SAMFUNNSØKONOMISKE STUDIER

56

AN ECONOMIC MODEL OF FERTILITY, SEX AND CONTRACEPTION

EN ØKONOMISK MODELL FOR FRUKTBARHET, SEKSUELL AKTIVITET OG PREVENSJONSBRUK

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PREFACE

This publication presents a theoretical model for the relationship between use of contraception, coital frequency and the attitude to having another child. The model is estimated with data from the Norwegian Fertility Survey 1977, which was planned and executed by the Central Bureau of Statistics.

The present publication is a slightly revised and abridged version of the author's Ph. D. dissertation at the University of Michigan, Ann Arbor. Financial support in the early stage of the project was given by the Norwegian Research Council for Science and the Humanities. The dissertation was completed while the author was a researcher at the Central Bureau of Statistics of Norway. In addition to these institutions, he also received financial and other support from the Population Studies Center of the University of Michigan, Ann Arbor.

Central Bureau of Statistics of Norway, Oslo, 1 August 1984

Arne Øien

FORORD

Denne publikasjonen presenterer en teoretisk modell for sammenhengen mellom prevensjonsbruk, seksuell aktivitet og holdningen til å få flere barn. Modellen er estimert med data fra Fruktbarhetsundersøkelsen 1977, som ble planlagt og gjennomført av Statistisk Sentralbyrå.

Publikasjonen er en litt bearbeidet og forkortet utgave av forfatterens avhandling for graden Doctor of Philosophy (Ph.D.) ved University of Michigan i Ann Arbor. Arbeidet med avhandlingen ble påbegynt i USA med stipend fra Norges Almenvitenskapelige Forskningsråd og fullført ved Sosiodemografisk forskningsgruppe i Statistisk Sentralbyrå. I tillegg til disse institusjonene har arbeidet også fått økonomisk og annen støtte fra Population Studies Center ved University of Michigan.

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ABSTRACT

In most micro-economic models of fertility total life-time family size is the decision variable. The model presented in this dissertation is of the sequential decision-making type, i.e. couples are assumed to make decisions about child-bearing in the next period conditional on achieved family size, previous experience, current economic situation, and expectations for the near future.

When the desire for an additional child is given, a couple has only two ways of influencing the probability of pregnancy: through sexual activity and through use of contraception. Besides affecting the probability of conception, sex yields pleasure in itself whereas contraception usually yields some disutility. We postulate a utility function over two periods (present and near future) with children, consumption, sex and contraception as arguments. Since a childbirth is an uncertain event, couples are assumed to maximize their expected utility, where the probability of having another child depends on coital frequency and effectiveness of contraception.

From this optimization model a number of testable propositions can be derived about the effects of children, income, and prices on the desire for an additional child soon; the effects of this desire for the use of contraception and sexual activity; and the relationship between contraception and coital frequency.

Assuming a specific form for the utility function, we derive specific "demand" equations for the desire for an additional child soon, coital frequency, and contraceptive effectiveness. These demand equations are estimated using ordinary least squares and a modified two-stage method, with data on 3000 married women from the Norwegian Fertility Survey 1977. The estimation is done in two steps to avoid "pollution" of the data, first on one random quarter sample to experiment with functional forms, variables and estimation methods, and then on the rest of the sample to test the results obtained in the first step. Most of the hypotheses derived from the theoretical model are confirmed by the empirical analysis, e.g. that the wage of the woman has a negative effect on the desire to have a child soon, and that there is a non-linear relationship between coital frequency and contraception.

CHAPTER 1

INTRODUCTION

The modern economic theory of fertility is usually assumed to start with the well-known article of Gary Becker (1960), although Harvey Leibenstein presented a more general framework for decisions about children in 1957. Leibenstein argues that children yield three types of utility (through psychological satisfaction, as labour, and as security during old age and illness), and two types of costs (direct money costs and opportunity costs). These factors develop differently as the income level of a society grows: The utility of children from labour and security decreases and the costs increase, thereby reducing the motivation for having many children.

Becker (1960) was the first, however, to apply neoclassical economic microanalytical theory to fertility behaviour, treating children in much the same way as consumer durables. Perhaps the most important contribution of his 1960-article is his introduction of the concept "quality of children" in addition to the quantity of children. By child quality Becker means the average expenditure per child. As family income rises, couples want to increase both the quantity and the quality of children, but the quality elasticity with regard to income is much greater than the quantity elasticity. The frequently found observations of a negative relation between income and family size can be explained by differential knowledge and use of contraception, he argues.

Becker's seminal article gave rise to great interest and research activity in the field of fertility theory. Two "schools" of economic fertility theories have developed. The first school is inspired by Becker and comprises micro-economic consumer-theory approaches to the study of fertility behaviour, concentrating on cross sectional analyses, i.e. attempting to explain differences in fertility between women or couples at a given point in time. This school is called the New Home Economics or the Chicago-NBER school and may have culminated with the two volumes of the Journal of Political Economy edited by T.W. Schultz (1973, 1974a).

The other school of economic fertility theories is associated with Richard Easterlin (e.g. 1973), whose well-known hypothesis is an attempt to explain the fertility waves observed in most industrialized countries since the 1930's. The Easterlin hypothesis is best suited to explain fertility variations over time, although he has introduced ideas and concepts that are also useful in studies of cross-section differences, especially his emphasis on relative income and consumer aspirations, and his discussion of how preferences are formed.

The two schools are not as different as they may appear at first glance, and a considerable narrowing of the gap between them has occurred (Sanderson 1976). There exist attempts at analysing time trends of fertility using ideas from Becker, see e.g. Butz and Ward (1979) which is one of the few studies outside the Easterlin tradition capable of explaining both the baby boom and the baby bust during the past World War II period.

Although the New Home Economics models of fertility have greatly improved our understanding of the relationship between fertility and economic factors, e.g. the importance of the time costs of child bearing and the price of time, there are problems with them and they have been critized on several grounds, see e.g. Blake (1968), Namboodiri (1972a, 1975), Perlman (1975), Bean (1975), Turchi (1975), and Bagozzi and van Loo (1978).[1)]

The sociologist Judith Blake (1968) argues that couple cannot freely choose the living standard of their children, i.e. the child quality, because it is determined by norms and conventions. Parents cannot, for example, give their children housing and clothing of a completely different standard than their own. In a later article, Becker and Lewis (1973) admit that the shadow price of children with respect to their quality is greater the higher their quality is, and that the shadow price of children with respect to their quality is greater the greater the number of children. They also show that the budget constraint of Becker's (1960) original maximization model is non-linear, and that no specific testable hypotheses can be derived from this model (see also Sanderson 1974, 1976).

Another criticism is that these models are static and refer to total desired life-time fertility. The models assume that couples decide on the number (and quality) of children they want at the beginning of their marriage. Implicit is an assumption of perfect knowledge about future prices and incomes and of

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1) For a recent Norwegian critique of economic models of fertility, see Kristiansen (1982), and the comment by Brunborg and Vislie (1982). Other contributions in Norwegian to the economics of fertility literature include Brunborg (1973,1974) and Vislie (1979).

constant preferences over time, or alternatively, that there is uncertainty but that couples maximize their utility on the basis of certain expectations about prices, income etc (certainty equivalence). Thus, there is no room for learning from experience, for correction of mistakes, and for couples to change their minds. In other words, these models do not recognize that family building is a sequential process. Neither do they recognize that it is a stochastic process. There is considerable uncertainty in reproduction, and the outcome is not always as expected.

Ideally, a realistic model of fertility decision-making should be dynamic. The problem with dynamic models of fertility is that they easily become very complicated, making the derivation of analytical results and estimation extremely difficult if not impossible, in addition to data problems. One way of overcoming such problems is micro-simulation. For an example of this, see Cohen and Stafford (1974) who simulated a dynamic life-time model of fertility and labour-force participation, with interesting results.

Another way of solving the problems mentioned above is to take a sequential approach, i.e. by only studying the decisions to have another child, and not the full life-time fertility. With this approach the past history can be taken as given and a number of variables can be treated as exogenous. Moreover, sequential models allow for modifications of the behaviour based on past experience.

In the 1970's economists as well as non-economists became interested in the sequential nature of child-bearing and important theoretical contributions appeared (Namboodiri 1972a, Leibenstein 1974,1975, Michael 1973, Hass 1974, Heckman and Willis 1976, Michael and Willis 1976). Some of these take the stochastic nature of reproduction into account (the last two references mentioned above). There is also a growing number of interesting but primarily empirical analyses based on this framework (Namboodiri 1972b,1974,1975,1980,1981, Berndt and Wales 1974, Simon 1975a,b, Snyder 1975, Rosenzweig and Seiver 1975, Hofferth and Udry 1976, Rosenzweig 1976, Khan and Sirageldin 1977, Lee and Khan 1978.) The problem with many of the empirical studies of the sequential decision-making strain is that the theory is usually of an ad hoc-nature and that the equations that are estimated are not dervied from an analytic optimization model.

Nevertheless, empirical analyses have yielded several interesting results. They show, e.g., that the effects of economic factors on parity progression ratios vary strongly with the birth order (Simon 1975a, b, Snyder 1975). Namboodiri (1974) finds that social and economic background variables have stronger effects at higher parities than at lower ones while the opposite is true of demographic characteristics. Namboodiri's analysis has been criticizied by Rosenzweig and Seiver (1975) who do not find evidence of any threshold parity level for the effects of socioeconomic variables, as Namboodiri (1974) and Lee and Khan (1978) do, but who nevertheless find that the effects on the attitude towards having more children of variables like income and education vary strongly with the birth order.

Apart from the short-comings of the Chicago-NBER models of fertility, a further reason for the growing interest of economists in sequential decision-making is a feeling that the original models have been developed about as far as possible. The most sophisticated and elegant static analysis of life-time fertility so far is that of Willis (1973), and indeed, he has also made important contributions to the theory of sequential decision-making (with Heckman and Michael, respectively).

The model presented in the next chapter is based on the assumption that people make child-bearing decisions one child at a time, based on their previous experiences with child-bearing, current circumstances (income, prices, etc.), and expectations for the near future. The couples may still have an ultimate family-size goal in the back of their minds, but this model allows for the possibility of changes in these goals. (The history of fertility surveys in the USA shows how volatile ideal family size and other such measures are; see Lee 1977.)

The model also recognizes that child-bearing is a stochastic process and that the demand for children is related to the demand for sex and contraception. There are two reasons why people have intercourse: one reason is that they enjoy sex in itself, and the other reason is that they may want to have a child. That is, we have what we call joint products in production theory. However, quite often couples are only interested in sex for pleasure and do not want to conceive a child, i.e. pregnancy is an unwanted by-product. The way to separate sex from reproduction is to use contraception, and this has been introduced into the model. Thus, the model incorporates short-term decisions about both frequency of intercourse and contraception.[1)] If the strength of the desire to have (or not to have) an additional child soon is given, a couple has only two ways of influencing the probability of pregnancy: through their sexual activity and through their use of contraception.

One hypothesis we want to investigate is that there is an association between contraceptive effectiveness and coital frequency. Westoff (1974) and Trussell and Westoff (1980) found that higher frequencies were associated with use of the most effective methods (husband sterilized, pill, IUD), and also with use of coitus-independent methods and female-oriented methods.[2)] Jones et al. (1980) tested the relationship between coital frequency and contraceptive failure, but with inconclusive results. This does not weaken the hypothesis mentioned above, however, since it is only concerned with actual use of contraception (ex ante), and does not say anything about the association between coital frequency and the outcome of contraceptive use (ex post). There will, over time, be some feedback from experience to actual use, of course.

The analysis of sexual activity plays an important role in this dissertation, both in the theoretical and in the empirical part. The reason for this is not only because sexual behaviour is linked to re-

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1) The only other economic model we are aware of which does this is by David and Sanderson (1976), but theirs is a life-time model of fertility and not a model of the decisions to have an additional child. The treatment of contraception in our model is inspired by the work of Michael (1973), and Michael and Willis (1976).

2) Trussell and Westoff (1980:24a) found, using interview data of the same women in 1970 and 1975, "that women who switched to a more effective method experienced the least decline in coital frequency (0.5) and those who switched to a less effective method experienced the greatest decline (2.0). Women who did not change methods over the five-year period experienced an intermediate decline (1.0)."

production, but also because sexual life is of interest in itself, being one of the most important dimensions of human behaviour. Likewise, contraception is of interest not only because it affects reproduction, but also because it is an important condition of sexual satisfaction.

Parts of our model appear to be quite similar to the model of Luker (1977), who applies cost-benefit analysis and behavioural decision theory to the contraceptive process.[1)] Her methodological approach is different from ours, however, in that her model is based on psychological decision theory. Moreover, she does not formulate and analyze her model mathematically. Her empirical analysis is based on abortion-seeking women in California, including 50 in-depth interviews. Crosbie and Bitte (1982) have tested Luker's theory but conclude that their research does not support it.[2)]

The model presented in this dissertation is not a general model of fertility decision-making. We only attempt to capture some aspects of this, thereby hoping to provide an incremental improvement in the tradition of fertility studies in general, and a greater understanding of decision-making concerning children, contraception and sex in particular. The model is perhaps most appropriate for couples who have at least one child already. It may also apply most closely to

1) "... the theory of contraceptive risk taking assumes that individual women go through a decision making process involving assessments of the utilities and probabilities described above". These assessments include "... assignment of utilities to contraceptive use; assignment of utilities to pregnancy; assignment of probabilities to becoming pregnant; and assignment of probabilities to reversibility of pregnancy." (p. 193.)

2) We became aware of these studies only near the completion of this dissertation.

couples who want at most one additional child.

The theoretical model of fertility, sex, and contraception is developed in the next chapter, where section 2.10 reviews other factors influencing the endogenous variables. The data which come from the Norwegian Fertility Survey 1977 are discussed in chapter 3, and the equations to be estimated and the estimation methods in chapter 4. Chapter 5 contains the empirical analysis using one quarter of the sample for experimental purposes, whereas the sixth chapter gives the results from the analysis of the rest of the sample. We have only looked at married women, except for some sections in chapter 3, since we need data for couples, and cohabiting women are too few and special. Concluding remarks and a brief summary of the results complete the dissertation (chapter 7).

CHAPTER 2

THEORY

2.1 Introduction

In this chapter we present an economic model of fertility that incorporates sex and contraception. The model is of the sequential decision-making type, i.e. it is concerned with a couple's attitudes to have an additional child soon, and not the total number of children the couple desires. We focus on how a couple can influence the probability of conception, i.e. by their sexual activity and use of contraception. The model recognizes the uncertainty in childbearing in that the von Neumann - Morgenstern (1953) approach is used, i.e., the expected utility is maximized.

2.2 Family Planning Under Uncertainty

We assume that in any given period, a couple receives satisfaction from the number of children they have, their consumption of goods and services, and their sexual activity.[1] (To simplify the model we disregard other factors affecting the well-being, like leisure time etc.) If the couple does not want to have another child in the near future, they may use contraception to reduce the probability of concep-

1) The type of couples we have in mind are relatively stable marital or non-marital unions. We also assume that extramarital affairs are of no importance. For a theory of this see Fair (1978), who has developed a model that explains the allocation of an individual's time among spouse, paramour, and work.

tion. Use of contraception usually yields some disutility per se. If people were totally unconcerned about the risk of pregnancy, they would be better off by not using any contraception, with a few exceptions (condom to avoid transmittance of sexual diseases, use of pill for menstrual regulation, etc.) The direct and indirect utility effects of contraception for couples who want to avoid pregnancy will be discussed later.

