain period of time may be correlated because of contagious diseases.

9. These variables might vary as women age, and ideally, they should be measured at, for example, the beginning of each phase. Such information is not availble from the survey. However, changes in most of these variables would typically be small. We, therefore, think it is better to control for their effects as best as we can.

10. An alternative would have been to exclude all those women. We found that dropping them had little impact on the estimated coefficients or the results of hypothesis testing.

11. It was reported that 21% of the women interviewed in VNDHS-88 and 13% of their husbands knew how to read and write although they had no formal education. Some might have taught themselves, but for most literacy would have resulted from attending educational centres established to help illiterate adults. Note that while it might take a person only a year or so to become literate, formal primary education requires eight years to complete. Thus it is important to distinguish those who were literate but had no formal education from those who had primary education.

12. This measure of mortality corresponds to the probability approach in which the number of deaths is compared with the risk set, the number of persons at the beginning of an age interval. However, the risk set must take into account right censoring when it exists, and that is done in this study, based on methods resembling those used in the construction of life tables (see, for example, Kiefer 1988). That is, we use the number of potential child years to measure the risk set. An alternative measure of mortality could be based on the "rate" approach, in which the number of deaths is divided by the number of *actual* child years. We note that the two measures are closely related. (For our data the two measures have a correlation coefficient of 0.993.) We estimated regressions in which the first measure was replaced by the second, and found almost no change in the regression results. We also found that the models performed equally well (in terms of goodness of fit) when the under-five mortality rate was used instead, and that the estimated coefficients of other variables changed very little.

13. In the case of the Poisson model, the success ratio based on the predicted expectation is sensitive to the proportion of women in the sample with no children. In particular, as shown Appendix B, for women with no children, prediction by this method is much less accurate. This can be explained as follows. If the predicted expectation is between 0.5 and 1.0, a woman is predicted to have one child. However, it can be shown that with the expectation falling in this range, the Poisson distribution has the largest probability at zero, not one. It is not clear why the Poisson model gives better prediction results for other values. A corollary is that for the Poisson model the accuracy is sensitive to the proportion of women with no children.

14. The ordered-logit model could also be applied for this purpose, although the computation would be quite cumbersome. However, similarities between the pseudo-OLS coefficients of this model and those of the Poisson model imply that the results would be little different.

15. Education may have an information effect (for example, it may influence knowledge of contraception), which may also be different for rural and urban residents. However, the differences tend not to be significant for Vietnam, given the evidence of widespread knowledge about contraception among women (see Vietnam 1990b).

16. It is even proposed that "in any population, there exist a normative family-size floor. Fertility plans and behavior of couples below that floor are primarily determined by normative pressures; above the floor, cost-benefit calculations and similar considerations are primary." (Namboodiri 1983, p. 445) The sequential-response model, which assumes decisions are made after each event, still applies in this case. If, for example, having two children was a strict social norm, then we would expect the first fertility decision to start after parity two. Since in practice the family-size floor tends to vary across couples, it would be helpful to estimate the model while assuming that decisions are made after marriage and after each birth and then examine patterns of the family-size floor. We note in addition that the death of a child in any stage might induce its parents to adjust the timing of future births. The present model is not designed to take such adjustments into account.

17. As noted above, other individual characteristics of the parents might have changed over time, but that is not known from the survey. However, even if such information were available, the above findings (of insensitivity of the estimated effects of sex preference and child mortality to different assumptions of the timing of decision-making) suggests that there would be little change in the estimated effects of sex preference and child mortality.

18. The sex ratio for newborns is close to one (about 105 males for every 100 females), and relatively high mortality for male infants leads to subsequent sex balance.

19. We note that the supply effect we tested for pertains to the impact of child deaths on fertility by influencing the length of breastfeeding. However, child deaths may have other kinds of supply effects on fertility.

20. Previous studies of the effects of sex preference on fertility either ignore the mortality problem or or did not dealt with it satisfactorily. For example, Pong (1995) adjusts parities to account for child deaths and then used the adjusted parities to analyze the effects of sex preference. Specifically, "having one son at parity 3 may mean having only two children, because one child died. The adjusted parity will be

2 rather than the usual 3." (Pong 1995, p. 141) Thus, if a couple had three children but only one female child alive, it would be considered as if it stopped reproduction after parity one, regardless the ages at which the two children died.

21. This behavior is consistent with the old-age security reason for son preference, given that the Vietnamese custom is for parents in their old age to reside with a son and his family. This is different from the Thai custom, for example, where parents often live with a daughter (Knodel et al. 1987, p. 65). As discussed above, other economic arguments seem not to explain the pattern of sex preference in Vietnam. Our finding that parents have a strong desire to have at least one son is consistent with the Vietnamese belief (discussed in Chapter 2) that "if you have a son, you can say you have a descendant. But you cannot say so if you have even ten daughters." (UNESCO 1989, p.2) Thus, economic factors are not the only, and perhaps not even the main, reason for son preference.

22. Of course biological constraints mean that the timing of births cannot be precise, and that makes the modelling complicated, as seen below.

23. In the empirical estimation below, the small proportion of births that took place before the first marriage were excluded and the first transition was from her (first) marriage to the first subsequent birth. However, excluding those women from the analysis had very little effect on the estimates. "Early" births were also observed; some would be due to biological factors and, in the case of first-order births, some would be the result of unintended pregnancies from premarital intercourse. In such cases birth intervals, by our definition, would be negative but we adjusted them to zero.

24. The death of a child with a terminal illness might be forseen, for example, but we do not have the information to take such matters into account.

25. The probability density function for a variable *Z*, f(Z=z), that follows an extreme value function is defined as

$$f(z) = exp(z-e^{z}) \qquad -\infty<z<+\infty$$

For the exponential distribution the probability density function, *f(.)*, and the hazard function, *h(.)*, are defined as follows (*T* denotes a random failure-time variable):

$$f(T=t) = \mu e^{-\mu t} \qquad \text{for } \mu>0, \qquad h(t) = \mu$$

For the Weibull distribution they are

$$f(T=t) = \mu p(\mu t)^{p-1} e[-(\mu t)^{p}] \qquad for\ \mu>0\ and\ p>0, \qquad h(t)=\mu p(\mu t)^{p-1}$$

where μ and p are parameters. Thus the exponential distribution is a special case of the Weibull distribution with p=*1*. For details of these and other related distributions see, for example, Cox and Oakes (1984, pp. 13-28) or Kalbfleisch and Prentice (1980, pp. 21-30).

26. The Weibull distribution is a special case, as it belongs to both proportional hazard and accelerated failure-time specifications (see Kalbfleisch and Prentice 1980, pp. 34-5). In this case, it follows that $-\alpha=\beta/\sigma$, $\beta_0=-ln\,\mu$, and $\sigma=1/p$, where μ and p are parameters of the Weibull distribution (see note 24). As noted above, the exponential distribution is a special case of the Weibull distribution, where $p=1$.

27. Note that in Newman and McCulloch (1984) the first transition was estimated separately, but higher transitions were combined while in Trussell et al. (1985)

transitions one and two were not considered.

28. See Lillard (1993) for a model of birth spacing that adopts a simultaneous equation approach.

29. Since we suspected that whether a woman started the interval before 1975 or after 1975 might affect the hazard rate, we included a square origin-year spline variable, as discussed below, and its interaction with *North*. We found that they were not significant and that the estimates of other coefficients were little affected. Let Y_{j-1} denotes the calendar year when a woman had birth (j-1) and her j[th] interval started. It follows that

$$Y_{j-1} = 1988 - (Age\text{-}Age_{j-1})$$

Hence,

$$Y_{j-1} > 1975 \qquad \text{if} \quad 13 - (Age\text{-}Age_{j-1}) > 0$$

Correspondingly, the origin-year spline variable, denoted *Orspline*, was defined as

$$Orspline = 0 \qquad \text{if} \quad 13 - (Age\text{-}Age_{j-1}) \leq 0$$

$$Orspline = [13 - (Age\text{-}Age_{j-1})]^2 \qquad \text{if} \quad 13 - (Age\text{-}Age_{j-1}) > 0$$

30. To understand this calculation, refer to equation (31). The ratio of the two hazards, after and before and increase in Age_j (j=2) by one unit, is

$$\frac{h_0(t)\, e^{31 * \ln 1.1929 + 31^2 * \ln 0.9965 + Z\alpha_Z}}{h_0(t)\, e^{30 * \ln 1.1929 + 30^2 * \ln 0.9965 + Z\alpha_Z}} = 1.1929 * 0.9965^{61}$$

where Z is a vector of other regressors and α_Z a corresponding vector of coefficients. Note that $ln 1.1929$ and $ln 0.9965$ are the α-coefficients of Age_j and $Age2_j$, respectively.

APPENDIX A: THE CALCULATION OF THE PSEUDO-OLS COEFFICIENTS

In this appendix we explain the calculations of the pseudo-OLS coefficients for the Poisson and ordered-logit models. Our aim is to estimate the effects of unit increases in explanatory variables on the expected number of children ever born. We first note two general points:

(i) We do not use derivatives, but calculate the differences associated with (caused by) whole "unit" increases in independent variables. For example, to calculate the impact of an increase in maternal education from the primary to the secondary level, we calculate the predicted values of children ever born for those two educational levels (ignoring other variables for the moment), and then subtract the first predicted number from the second. The resulting number has a meaning similar to the coefficient of the variables *Wed4* in the OLS model. There are two reasons for doing this. First, there are no closed-form formulae for the derivatives in the case of the ordered-logit model. Second, strictly speaking, the method of derivatives is not applicable to discrete variables.

(ii) To measure the effect of one independent variable, we need to fix the levels of others. It is conventional to fix them at their means. We follow this practice with some modification to make the calculations suitable for the dummy variables. Returning to our example above, we fix all independent variables, including dummy variables, at their means with the exception of the dummy variables specifying the mother's education. Among these variables, those that need to be fixed are set equal to zero. Thus, to calculate the predicted number of children ever born for a "typical" woman with secondary education, *Wed4* is set equal to 1; *Wed1*, *Wed2*, and *Wed5* are set to zero, *not their means*; all other independent variables are set equal to their means.

In practice, the calculation for the ordered-logit model would be cumbersome if we were to use equation (19) to calculate predicted probabilities and, from that, the predicted number of children ever born. However, there is a simple trick that helps. The procedure outlined below works with the Stata statistical package, but is applicable to others with some modification. One feature of Stata is that we can easily obtain the predicted number of children ever born for all observations with complete information on the independent variables, *including observations excluded from the regression*. Exploiting this feature, we can create observations in order to calculate the pseudo-OLS measures. For example, to calculate the effect of a switch in the variable *Instab* from 0 to 1 we create two new observations. The first has *Instab* set equal to 0, the second to 1; other variables are fixed at their means. These created observations are included in the data input, but of course not in the sample used for regressions. The predicted number of children ever born for individual women is then calculated for both cases. We need only to deduct the predicted number of children ever born for the first created observation (with *Instab*=0) from the corresponding figure for the second observation (with *Instab*=1) to obtain the pseudo-OLS coefficient.

We could use this procedure for every independent variable included in the

Poisson and ordered-logit regressions. Note, however, two things. First, we want to estimate the marginal effects of changes in continuous variables -- that is, we want to evaluate derivaties. The values of derivatives can be closely approximated by estimating the effects of unit changes, and that is the method applied to the variable *Commort*. (A unit increase in this variable from its mean level implies a 100-fold increase.) We increased this variable from it mean by 0.01 and then multiplied the resulting difference in the predicted number of children ever born by 100. Second, note that if the ordered-response model is applied to an ordinal instead of a cardinal dependent variable, the calculation of expected values may not be meaningful

APPENDIX B: PREDICTION SUCCESS TABLE FOR THE NUMBER OF CHILDREN EVER BORN (CEB) FOR THE POISSON MODEL

(Using estimated expectation (first line) and probability (second line))

Actual CEB	Predicted CEB													Actual count	Pred. index 2
	0	1	2	3	4	5	6	7	8	9	10	11	12		
0	**21** **172**	203 64	16 4											240 240	0.09 71.1
1	3 174	**412** **346**	145 61	30 16	11 5	4 4	6 5							611 611	67.4 56.5
2	0 9	156 373	**372** **246**	160 93	46 28	20 8	5 3	5 5	1 0					765 765	48.6 32.2
3	0 0	11 69	182 257	**256** **203**	142 93	52 32	18 9	3 1						664 664	38.6 30.6
4	0 1	1 5	28 88	164 191	**183** **157**	92 50	36 16	6 8	8 3	1 1				519 519	35.2 30.3
5		0 1	4 16	53 83	99 118	**104** **69**	41 20	9 6	3 3					313 313	33.2 22.0
6			0 1	6 19	41 64	65 60	**62** **49**	27 16	10 2	1 1				212 212	29.2 23.1
7				2 7	19 25	37 48	45 37	**24** **21**	17 7	2 1	1 1	0 0	0 1	148 148	16.2 14.2
8					2 8	12 15	22 25	18 16	**17** **9**	2 1	1 0			74 74	23.0 12.2
9					1 3	5 11	17 16	13 8	5 6	**3** **0**				44 44	0.1 0.0
10						4 5	8 13	10 9	8 6	4 1	**0** **1**	1 0		35 35	0.0 0.0
11						0 1	3 4	6 8	7 4	1 0				17 17	0.0 2.9
12							0 1	3 3	2 2	2 1				7 7	0.0 0.0
Predicted count	24 356	783 858	747 673	671 612	544 501	395 303	263 198	124 101	78 39	16 5	2 2	1 0	0 1		
Pred. index 1	87.5 48.3	52.6 40.3	49.8 36.6	38.1 33.2	33.6 31.3	26.3 22.8	23.6 24.8	19.4 20.8	21.8 23.1	18.8 0.0	0.0 50.0	0 0	0 0		

Overall Prediction Success Ratios:
- Using the predicted expectation : 39.8
- Using predicted probability : 34.9

APPENDIX C: AUXILIARY REGRESSIOINS

(Poisson model estimates with additional independent variables included and ran for the rural and urban observations separately)

Variable	Rural		Urban	
Mardur	0.1251	(16.10)		(9.67)
Mardur2	-0.0017	(7.93)	-0.0020	(4.76)
Age	0.0477	(0.91)	-0.0147	(0.12)
Age2	-0.0008	(1.16)	-0.00004	(0.02)
Agespline	-0.0041	(1.72)	-0.0047	(0.92)
North	1.3893	(1.45)	-1.9130	(0.77)
NAge	-0.0701	(1.37)	0.1167	(0.88)
NAge2	-0.0008	(1.14)	-0.0017	(0.99)
NAgespline	-0.0042	(1.62)	-0.0008	(0.11)
Marrno	-0.2195	(4.35)	-0.2217	(2.10)
Instab	-0.0346	(1.48)	-0.0877	(1.65)
Cominform	-0.0155	(2.22)	0.0093	(0.49)
Commort	1.8511	(2.35)	3.5729	(1.87)
Wed1 vs Wed3	-0.7628	(0.39)	1.5573	(0.26)
Wed2 vs Wed3	0.3115	(0.25)	1.7446	(0.52)
Wed4 vs Wed3	-1.2700	(0.48)	0.4800	(0.15)
Wed5 vs Wed3	-1.6674	(0.37)	-3.7234	(0.68)
Hed1 vs Hed3	-0.3449	(0.12)	-5.0998	(0.56)
Hed2 vs Hed3	1.5676	(1.11)	0.0958	(0.03)
Hed4 vs Hed3	0.9836	(0.73)	-0.4586	(0.15)
Hed5 vs Hed3	0.8293	(0.34)	-0.1301	(0.03)
Wind2 vs Wind1	-0.0319	(0.59)	-0.1405	(1.27)
Wind3 vs Wind1	-0.0087	(0.18)	-0.1306	(1.12)
Wind4 vs Wind1	-0.0755	(0.48)	-0.2844	(1.26)
Wind5 vs Wind1	-0.0327	(0.24)	-0.0516	(0.45)
Hind2 vs Hind1	-0.0810	(2.18)	0.0404	(0.40)
Hind3 vs Hind1	-0.0712	(1.71)	-0.0424	(0.40)
Hind4 vs Hind1	-0.2002	(3.30)	-0.0750	(0.56)
Hind5 vs Hind1	-0.0950	(1.64)	-0.0433	(0.37)
Wed1*Age	0.0355	(0.34)	-0.0593	(0.18)