Since current sexual and contraceptive behaviour influences the probability of having an additional child in the near future, the present behaviour influences future satisfaction from children and goods. Thus there is a trade-off between (dis)utility from sex and contraception now and (dis)utility from children and consumption in the future.[1)]

A simple way of studying this problem is to use a two-period model. At the beginning of period 1 (or the end of the previous period), the couple has N children, and depending on how much they would like (or not like) to have another child in the next period, they decide on what kind of contraception (if any) they should use in period 1, and how often they should have intercourse.[2)] At the beginning of period 2 (or the end of period 1) they know the outcome of their behaviour in the previous period, i.e., whether they have another child or not in period 2. The couple may have another child whether

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1) This conforms well with the finding of Luker (1982): "The women in this study weighed the immediate costs and benifits of contraception versus the anticipated costs and benefits of pregnancy." (p.193)

2) There is considerable spontaneity in sexual behaviour, of course, but we believe nevertheless that the average level of sexual activity and perhaps also the degree of spontaneity are affected by the feelings about having or not having an additional child soon, particularly if these feelings are strong.

or not they contracept in period 1, unless they do not have intercourse at all, their method of contraception is 100% effective, or they are infecund.

There are some problems in defining the length of the time period. Ideally, the first period should be approximately one month long, since a couple in principle knows at the end of each menstrual cycle whether conception occurred. (In practice, there is a "blind" period of a couple of weeks where it is unclear whether the woman is pregnant or not.) However, if the couple conceives in one month, they do not have to use contraception in the next 8 months (if there is no spontaneous or induced abortion), and there will be a birth after 9 months, followed by a period of postpartum amenorrhea which could last from one month to a couple of years if the woman breastfeeds. For a discussion of this, see Leridon (1977).

Taking all this into consideration, we would need a three-period model (at least), with periods of different lengths. To simplify we will assume that the first period is approximately one month, and the second period approximately one year, or 8-9 months, defined so that there cannot be more than one live birth in the second period.

The assumption that the couple maximizes the utility over two periods, which is only one year or less into the future, is based on the belief that most people are fairly myopic in their decision-making. Their decisions are mostly based on current circumstances and expectations for the near future. We believe that people usually have quite unclear ideas about what the future will look like, and that if they make any forecasts, these are mostly extrapolations of current circumstances like income, prices etc. (Demographers cannot boast of using much more refined techniques of forecasting.) Couples do realize, however, that time and money costs of children change with the age of the children, but they may not have any clear perceptions about these before they have any experience themselves.

2.3 Probability of Conception

The probability of conception during a period, p , depends primarily on sexual activity, contraceptive effectiveness, and fecundity. Before we discuss this relationship we will define some concepts. By fecundity we mean the physiological capacity to have children, which depends on age, health, nutrition, time since previous delivery, breast-feeding etc., but which is, in principle, independent of sexual activity and use of contraception. By fecundability (also called natural fecundability) we mean the probability of conceiving in a menstrual cycle when no contraception is used (Sheps and Menken 1973, Leridon 1977). This definition does not say anything about sexual activity, but implicitly assumes that there is at least one intercourse per period. Estimates of the mean fecundability range from 0.14 to 0.32 for different populations (Leridon 1977). Bongaarts and Tietze (1977) assume that the natural fecundability increases from 0.14 for women in ages 15-19 to 0.2 for women aged 20-34 and then declines to 0.16 (ages 35-39) and 0.09 (ages 40-44).

Finally, the intrinsic fecundability, r , is defined as the probability of conceiving in a single unprotected coitus when no contraception is used. A common estimate of r is 0.03 (Tietze 1960).

If we assume that all intercourses S during a period have the same probability of conception (r), we have a binominal distribution with the probability of conceiving during one period equal to

(2.1) $p = 1 - (1-r)^S$.

This equation can be simplified by expanding the parentheses and keeping the first two terms.

(2.2) $p \doteq Sr$,

i.e. the probability of conception in one period is approximately proportional to the number of intercourses and the intrinsic fecundability. A common estimate of p is 0.2, which corresponds to a coital frequency of 6-7 times per month.

Equation (2.2) is not always a good approximation, however. First, since the probability p cannot be greater than one, the approximation does not hold for very large (and unrealistic) values of S. (If r is 0.03, S has to be less than 34.) Second, the intrinsic fecundability r may depend on S: at high frequencies of intercourse, the quality of the sperm may be somewhat reduced, although there seems to be little evidence of this, see Barrett (1971).

The most important problem with approximation (2.2), however, is that the probability of conception not only depends on the number of intercourses but also on the timing of them relative to the ovulation. Lachenbruch (1967) has estimated the probability of conception for different frequencies and distributions of intercourse, using a micro-simulation model. He found, e.g., that the monthly probability of conception is 0.28 if a monthly coital frequency of 6 is concentrated around the middle of the cycle, compared with 0.19-0.22 if the probability of coitus is equal for any day of the cycle, and 0.08-0.21 if there is no intercourse during the middle of the cycle. The estimates depend on the assumption about the length of the fertile period.

Barrett and Marshall (1969) have estimated the probability of conception for different days of the fecund period using detailed data for 241 couples, and find that it increases from 0.13 if there is intercourse five days before ovulation, to 0.3 two days before ovulation, and decreases to 0.07 one day after ovulation.[1)]

Couples who want to become pregnant may concentrate their sexual activity on susceptible days, and vice versa for couples wanting to avoid conception. But couples who contracept probably space their sexual activity more evenly over the menstrual cycle than couples who do not contracept. David and Sanderson (1976) include intercourse on both susceptible and nonsusceptible days explicity in their theoretical analysis.(There is no information in the data we intend to use about when in the menstrual cycle the intercourses take place.) The timing of the intercourses is mostly of importance if the frequency is low, since a couple with high sexual activity is likely to have intercourse on susceptible days anyway.

Figure 2.1 shows the relationship between monthly probability of conception and coital frequency per month using different methods: equations (2.1) and (2.2), data from Barrett and Marshall (1969), and from Leridon (1977:42), with two different assumptions about the length of the fertile period. We see that the linear approximation (2.2) is quite good for frequencies below 11 or 12. We also notice the strong effect of coital frequency on the probability of conception: Barrett and Marshall's estimates range from 0.17 when there is intercourse once every six days to 0.68 when it takes place every day.

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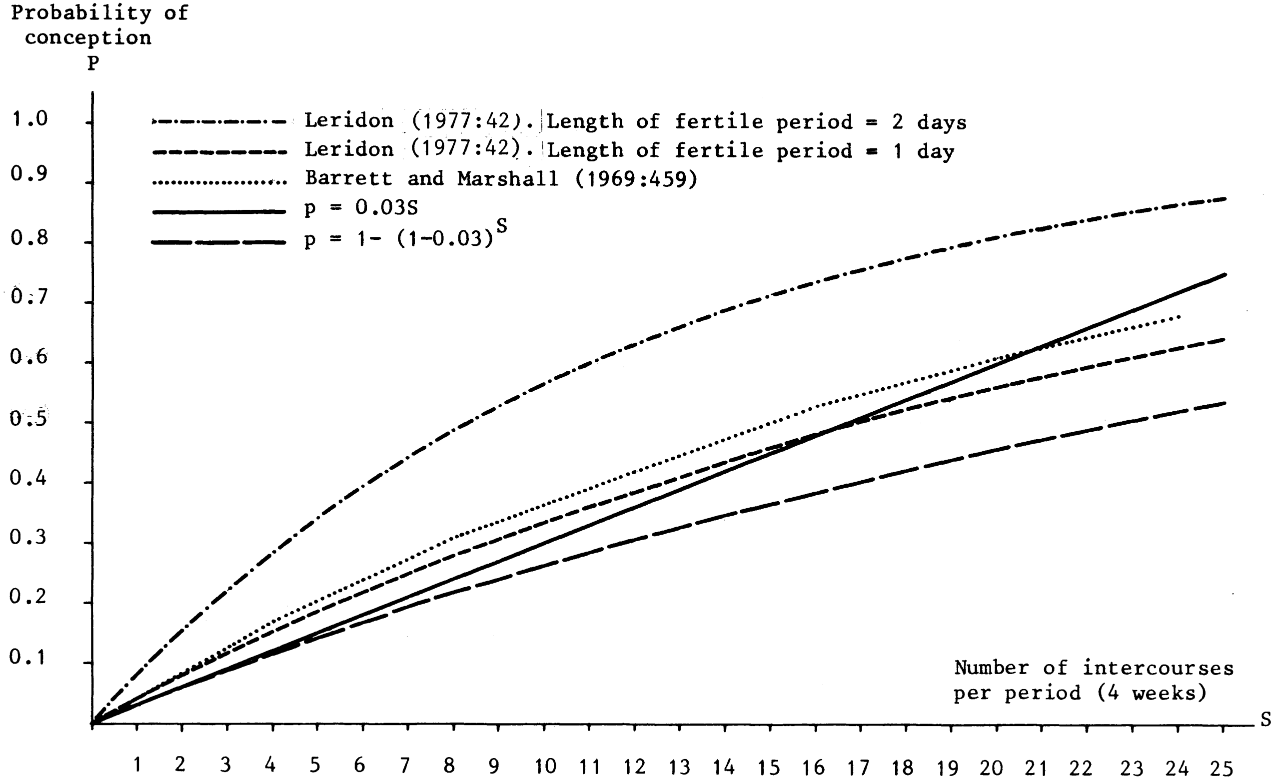
1) There is evidence that even under exact timing of intercourse the chance of conception is only about 0.5. (Glass and Grebenik 1954, quoted from Lachenbruch 1967)

Figure 2.1 Probability of conception as a function of coital frequency, when no contraception is used



It would have been possible to use formula (2.1) instead of approximation (2.2), or another approximation, e.g. a logarithmic function. The approximation cannot be seriously wrong, however, and besides, the analytical results of the model come out much simpler with this approximation.

Formulae (2.1) and (2.2) also hold if r is the monthly probability of conception and p is the probability of conceiving within S months. (The probability of no conception in S months is $(1-r)^S$, which implies that the probability of conception in S months is $1-(1-r)^S$.)

If a couple uses contraception, the probability of conception is reduced by the factor $1-e$:

(2.3) $p \doteq Sr(1-e)$,

where e is the effectiveness of contraception.[1)] Note that this definition of contraceptive effectiveness is different from the so-called Pearl index, which is measured as the number of pregnancies per 100 women-years of use of a certain method (Leridon 1977: 123). The two measures are only directly related for values of the Pearl index limited to the first month.

The probability p of conceiving during a menstrual cycle, which is of approximately the same length as our first period, is the same as the probability of having an additional child in the second period, if we disregard spontaneous and induced abortions. Abortions can be counted as part of the cost of failure of contraception. Introducing induced abortions into the model would complicate it substantially, however. One way of doing this would be to assume that the pro-

1) This formulation is borrowed from Michael and Willis (1976).

bability of having an additional child in the next period is zero for those who do not wish to and who are willing to have an induced abortion. But the assumption about costless contraception becomes less realistic when we include abortion as a method of birth control or as a back-up method. Moreover, the probability of needing to have an induced abortion is always less than unity and is influenced by the frequency of intercourse and the contraceptive failure rate. Thus, contraceptive and sexual behaviour depend both on the strength of the desire not to have another child in the next period and on the attitude towards abortion.[1)]

2.4 Utility Function

2.4.1 General

We assume that the representative couple[2)] has the following utility function over periods 1 and 2:

(2.4) $U = U(N_1, N_2, X_1, X_2, S_1, M_1; Z)$

where U is a well-behaved quasi-concave utility function,

N_1 is the number of children in the first period,

N_2 is the number of children in the second period; $N_2 = N_1$ or $N_2 = N_1 + 1$;

X_i is the consumption of purchased goods by the parents in period i; i=1,2,

S_1 is the frequency of intercourse in period 1,

M_1 is the method of contraception in period 1, and

Z is a vector of parameters of the utility function, i.e.,

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1) See Luker (1977) for a study of contraceptive risk-taking and abortion.

2) It falls outside the scope of this dissertation to incorporate marital conflicts. We assume that the utility function in (2.4) is a family "social welfare" function, and that it is the outcome of interaction between the spouses including bargaining.

factors that influence the shape of the function, e.g. the length of the open birth interval and the ages of the partners.

We assume that the couple receives a stream of utility from the number N_i of children they have in period i.[1] Thus, there is no explicit trade-off between quantity and the so-called quality of children, as there is in the Chicago-NBER school of fertility theories (Becker 1960, Willis 1973, Becker and Lewis 1973, and others). We make this assumption to keep the model as simple as possible.

The quantity X_i is the amount of goods and services purchased in the market in period i and which is consumed by the parents. Thus, there is a trade-off between children and consumption: children yield utility but they also demand resources which reduce the amount of goods and services that the parents can consume themselves. (There are problems in distinguishing between consumption by parents and their children, see Blake 1968). The amount of goods and services which can be purchased is limited by family income, which will be defined in subsection 2.5.2. To simplify we will assume that there is no saving or borrowing over time.

Sexual activity has two functions: it yields pleasure in itself and it influences the probability of having children. We will somewhat crudely measure the satisfaction from sex by the frequency of intercourse per period, S. We will assume that there are no money costs of contraception and that all costs of contraception are in terms of loss of utility. Use of contraception will always yield

1) Couples need not necessarily have children themselves to receive utility from children, as discussed by Rottenberg (1975). Engagement in childrelated activities like teaching, club-leadership etc. may yield utility from children of others. Moreover, there exists a market for children, although small, in that children can be adopted.

some disutility, when we abstract from the influence of contraception on the probability of conception. There are several causes of the disutility of contraception: interference with intercourse, side effects, health consequences, inconvenience and embarassment when buying contraception or visiting a doctor, etc. More about this later (section 2.8).

There are serious problems in measuring the "quantity" of contraception. For the time being we will treat contraception as a discrete variable. We will later in this chapter treat contraception as a continuous variable and discuss the problems with this assumption.

The reason why sex and contraception for the second period, S_2 and M_2, are not included in the utility function (2.4) is that the couple does not have to make choices about these variables until they know the outcome of their behaviour in the first period, i.e. whether they are having another child or not. Their choices for the first period may influence the probability distribution of the situations in period 2, however. For example, if they have another child, they do not need to use contraception in the second period since pregnancy is a perfect contraceptive. Thus, the couple's state of well-being in period 2 depends both on the outcome of the first period and their decisions about sexual and contraceptive behaviour in the second second period. Another reason for not including S_2 and M_2 in the utility function is that we believe that people are even more myopic with regard to sex and contraception than with regard to children and consumption.

Even if the couple does not know what the optimal values for S_2 and M_2 are until the beginning of the second period, they could still make alternative plans for S_2 and M_2 at the beginning of period 1 conditional on whether they have another child or not. This is the so-called strategy principle in planning (Johansen 1977-78).

We conclude that it is possible to include S_2 and M_2 in the utility function, but it would complicate the model without adding much of substantial interest. To simplify the notation we set $S=S_1$ and $M=M_1$ from now on.

To simplify the mathematics, we assume that the utility function (2.4) is separable:

$$(2.5)\quad U = U(N_1, N_2, X_1, X_2, S, M; Z) = f(N_1, N_2, X_1, X_2; Z_f) + g(S, M; Z_g).$$

This implies that the utility of sex and contraception does not depend on the number of children or the level of consumption. This seems to be a reasonable assumption, although it may be argued that this is not always the case. It could, e.g., be hypothesized that the more children a couple has, the less time and privacy do they have for an undisturbed sexual life, and that part of this could be overcome by living in a larger house, for example. The ages of the children may also affect the sexual activity.