APPENDIX C: (continued)

Variable	Rural		Urban	
Wed1*Age2	-0.0004	(0.29)	0.0006	(0.02)
Wed2*Age	-0.0120	(0.19)	-0.1021	(0.57)
Wed2*Age2	0.0001	(0.15)	0.0015	(0.64)
Wed4*Age	0.0661	(0.04)	-0.0223	(0.13)
Wed4*Age2	-0.0009	(0.45)	0.0002	(0.09)
Wed5*Age	0.0771	(0.32)	0.2172	(0.76)
Wed5*Age2	-0.0009	(0.30)	-0.0031	(0.83)
Hed1*Age	0.0293	(0.20)	0.2763	(0.57)
Hed1*Age2	-0.0005	(0.27)	-0.0036	(0.57)
Hed2*Age	-0.0847	(1.15)	0.00002	(0.00)
Hed2*Age2	0.0011	(1.16)	-0.0001	(0.04)
Hed4*Age	-0.0512	(0.70)	0.0130	(0.08)
Hed4*Age2	0.0006	(0.65)	-0.0001	(0.06)
Hed5*Age	-0.0435	(0.33)	-0.0142	(0.07)
Hed5*Age2	0.0005	(0.28)	0.0003	(0.12)
Wed1*Agepline	0.0020	(0.34)	-0.0244	(0.91)
Wed2*Agespline	0.0005	(0.13)	-0.0062	(0.73)
Wed4*Agespline	0.0045	(0.78)	-0.0046	(0.56)
Wed5*Agespline	0.0210	(0.78)	-0.0298	(0.92)
Hed1*Agespline	0.0020	(0.30)	0.0150	(0.68)
Hed2*Agespline	-0.0020	(0.48)	0.0001	(0.01)
Hed4*Agespline	-0.0036	(0.97)	0.0020	(0.39)
Hed5*Agespline	-0.0196	(1.29)	0.0053	(0.30)
Wed1*NAgespline	-0.0259	(1.18)	0.0000	.
Wed2*NAgespline	-0.0021	(0.61)	0.0063	(0.34)
Wed4*NAgespline	-0.0017	(0.45)	0.0012	(0.13)
Wed5*NAgespline	-0.0289	(1.20)	0.0381	(0.93)
Hed1*NAgespline	-0.0024	(0.18)	0.0000	.
Hed2*NAgespline	0.0010	(0.26)	0.0045	(0.49)
Hed4*NAgespline	0.0025	(0.91)	0.0091	(1.10)
Hed5*NAgespline	0.0200	(1.46)	0.0080	(0.30)
Constant	-0.5154	(0.53)	0.4486	(0.20)

Note: Figures in parentheses are t-ratios.

APPENDIX D: ESTIMATED SURVIVAL AND HAZARD FUNCTIONS FOR THE FIRST SIX BIRTHS

1. First Birth

Interval	Number of observations[a]	Number of women who conceived	Number of censored observations	Survival rates[b]		Hazard rates[b]	
0 - 5	3701	573	62	0.8439	(0.0060)	0.0339	(0.0014)
5 - 10	3066	562	106	0.6865	(0.0077)	0.0411	(0.0017)
10 - 15	2398	731	0	0.4772	(0.0084)	0.0719	(0.0026)
15 - 20	1667	497	37	0.3333	(0.0080)	0.0710	(0.0031)
20 - 25	1133	272	0	0.2533	(0.0074)	0.0546	(0.0033)
25 - 30	861	203	0	0.1936	(0.0067)	0.0535	(0.0037)
30 - 35	658	153	19	0.1479	(0.0061)	0.0535	(0.0043)
35 - 40	486	70	0	0.1266	(0.0057)	0.0310	(0.0037)
40 - 45	416	76	12	0.1031	(0.0052)	0.0409	(0.0047)
45 - 50	328	82	0	0.0774	(0.0046)	0.0571	(0.0062)
50 - 55	246	31	0	0.0676	(0.0044)	0.0269	(0.0048)
55 - 60	215	38	4	0.0555	(0.0040)	0.0392	(0.0063)
60 - 65	173	34	0	0.0446	(0.0036)	0.0436	(0.0074)
65 - 70	139	14	7	0.0400	(0.0035)	0.0218	(0.0058)
70 - 75	118	9	0	0.0370	(0.0033)	0.0159	(0.0053)
75 - 80	109	17	2	0.0311	(0.0031)	0.0342	(0.0083)
80 - 85	90	6	0	0.0291	(0.0030)	0.0138	(0.0056)
85 - 90	84	10	0	0.0256	(0.0028)	0.0253	(0.0080)
90 - 95	74	11	5	0.0217	(0.0026)	0.0333	(0.0100)
95 - 100	58	3	0	0.0205	(0.0026)	0.0106	(0.0061)
>100	55	38	17	0.0038	(0.0013)	.	.

Notes: a. Counted at the beginning of intervals. b. Figures in parentheses are standard errors

2. Second Birth

Interval	Number of observations[a]	Number of women who conceived	Number of censored observations	Survival rates[b]		Hazard rates[b]	
0 - 5	3441	184	259	0.9444	(0.0040)	0.0114	(0.0008)
5 - 10	2998	270	59	0.8585	(0.0062)	0.0191	(0.0012)
10 - 15	2669	514	66	0.6911	(0.0083)	0.0432	(0.0019)
15 - 20	2089	673	35	0.4666	(0.0090)	0.0776	(0.0029)
20 - 25	1381	329	30	0.3542	(0.0087)	0.0548	(0.0030)
25 - 30	1022	267	25	0.2605	(0.0081)	0.0610	(0.0037)
30 - 35	730	158	16	0.2035	(0.0075)	0.0491	(0.0039)
35 - 40	556	105	20	0.1644	(0.0070)	0.0426	(0.0041)
40 - 45	431	70	28	0.1368	(0.0065)	0.0366	(0.0044)
45 - 50	333	46	15	0.1175	(0.0062)	0.0304	(0.0045)
50 - 55	272	39	10	0.1003	(0.0059)	0.0315	(0.0050)
55 - 60	223	36	17	0.0835	(0.0055)	0.0366	(0.0061)
60 - 65	170	18	3	0.0745	(0.0053)	0.0226	(0.0053)
65 - 70	149	19	3	0.0649	(0.0051)	0.0275	(0.0063)
70 - 75	127	11	8	0.0591	(0.0049)	0.0187	(0.0056)
75 - 80	108	15	3	0.0508	(0.0047)	0.0303	(0.0078)
80 - 85	90	13	4	0.0433	(0.0044)	0.0319	(0.0088)
85 - 90	73	6	3	0.0397	(0.0043)	0.0175	(0.0071)
90 - 95	64	7	0	0.0353	(0.0041)	0.0231	(0.0087)
95 - 100	57	2	7	0.0340	(0.0041)	0.0076	(0.0054)
>100	48	27	21	0.0095	(0.0027)	.	.

Note: As for the first birth.