A non-separable utility function could be used, but the analysis becomes simpler and the results are less ambiguous and easier to interpret when we assume a separable utility function.

2.4.2 Utility of sex and contraception

In this subsection we will look at possible forms of the utility function of sex when contraception is used and when it is not used, respectively. We assume that time and money are of negligible importance as constraints on sexual activity. There are, however, some indirect resource costs of sex, in that sex influences the chance of having an additional child.

We assume that for a given contraceptive method, $\bar{M}$, the marginal utility of intercourse is:

$$g_s = \frac{\partial g\ (S,\bar{M})}{\partial S} \begin{cases} > 0 \text{ for } S<\tilde{S} \\ = 0 \text{ for } S=\tilde{S} \\ < 0 \text{ for } S>\tilde{S} \end{cases}$$

and that the second partial derivate

$$g_{ss} = \frac{\partial^2 g\ (S,\bar{M})}{\partial S^2} < 0 \text{ for all } S,$$

i.e. $g(S,\bar{M})$ is a concave function.

The frequency of intercourse where the marginal utility is zero, $\tilde{S}$, can be called the satiation level of sex. It would be the optimal frequency of sex if sex did not effect the probability of having an additional child.

Thus, if no contraception is being used, for example, the utility of sex $g(S,0)$ as a function of the frequency of intercourse may look something like this:

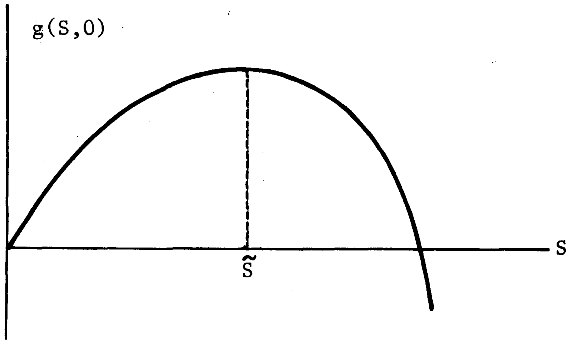

Figure 2.2 Utility of sex without contraception

As mentioned earlier, we assume that there are no money costs of contraception and that all "costs" can be measured in terms of a utility loss. The utility costs of contraception are of two kinds: variable if the method is coitus-related, like withdrawal, condom and the diaphragm; and fixed if the use of the method is unrelated to the intercourse, like pill, IUD, and sterilization.

A simple linear formulation of the effect of contraception on utility would be

$$g(S,M_j) = g(S,0) - a_j - b_j S,$$

where a_j and b_j are non-negative constant parameters for method M_j.

If there are only variable costs of contraception, i.e. $a_i=0$, $g(S,M_j)$ and $g(S,0)$ may look something like:

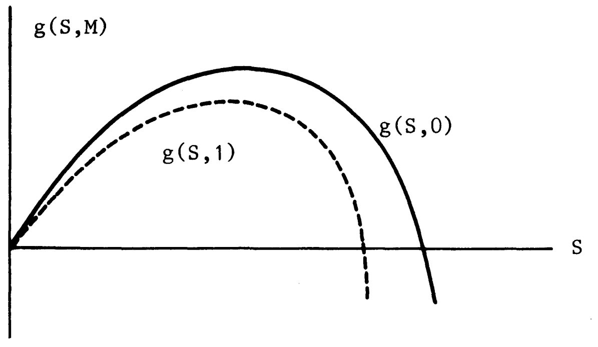

Figure 2.3 Utility of sex with variable costs of contraception

We notice that the the peak is moved to the left, i.e. the satiation level of sex is reduced when contraception with variable costs is used.

If all costs of contraception are unrelated to intercourse, i.e. $b_i=0$, use of contraception should not affect $\tilde{S}$, and the two curves may look like this:

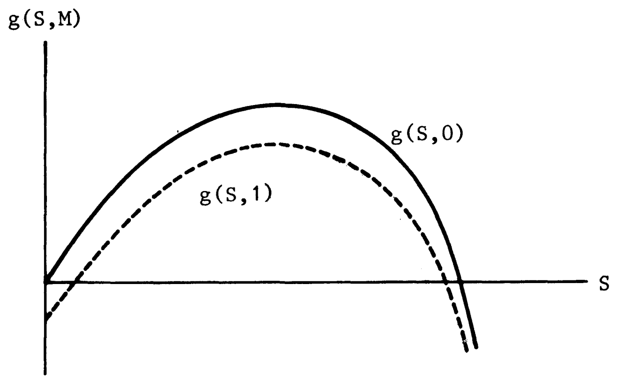

Figure 2.4 Utility of sex with fixed costs of contraception

This shows that a couple may be worse off using a method with high fixed costs if the coital frequency is low, than not having intercourse at all.

If there are both fixed and variable costs we get a combination of figures 2.3 and 2.4:

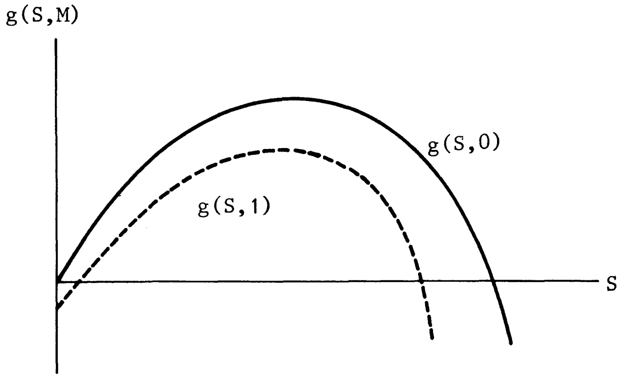

Figure 2.5 Utility of sex with both variable and fixed costs of contraception

If there is more than one method of contraception, we get a whole set of curves, $\{g(S,M_i)\}$.

Some people, and particularly women, argue that if they have a strong desire not to become pregnant, the use of contraception may actually increase the pleasure from sex since they would not worry about becoming pregnant during the coitus. If they do not contracept, the fear of conception supposedly interferes with the sexual experience. However, some or all of this hypothesized positive marginal utility of contraception may be captured by the increase in expected utility due to a lower probability of conception. It seems hard to disentangle the probability effect from what we could call the "less-worry" or "relaxation" effect.

We will later allow for the possibility of a positive marginal utility of contraception for couples who do not want another child.

2.5 Utility Maximization

2.5.1 Expected Utility

Since two of the arguments in the utility function, N_2 and X_2, are uncertain we have an optimization problem under uncertainty. To solve this we use the approach of von Neumann and Morgenstern (1953), and maximize the expected utility, V=EU, subject to budget constraints.

Before we do this we may ask whether fertility decisions can be studied within the expected utility framework. (For a recent survey and critique of the expected utility model in general, see Schoemaker 1982.) Namboodiri (1972a) discusses this in an appendix, where he examines the plausibility of the underlying axioms of the expected utility theory. He concludes that fertility decisions cannot be studied by the expected utility approach "if it is valid to assume that there exists a family threshold below which nobody would want to remain voluntarily . ... Beyond this level, however, each individual addition can be studied within the framework under discussion" (p.206). Although few people in a country like Norway want to have zero or only one child (only around 1 and 2 per cent, respectively, among women 18-24 years of age according to the Norwegian Fertility Survey 1977), there are some who choose this voluntarily, so Namboodiri's objection does not seem to be totally valid for Norway. Nevertheless, the assumptions of the expected utility model may be more realistic for couples who have at least one child already.

It can be proven that the expected utility function V exists under certain assumptions (axioms), and that it is unique up to a monotonic transformation,see Varian (1978). If the expected utility function is concave the consumer is risk averse. The measure of risk aversion is simple if there is only one argument X of the expected utility function, namely the Arrow-Pratt measure $-V''(X)/V'(X)$ (Pratt 1964), but quite complicated when there are several arguments, see Karni (1979), and Stiglitz (1969) for a discussion of the case with many uncertain commodities. Our expected utility function is somewhat special in this respect, however, in that there is a mixture of certain and uncertain objective variables; that the two uncertain variables, N_2 and X_2, have the same probability distribution; and that the probability p is a function of some of the arguments of the utility function (S, and effectiveness e as a function of method M). These features do not seem to cause any problems.

Now back to our maximization problem. There are only two possible states in period 2: the couple has an additional child or it does not have an additional child. I.e., N_2 is equal to N_1 with probability p and to N_1+1 with probability 1-p, and the expected value of N_2 is

$$EN_2 = p(N_1+1) + (1-p)N_1 = N_1+p.$$

The expected utility function is:

$$(2.6)\quad V = EU = pU(N_1,N_1+1,X_1,X_2^*,S,M;Z) + (1-p)U(N_1,N_1,X_1,X_2;S,M;Z),$$

where X_2^* is the couple's consumption of goods in period 2 if the couple has an additional child in that period, and X_2 is their consumption without another child.[1]

When we introduce the separability assumption (2.5) and set $N_1=N$ for simplicity, the expected utility becomes

$$(2.7)\quad V = EU = p[f(N,N+1,X_1,X_2^*) - f(N,N,X_1,X_2)]+f(N,N,X_1,X_2)+g(S,M)$$
$$= f^o + py + g(S,M),$$

where

(2.8) $f^o = f(N,N,X_1,X_2)$ is the utility of children and consumption over the two periods when the couple does not have an additional child in the second period,

(2.9) $f^* = f(N,N+1,X_1,X_2^*)$ is the utility when the couple has an additional child, and

(2.10) $y = f^*-f^o = f(N,N+1,X_1,X_2^*) - f(N,N,X_1,X_2)$ is the difference in child-consumption utility between having and not having an additional child. We have deleted the vector of other exogenous variables from the f and g functions to simplify the notation, since they do not affect the derivation that follows. The Z-variables will be included later, however.

1) Note that the expression (2.6) for the expected utility is in general not the same as the utility of the expected values of the arguments, $U(N_1,EN_2,X_1,EX_2,S,M)$. The two expressions are only equal when the utility function U is linear in the stochastic arguments N_2 and X_2. Thus, our approach differs from the approach of David and Sanderson (1976), who maximize a multiargument lifetime utility function where the total expected number of children is one of the arguments.

The variable y can be interpreted as the pure incremental utility of having another child in period 2, when we abstract from the (dis)utility of sex and contraception in period 1 that would be associated with attempting or avoiding to have an additional child. We can say that if y is positive, the couple "wants" an additional child in period 2, and if y is negative they do not want another child in that period.[1)]

2.5.2 Budget Constraints

Before we can go ahead and do the mathematical derivation of the equilibrium solution, we need to specify the budget constraints. To make the model as simple as possible we assume that sex and contraception are free goods in terms of money (and time) as mentioned already. The price of goods and services bought in the market is Π_x, and the "price" of children is Π_N.

The price of children is assumed to be constant over the two periods, but may vary from couple to couple. By the price of children we mean the full resource costs per child, i.e. the sum of direct money costs for food, clothing, child-care etc., and the opportunity costs in the form of time costs of child rearing, less child allowance. (This definition of the price of children is borrowed from

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1) Note that "non-wanters", i.e. couples who do not want an additional child soon and for which y is negative, are not the same as "terminators", in Lee's (1977) terminology. Terminators do not want more children at all, whereas non-wanters do not want an additional child soon. But "wanters" (y>0) are also "non-terminators", of course. On the other hand, non-terminators are only wanters if they want to have their next child soon, i.e. in the next period.

Vislie 1979.) The subjective costs of children are captured by the utility function.

The income I_i in each period is the full potential income of the couple, i.e. the total family income if both spouses were working full time.

To simplify the model further we assume that there is no borrowing or saving from one period to the next. This assumption is unrealistic, but we do not believe that it is of any great importance. We could again appeal to the myopia mentioned earlier: most people may be primarily concerned with the amount of income they have in the current period. In addition, there may be institutional constraints against borrowing. Implicitly, we assume that there is no pure time preference.

The budget constraint for the first period is

(2.11) $\Pi_X X_1 + \Pi_N N = I_1$, where $N = N_1$.

This budget constraint together with the separable utility function (2.5) implies that there are no degrees of freedom for maximizing expected utility with regard to X_1, since the number of children, family income and the prices are given. The "price" of children, Π_N, is not given in the market, but pre-determined (before the current period and outside this model) by the couple's preferences for consumption for themselves versus their children, and how they value market work versus time for child-care.

Still, the values of X_1 and I_1, the income and consumption in the first period, affect the choice of consumption in the second period via the substitution elasticity between consumption in the two periods, and the habit-forming effect of a certain standard of living.

Another implication is that the total time devoted to child care instead of market work is proportional to the number of children, not allowing for any economies of scale.[1] Still, this implicit assumption is not entirely unrealistic, particularly for couples with only a few children, say three or less, which has become common in industrial societies.

The problem with period 2 is that N_2 is a stochastic variable, which also makes X_2 stochastic since X_2 is a function of N_2. Thus, there are two alternative budget constraints for period 2: One on the condition that an additional child is born, and another one on the condition that the total number of children stays the same:

$$\Pi_x X_2^* + \Pi_N(N+1) = I_2 \qquad \text{if } N_2 = N+1, \tag{2.12}$$

$$\Pi_x X_2 + \Pi_N N = I_2 \qquad \text{if } N_2 = N. \tag{2.13}$$

If we let the price of goods be the <u>numéraire</u>, i.e. $\Pi_x = 1$, let $\Pi_N = \Pi$, and solve (2.11), (2.12), and (2.13) with respect to X_i, we get:

$$\text{(2.14)} \quad \begin{cases} X_1 = I_1 - \Pi N \\ X_2^* = I_2 - \Pi(N+1) \\ \text{and} \\ X_2 = I_2 - \Pi N = X_2^* + \Pi. \end{cases}$$

1) There may, of course, be compensating effects resulting in an approximately constant Π_N even if its components change.

The last equation above implies that $X_2 - X_2^* = \Pi$, i.e. the "price" of a child is the same as the loss in consumption for the parents caused by an additional child.

We see that all the X's are functions of the exogenous variables I_1, I_2, and the predetermined variable N. Substituting these expressions and expression (2.3) for p into the expression for expected utility (2.7) give us:

$$(2.15) \quad V = EU = f^o + Sr(1-e)y + g(S,M),$$

where

$$(2.16) \quad f^o = f(N,N,I_1 - \Pi N, I_2 - \Pi N),$$

and

$$(2.17) \quad y = f(N,N+1,I_1 - \Pi N, I_2 - \Pi N - \Pi) - f(N,N,I_1 - \Pi N, I_2 - \Pi N).$$

Thus, we have reduced the constrained maximization problem to an unconstrained problem, with the only decision variables being the frequency of intercourse S and the method of contraception M. We also notice that the consumption in the two periods are not arguments in the expected utility function - only the number of children in the first period, income in the two periods, and coital frequency and contraceptive use in the first period.

We will in the next sections present three different approaches to maximizing (2.15) with respect to S and M, depending on the assumption about the contraceptive use, M:

i) there is only one method of contraception,

ii) there are many but discrete methods of contraception,

iii) contraception is a continuous variable.

2.6 Only One Method of Contraception

We assume that there is only one method of contraception, with given effectiveness e . The couple has only two choices besides choosing the optimal level of sex: contraception with effectiveness e or no contracpetion at all. Thus, we define M as a dichotomous variable:

a) M = 0 if the couple does not contracept,

b) M = 1 if the couple contracepts.

This section is devoted to analysis of optimal behaviour in the discrete case. We are going to prove three theorems about contraceptive use: Couples wanting to have an additional child soon are for any frequency of intercourse better off not using contraception (Theorem 2.1), which implies that they will never use contraception (Theorem 2.2). On the other hand, couples who do not want to have an additional child soon, may choose not to use contraception (Theorem 2.3), depending on their preferences for contraception and for childbearing. These theorems are trivial and are not of much interest in themselves. They are included here as a test of the realism of the model. Inability to prove the theorems would indicate that there could be something seriously wrong with the model.

We think of the optimization process as being done in two stages: First, the couple maximizes its expected utility with and without contraception, respectively. This results in two optimal levels of sex, S_1 and S_0. Second, the couple compares its expected utilities with and without contraception, $EU(S_1,1)$ and $EU(S_0,0)$. If $EU(S_1,1)$ is greater than $EU(S_0,0)$ it will use contraception, otherwise not. We will go through this analytically and derive some obvious but nevertheless interesting results.

a) Let $M = 0$, i.e. the couple does not contracept, i.e. the effectiveness $e = 0$. Differentiating (2.15) with respect to S yields

(2.18) $dV/dS = ry + g_{so}$,

where $g_{so} = dg(S,0)/dS$ is the marginal utility of sex when the couple does not contracept. Setting (2.18) equal to zero and solving yields the following necessary equilibrium condition for a local maximum:

(2.19) $g_{so} = -ry$.

b) Let $M = 1$, i.e. the couple contracepts with effectiveness e. Differentiating (2.15) with respect to S yields

(2.20) $dV/dS = (1-e)ry + g_{s1}$,

where $g_{s1} = dg(S,1)/dS$ is the marginal utility of sex when the couple uses contraception. This yields the following first-order condition:

(2.21) $g_{s1} = -(1-e)ry.$

Note that the sufficient second-order condition for a local maximum is met in both case a and b:

$$d^2V/dS^2 = d^2g(S,M)/dS^2,$$

which was assumed to be negative in subsection 2.4.2.

Thus, we see from the two alternative equilibrium conditions (2.19) and (2.21) that the optimal value of S depends on the value of the predetermined variable y, the incremental utility of an additional child in period 2.[1] If y is positive, i.e. the couple wants an additional child soon, the right-hand side of both equations becomes negative, which implies that the marginal utility of sex is negative and that the optimal value of sex is greater than the satiation value for couples who want to have an additional child soon, see figure 2.6. Thus, such couples lose some "sex"-utility by having a higher frequency of intercourse than they would consider ideal otherwise, but on the other hand they gain in "child-consumption" utility because of the higher probability of conception.

If, on the other hand, the couple wants to avoid a pregnancy ($y<0$), the marginal utility of sex is positive and the optimal value of sex is less than the satiation value, see fig. 2.7, because of the negative effect of sex on the probability of conceiving. These results are the same whether or not the couple uses contraception.[2]

The third case is couples who are indifferent to having an additional child soon, i.e. $y = 0$. We see from (2.19) or (2.21) that the marginal utility of sex is zero for them, and consequently their optimal frequency of intercourse is equal to the satiation value $\tilde{S}$.

1) The sign and magnitude of y depend on the form of the utility function f and the exogenous arguments N (parity), I_1 and I_2 (income) and Π (prices). As mentioned earlier, the form of the utility function also depends on the parameters Z. It seems reasonable that the desire to have, or not have, an additional child soon is influenced by factors like the duration of the marriage/relationship or the age of the youngest child if there is no child mortality, the sex composition of the children born already, and more general taste variables that are relatively stable over time, like education, and religious and cultural attitudes. Likewise, y may be greater if the couple wants several more children than if they only want one more.

2) These results also seem to be consistent with Westoff's (1974) finding that couples have more frequent sexual relations if they intend to have additional children than if they wish to have no more children.

Equations (2.19) and (2.21) imply

(2.22) $g_{s1} = (1-e)g_{so}$,

which implies that

(2.23) $|g_{s1}| \leq |g_{so}|$,

since e is between 0 and 1.

Let us first study couples who want to have an additional child, i.e. y is positive. If the utility curves look like in figure 2.6, it follows from (2.23) that $S_0 > S_1$, i.e. the optimal frequency of sex is higher if the partners use contraception than if they do not.[1)] We can prove that this is always the case if, e.g., g(S,1) is a linear transformation of g(S,0), i.e.

(2.24) $g(S,1) = g(S,0) - a - bS$,

where a and b are non-negative constants.

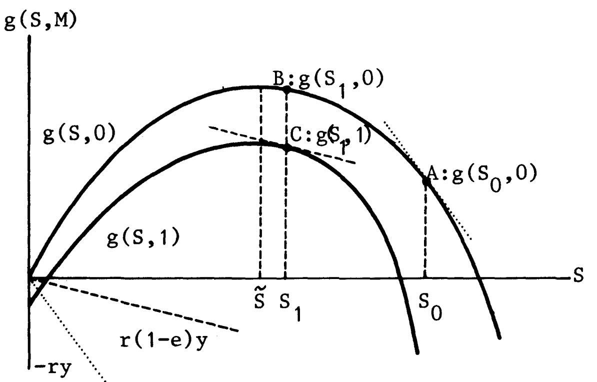

Figure 2.6 Optimal frequency of intercourse with and without contraception, for couples wanting an additional child soon

1) Figures 2.6 - 2.8 are drawn with approximately the same satiation levels with and without contraception. The conclusions are not essentially affected by introducing different satiation levels.

With other assumptions about the relationship between g(S,1) and g(S,0), we could in principle get the opposite result, $S_1 \geq S_0$, but this is of little interest since we can prove that couples wanting to have an additional child soon will never use contraception (Theorem 2.2). Before we prove this, we will prove the following, also obvious, theorem:

Theorem 2.1 A couple wanting to have an additional child soon is for any frequency of intercourse better off not using contraception than using contraception, or in symbols:

(2.25) $V(S,0) - V(S,1) > 0$ for all $S>0$ if $y>0$.

Proof: Setting $M = e = 0$ and $M = 1$, respectively, in (2.15) and subtracting yields

(2.26) $V(S,0) - V(S,1) = Srey + [g(S,0) - g(S,1)]$.

The bracketed term represents the direct or pure costs of contraception and is always positive, since we have argued previously that people are always better off not using contraception than using contraception, if we disregard the effects on the probability of conception and the possibility of a direct positive "relaxation" effect of contraception. The other term on the right-hand side of (2.26), Srey, can be interpreted as the gain in utility from consumption and children by not using contraception, and is positive when y is positive. Thus, (2.26) is positive for all S when y is positive, which concludes the proof of Theorem 2.1.

We will now prove

Theorem 2.2 A couple wanting to have another child soon will never use contraception, or with our notation

(2.27) $V(S_0,0) - V(S_1,1)>0$ for $y>0$,

where S_1 and S_0 are the optimal values of sex with and without use of contraception, respectively. Note that in theorem 2.1 we compare expected utility for the same level of S, while in theorem 2.2 we look at different levels of S.

Proof: Adding and subtracting the term $V(S_1,0)$ to the left-hand side of (2.27) yields

(2.28) $V(S_0,0) - V(S_1,1) = [V(S_0,0) - V(S_1,0)] + [V(S_1,0) - V(S_1,1)]$.

The first bracketed term on the right hand side is the difference in total expected utility with a coital frequency of S_0 and S_1, respectively, when the couple is not contracepting. This term must be positive, since S_0 is the value of S that maximizes expected utility when the couple is not using contraception, i.e. the total expected utility must be greater at A than at B in figure 2.6. The second bracketed term in (2.28) is the difference in expected utility with and without contraception, when the frequency of intercourse is equal to S_1. This term is also positive according to Theorem 2.1. In figure 2.6 this means that the total expected utility is greater at B than at C, since a couple wanting another child soon loses utility by contracepting both by a reduction in g, i.e. the utility of sex, and through a lower probability of conception. Thus, we have shown that both terms on the right hand side of (2.28) are positive, which concludes our proof of Theorem 2.2.

Let us now look at couples not wanting to have an additional child soon, i.e. y is negative. It follows from (2.23) that $S_0<S_1<\tilde{S}$

if the utility curves look like in fig. 2.7.

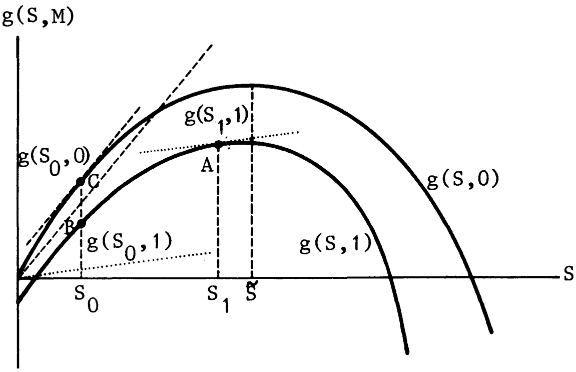

Figure 2.7 Optimal frequency of intercourse with and without contraception, for couples not wanting an additional child soon

This is a plausible result: Couples who do not want another child soon have a lower frequency of intercourse if they do not contracept than if they do. Indeed, if the method of contraception is 100% effective, it follows from (2.21) that the marginal utility of sex is zero and $S_1 = \tilde{S}$, since no matter how often the couple has intercourse, the probability of conception is zero. This is exactly the goal of contraception: Severing the link between reproduction and sex.

In special cases, however, as in figure 2.8, we may get the opposite result: $S_1 \leq S_0$ when y<0. This could happen if contraception has a strong non-linear negative effect on the utility of sex, e.g. if b in (2.24) is a function of S or e. Coitus-related methods that are felt to interfere strongly with intercourse could have this

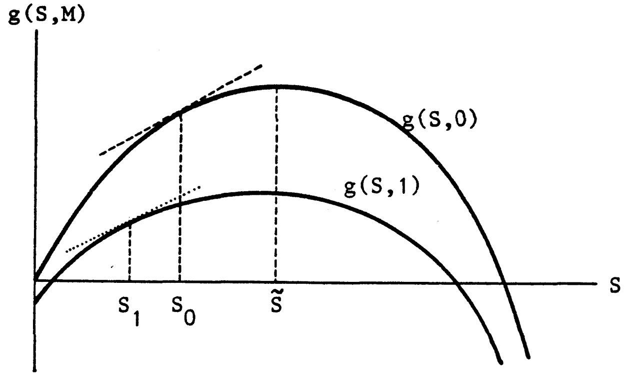

Figure 2.8 Optimal frequency of contraception for couples not wanting an additional child soon, when contraception has a strong non-linear effect on utility

effect, as withdrawal or condom. It seems reasonable that couples feeling this have a lower optimal coital frequency using an uncomfortable method than if they do not use any, although we may wonder why they would not be better off by not using contraception at all (or using another method).

We proved above that couples wanting to have an additional child soon will never use contraception (Theorem 2.2). We cannot prove the opposite, however, that couples not wanting to have an additional child soon will always use contraception. Instead we will prove the weaker theorem:

Theorem 2.3 A couple not wanting to have an additional child soon may or may not choose to use contraception, or in our notation:

(2.29) $V(S_1,1) - V(S_0,0) \gtreqless 0$ if $y<0$.

Proof: As previously, we add and subtract the same term, getting

(2.30) $V(S_1,1) - V(S_0,0) = [V(S_1,1) - V(S_0,1)] + [V(S_0,1) - V(S_0,0)]$.

The first bracketed term on the right-hand side is the difference in total expected utility with a coital frequency of S_1 and S_0, respectively, when the couple is contracepting. This term must be positive, since S_1 is the value of S that maximizes $V(S,1)$, i.e. the expected utility at A is greater that at B in figure 2.7). The second bracketed term in (2.30) is the difference in expected utility with and without contraception, when the frequency of intercourse is equal to S_0, compare points B and C in fig.2.7. This term is the negative of the left-hand side of (2.26), which is a sum of one negative and one positive term when y is negative. This implies that the sign of (2.30) is ambiguous, which concludes the proof of Theorem 2.3.

The interpretation of this theorem is that a couple not wanting to have an additional child soon would gain some utility by not using contraception, but it would at the same time lose utility in that intercourse without contraception increases the probability of an "unwanted" birth in the next period. We cannot say anything in general about the magnitudes of these terms, without specifying the form for the utility function and the values of its parameters.[1)]

Our conclusion is that if the dislike for contraception is very strong, a couple may choose not to contracept even if they would prefer not to have an additional child soon, especially if this desire is relatively weak. This seems to be a plausible conclusion. The characteristic of modern methods of contraception, for example, is

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1) If, as discussed earlier, use of contraception <u>increases</u> the pleasure of sex, i.e. $g(S,1)>g(S,0)$ for all $S\geq 0$, couples not wanting to have an additional child soon would always use contraception.

that the monetary, practical, and psychological costs of using them are perceived to be so low by many people that they choose to contracept if they want to avoid a pregnancy. This conclusion is similar to the finding of Luker (1977).[1)]

To conclude: this two-stage procedure of calculating the optimal frequency of intercourse with and without using contraception, respectively, and choosing that combination which yields the highest expected utility, implicitly define the demand equations for sex and contraception:

(2.31) $S = S(N,\Pi;I_1,I_2;Z_S)$

(2.32) $M = M(N,\Pi;I_1,I_2;Z_M)$

where M is a dichotomous variable.

Alternatively, the variable y, which may be interpreted as the demand for having an additional child soon, may be treated as an intermediate variable. This yields the following system of demand equations:

(2.33) $y = y(N,\Pi,I_1,I_2;Z_y)$

(2.34) $S = S(y;Z_S)$,

(2.35) $M = M(y;Z_M)$.

---

1) "More specifically, she held that if the utilities assigned to contraceptive outcomes (e.g. procurement and planning efforts) were high and the utilities assigned to pregnancy outcomes (e.g., role and lifestyle changes) were low, then the motivation to maximize outcomes would lead one to favor contraceptive use. On the other hand, if the utilities assigned to contraceptive outcomes were low and the utilities assigned to pregnancy outcomes were high, then the maximization of outcomes would lead one to favor contraceptive non-use, or risk-taking". (Quoted from Crosbie and Bitte 1982:67).

This is a partly recursive system since y is a function of exogenous variables only, and S and M are simultaneously determined by the predetermined variable y and the exogenous Z_S and Z_M variables.

2.7 Many Methods of Contraception

The case with many different methods of contraception is a straight-forward extension of the one-method case:

Assume that there are J different methods of contraception, $M_1, M_2, \ldots, M_J$, each with effectiveness e_j. Let method no. 1 be "no contraception", i.e. $e_1=0$.

The optimization strategy is the same as when there is only one method of contraception:

1. Maximize expected utility V_j as given in (2.15) with respect to S, for each contraceptive method M_j, j=1,2,...J. This gives us a set of optimal frequencies, $\{S_j\}$.
2. Calculate $V(S_j,M_j)$ for each j.
3. Choose the method M_j that yields the highest expected utility $V(S_j,M_j)$.

This two-stage optimization procedure determines the optimal method of contraception and the optimal frequency of intercourse, as functions of parity, prices, incomes and tastes. Or in other words, this optimization procedure implicitly defines the derived demand equations for sex and contraception:

(2.36) $S = S(N,\Pi,I_1,I_2;Z)$

(2.37) $M_j = M(N,\Pi,I_1,I_2;Z)$,

where M_j is a polytomous variable. Alternatively, we may introduce the y variable and define the demand function for y, S, and M_j, as in section 2.6.