3. Third Birth

Interval	Number of observations[a]	Number of women who conceived	Number of censored observations	Survival rates[b]	Hazard rates[b]
0 - 5	2809	105	256	0.9608 (0.0037)	0.0080 (0.0008)
5 - 10	2448	142	51	0.9045 (0.0058)	0.0121 (0.0010)
10 - 15	2255	275	70	0.7925 (0.0081)	0.0264 (0.0016)
15 - 20	1910	542	37	0.5654 (0.0101)	0.0669 (0.0028)
20 - 25	1331	265	54	0.4505 (0.0102)	0.0452 (0.0028)
25 - 30	1012	235	48	0.3433 (0.0099)	0.0540 (0.0035)
30 - 35	729	138	28	0.2771 (0.0094)	0.0427 (0.0036)
35 - 40	563	86	33	0.2335 (0.0091)	0.0342 (0.0037)
40 - 45	444	52	31	0.2051 (0.0088)	0.0258 (0.0036)
45 - 50	361	44	22	0.1793 (0.0085)	0.0268 (0.0040)
50 - 55	295	45	25	0.1508 (0.0081)	0.0346 (0.0051)
55 - 60	225	13	15	0.1418 (0.0080)	0.0123 (0.0034)
60 - 65	197	18	12	0.1284 (0.0079)	0.0198 (0.0047)
65 - 70	167	14	9	0.1173 (0.0077)	0.0180 (0.0048)
70 - 75	144	10	9	0.1089 (0.076)	0.0149 (0.0047)
75 - 80	125	9	5	0.1009 (0.0075)	0.0153 (0.0051)
80 - 85	111	8	4	0.0935 (0.0074)	0.0152 (0.0054)
85 - 90	99	5	7	0.0886 (0.0073)	0.0108 (0.0048)
90 - 95	87	1	4	0.0876 (0.0073)	0.0024 (0.0024)
95 - 100	82	2	7	0.0856 (0.0073)	0.0052 (0.0036)
>100	73	12	61	0.0613 (0.0079)	. .

Note: As for the first birth.

4. Fourth Birth

Interval	Number of observations[a]	Number of women who conceived	Number of censored observations	Survival rates[b]		Hazard rates[b]	
0 - 5	2021	83	162	0.9572	(0.0046)	0.0087	(0.0010)
5 - 10	1776	95	45	0.9054	(0.0068)	0.0111	(0.0011)
10 - 15	1636	182	54	0.8029	(0.0093)	0.0240	(0.0018)
15 - 20	1400	323	30	0.6157	(0.0116)	0.0528	(0.0029)
20 - 25	1047	184	39	0.5054	(0.0120)	0.0393	(0.0029)
25 - 30	824	163	45	0.4026	(0.0120)	0.0453	(0.0035)
30 - 35	616	103	23	0.3340	(0.0117)	0.0373	(0.0037)
35 - 40	490	58	24	0.2935	(0.0114)	0.0258	(0.0034)
40 - 45	408	43	28	0.2615	(0.0112)	0.0231	(0.0035)
45 - 50	337	28	11	0.2394	(0.0110)	0.0176	(0.0033)
50 - 55	298	20	25	0.2226	(0.0108)	0.0145	(0.0032)
55 - 60	253	18	20	0.2061	(0.0107)	0.0154	(0.0036)
60 - 65	215	14	15	0.1922	(0.0106)	0.0140	(0.0037)
65 - 70	186	7	33	0.1843	(0.0106)	0.0084	(0.0032)
70 - 75	146	5	11	0.1777	(0.0106)	0.0072	(0.0032)
75 - 80	130	4	10	0.1720	(0.0106)	0.0065	(0.0033)
80 - 85	116	4	8	0.1659	(0.0107)	0.0073	(0.0036)
85 - 90	104	5	4	0.1578	(0.0108)	0.0101	(0.0045)
90 - 95	95	1	3	0.1561	(0.0108)	0.0022	(0.0022)
95 - 100	91	0	6	0.1561	(0.0108)	0.0000	.
>100	85	14	71	0.1119	(0.0126)	.	.

Note: As for the first birth.

5. Fifth Birth

Interval	Number of observations[a]	Number of women who conceived	Number of censored observations	Survival rates[b]		Hazard rates[b]	
0 - 5	1354	63	124	0.9512	(0.0060)	0.0100	(0.0013)
5 - 10	1167	46	29	0.9133	(0.0079)	0.0081	(0.0012)
10 - 15	1092	98	33	0.8301	(0.0108)	0.0191	(0.0019)
15 - 20	961	202	25	0.6533	(0.0139)	0.0477	(0.0033)
20 - 25	734	116	21	0.5485	(0.0147)	0.0349	(0.0032)
25 - 30	597	119	34	0.4360	(0.0149)	0.0457	(0.0042)
30 - 35	444	60	17	0.3759	(0.0147)	0.0296	(0.0038)
35 - 40	367	43	21	0.3306	(0.0145)	0.0257	(0.0039)
40 - 45	303	23	25	0.3044	(0.0143)	0.0165	(0.0034)
45 - 50	255	13	15	0.2884	(0.0142)	0.0108	(0.0030)
50 - 55	227	11	22	0.2737	(0.0142)	0.0105	(0.0032)
55 - 60	194	11	16	0.2575	(0.0142)	0.0122	(0.0037)
60 - 65	167	8	18	0.2445	(0.0142)	0.0104	(0.0027)
65 - 70	141	2	9	0.2409	(0.0142)	0.0030	(0.0021)
70 - 75	130	5	19	0.2309	(0.0143)	0.0085	(0.0038)
75 - 80	106	5	6	0.2197	(0.0144)	0.0101	(0.0044)
80 - 85	95	1	8	0.2173	(0.0145)	0.0022	(0.0022)
85 - 90	86	2	5	0.2121	(0.0146)	0.0048	(0.0034)
90 - 95	79	2	5	0.2065	(0.0147)	0.0053	(0.0037)
95 - 100	72	0	8	0.2065	(0.0147)	0.0000	.
>100	64	4	60	0.1822	(0.0173)	.	.

Note: As for the first birth.

6. Sixth Birth

Interval	Number of observations[a]	Number of women who conceived	Number of censored observations	Survival rates[b]		Hazard rates[b]	
0 - 5	833	40	68	0.9499	(0.0077)	0.0103	(0.0016)
5 - 10	725	38	19	0.8995	(0.0108)	0.0109	(0.0018)
10 - 15	668	55	21	0.8242	(0.0139)	0.0175	(0.0024)
15 - 20	592	125	15	0.6480	(0.0177)	0.0479	(0.0043)
20 - 25	452	58	11	0.5638	(0.0186)	0.0278	(0.0036)
25 - 30	383	68	23	0.4606	(0.0189)	0.0103	(0.0049)
30 - 35	292	39	5	0.3986	(0.0188)	0.0289	(0.0046)
35 - 40	248	27	12	0.3541	(0.0185)	0.0236	(0.0045)
40 - 45	209	16	14	0.3260	(0.0184)	0.0165	(0.0041)
45 - 50	179	16	14	0.2957	(0.0181)	0.0195	(0.0049)
50 - 55	149	8	10	0.2793	(0.0180)	0.0114	(0.0040)
55 - 60	131	4	10	0.2704	(0.0180)	0.0065	(0.0032)
60 - 65	117	7	6	0.2538	(0.0180)	0.0127	(0.0048)
65 - 70	104	1	10	0.2512	(0.0180)	0.0020	(0.0020)
70 - 75	93	1	7	0.2484	(0.0180)	0.0022	(0.0022)
75 - 80	85	2	3	0.2425	(0.0180)	0.0048	(0.0034)
80 - 85	80	1	5	0.2394	(0.0181)	0.0026	(0.0026)
85 - 90	74	3	7	0.2292	(0.0182)	0.0087	(0.0050)
90 - 95	64	1	4	0.2255	(0.0183)	0.0033	(0.0033)
95 - 100	59	0	4	0.2255	(0.0183)	0.0000	.
>100	55	5	50	0.1879	(0.0216)	.	.

Note: As for the first birth.

REFERENCES

Agresti, A. (1984), *Analysis of Ordinal Categorical Data*. New York: Wiley

Allen, Susan (1990), "Women in Vietnam", Cooperation Internationale pour le Dévelopment et la Solidarité (C.I.D.S.E.) working paper, Hanoi, Vietnam, 1990.

Allison, Paul D. (1984), *Event History Analysis*, Beverly Hills: Sage Publication.

Amemiya, T. (1975), "Qualitative Models", *Annals of Economics and Social Measurment* 4: 363-72.

Andreopoulos, Spyros (1975), *National Health Insurance: Can We Learn from Canada*. New York: John Willey & Sons.

Barlet, Peggy F. (1980), "The Anthropological Approach to Fertility Decision-making", in Burch, ed., (1980), 163-183.

Banister, Judith (1992), "Vietnam Population Dynamics and Prospects", CIR staff paper No.65, Center for International Research, U.S. Bureau of Census, Washington D.C.