2.8 Characteristics of Contraceptive Methods

Before we do the analysis with the assumption that contraception is a continuous variable, it may be useful to discuss some problems that arise in connection with this: How is the variable M defined, through what mechanisms does contraception yield disutility, and finally, what is the relationship between the variable for contraceptive use, M, and effectiveness, e ?

The most serious problem is that contraception is a multidimensional good; there is more than effectiveness that characterizes each method. In addition to money costs, there is interference or obtrusiveness with sex (O), side effects (W), health consequences (H), need to see a doctor (D), etc.[1]

The utility of contraceptive method number j is a function of these and other attributes:

$$W(M_j) = W(O_j, W_j, H_j, D_j, \ldots)$$

If we could measure these characteristics, the utility $W(M_j)$ could be substituted for M_j in the utility function $g(S, M_j)$.

The effectiveness e does not really belong in this function if we only consider those characteristics that yield direct (dis)utility, except for those who may enjoy sex more as a result of high effectiveness of contraception, as mentioned earlier. The money costs of contraception does not belong there either, but in the budget constraint. We do not consider money costs to be an important determinant

1) Luker (1977:192) finds that "Four major categories of costs associated with contraception emerged from the interviews: (1) costs imposed by the larger social and cultural meanings of contraception; (2) costs associated with maintaining contraception over time; (3) costs of obtaining access to contraceptive; and (4) costs related to the medical and biological aspects of contraception". Crosbie and Bitte (1982) list ten different characteristics of contraception as a result of interviews with college students. Most of these are of little relevance for adult couples, however, as "Others discover your sexual activity".

of contraceptive choice, however.[1)]

People's perceptions of the use-effectiveness and money costs of existing contraceptive methods (including combinations of methods) may be estimated using survey methods. But it is much harder to define and measure other costs of contraception, i.e. variables like O, W and H. To our knowledge, few attempts have been made at this.[2)]

To indicate the variations of characteristics of the different methods of fertility regulation, we have assigned values of zero, low, medium, high, or very high to each method, as shown in table 2.1. The use-effectiveness values are based on Michael (1973). In addition to most of the methods mentioned by him, we have included sterilization, abortion and abstinence.

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1) In a Danish fertility survey in 1970, only 9-12 % reported that money cost was the most important consideration in the choice of a contraceptive (Ussing and Bruun-Schmidt 1977). In a limited Norwegian fertility survey in two counties in 1974, only 2-3 % reported that they had stopped using a method because it was too expensive (Grimsmo 1978).
2) In the Danish survey referred to above, the most important characteristics of a good contraceptive method were the effectiveness of the method (85-93 % of the women); no side-effect (45-55 %); that the method cannot be "felt" (23-33 %); that there is no interference with intercourse (12-16 %); and that it is not necessary to see a physician to use the method (4-12 %) (Ussing and Bruun-Schmidt, 1972). In the Norwegian survey, the reasons for discontinuing a method varied from method to method. The proportion reporting "Method too unsafe" ranged from 4 % for the pill to 60 % for jelly/ spermicides; "Do not like the method" ranged from 6 % for IUD to 85 % for jelly/spermicides. Side-effects and complications were reported as important reasons for discontinuing only for IUD and the pill (Grismo 1978). Questions more in line with our analysis were asked in a survey carried out for the University of North Carolina, where the respondents were asked to rank and indicate on a scale how well they liked each contraceptive method, not taking the money costs and effectiveness of each method into consideration. The respondents were also asked to give their subjective estimate of the effectiveness of each method. We have not seen the results from this survey yet, however. (The questionnaire was kindly provided to me by Boone Turchi.)

Table 2.1 Characteristics of methods of fertility regulation.[1]

	Contraceptive[2] effectiveness e		Inter- ference with sex	Side effects	Health con- sequences	Money costs
Sterilization	1.0	Very high	zero	?	low ?	high/low
Abortion	1.0	" "	zero	high ?	medium ?	" "
Abstinence	1.0	" "	very high(!)	high?	?	zero
Pill	.996	high	zero	medium	medium ?	medium
IUD	.990	"	zero	low ?	low	low
Condom	.943	medium	high	zero	zero	medium
Diaphragm	.940	"	high	"	"	low
Withdrawal	.930	"	very high	zero	zero	zero
Jelly	.922	"	medium	zero(?)	"	medium
Foam tablets	.916	"	"	" (?)	"	medium
Rhythm	.840	low	"	"	"	zero
Douche	.832	low	"	"	"	medium
No method	0.0	zero	zero	" (?)	" (?)	zero

1) Christopher Tietze thinks that the estimates of the effectiveness of withdrawal, foam tablets, and douche are too high, and that the side-effects and health consequences of abortion are not so high, although perhaps not the perception of these effects and consequences by the uninformed. (Personal communication in letter of June 8, 1978.)

2) The estimates of contraceptive effectiveness are taken from Michael (1973), except for the three methods at the top of the table.

The three methods at the top of the table have all been assigned perfect effectiveness.[1] All of them may have relatively high utility costs, however, at least as perceived by some couples. The major disutility of sterilization is that it is usually not reversible, or in other words, the cost of avoiding a pregnancy now with certainty is that the couple cannot usually have another child in the future if they

1) Sterilization is not a 100 percent effective method. It is difficult to give an estimate of the contraceptive effectiveness of sterilization, as this depends on the surgical procedure and whether it is male or female sterilization. Estimates of the failure rate range from zero to a few per cent, see Population Reports Series D, no. 1, and Series C, nos. 2-6. Vasectomy, for example, is reported to have a failure rate of about 0.15 per 100 person-years, which approximately corresponds to an effectiveness value of 0.9993.

change their mind. The major cost of having an abortion may be psychological in addition to pain and discomfort. The money costs of an abortion vary from country to country depending on whether the woman has to pay for the abortion herself, whether it is legal or illegal, and whether she loses income during convalescence. The major disutility of abstinence is the difficulty in practicing the method consistently, which may often make the method less than 100 per cent effective.

The other use-effectiveness values in table 2.1 are based on interview surveys and are in some sense "objective" although there are considerable measurement problems and errors. One problem with such estimates is that the effectiveness does not only depend on the contraceptive method, but also on the motivation of the couple. Couples who are highly motivated to avoid a pregnancy may use a given method with far less failures than other couples. This has been documented in a number of studies, see e.g. Vaughan et al. (1977), Jones et al. (1980), Dryfoos (1982), and Schirm et al. (1982), who show that women who intend no more children practice contraception with more success than those who intend more but want to delay further child-bearing. These studies show that contraceptive effectiveness also depends on age, parity and certain socio-economic factors, like income.

Another problem for our analysis, however, is that the subjective or perceived probability of the effectiveness of a contraceptive may be more important for people's behaviour than the "objective" probabilities discussed above. It is hard to measure these, however.

Most people would probably agree to the ordinal values assigned to each method in the table. There are two major problems with this way of characterizing contraceptive methods, however:

First, the side-effects and health consequences etc. are different for different people. Some women are for medical reasons not able to use the IUD at all, for example, or only at infinitely high costs, to use economic terminology. Older women who smoke should not use the pill, whereas younger women are advised not to use the IUD.[1)]

Second, and more seriously, people attach different weights to the various characteristics. Some couples have a strong dislike for methods that interfere with the sexual enjoyment and are less concerned abouth the health consequences. Other couples may be so concerned about the health consequences of a method, e.g. the pill, that theychoose not to use it, even if they consider it superior in all other respects.

Blake (1977) summarizes the health risks associated with the use of the pill, and reports results on public attitudes towards the pill. From the beginning of the 1970's an increasing proportion of US women and men think that birth control pills are unsafe. (In 1977 62 per cent of women and 48 per cent of men claimed that the pill is unsafe.) She concludes that "Until recently it seemed obvious that oral contraception greatly reduced the costs of fertility control. ... It now appears that significant costs to health may

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1) See Population Reports for surveys of effectiveness, health consequences, side-effects, etc. of different contraceptives, e.g. number A-6 (1982) on oral contraceptives, B-3 (1979) on IUD's, H-4 (1976) on diaphragms, H-5 (1979) on spermicides, H-6 (1982) on condoms, and I-3 (1981) on safe periods (rhythm).

exist and that people are increasingly evincing concern about these physiological consequences". (Note that she uses the same terminology as ours, "the costs of fertility control" etc., although she is a sociologist who has been very critical of economic theories of fertility, as in Blake 1968).

Recently there have also been reports of positive health consequences of the pill, as in Ory (1982). Such reports may reduce the anxiety many women have against using the pill.

Our conclusion from this section is that there are a number of difficult problems related to methodology and data in analyzing contraceptive behaviour. It would be of great help to have more knowledge about people's attitudes towards the different contraceptive methods. Such data are relatively rare, and there are problems with the interpretation of those that exist.

2.9 Continuous Contraception

2.9.1 Contraceptive Effectiveness and Disutility

The simplest approach to the problems mentioned in the previous section is to let the method of contraception be characterized only by its effectiveness[1], e, i.e. $M = e$, which implies

1) Heckman and Willis (1976) make the same assumption.

(2.38) $g(S,M) = g(S,e)$.

In this long and technical section we are going to analyse the signs of the effects of changes in the exogenous variables on S, e, p and V. To do this we use the method of comparative statistics. Most of the results are reasonable and as expected, but a few results seem to be counter-intuitive, namely $dS/dy<0$ and $de/dy>0$. This indicates that there may be something seriously wrong with the model, but we are fortunately able to show that these results probably never occur, due to the constraints on S and e. The results are summarized in tables 2.2 and 2.4.

We will also assume that the "more" contraception a couple is using, i.e. the higher the effectiveness, the greater is their dis-utility:

(2.39) $g_e = \dfrac{\partial g(S,e)}{\partial e} < 0.$

This relationship between effectiveness and dis-utility is assumed to hold for each couple. If, e.g., a couple considers the pill both the most effective and least costly of all methods, they would not consider other contraceptive methods at all. For them the choice would be between the pill or no method. The condom, for example, would not be on the efficiency frontier for this couple. Other couples may, e.g., consider the condom as the least costly at a given level of effectiveness, but if it became very important for them to improve their contraceptive efficacy, they would change to a method like the pill. In spite of their advantages, modern methods like the pill and the IUD are increasingly perceived by many couples as having health hazards that are not found with more traditional methods.

However, there is no guarantee that this monotonic relationship between effectiveness and disutility holds in the aggregate. Therefore, estimating the demand for sex and contraception using cross-section data for only one time point rests on shaky foundations. It would be somewhat better to use the individual contraceptive history of couples and look at changes in contraceptive use.

In the subsequent analysis we may think of e not only as contraceptive effectiveness, but also more generally as the "amount" of contraception being used. E.g., increasing e may be interpreted as using "more" contraception, which may be done by using the existing method more (more often or more carefully), or shifting to another (and more effective) method.

It will be shown later (2.48) that the sign of the second partial derivative, g_{ee}, must be negative if the second-order condition for maximum is going to be met, so we do not have to make any special assumption about it. In other words, g_{ee} is negative if an interior maximum exists - but we cannot be sure that an interior maximum always exists, or that there is only one interior maximum. This result (2.48) means that the disutility of contraception increases faster the closer e is to unity. Thus, for a given frequency of intercourse, $\bar{S}$, the (dis)utility of contraception may look like one of two downward sloping curves in figure 2.9, depending on the level of S.

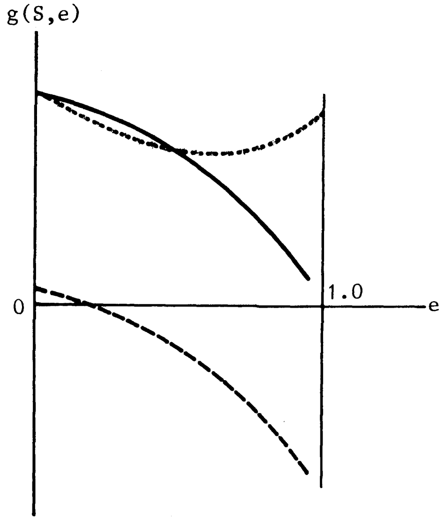

Figure 2.9 Utility of contraception as a function of effectiveness e.

The broken curve may be representative of couples with large fixed costs of contraception, e.g. catholics.

This assumption (2.39) may appear to be somewhat counter-intuitive, however. It is not unthinkable that the marginal utility of contraception may be <u>positive</u> for high values of e . The direct utility of contraception is, perhaps, the lowest for coitus-related methods, and higher for methods unrelated to coitus. Thus, it is not entirely impossible that the utility of contraception as a function of contraceptive use may look like the dotted curve in figure 2.9.

We will also need to assume something about the second partial cross-derivate, $g_{se} = g_{es}$. It seems reasonable that

$$(2.40) \quad g_{se} = g_{es} = \frac{\partial^2 g(S,e)}{\partial S \partial e} \leq 0,$$

i.e. the marginal utility of sex is smaller the "more" contraception is being used, or, the marginal disutility of contraception is greater the higher the coital frequency. This means that the difference between the two curves in figure 2.10 increases as S increases.

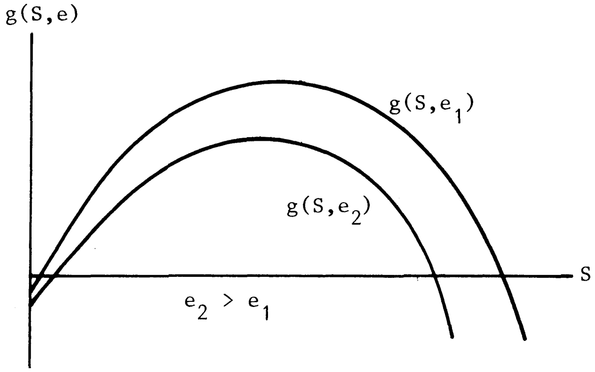

Figure 2.10 Utility of sex for different levels of contraceptive effectiveness

For methods that are unrelated to coitus, the (dis)utility of contraception does not depend on the coital frequency, and we have $g_{es} = g_{se} = 0$.

If a coitus-related method is being used, it seems reasonable to assume that the closer e is to unity, the smaller is $g_{se} = g_{es}$. For example, to use the condom with almost 100% efficacy might require such a high degree of caution that it would seriously distract from the pleasure of sex. Thus, we will assume that $g_{es} (=g_{se})$ approaches a large negative number (or minus infinity) as e approaches unity.

2.9.2 Maximization of Expected Utility

Having made assumptions (2.38)-(2.40) we are ready to set up the maximization problem, which is to maximize the expected utility, V, with respect to coital frequency, S, and contraceptive effectiveness, e. Setting $M=e$ in the expression (2.15) for expected utility, differentiating it with respect to S and e, and setting the derivatives equal to zero, yield the necessary first-order equilibrium conditions for a (local) maximum:

$$(2.41)\quad g_S + ry(1-e) = 0$$

$$(2.42)\quad g_e - Sry = 0.$$

Equation (2.41) was discussed in section 2.6 (eq. 2.21). Equation (2.42) says that the marginal utility of contraception is negative if the couple does not want an additional child in the next period. The equation also says that g_e is positive - which is unlikely - if the couple wants another child soon. This is consistent with Theorem 2.2 that "wanters" never contracept, which means that we have a corner solution, $e = 0$, in this case. The optimum level of contraception being such that the marginal utility is positive for wanters, means that they would like to reduce the contraceptive effectiveness below zero, which is not possible, of course.

The effects of changes in the exogenous variables on the optimal values of sex and contraception, S and e, can be studied by the method of comparative statics. We will do this in three stages:

i) We first study the effects on S and e (and p and V) of changes in the desire for an additional child, y, and the intrinsic fecundability, r. This is done by total differentiation of equations (2.41) and (2.42) and solving with respect to dS/dy, de/dy, dS/dr and de/dr (subsections 2.9.3.1 to 2.9.3.5).

ii) Second, we study the effects on the endogenous variable y of changes in parity, N, incomes, I_1 and I_2, and price of children, Π. This is done by total differentiation of equation (2.17) (subsection 2.9.4).

iii) Third, we combine (i) and (ii) to see the effects of changes in N, I_1, I_2 and Π on S and e (subsection 2.9.5).

2.9.3 Effects of Changes in Pregnancy Attitude and Fecundity

Total differentiation of the equilibrium conditions (2.41) and (2.42) yields

(2.43) $g_{ss}dS + (g_{se}-ry)de + r(1-e)dy + (1-e)ydr = 0$

and

(2.44) $(g_{es}-ry)dS + g_{ee}de - Srdy - sydr = 0,$

or

(2.45) $$\tilde{D}\begin{bmatrix} dS \\ de \end{bmatrix} = \begin{bmatrix} -r(1-e) \\ Sr \end{bmatrix} dy + \begin{bmatrix} -(1-e)y \\ Sy \end{bmatrix} dr$$

where the matrix

$$\tilde{D} = \begin{bmatrix} g_{ss} & g_{se}-ry \\ g_{es}-ry & g_{ee} \end{bmatrix} .$$

The determinant $D = |\tilde{D}|$ is positive if the second-order condition for maximum is met (Allen 1962:497), i.e.

$$(2.46) \quad D = g_{ss} \cdot g_{ee} - (g_{se}-ry)^2 > 0,$$

which implies

$$(2.47) \quad g_{ss} \cdot g_{ee} > (g_{se}-ry)^2.$$

We see that the two partial derivatives g_{ss} and g_{ee} must have the same sign, and since we have assumed that g_{ss} is negative (subsection 2.4.2), it follows that g_{ee} must also be negative to meet the second-order condition for a (local) maximum:

$$(2.48) \quad g_{ee} < 0.$$

Setting dy = 0 and dr = 0, respectively, in (2.45), and solving the linear equations system by Cramér's rule, yield the following results:

$$(2.49) \quad dS/dy = r[-(1-e)g_{ee}-Sg_{se}+Sry]/D,$$

$$(2.50) \quad de/dy = r[Sg_{ss}+(1-e)g_{es}-(1-e)ry]/D,$$

$$(2.51) \quad dS/dr = y[-(1-e)g_{ee}-Sg_{se}+Sry]/D,$$

$$(2.52) \quad de/dr = y[Sg_{ss}+(1-e)g_{es}-(1-e)ry]/D.$$

The signs of these expressions depend, <u>inter alia</u>, on the sign of y. However, as proven in section 2.6, couples will not use any contraception at all ($e=0$) if they want an additional child in the next period ($y>0$), or if they are indifferent ($y=0$). Thus, the results (2.49)-(2.52) can only be used to study the effects of small changes in y and r when y is negative, see subsection 2.9.3.3. When y is positive or zero the optimization procedure has to be repeated with $e=0$, see subsection 2.9.3.1 and 2.9.3.2. Effects on the probability of conception, p, and the expected utility, V, are analyzed in subsection 2.9.3.4.

2.9.3.1 Couples Wanting a Child Soon ($y>0$)

To account for the fact that couples who want to have a child soon are not using any contraception, we set $e=0$ in expression (2.15) for expected utility, and maximize with respect to S only. This results in the first-order maximum condition

$$g_s + ry = 0. \tag{2.53}$$

Total differentiation of this equation and some manipulation yield

$$dS = -\frac{r}{g_{ss}}\,dy - \frac{y}{g_{ss}}\,dr.$$

We see that

$$dS/dy = -r/g_{ss} > 0 \tag{2.54}$$

and

$$dS/dr = -y/g_{ss} \geq 0, \text{ since } y \geq 0. \tag{2.55}$$

The first of these results is reasonable: The more a couple wants a child soon the higher is their coital frequency. But the second result seems counter-intuitive: The higher a couple's fecundability the higher their coital frequency! Intuitively we would expect that a couple who thought that their fecundity went up would reduce their coital frequency, since we believe that the marginal utility of sex is negative for couples wanting a child soon.

Although this result (2.55) seems surprising at first glance, it becomes more reasonable when we think about it. The reason for the positive effect of fecundity on sexual activity ($dS/dr>0$) is that the expected utility of an intercourse increases when r increases. (This can be seen from equation (2.68): $\partial^2 V/\partial S \partial r = y > 0$, for $y > 0$ and $e = 0$.) An increase in perceived fecundity leads to an addition in "child utility" through the increase in the probability of conception, Sr. This addition is compensated for by the reduction in "sex utility" caused by the increase in coital frequency. The increase in r results both in a higher probability of conception and a higher total expected utility, see table 2.2. This seems reasonable: Couples wanting an additional child soon become happier if their probability of conception increases.

This situation can be compared to a lottery: when the probability of winning a prize goes up (analogous to r going up) people buy more tickets (analogous to increasing S). Just as lottery tickets cost money, there is a cost to increasing the number of intercourses, since the marginal utility for sex is negative.[1)]

The result (2.55) can also be seen graphically, see fig. 2.11,

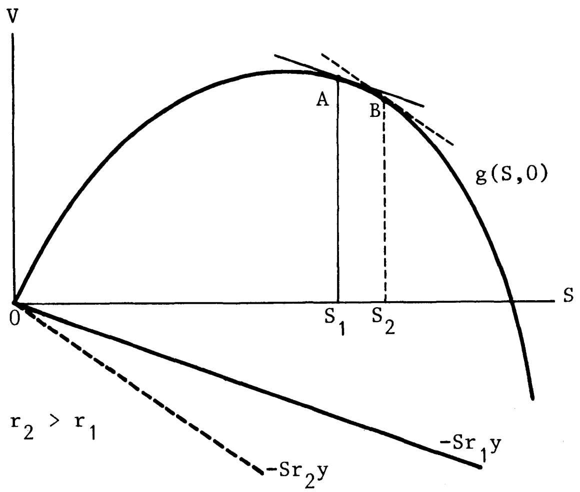

Figure 2.11 Effect on coital frequency of an increase in fecundity for couples wanting a child soon

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1) This analogy was pointed out by Per Sevaldson. The following comment on this result by Ronald Lee in a letter of December, 1979, may also be clarifying: " ... am I right in thinking that it rests particularly on the assumption that it is expected utility which is being maximized, rather that the utility of the expected number of kids? If the utility of the expected number of kids were being maximized, then the increase in r would cause an increase in expected kids, and presumeably a <u>decrease</u> in the <u>marginal</u> utility of kids, so the marginal utility of intercourse might either go <u>down</u>, due to diminishing marginal utility of kids, or up (the case you discuss) due to each act of coitus having more likelihood of leading to conception. With the approach you take (maximize expected utility), the expected utility must be a linear function of the probability of conception; therefore increased fecundity does not cause the marginal utility of expected kids to fall, so there is no change to offset the increase in r, and you get your unambiguous result."

Maximizing expected utility V in equation (2.15) with e=0, is the same as maximizing the difference between the g-curve and the straight line -sry. The optimal point is at A, where the tangent line to the g-curve has the same slope as the straight line. When fecundity increases from r_1 to r_2 the line -sry becomes steeper and this causes the optimal coital frequency to increase from S_1 to S_2.

Finally, let us for curiosity look at the effect on e of changes in y and r, not assuming that e is constrained to zero. We see from (2.50) and (2.52) that these effects are unambiguously negative when $y \geq 0$. I.e., both higher fecundity and higher desire for an additional child lead to lower contraceptive effectiveness, see column 2 in table 2.2.

2.9.3.2 Couples Indifferent to Pregnancy Soon (y=0)

Couples who are indifferent to becoming pregnant soon do not have any reason for using contraception, as shown in section 2.6.

We expect such couples to react to changes in the desire to become pregnant (an increase in y would make them "wanters"), but not to any change in the fecundability, as this would not affect their desire to become pregnant, only their probability of conception and consequently their expected utility would change.

These expectations are confirmed by (2.54) and (2.55), see column 3 in table 2.2. The results are the same as for "wanters" (y>0), except for variables that are not affected by a change in y.

Table 2.2 Effects on S, e, p, and V of changes in y and r[1)2)]

	$y > 0$		$y=0$	$0>y\geq\bar{y}$	$\bar{y}>y\geq\underline{y}$	$\underline{y} > y$	
				Interior solutions		Corner solutions	
	e=0	e unconstrained	e=0			s>0, e=1	S=e=0
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
dS/dy	+	+	+	+	−	0 or −	0 or +
de/dy	0	−	−	−	+	0 or −	0 or +
dS/dr	+	+	0	−	+	0	0 or +
de/dr	0	−	0	+	−	0	0 or +
dp/dy	+	+	+	+	?	0 or +	0 or +
dV/dy	+	+	+	+	+	0	0
dp/dr	+	+	+	?	?	0	0 or +
dV/dr	+	+	0	−	−	0	0
	*		*	*		*	

1) The *-marked columns indicate the most realistic situations. The other columns are included for reasons of comparison and completeness. All non-zero results except those in columns (6) and (7) assume that $S\neq 0$, $r\neq 0$ and $e\neq 1$. Otherwise most results will equal zero, see equations (2.49)-(2.52) and (2.63)-(2.68).

S = coital frequency

e = contraceptive effectiveness

p = Sr(1-e) = probability of conception

V = expected utility (equation (2.15))

y = desire to become pregnant in the next period

$\underline{y}$ = smallest value of y with interior solution, see (2.61a-g)

$\bar{y}$ = smallest permissible value of y with no "abnormal" results

r = fecundity

2) Remarks to column 5: Note that the region $y\in(\underline{y},\bar{y})$ is probably very small and may be empty. Note also that dS/dy and de/dy, and dS/dr and de/dr, cannot have opposite sign similtaneously, see the second footnote in subsection 2.9.3.3, part A. If, e.g. dS/dy is negative, de/dy is also negative.

2.9.3.3 Couples Not Wanting a Child Soon ($y<0$)

A Effects of an increase in y

Consider first equation (2.49): g_{ee} is negative because of (2.48) and since we have assumed that g_{se} is negative (2.40). This makes the two first terms positive and the last term negative (since $y<0$). Thus, the effect of an increase in y on the coital frequency is ambiguous. However, for small values of $|y|$ the two positive terms will dominate the negative term and dS/dy becomes positive.

The same reasoning applies to (2.50), where we see that de/dy is negative for small values of $|y|$. These results seem reasonable. For couples with a relatively weak or perhaps a normal desire to avoid a pregnancy, a reduction in this desire makes them want to increase their coital frequency and reduce their contraceptive effectiveness - which would increase the probability of conception, of course, see column 4 in table 2.2. The reason for this is that the gain in utility from more sex and less contraception is greater than the loss in utility from a higher probability of pregnancy.

What about large negative values of y, i.e. $|y| \gg 0$? It is obvious that for large negative values of y the last term in the numerator of (2.49) may dominate the two positive terms and the whole expression would become negative, as long as the denominator is positive. The interpretation of this is that a reduction in a strong desire to avoid a pregnancy would lead to a decline in the optimal coital frequency.

However, for large values of $|y|$ the denominator D (eq. 2.46) may become negative, and the second-order condition for an interior solution of the maximum problem breaks down. Moreover, the two other constraints

(2.56) $e \in [0,1]$ and $S \geq 0$

may imply that there is no interior solution when y is large. This can be illustrated graphically, see fig. 2.12. As explained previously, the optimal coital frequency for a given contraceptive effectiveness is at the point where the tangent line to the g-curve has the same slope as the straight line, $z = -Sr(1-e)y$. When y is large negative this line may be so steep that the optimal solution is at origo.

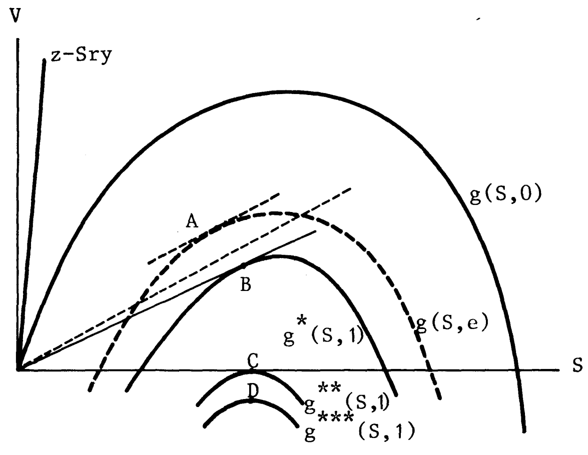

Figure 2.12 Utility maximization when y is large negative

Normally, the optimal point would be at A, with $S > 0$ and $e < 1$. If e is increased to its maximum, we may get a solution with $e = 1$ and $S > 0$ as at B or C. But if the disutility of contraception becomes very large as e approaches or becomes equal to one, the g-curve might everywhere fall below the S-axis, and the couple would be better off with the corner solution, $S = e = 0$. In this latter case, we see that it might be optimal to use contraception with effectiveness greater than unity, as at D. (At this point a small increase in y would reduce the slope of the z-line, causing S to decline, i.e. $dS/dy < 0$ when $e > 1$.)

The corner solution $S = 0$ and $e = 1$ will never be chosen, as use of contraception when there is no intercourse would not affect the probability of conception and would only result in a loss of utility.

Thus, there may be no interior solution when y is large negative. We cannot prove in general that there is no region of y where we get the "abnormal" results $dS/dy < 0$ or $de/dy > 0$, but it is likely that this region is quite small, or empty.[1)]

Comparing our results with the effects of a price or income change in consumer (or production) theory, it is not surprising that we may get such seemingly counter-intuitive results as those discussed above. Such results may occur when one of the goods is inferior and the relative prices change.

From micro-economic theory we know that when the price of a good increases and there are two (or more) goods, there is reduced demand for

1) This suspicion is confirmed by numerical experiments reported in Appendix 2A in the original version of the dissertation.

one of the goods, but not necessarily for both. Similarly, we exclude the possibility of having dS/dy<0 and de/dy>0 simultaneously, but both of them may have the same sign at the same time.[1)]

Figure 2.13 shows the effect on S when y changes. Point $A(S_1,e_1)$ is the optimal point for $y=y_1$. The effect of a small increase in y , i.e. a reduction in the absolute value $|y|$, can be divided into

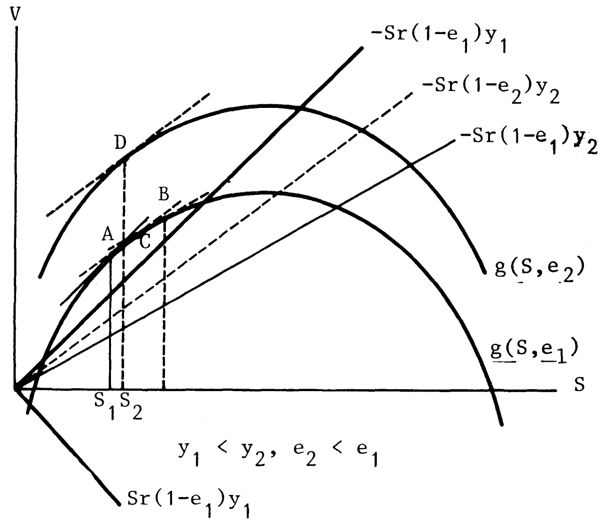

Figure 2.13 . Effect on coital frequency of an increase in y when y is negative and e is fixed

two (or three) partial effects:

(1) An increase in y from y_1 to y_2 reduces the slope of the straight line $-Sr(1-e_1)y$. If e is kept constant, the new optimal point is at B. The effect AB is obviously positive. I.e. the coital frequency S increases when y increases and e is fixed.