Beach, L. R. et al. (1979), "Subjective Expected Utility and the Prediction of Birth Planning Decisions, *Organization Behavior and Human Performance* 24, 18-28.

Becker, Gary S. (1960), "An Economic Analysis of Fertility", in *Demographic and Economic Change in Developed Countries, a Report of the National Bureau* *of Economic Research*, Princeton, 137-56.

--------. (1965), "A Theory of the Allocation of Time", *Economic Journal* 75, 493-517.

--------. (1990), "Human Capital, Fertility, and Economic Growth", *Journal of Political Economy* 98, S12-S37.

--------. (1991), *A Treatise on the Family*, Cambridge: Harvard University Press.

--------. (1992), "Fertility and the Economy", *Journal of Population Economics* 5: 185-201.

Becker, Gary S. and Gregg Lewis (1973), "On the Interaction between the Quantity and Quality of Children", *Journal of Political Economy* 81, 279-88.

Becker, Gary S. and Robert J. Barro (1988), "A Reformulation of the Economic Theory of Fertility", *Quarterly Journal of Economics* 103, 1-25.

Beckman, Linda J. (1978) "Couples' Decision-Making Process Regarding Fertility", in Karl E. Taeuber, Larry L. Bumpass, and James A. Sweet ed., *Social Demography*. New York: Academic Press, 1978, 57-81.

Behrman, Jere R. (1988), "Intrahousehold Allocation of Nutrition in Rural India: Are Boys Favored? Do Parents Exhibit Inequality Aversion?" *Oxford Economics Papers* 40: 32-54.

Ben-Porath, Yoram and Finis Welch (1976), "Do Sex Preferences Matter?", *Quarterly Journal of Economics* 90, 285-307.

Berelson, R. (1975), *The Great Debate on Population Policy: An Instructive Entertainment*. New York: Population Council.

Blake, Judith (1968), "Are Babies Consumer Durables?" *Population Studies* 22, 5-25.

Bongaarts, John (1978) "A Framework for Analyzing the Proximate Determinants of

Fertility", *Population and Development Review* 4, 105-32.

--------. (1990), "The Measurement of Wanted Fertility", *Population and Development Review*, 487-506.

--------. (1993), "The Supply-Demand Framework for the Determinants of Fertility: An Alternative Implementation", *Population Studies* 47, 437-56.

Broström, Göran (1985), "Practical Aspects on the Estimation of the Parameters in Coale's Model for Marital Fertility", *Demography* 22: 625-31.

Bulatao, Rofdolfo A. and Ronald D. Lee (1983), ed. *Determinants of Fertility in Developing Countries*. New York: Academic Press.

Burch, Thomas K., ed., (1980), *Demographic Behavior: Interdisciplinary Perspectives on Decision-making*. Washington: Westview Press.

Butz, William P. and Michael P. Ward (1979), "The Emergence of Counter-cyclical U.S. Fertility", *American Economic Review* 69, 318-28.

Cain, G. Glen and Martin D. Dooley (1976), "Estimation of a Labor Supply, Fertility and Wages of Married Women", *Journal of Political Economy* 84, part 2, S179-199.

Caldwell, John C. (1976), "Toward a Restatement of Demographic Transition Theory", *Population Development Review* 1, 321-66.

--------. (1980), "Mass Education as a Determinant of the Timing of Fertility Decline, *Population Development Review* 6, 225-55.

--------. (1982), Theory of Fertility Decline, New York: Academic Press.

Cameron, Colin A. and Pravin K. Trivedi (1986), "Econometric Models Based on Count Data: Comparisons and Applications of Some Estimators and Tests", *Journal of Applied Econometrics* 1: 29-53.

Cameron, Colin A. and Pravin K. Trivedi (1990), "Regression-Based Tests for Overdispersion in the Poisson Model", *Journal of Econometrics* 46: 347-63.

Chesnais, Jean-Claude (1992), *The Demographic Transition -- Stages, Patterns and Economic Implications*. Oxford: Clarendon Press.

Chowdhury, A. K. M. Alauddin, Atiqur Rahman Khan, and Lincoln C. Chen (1978), "Experience in Pakinstan and Bangladesh", in Samuel H. Preston, ed., *The Effects of Infant and Child Mortality on Fertility*. New York: Academic Press, 1978.

Cigno, A. (1992), "Children and Pension", *Journal of Population Economics* 3, 175-83.

Coale, Ansley J. and Susan. C. Watkins, ed., (1986), *The Decline of Fertility in Europe*. Princeton: Princeton University Press.

Coale, Ansley and E. M. Hoover (1958), *Population Growth and Economic Development in Low-Income Countries*. Princeton: Princeton University Press.

Cochrane, Susan (1979), *Fertility and Education: What Do We Really Know?* Baltimore, Md: The John Hopkins University Press.

--------. (1983) "Effects of Education and Urbanization on Fertility", *in Determinants of Fertility in Developing Countries*, Vol.2, ed., Rofdolfo A. Bulatao and Ronald D. Lee. New York: Academic Press.

Cole, H. S. D et al. (1973), *Thinking about the Future: A Critique of the Limits to Growth*, Chatto and Wendus.

Coleman, James S. (1990), *Foundations of Social Theory*. Cambridge: Harvard

University Press.

Computing Resource Center (1992), *Stata Reference Manual*: Release 3. 5th ed. Santa Monica, CA.

Cox, D. R. (1972), "Regression Models and Life-Tables", *Journal of the Royal Statistical Society* 34: 187-202.

Cox D. R. and D. Oaks (1984), *Analysis of Survival Data*. London: Chapman and Hall.

Crosbie, Paul (1986) "Rationality and Models of Reproductive Decision-Making", in *Culture and Reproduction: An Anthropological Critique of Demographic Transition Theory*, ed. W. Penn Handwerker, 30-58. Boulder: Westview Press.

Dang Thu (1993), *Reports and Articles on Population of Vietnam*, National Centre for Social Sciences of Vietnam, Centre for Population and Development Studies.

David, Kingsley (1959), "The Sociology of Demographic Behavior", in *Sociology Today*, ed., Robert K. Merton, Leonard Broom, and Leonard S. Cottrell, Jr. New York: Basic Books, Inc.

Davis, Kingsley (1970), "The Theory of change and Response in Modern Demographic History", in Ford and De Jong, ed., (1970), 23-43.

--------. and Judith Blake (1956), "Social Stucture and Fertility: an Analytical Framework", *Economic Development and Cultural Change* 4, 211-235.

Davis, Kingsley, Mikkahl S. Bernstam and Rita Ricardo-Cambell, ed., (1987), *Below-Replacement Fertility in Industrial Society*. Cambridge: Cambridge

University Press.

De Tray, Dennis (1974), "Child Quality and the Demand for Children", in *Economics of the Family: Marriage, Children, and Human Capital*, ed. Theodore W. Schultz. Chicago: University of Chicago Press, 91-116.

Denton, T. Frank (1985), "Data Mining as an Industry", *The Review of Economics and Statistics* 67: 124-127.

Denton, Frank T. and Byron G. Spencer (1989), "Macro-effects of Changes in Household Preferences for Children", *Journal of Population Economics* 2, 165-88.

Donaldson, Loraine (1991), *Fertility Transition, The Social Dynamics of Population Change*. Oxford: Basil Blackwell.

Dooley, D. Martin and Peter Gottschalk (1984), "Earnings Inequality Among Males in the U.S.: Trends and the Effects of Labor Force Growth", *Journal of Political Economy* 92, 59-88

Duesenburry, S. James (1960), "Comment", in *Demographic and Economic Change in Developed Countries*, a Report of the National Bureau of Economic Research, New York, 231-34.

Easterlin, Richard A. (1966) "Economic-Demographic Interactions and Long Swings in Economic Growth", *American Economic Review* 56, 1063-1104

--------. (1968), *Population, Labor Force and Long Swings in Economic Growth*. New York: Columbia University Press.

--------. (1969), "Toward a Socio-Economic Theory of Fertility: a Survey of Recent Research on Economic Factor in American Fertility", in *Fertility and Family*

Planing: A world View, ed., S. J. Behrman et al., 127-56. Ann Arbor: University of Michigan Press.