1) This can be proved from equation (2.60) and (2.62) below. We see from (2.62) that dS/dy<0 implies de/dy<0, and from (2.60) that de/dy>0 implies dS/dy>0 (which is logically equivalent), assuming g_{se} zero or small. Thus, both expressions cannot have the "wrong" sign simultaneously.

(2) Next, let us keep y constant and change e. The increase in y will usually lead to a reduction in e, from e_1 to e_2, see below. The reduction in e has two effects:

a) The straight line becomes steeper and we arrive at a new optimal point, C. This implies a reduction in S.

b) The g-curve is shifted up, and the final optimum is at D. The partial effect of this on S is unclear. If the partial derivative $g_{se} = 0$, the slope of g is not affected by a change in e, and the value of S is the same at C as at D.

Since it is difficult to distinguish between the (2a) and (2b) effects we combine them into one effect, i.e. the effect of changing e when y is kept constant. This effect may be positive or negative.

Thus, we have divided the effect of a change in y into two effects, AB and BD:

$$(2.57) \quad \frac{dS}{dy} = \left(\frac{\partial S}{\partial y}\right)_{e \text{ constant}} + \left(\frac{\partial S}{\partial e}\right)_{y \text{ constant}}.$$

This equation resembles the Slutsky equation in the theory of consumer behaviour (see e.g. Henderson and Quandt 1958), although there are major differences. There is, e.g., no "compensation" here as in the Slutsky equation. The first part of (2.57) may be called the pure "desire" effect or "value-of-an-additional-child" effect, which is analagous to the income effect in consumer theory, with y being analagous to income (y can be interpreted as the "value" of an additional child). This effect is always positive.

The second effect may be called the "substitution" effect (or pure contraception effect), with contraceptive effectiveness e being analogous to "price" (i.e. the cost of intercourse). This is the effect of substituting e for S when y is fixed. This substitution is done to change both the probability of conception and the utility of sex and contraception in an optimal direction.

The problem is: when is the substitution effect in (2.57) so large that the total effect on dS is negative, i.e. D lies to the left of A? We will derive the mathematical expressions for these effects.

The "income" effect AB can be found by setting de = 0 and dr = 0 in (2.43):

$$(2.58)\qquad \left(\frac{\partial S}{\partial y}\right)_{e\ \text{constant}} = -\frac{r(1-e)}{g_{ss}}\ .$$

This is always positive (for $e \leq 1$), since g_{ss} is assumed to be negative.

The substitution effect BD can be found by subtracting the income effect AB (2.58) from the total effect AD (2.49):

$$(2.59)\qquad \left(\frac{\partial S}{\partial e}\right)_{y\ \text{constant}} = \frac{dS}{dy} - \left(\frac{\partial S}{\partial y}\right)_{e\ \text{constant}}$$

$$= -\frac{(g_{se}-ry)}{g_{ss}} \cdot \frac{r\left[Sg_{ss}+(1-e)(g_{es}-ry)\right]}{D} = -\frac{g_{se}-ry}{g_{ss}} \cdot \frac{de}{dy}\ .$$

Thus, we have found that the effect on S can be written as

$$(2.60)\qquad dS/dy = -r(1-e)/g_{ss} - (g_{se}-ry)/g_{ss} \cdot de/dy.$$

We notice that dS/dy is a function of de/dy.

The sign of this expression is normally negative, i.e. when de/dy is negative and g_{se} is small or zero. To study the sign more carefully we have to take the second-order condition and the other constraints into consideration. To simplify the notation we will define a number of "critical" values of y:

i) The second-order condition, D > 0, implies

$$y > -g_{se}/r \mp \sqrt{g_{ss}g_{ee}}/r.$$

Since we are only concerned with y < 0 here, and $g_{se} \leq 0$, only the negative value above is binding and we define the value y_D such that

(2.61a) $y \geq y_D = -g_{se}/r - \sqrt{g_{ss}g_{ee}}/r \Rightarrow D > 0.$

ii) The constraint on e, $e \in [0,1]$, defines the value y_{el} such that

(2.61b) $y \geq y_{el} \Rightarrow e \leq 1.$

iii) The constraint on S, $S \geq 0$, defines the value y_S such that

(2.61c) $y \geq y_{so} \Rightarrow S \geq 0.$

Thus, the smallest value of y with an interior solution is

(2.61d) $\underline{y} = \max(y_D, y_{so}, y_{el}).$

We will also define two other critical values of y:

iv) The smallest value of y that results in dS/dy>0:

(2.61e) $y \geq y_{ds} = g_{se}/r + (1-e)g_{ee}/Sr \Rightarrow dS/dy > 0.$

v) The smallest value of y that results in $de/dy < 0$:

(2.61f) $y \geq y_{de} = g_{es}/r + Sg_{ss}/r(1-e) \Rightarrow de/dy < 0.$

Now, we do not know which of these critical values of y is the greatest. This depends on the properties of the utility function g and on the value of the exogenous variable r. If, e.g., $y_{ds} \leq y_D$, we will always have $dS/dy > 0$. On the other hand, if $y_D < y_{ds}$ we get the "abnormal" result $dS/dy < 0$ for $y \in [y_D, y_S)$.

We define the smallest permissible value of y with only "normal" results ($dS/dy > 0$ and $de/dy < 0$)

(2.61g) $\bar{y} = \max(\underline{y}, y_{ds}, y_{de}).$

Notice that we may have $\bar{y} = \underline{y}$.

To simplify the analysis let us assume that

$$y_{de} \leq y_{so} \leq y_D \leq y_{el} \leq y_{ds} \leq g_{se}/r \leq 0,$$

which is the case in the base run and most other examples in the simulations reported in Appendix 2A in the original version of the dissertation.[1)]

With these notations and assumptions the sign of (2.59) can be seen from table 2.3.

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1) We did not find any value for y that made de/dy negative. The value of g_{se}/r depends on y but is always a little greater than y, i.e. the region $[g_{se}/r, 0]$ is empty.

Table 2.3 Signs of effects of an increase in y when y is negative

y_{de} y_{so} y_D y_{el} y_{ds} g_{se}/r (*) 0

y-line						
$-g_{ss} > 0$						
$-g_{ee} > 0$						
$g_{se} - ry > 0$						
$de/dy > 0$						
$dS/dy > 0$						
$(\frac{\partial S}{\partial e})_{y\ const.} = \frac{g_{se}-ry}{-g_{ss}} \cdot \frac{de}{dy} > 0$	Interior solution does not exist			Subst. effect negative and so large that dS/dy becomes negative	Subst. effect negative but too small to make dS/dy positive	Subst. effect positive*)
$(\frac{\partial e}{\partial S})_{y\ const.} = \frac{g_{se}-ry}{-g_{ee}} \cdot \frac{dS}{dy} > 0$	Interior solution does not exist			Subst. effect negative	Subst. effect positive but too small to make de/dy positive	Subst. effect negative*)

1) The symbols are explained in the footnotes to table 2.2.
*) This region is likely to be empty.

Thus, we see that for large permissible values of y the substitution effect may become negative and so large that it dominates the "income" effect.

The interpretation of this is that a decrease in the desire to avoid an additional child will always lead to a higher frequency of intercourse - if the contreceptive effectiveness remains fixed. (Likewise, it will be shown below that the effectiveness will always be reduced if the coital frequency does not change.) These partial effects work through the probability of conception, $p = Sr(1-e)$.

Now, holding y constant and reducing e (from B) necessitates that S is reduced somewhat to avoid a too large increase in the probability of conception. It is as if there were an overreaction in this reduction when the desire to avoid a pregnancy is strong - but not so strong that we do not get any interior solution to the maximization problem.

To stretch the analogy mentioned above: Just as increasing income may have a negative effect on the demand for a good (e.g. potatoes) for low-income consumers, i.e. the good is inferior, decreasing desire to avoid an additional child may have a negative effect on the demand for sex for couples with a very strong desire to avoid a pregnancy, i.e. sex may be an inferior good! (Remember, though, that inferiority here only pertains to this special economic effect - it does not have any quality connotations.)

We will now look at what happens to contraceptive effectiveness when the desire to avoid a pregnancy is reduced. We expect the effectiveness to be reduced. This is confirmed by expression (2.50), but we notice that there may exist an interval $[\underline{y}, y_{de})$ where there is a positive effect on contraceptive effectiveness.[1)] As for coital frequency, a diagram may help us:

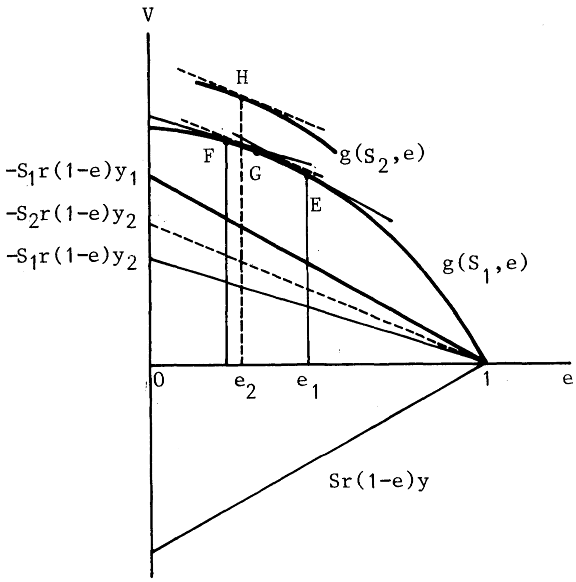


Figure 2.14 Effect on contraceptive effectiveness of an increase in y when y is negative and S is fixed

The point where expected utility V is maximized is at E. An in-

---

1) In the numerial examples reported in the dissertation we did not find any permissible value of y ($y>\underline{y}$) such that de/dy > 0. In fact, in most examples we did not find any value of y at all that resulted in a positive de/dy.

crease in y, i.e. a decrease in $|y|$, when S is kept constant, reduces the slope of the straight line and we get a new optimal point at F. As above, the effect of an increase in y can be divided into two (or three) separate effects:

1) S is kept constant. A reduction in $|y|$ reduces the slope of the straight line and we get a new optimal point on the g-curve at F. The effect of this is a reduction in e.

2) y is kept constant (at its new value) and S increases (usually). This causes

a) a movement to the right on the g-curve to G, i.e. an increase in e,

b) an upward shift of the g-curve; the final optimal point is at H.

Thus, we have

$$\frac{de}{dy} = \left(\frac{\partial e}{\partial y}\right)_{S\ \text{constant}} + \left(\frac{\partial e}{\partial S}\right)_{y\ \text{constant}}$$

As above the first expression on the left-hand side may be called the "desire" or "value-of-an-additional-child" or "income" effect, and the second the "substitution" or "price" effect. The "income" effect is always negative, whereas the substitution effect is usually positive but it may become negative in extreme cases. The "income" effect is caused by the reduced need for contraception when the desire to avoid a pregnancy goes up. It can be calculated by setting $dS = dr = 0$ in (2.44):

$$(\partial e/\partial y)_{S\ \text{constant}} = Sr/g_{ee}.$$

The "substitution" effect FH can be found by subtracting the "income" effect EF from the total effect EH (2.50):

$$\left(\frac{\partial e}{\partial S}\right)_{y\ \text{constant}} = \frac{de}{dy} - \left(\frac{\partial e}{\partial y}\right)_{S\ \text{constant}}$$

$$= -\frac{g_{se}-ry}{g_{ee}} \cdot \frac{-r(1-e)g_{ee}-rS(g_{se}-ry)}{D}$$

$$= -\frac{g_{se}-ry}{g_{ee}} \cdot \frac{dS}{dy} .$$

This effect is usually positive, see table 2.3.

Thus, we have found that the effect on e of a change in y can be written as

$$(2.62)\quad de/dy = Sr/g_{ee} - (g_{se}-ry)/g_{ee} \cdot dS/dy.$$

Finally a few comments on the results when we have a corner solution, see fig. 2.12 and table 2.2. There are two kinds of corner solution, one where there is perfect contraception (e=1, S>0) and one where there is no intercourse and consequently no need for contraception (S=e=0). The choice between these two corner solutions depends, of course, on the specific utility function, i.e. on the relative strength of the utility of intercourse, contraception, children and other consumption. However, modern methods of contraception are characterized by almost perfect effectiveness and relatively little disutility - in the view of many, but far from all. Thus, even couples with a very strong desire to avoid a pregnancy may have intercourse with little risk of conception.

When we have the first kind of corner solution, i.e. e = 1, the optimal frequency of intercourse is equal to the satiation level and does not depend on y at all as long as it is negative, which we see by setting M = e in (2.15) and maximizing with respect to S. Thus, a small change in y would have no effect on S unless it caused a jump to an interior solution, in which case the use of contraception would drop and consequently the coital frequency would have to go down i.e. $dS/dy < 0$ and $de/dy < 0$, see col. 6 in table 2.2.

Similarly when we have a corner solution with $S = e = 0$: A small increase in y would either have no effect on S and e at all, or it would cause a jump to an interior solution, in which case we would have $dS/dy > 0$ and $de/dy > 0$.

B. Effects of an increase in r

We will now look at the effects of changes in the perceived fecundity, r. We notice from (2.49)-(2.52) that the only difference between the effects of changes in y and r is that the first r is replaced by y. Thus, most of the results for dS/dr and de/dr have opposite signs of the results for dS/dy and de/dy, see table 2.2.

First, we see that dS/dr is negative and that de/dr is positive when $y \in [\bar{y}, 0)$. This is as expected: When the perceived fecundity increases the couples will reduce their coital frequency and increase their contraceptive effectiveness. This is done to compensate for the increase in the probability of conception, $p = Sr(1-e)$, from higher r, with an ambiguous net effect on p. On the other hand, the net effect on expected utility is negative, see subsection 2.9.3.4. This seems intuitively correct: Couples who do not want an additional child soon are happier the smaller their fecundity is.

What about permissible values of y less than y_{ds} (or y_{de})? We see that we get the counter-intuitive results $dS/dr > 0$ or $de/dr < 0$ for this region, which is likely to be empty or rather small.

For even smaller y, we will get corner solutions, as discussed before.

If we have the first kind of corner solution, $e = 1$ and $S > 0$, a small increase in r will either have no effect at all on S and e, or it will cause a jump to an interior solution, in which case both S and e go down, i.e. $dS/dr < 0$ and $de/dr < 0$, see col. 6 in table 2.2. Also at the other corner solution where $S = e = 0$ a change in r will have no effect on S and e, but if we get a jump to an interior solution both S and e will go up, i.e. $dS/dr > 0$ and $de/dr > 0$, see col. 7 in table 2.2.