--------. (1978), "The Economics and Sociology of Fertility: A Synthesis", in *Historical Studies of Changing Fertility*, ed., Charles Tilly, 57-133. Pricenton: Princeton University Press.

Easterlin, Richard A. and Eileen M. Crimmins (1985), *The Fertility Revolution, Supply-Demand Analysis*. Chicago: University of Chicago Press.

Easterlin Richard A., Robert A. Pollak and Micheal L. Wachter (1980), "Toward a More General Model of Fertility Determination: Endogenous Preferences and Natural Fertility", in *Population and Economic Change in Developing countries*, ed., Richard A. Easterlin. Chicago: University of Chicago Press.

East-West Center (1995), "Evidence Mount for Sex-Selective Abortion in Asia", *Asia-Pacific Population & Policy* No. 34, Program on Population, East-West Center, Honolulu, U.S.A.

Ermisch, John F. (1988), "The impacts of Generation Size on Relative Earnings of Young Men", *Scottish Journal of Political Economy* 35, 266-282.

Farooq, Ghazi M. and George B. Simmons (1985), ed., *Fertility in Developing Countries -- An Economic Perspective on Research and Policy Issues*. Hampshire: MacMillan.

Feeney, Griffith and Peter Xenos (1992), "The Demographic Situation in Vietnam: Past, Present, Prospect", in *The Challenges of Vietnam's Reconstruction*, ed., Neil L. Jamieson, Nguyen Manh Hung, and A. Terry Rambo, reprinted in East-West Center Reprints: Population Series No 289, 56-78.

Feldstein, Martin (1982), "Inflation, Tax Rules and Investment: Some Econometric Evidence", *Econometrica* 50: 825-62.

Fishbein, M. et al. (1980), "Predicting and Understanding Family Planning Behaviors", in *Understanding Attitudes and Predicting Social Behavior*, ed., I. Ajzen and M. Fishbein. Englewood Cliffs: Prentice-Hall, 130-147.

Ford, Thomas R. and Gordon F. De Jong ed. (1970), *Social Demography*. Englewood Cliffs: Prentice-Hall.

Fforde, Adam and Stephan de Vylder (1988), *Vietnam -- The Economy in Transition*, Swedish International Development Authority, Stockholm.

Forrester, J. W. (1971), *World Dynamics*. Massachusetts: Wright-Allen Press, Inc.

Freedman, Ronald (1970), "The Sociology of Human Fertility", in Ford and De Jong ed., (1970), 44-52.

--------. (1995), "Asia's Recent Fertility Decline and Prospects for Future Change", East-West Center's Asia-Pacific Population Research Report No. 1, Jan. 1995.

Goodkind, Daniel (1994), "Abortion in Vietanm: Measurement, Puzzles, and Concerns," *Studies in Family Planning 25*: 342-52.

Green, William H. (1989), *Limdep Version 5.1* (Manual). New York: Econometric Software Inc.

Greene, William H. (1993), *Econometric Analysis*, 2nd. edition. New York: McMillan.

Greenhalgh, Susan (1994), "Anthropological Contribution to Fertility Theory", Working Paper No. 64, Research Devision, Population Council, forthcoming in *Situating Fertility: Anthropology and Demographic Inquiry*, ed., Susan Greenhalgh. Cambridge: Cambridge University Press.

GSO (1978), *Tinh Hinh Phat Trien Kinh Te va Van Hoa Mien Bac Xa Hoi Chu Nghia Vietnam 1969-1975* (Socioeconomic Development of Northern Socialist Republic of Vietnam 1960-1975), Vietnam General Statistical Office, Hanoi, Vietnam.

GSO (1990), *Sample Results*, a report on Vietnam population census 1989, General Statistical Office, Hanoi.

--------. (1991), *A Detailed Analysis of Sample Results*, a report on Vietnam population Census 1989, Vietnam General Statistical Office, Hanoi, Vietnam.

--------.(1991), *Nien Giam Thong Ke 1989* (Statistical Yearbook 1989), Vietnam General Statistical Offices, Hanoi, Vietnam.

--------. (1993), *Statistical Yearbook 1992*, Vietnam General Statistical Office. Hanoi: Statistical Publishing House.

Gulati, S. C. (1988), *Fertility in India: An Econometric Analysis of a Metropolis*. New Delhi: Sage Publications.

Hammel, E. E. (1990), "A Theory of Culture for Demography", *Population and Development Review 16*, 455-485.

Handwerker, Penn W. (1988a), "Cultural Reproduction: Exploring Micro/Micro Linkages" in *Culture and Reproduction: An Anthropological Critique of Demographic Transition Theory*, ed. W. Penn Handwerker. Boulder: Westview Press.

Handwerker, Penn W. (1988b), ed. *Culture and Reproduction: An Anthropological*

Critique of Demographic Transition Theory, ed. W. Penn Handwerker. Boulder: Westview Press.

Haughton, Jonathan and Dominique Haughton (1995), "Son Preference in Vietnam", *Studies in Family Planning* 26: 325-37.

Hausman, Jerry, Bronwyn H. Hall, and Zvi Griliches (1984), "Econometric Models for Count Data within an Appication to the Patents-R&D Relationships", *Econometrica* 52: 909-38.

Heckman, James J. and James R. Walker (1987), "Using Goodness of Fit and Other Criteria to Choose among Competing Duration Models: A Case Study of Hutterite Data", in *Sociological Methodology* Vol. 17: 247-308.

Heckman, James J. and James R. Walker (1990), "The Relationship between Wages and Income and the Timing of Births: Evidence from Swedish Longitudinal Data", *Econometrica* 58: 1411-41.

Heckman, James J. and James R. Walker (1991), "Economic Models of Fertility Dynamics: A Study of Swedish Fertility", in *Research in Population Economics*, Vol. 11, ed., T. Paul Schultz. Greenwich: JAI Press Inc.

Heckman, James J., V. Joseph Hotz and James R. Walker (1985), "New Evidence on the Timing and Spacing of Births", *American Economic Review* 75: 179-84.

Heckman, James and Robert Willis (1976), "Estimation of a Stochastic Model of Reproduction: An Econometric Approach", in *Household Production and Consumption*, ed., Nestor E. Terleckyj, 99-138. New York: Columbia University Press.

Hirschman, Charles (1994), "Why Fertility Changes", *Annual Review of Sociology 20*, 203-33.

Hirschman, Charles and Philip Guest (1990a), "The Emerging Demographic Transition of Southeast Asia", *Population and Development Review* 16, 125-52.

--------. (1990b), "Multilevel Models of Fertility Determination in Four Southeast Asian Countries: 1970 and 1980" *Demography* 27, 369-96.

Hoffman, Saul D. and Gref J. Duncan (1988), "Multinomial and Conditional Logit Discrete-Choice Models in Demography", *Demography* 25: 415-27.

Hoffman, Lois W. and Martin L. Hoffman (1973): "The Values of Children to Parents", in *Psychological Aspects of Population*, ed. J. T. Fawcet. New York: Basic Books.

Hotz, V. Joseph and Robert A. Miller (1988), "An Empirical Analysis of Life Cycle Fertility and Female Labour Supply", *Econometrica* 45, 91-118.

Jaccard, J. J. and A. R. Davidson (1972), "Toward and Understanding of Family Planning Behaviors", *Journal of Applied Social Psychology* 2, 228-35.

Jensen, Eric (1985): "Appendix: The Formal Structure of Micro-economic Models of Fertility Behavior", *Fertility in Developing Countries -- An Economic Perspective on Research and Policy Issues*, ed., Ghazi M. Farooq and George B. Simmons. Hampshire: MacMillan.

Jones, Gavin W. (1993), "Consequences of Rapid Fertility Decline for Old-Age Security" in R. Leete and I. Alam, ed., (1993), 3-14.

Johnson, Gale D. (1994), "Effects of Institutions and Policies on Rural Population Growth: The Case of China", *Population and Development Review* 20, 503-32.

Johston, J. (1984), *Econometric Methods*, 3rd. edition. London: McGraw-Hill.

Judge, G. G., W. E. Griffiths, R. C. Hill, and T. C. Lee (1985), *The Theory and Practice of Econometrics*. New York: Willey.

Kahan, James P. (1974), "Rationality, The Prisoner's dilemma and Population", *Journal of Social Issues* 30, 189-210.

Kalbfleisch, John D. (1980) and Ross L. Prentice, *The Statistical Analysis of Failure Time Data*. New York: John Wiley & Sons.

Keeley, Michael C. (1975), 'A Comment on "An Interpretation of the Economic Theory of Fertility"', *Journal of Economic Literature* 13, 461-68.

Kelley, Allen. C. (1988a), "Economic Consequences of Population Change in the Third Word", *Journal of Economic Literature* 26, 1685-1728.

--------. (1988b) "Population Pressure, Saving and Investment in the Third World: Some Puzzles, *Economic Development and Cultural Change* 36, 449-64.

Kiefer, Nicholas M. (1988), "Economic Duration Data and Hazard Functions", *Journal of Economic Literature* 26: 646-79.

King, Gary (1989), Variance Specification in Event Count Model: From Restricive Assumption to a Generalized Estimator", *American Journal of Political Science* 33: 762-84.

King, Gary (1989), *Unifying Political Methodology*. Cambridge: Cambridge University Press.

Larsen, Ulla. (1990),"An Assessment of the One-Child Policy in China from 1980 to 1985", *European Journal of Population* 6, 257-84.

Leete, Richard and Iqbal Alam (1993), *The Revolution in Asian Fertility: Dimensions,* *Causes and Implications*. Oxford: Clarenden Press.

Leibenstein, Harvey (1957), *Economic Backwardness and Economic Growth: Studies in the Theory of Economic Development*. New York: John Wiley and Sons Inc.

--------. (1974), "An Interpretation of the Economic Theory of Fertility: Promising Path or Blind Alley", *Journal of Economic Literature* 12, 457-79.

--------. (1975), "On the Economic Theory of Fertility: A Reply to Keeley", *Journal of Economic Literature* 13, 469-72.

--------. (1981), "Economic Decision Theory and Human Fertility Behavior", *Population and Development Review* 7, 381-400.

Lightbourne, Robert (1987), "Reproductive Preferences and Behavior", in *The World Fertility Surveys*, ed. John Cleland and Chris Scott, 838-61. Oxford: Oxford University Press.

Lillard, Lee A. (1993), "Simultaneous Equations for Hazards", *Journal of Econometrics* 56: 189-217.

Lovell, Michael C. (1983), "Data Mining", *The Review of Economics and Statistics* 65: 1-12.

McDonald, Peter (1993), "Fertility Transition Hypothesis", in *Revolution in Asian Fertility: Dimensions, Causes, and Implications*, ed., Richard Leete and Iqbal Alam, 3-14. Oxford: Clarendon Press.

McNicoll, Geoffrey (1978), "Population and Development: Outlines for a Structuralist Approach" *Journal of Development Studies* 14, 79-99.

--------. (1980), "Institutional Determinants of Fertility", *Population and Development*

Review 6, 441-62.

--------. (1984), "Consequences of Rapid Population Growth: Overview and Assessment", *Population and Development Review* 10, 1977-2040.

Maddala, G. S. (1983), *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

Mason, Karen O. (1987), "The Impact of Women's Social Position on Fertility in Developing Countries", *Social Forum* 2, 714-45.

Mason, Karen O. (1992), "Culture and Fertility Transition: Thoughts on Theories of Fertility Decline", *Genus* 48, 1-14.

Meadow, D. H. et al. (1972), *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books.

Mincer, Jacob (1963), Market Prices, Opportunity Costs, and Income Effects", in *Measurement in Economics*, ed., C. Christ et al., 67-82. Stanford: Stanford University Press.

Moghadam, Valentine M. (1994), "Market Reforms and Women Workers in Vietnam: A Case of Hanoi and Ho Chi Minh City", working paper, United Nations university, Filand.

Montgomery, M and J. Trussell (1986), "Models of Marital Status and Childbearing", in *Handbook of Labor Economics*, ed., O. Ashenfelter and R. Layard. New York: North-Holland.

Namboordiri, N. Krishnan (1983) "Sequential Fertility Decision Making and the Life Course", *in Determinants of Fertility in Developing Countries*, Vol.2, ed. Rofdolfo A. Bulatao and Ronald D. Lee. New York: Academic Press.

Newman, David (1992), "Interpreting Demographic Effects in Duration Analyses of First Birth Intervals", *Journal of Population Economics* 5: 17-37.

Newman John L. and Charles E. McCulloch (1984), "A Hazard Rate Approach to the Timing of Birth", *Econometrica* 52: 939-61.

Newman, John L. (1988), "A Stochastic Model of Fertility", in *Research in Population Studies* Vol. 6, ed., T. Paul Schultz, 41-68. Greenwich: Jai Press Inc.

Nguyen Duc Hung (1991), "Uoc Luong Tong Ty Suat Sinh Tu Mot Cuoc Dieu Tra" (Estimation of the Total Fertility Rate Based on a Focused Survey), in *Hoi Thao Dan So va Phat Trien Nguon Nhan Luc* (Seminar on Population and Human Resource Development), Project VIE/89/P03, Hanoi.

Nguyen Luc, Nguyen Minh Thang, Ingrid Swenson, and Pham Bich San (1993), "Selected Determinants of Fertility in Vietnam: Age at Marriage, Marriage to First Birth Interval and Age at First Birth", *Journal of Biosocial Science* 25: 303-310.

Nugent, B. Jeffrey (1985), "The Old Age Security Motive for Fertility", *Population and Development Review* 11, 75-97.

Okun, Bernard (1960), "Comment", in *Demographic and Economic Change in Developed Countries*, a Report of the National Bureau of Economic Research, 235-40. New York: National Bureau of Economic Research.

Olsen, Randall J. (1980), "Estimating the Effect of Child Mortality on the Number of Births", *Demography* 17: 429-43.

--------. (1994), "Fertility and the Size of the U.S. Labor Force", *Journal of Economic Literature* 32, 60-100.

Page, H. J. (1977), "Patterns Underlying Fertility Schedules: A Decomposition by both Age and Marital Duration", *Population Studies* 31: 85-106.

Park, Chai Bin and Nam-Hoon Cho (1995), "Consequences of Son Preference in a Low Fertility Society: Imbalance of the Sex Ratio at Birth in Korea", *Population and Development Review* 21: 59-84.

Phan Dai Doan and Nguyen Quang Ngoc (1990), "Moi Quan He Lang Ho Va Gia Dinh Truyen Thong" (Relationship between Village, Kinship and Traditional Family), *Tap Chi Xa Hoi Hoc*, so 3 thang 9 nam 1990 (Sociological Review No. 3 September 1990).

Pollak, Robert A. and Terence J. Wales (1992), *Demand System Specification and Estimation*. New York: Oxford University Press.

Pollak, Robert A. and Susan C. Watkins (1993), "Cultural and Economic Approaches to Fertility: A Proper Marriage of Mesalliance?", *Population and Development Review* 19, 467-96.

Pong, Suet-ling (1994), "Sex Preference and Fertility in Peninsular Malaysia", *Studies in Family Planning* 25: 137-48.

Preston, Samuel H. (1978) "Introduction", in *The Effects of Infant and Child Mortality on Fertility*, ed. Samuel H. Preston. New York: Academic Press.

Prittchet, Lant H. (1994), "Desired Fertility and the Impact of Population Policies", *Population and Development Review* 20: 1-55.

Razin, Assaf (1979), "Number, Spacing, and Quality of Children: A Microeconomic Viewpoint", in *Research in Population Studies* Vol. 2, ed., Julian L. Simon and Julie Da Vanzo, 279-94. Greenwich: JAI Press Inc.

Repetto, Robert (1972), "Son Preference and Fertility Behaviour in Developing Countries, *Studies in Family Studies* 3: 70-6.

Robert, M. J. (1974), "The Limits of The Limits to Growth" in *The Energy Quetion -- An International Future of Policy*, Vol. 1, ed., E. W. Erickson and L. Wavermand. Toronto: University of Toronto Press.

Robey, Bryant, Shea O. Rutstein, and Leo Morris (1993), "The Fertility Decline in Developing Countries", *Scientific American* 269, 60-66.

Robinson, Warren C. and Sarah F. Harbison (1980), "Toward a Unified Theory of Fertility, in Burch, ed., (1980), 201-35.

Rodriguez, G., J. Hobcraft, J. McDonald, J. Manken, and J. Trussell (1983), "A Comparative Analysis of Birth Intervals", *Comparative Studies* No. 30. London: World Fertility Survey.

Rosenzweig, Mark R. and T. Paul Schultz (1985), "The Demand for and Supply of Births: Fertility and its Life Cycle Consequence", *American Economic Review* 75, 993-1017.

Ryder, Norman B. (1974), "Comment", in *Economics of the Family: Marriage, Children, and Human Capital*, ed., Theodore W. Schultz, 3-24. Chicago: University of Chicago Press.

Schuler, S. R. et al. (1994), "Misinformation, Mistrust, and Mistreatment: Family Planning among Bolivian Market Women", *Studies in Family Planning* 25, 211-21.

Schultz, T. Paul (1976) "Determinants of Fertility: a Microeconomic Model of Choice", in, *Economic Factors in Population Growth*, ed., Ansley J. Cole, 89-

1224. New York: John Wiley and Sons.

--------. (1978), "The Influence of Fertility on Labour Supply of Married Women: Simultaneous Equation Estimates", in *Research in Labour Economics*, Vol. 2, ed., Ronald G. Ehrenberg, 273-352. Greenwich: JAI Press.

--------. (1990), "Testing the Neoclassical Model of Family Labor Supply and Fertility", *Journal of Human Resources* 25, 599-634.

Schultz, Theodore W. (1974), "Fertility and Economic Values", in *Economics of the Family: Marriage, Children, and Human Capital*, ed. Theodore W. Schultz, 3-24. Chicago: University of Chicago Press.

Simon, J. L. (1976), "Population Growth May Be Good for LDCs in the Long Run: A Richer Simulation Model", *Economic Development and Cultural Change* 24, 309-37.

--------. (1993), "Economic Thought about Population Consequences: Some Reflections", *Journal of Population Economics* 6, 137-52.

Simmons, George B. (1985), "Theory of Fertility", in *Fertility in Developing Countries -- An Economic Perspective on Research and Policy Issues*, ed., Ghazi M. Farooq and George B. Simmons. Hampshire: MacMillan.

Swenson, E. Ingrid, Nguyen Minh Thang, Pham Bich San, Vu Qui Nhan, and Vu Duy Man (1993), "Factors Influencing Infant Mortality in Vietnam", *Journal of Biosocial Science* 25: 285-302.

Townes, B. D., L. R. Beach, F. L. Campbell, and R. L. Wood (1980), "Family Building: A Social Psychological Study of Fertility Decisions", *Population and Environment* 3: 210-20.

Trussell, J. and D. E. Bloom (1983), "Estimating the Covariates of Age at Marriage and First Birth", *Population Studies* 37: 403-16.

Trussell, James, Linda G. Martin, Robert Feldman, James A. Palmore, Mercedes Concepcion, and Datin Noor Laily Bt. Dato' Abu Bakar (1985), "Determinants of Birth-Interval Length in the Philippines, Malaysia, and Indonesia: A Hazard-Model Analysis", *Demography* 22: 145-68.

Turchi, Boone A. (1975a), *The Demand for Children: The Economics of Fertility in the United States*. Cambridge: Ballinger Publishing Company.

--------. (1975b), "Microeconomic Theories of Fertility: A Critique, *Social Forces* 54, 107-25.

UN (1990a), *Bao Cao Ve Nen Kinh Te Vietnam* (Report on the Economy of Vietnam), United Nations Development Programs (UNDP), Hanoi, Vietnam.

UN (1990b), *Socio-Economic Development and Fertility Decline: A Review of Some Theoretical Approaches*, United Nation, New York.

UNESCO (1989), *Status of Women: Vietnam*, RUSHSAP series on monographs and occasional papers No. 30, UNESCO Principal Regional Office for Asia and the Pacific, Bangkok.

UNICEF (1990), *Vietnam: The Situation of Children and Women*, United Nations Children's Fund Office of the Representative, Hanoi, Vietnam.

Vallin, Jaques and Alain Lery (1978) "Estimating the Increase in Fertility Consecutive to the Death of a Young Child", in *The Effects of Infant and Child Mortality on Fertility*, ed. Samuel H. Preston. New York: Academic

Press.

Veall, Michael R. and Klaus F. Zimmermann (1994), "Pseudo-R^2 Measures for Some Common Limited Dependent Variable Models", McMaster Universtiy and University of Munich, unpublished paper.

Vlassoff, Carol (1991), "Rejoinder to Cain: Widows, Sons, and Old-Age Security in Rural Maharashtra", *Population Study* 45, 529-35.

VN (1988), "Council of Minister Decision 162", translated and reprinted in *Population and Development Review* 15 (1989), 169-72.

VN (1990), *Selected Indicators on Women's Status in Vietnam 1975-1989*, by the National Centre for Social Sciences of Vietnam, Centre for Women's Studies. Hanoi: Statistical Publishing House.

VNDHS-88 (1990), *Demographic and Health Survey 1988*, National Committee for Population and Family Planning, Hanoi, Vietnam.

Vu, Manh Loi (1990), "Khac Biet Nam Nu Trong Gia Dinh Nong Thon Dong Bang Bac Bo" (Gender Differences in Rural Families in the Red River Delta), *Tap Chi Xa Hoi Hoc* (Sociological Review) No. 3: 34-42.

Vu, Quy Nhan (1989), Vietnam Knowledge and Attitude of Grassroots Family Planning Workers about Contraceptive Method, United Nations, Asian Population Studies Series, No 86-D.

Vu, Quy Nhan and Robert Hanenberg (1989), "The 1988 Vietnam Demographic and Health Survey", *Aisan-Pacific Population Journal* 4: 3-14.

Vu, Quy Nhan (1993), "Family Planning in Vietnam", National Committee for Population and Family Planning working paper, Hanoi, Vietnam.

Ward, Michael P. and William P. Butz (1980), "Completed Fertility and Its Timing", *Journal of Political Economy* 88: 917-40

Watkins, Watkins C. (1986), "Conclusions", in Coale and Watkin, ed., (1986), 420-451.

Welch, Finis (1979), "Effect of Cohort Size on Earnings: The Baby boom Babies' Financial Bust", *Journal of Political Economy* 87, S65-S98.

Westoff, Charles F. (1991), "Reproductive Preferences: A Comparative View", *Demographic and Health Surveys Comparative Studies* No. 3, Columbia, Md.: Institute for Resource Development/Macro System.

Winkelmann, Rainer (1995), "Duration Dependence and Dispersion in Count-Data Models", *Journal of Business & Statistics* 13: 467-74.

Williamson, Nancy E. (1976), *Sons or Daughters, a Cros-Cultural survey of Parental Preferences*. Beverly Hills: Sage Publication.

Willis, Robert J. (1973), "A New Approach to the Economic Theory of Fertility Behavior", *Journal of Political Economy* 81, S14-S69.

--------. (1974) "Economic Theory of Fertility", in *Economics of the Family: Marriage, Children, and Human Capital*, ed. Theodore W. Schultz. Chicago: University of Chicago Press.

Wolfe, Barbara L. and Jere R. Behrman (1987), "Women's Schooling and Children's Health", *Journal of Health Economics* 6: 239-54.

Wolpin, Kenneth I. (1984), "An Estimable Dynamic Stochastic Model of Fertility and Child Mortality", *Journal of Political Economy* 92: 852-73.

World Bank (1993), *World Development Report 1993*, The World Bank.

Wright, Robert E. (1985), "The Easterlin Hypothesis and European Fertility Rates", *Population and Development Review* 15.

Yen, Eva C. and Gili Yen (1992), "Female Education and Fertility Differentials: One Effect or Two?", *Atlantic Economic Journal* 20: 104.

Zhang, Junsen (1990), "Socioeconomic Determinants of Fertility in China: A Microeconomic Analysis", *Journal of Population Economics* 3: 105-23.

-------- and Byron G. Spencer (1992), "Who Signs China's One Child Certificate, and Why?" *Journal of Population Economics* 5: 203-15.