2.9.3.4 Effects on Probability of Conception and Expected Utility

We are also interested in seeing how changes in the attitude towards pregnancy, y , and the fecundability, r, affect the probability of conception, p, and the total expected utility, V. Since the probability of conception is

$$p = Sr(1-e),$$

it follows that

$$dp = S(1-e)dr + r(1-e)ds - Srde.$$ [1)]

Dividing by dy and dr, respectively, and setting $dr/dy = 0$ since r is exogenous, yields

1) As proven previously and discussed in subsection 2.9.3.1, couples wishing to become pregnant are not using any contraception, i.e. $e = 0$. However, all equations in the present section are valid for $e = 0$, but the interpretation of them is a little different, of course.

$$(2.63) \quad \frac{\partial p}{\partial y} = r(1-e)\frac{dS}{dy} - Sr\frac{de}{dy} ,$$

and

$$(2.64) \quad \frac{\partial p}{\partial r} = S(1-e) + r(1-e)\frac{dS}{dr} - Sr\frac{de}{dr} .$$

The effects on p of changes in y and r are unambiguous when y is positive, see table 2.2. An increase in the desire to become pregnant leads to a higher probability of conception, since the coital frequency increases and the contraceptive effectiveness declines. The same thing happens when the perceived fecundity increases.

The effects on p are more ambiguous when y is negative, and depend *inter alia* on the magnitude of y. When y is greater than $\bar{y}$ an increase in y leads to a higher probability of conception, since the coital frequency goes up and the contraceptive effectiveness goes down. The effect of an increase in the fecundity is unclear. The reason for this is that the direct effect of higher fecundity is higher probability of conception, of course, but higher r leads on the other hand also to reduced coital frequency and to higher contraceptive effectiveness. The net effect on the probability is positive when these indirect effects are small.

For the small region where y is less than $\bar{y}$ but greater than $\underline{y}$, we get ambiguous results for the effects of changes in y and r, since we cannot at the same time have two "abnormal" results, as shown in subsection 2.9.3.3

How is expected utility affected by changes in y and r? We should first note that what we are interested in is the *maximal* expected utility, $\tilde{V}$, i.e. expected utility (2.15) as a function of the *optimal* values of S and e. When the desire to become pregnant and the perceived fecundity change, the maximal expected utility is affected both via changes in y, which is also interpreted as the perceived increment in utility from an additional child, and via changes in the optimal values of S and e. All these effects are included by taking the total differential of the expression (2.15) for expected utility. Rearranging the terms yields

$$(2.65)\quad d\tilde{V} \doteq (r(1-e)y+g_s)ds + (g_e-Sry)de + S(1-e)ydr + Sr(1-e)dy + df^o.$$

The two first terms in brackets equal zero because of the first-order conditions (2.41) and (2.42). Let us, for simplicity, assume that $df^o = 0$, i.e., a change in $y = f^* - f^o$ results from a change in f^* only, i.e. the utility of having an additional child in the second period. Thus,

$$(2.66)\quad d\tilde{V} = S(1-e)ydr + Sr(1-e)dy.$$

By setting $dr = 0$ and $dy = 0$, respectively, in (2.66) we get[1)]

$$(2.67)\quad d\tilde{V}/dy = Sr(1-e) > 0,$$

and

$$(2.68)\quad d\tilde{V}/dr = S(1-e)y \begin{cases} > 0 \text{ if } y > 0 \\ = 0 \text{ if } y = 0 \\ < 0 \text{ if } y < 0 \end{cases}$$

It is interesting to note that the results (2.66)-(2.68) do not depend on the marginal utilities of sex and contraception, g_s and g_e, nor on any effects via changes in the optimal values of coital frequency (dS/dy and dS/dr) and contraceptive use (de/dy and de/dr). This is fortunate since there may be problems with the latter results, as mentioned in preceding sections.

---

1) The conclusions about the signs assume that $S \neq 0$, $e \neq 1$ and $r \neq 0$, otherwise $dV = 0$.

In (2.67) we get the plausible result that the maximal expected utility always increases, both when the desire to become pregnant is increased and the desire to avoid a pregnancy is reduced. It is also interesting to note that the expression for $d\tilde{V}/dy$ is equal to $Sr(1-e)=p$, or the probability of conception. Thus, the increase in expected utility $\tilde{V}$ is simply equal to pdy.

Expression (2.68) shows that the effect of a change in the perceived fecundity on the expected utility V is proportional to the desire to become pregnant. This is an expected result.

2.9.3.5 Concluding Remarks on Table 2.2

A large number of results is included in table 2.2. Only some of them may be considered realistic, namely those in columns 1, 3, 4, and 6. I.e., situations where either the couple wants to or is indifferent to having a child soon and is consequently not using any contraception, or the couple has a moderately strong desire to avoid a pregnancy, or finally, the couple has a very strong desire to avoid a pregnancy and is consequently using highly effective contraception. The results in column 5 are only valid under very special circumstances or not at all. The situation in column 7 where the couple chooses no intercourse and consequently no contraception to avoid a pregnancy is probably not very common in a modern society with easy access to effective methods of contraception. Column 2 is included to complete the mathematical analysis.

We notice from table 2.2 that the effects of a change in y are the same in almost all columns, i.e. regardless of whether y is positive, zero or negative small, including the most realistic situations, columns 1, 3, 4 and 5. This may seem surprising at first, but it does in fact make sense. A couple will always increase their (optimal) coital frequency and reduce their use of contraception when the desire to have another child increases, whether this desire is "positive" or "negative". It is also reasonable that the effect on sex and contraception of an increase in the perceived fecundity depends on whether they want to become pregnant or not.

2.9.4 Effects on y of Changes in N, I_1, I_2 and Π

We will now study the effects of changes in the exogenous variables N, I_1, I_2 and Π on the desire to have an additional child in the next period, y. Let us first introduce some simplifying symbols. The partial derivates of $f^* = f(N,N+1,X_1,X_2^*)$ and $f^o = f(N,N,X_1,X_2)$ are denoted [1)]

$$f_1^* = \frac{\partial f^*}{\partial N_1}\bigg|_{N_2 = N+1},$$

$$f_2^* = \frac{\partial f^*}{\partial N_2}\bigg|_{N_2 = N+1},$$

$$f_3^* = \frac{\partial f^*}{\partial X_1}\bigg|_{N_2 = N+1},$$

$$f_4^* = \frac{\partial f^*}{\partial X_2}\bigg|_{N_2 = N+1},$$

1) The number of children in the two periods, N_1=N and N_2=N or N+1, is in reality a discrete variable since children only come in discrete quantities. Thus, the utility function of children is a step-function. We assume, however, that f is an underlying continuous function that coincides with the step-function for integer values of N. This makes derivation possible.

$$f_1^o = \frac{\partial f^o}{\partial N_1} \Big| \; N_2 = N ,$$

etc.

f^* means that the function f is evaluated at $N_2 = N_1+1 = N+1$ and $X_2^* = I - \Pi(N+1)$, and f^o that the function is evaluated at $N_2 = N_1 = N$ and $X_2 = I - \Pi N$.

With these symbols, total differentiation of equation (2.17) yields

$$dy = K_1 dN + K_2 dI_1 + K_3 dI_2 + K_4 \Pi .$$

where

$$K_1 = (f_1^*-f_1^o) + (f_2^*-f_2^o) - \Pi(f_3^*-f_3^o) - \Pi(f_4^*-f_4^o),$$
$$K_2 = f_3^* - f_3^o,$$
$$K_3 = f_4^* - f_4^o,$$
$$K_4 = -N(f_3^*-f_3^o) - N(f_4^*-f_4^o) - f_4^*.$$

It seems reasonable to assume that

(2.68) $f_1^* = f_1^o$ and $f_3^* = f_3^o$,

i.e., the marginal utility of children and consumption, respectively, in the first period is the same whether or not the couple has an additional child in the second period.

We will also make the following assumptions about the signs of some partial derivatives:

(2.69) $f_2^* < f_2^o$, assuming decreasing marginal utility of children[1], and

(2.70) $f_4^* > f_4^o$, since $X_2^* < X_2$, and assuming decreasing marginal utility of consumption.

---

1) This may not always be the case in practice. The utility of child number N+1 may be higher than the average of the previous children if, e.g., the sex of child number N+1 is important.

With these assumptions we get

(2.71) $dy/dN = K_1 = (f_2^*-f_2^o) - \Pi(f_4^*-f_4^o) < 0,$

(2.72) $dy/dI_1 = K_2 = 0,$

(2.73) $dy/dI_2 = K_3 = f_4^* - f_4^o > 0,$

(2.74) $dy/d\Pi = K_4 = -N(f_4^*-f_4^o) - f_4^* < 0.$

These results seem plausible: the desire for an additional child in the next period is smaller the greater the number of children the couple already has; the smaller the income in the second period is expected to be; and the greater the "price" of children is. We also notice that changes in the current income have no effect on the desire to become pregnant. This is not surprising, since the income in period 1 is already known to the couple and cannot change. Moreover, I_1 does not affect the income in period 2 since we have assumed that there is no transfer of income between the two periods. Only the expected future income I_2 matters. Since dI_1 is eliminated we write $I = I_2$ from here on, to simplify the notation.

2.9.5 Effects on S and e of Changes in N, I and Π

We are now ready to study the effects on S and e of changes in the exogenous variables N, I and Π.

The effect on, say, S of a change in N can be found as a result of two effects: the effect on S of a change in y and the effect on y of a change in N, or

$$\frac{dS}{dN} = \frac{dS}{dy} \cdot \frac{dy}{dN} = \frac{dS}{dy} \cdot K_1.$$

Similarly for the effects on S and e of changes in the other exogenous variables. Thus, the signs can be found by combining the results in table 2.2 with (2.71)-(2.74), see table 2.4.

Table 2.4 Effects on S and e of changes in N, I and Π.[1)]

	$y > 0$		$y=0$	$0>y\geq\bar{y}$ Interior solutions	$\bar{y}>y\geq\underline{y}$	$\underline{y} > y$ Corner solutions	
	e=0	e unconstrained	e=0			S>0, e=1	S=e=0
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
dS/dN	–	–	–	–	+	0 or +	0
de/dN	ND	+	+	+	–	0	0
dS/dI	+	+	+	+	–	0 or –	0 or +
de/dI	ND	–	–	–	+	0	0
dS/dΠ	–	–	–	–	+	0 or +	0
de/dΠ	ND	+	+	+	–	0	0
	*		*	*		*	

1) N = number of live children, I = full family income in period 2, Π = price of children, ND = not defined. For explanation of other symbols and remarks to column 5 see the footnotes to table 2.2.

Most of the results in table 2.4 seem plausible. The main results are: The optimal frequency of intercourse is higher the fewer children the couple have, the higher their income in the next period, and the lower the price of children. The optimal contraceptive effectiveness is higher the more children the couple already have, the lower their income and the higher the price of children.

We notice that the results are the same for the first four columns in table 2.4, including the most realistic situations 1, 3 and 4. The reason for this is that dS/dy, and de/dy have the same signs for the corresponding columns in table 2.2 , as discussed in subsection 2.9.3.5.

2.9.6 Conclusions

To conclude section 2.9: the equilibrium conditions (2.41) and (2.42) implicitly define the derived demand equations for the desire to have an additional child soon, contraceptive effectiveness and coital frequency:

(2.75) $y = y(N, I, \Pi;\ Z_y)$,

(2.76) $e = e(y, S, r;\ Z_e)$,

(2.77) $S = S(y, e, r;\ Z_s)$,

where Z_y, Z_e and Z_s are vectors of other exogenous variables.

From the theoretical analysis in this section we expect the following signs for the partial derivates of the endogenous variables y, S, and e, see tables 2.2-2.4 and expressions (2.69)-(2.74):

$dy/dN < 0$

$dy/dI > 0$

$dy/d\Pi < 0$

$dS/dy > 0$

$de/dy < 0$

$$dS/dr = -de/dr = \begin{cases} > 0 \text{ for } y > 0 \\ = 0 \text{ for } y = 0 \\ < 0 \text{ for } y < 0 \end{cases}$$

$dS/dN < 0$

$de/dN > 0$

$dS/dI > 0$

$de/dI < 0$

$dS/d\Pi < 0$

$de/d\Pi > 0$.

2.10 The Model Seen in a Wider Perspective. Additional variables and relationships.

2.10.1 Introduction

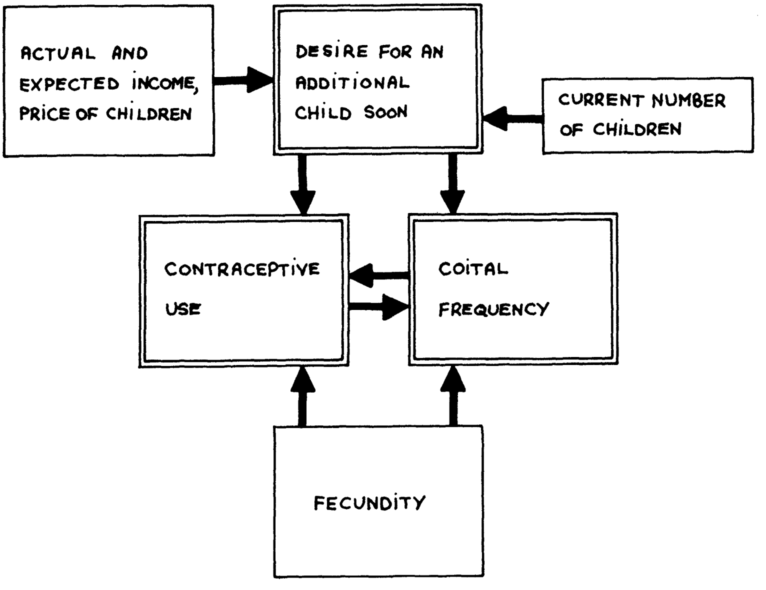
The model presented in the previous sections focuses on decisions about pregnancy, contraceptive use and coital frequency. The model is a short-horizon model emphasizing the sequential nature of childbearing decisions. An important characteristic of the model is that the uncertainty about pregnancy is introduced explicitly.

A path diagram of the model is shown in figure 2.16. The endogenous variables are the desire for an additional child soon, contraceptive use, and coital frequency. The exogenous variables - actual and expected income, price of children and current number of children - determine the desire to have an additional child soon. This desire, together with the perceived fecundity, determines simultaneously the use of contraception and the coital frequency, with the last two endogenous variables also affecting each other.

Although we believe that this model captures important features of childbearing decisions, it is a somewhat limited model that disregards many aspects of fertility. It may be argued, e.g., that people are usually not as short-sighted as assumed here. Long-term consequences of current behaviour are to some extent also considered.

There is no such thing as desired completed family size in a truly sequential model. Couples only have desires about whether they want an additional child soon or not. But there are reasons to believe that many couples have some idea - more or less in the back of their mind - about how many children they would want to have altogether.

Figure 2.16 Path diagram of theoretical model.



(The response to questions about desired, planned, intended or expected family size in numerous fertility surveys may be interpreted as an indication of this.) The point of the model is that desired family size is not decided upon once and for all, e.g. at the beginning of marriage as assumed in the Becker/New Home Economics type models of fertility. The desired total fertility is continuously revised, as a result of reproductive, contraceptive, marital, occupational, educational and other experience. Or, to use economic terminology, the optimal life-time number of children may change because the utility function and the budget constraint(s) may change over the life cycle.

In figure 2.17 we have indicated how the "pure" theoretical model can be extended by introducing additional variables and causal relationships. The "new" (and also the "old") variables can be divided into four categories:

1 <u>Factors in the budget constraint,</u>
i.e. factors affecting prices and variable resources.

Old variables: Current and expected income, price of children, number of children.

Other possible variables: Income and wage of each spouse, other prices (e.g. of childcare), time-use (if time-budget).

2 <u>Arguments of the utility function</u>

Old variables: Number of children, consumption, coital frequency, contraceptive use.

Other possible variables: Leisure time and leisure activities, sex composition of children, labour force participation, etc.

3 <u>Variables affecting the form of the utility function</u>

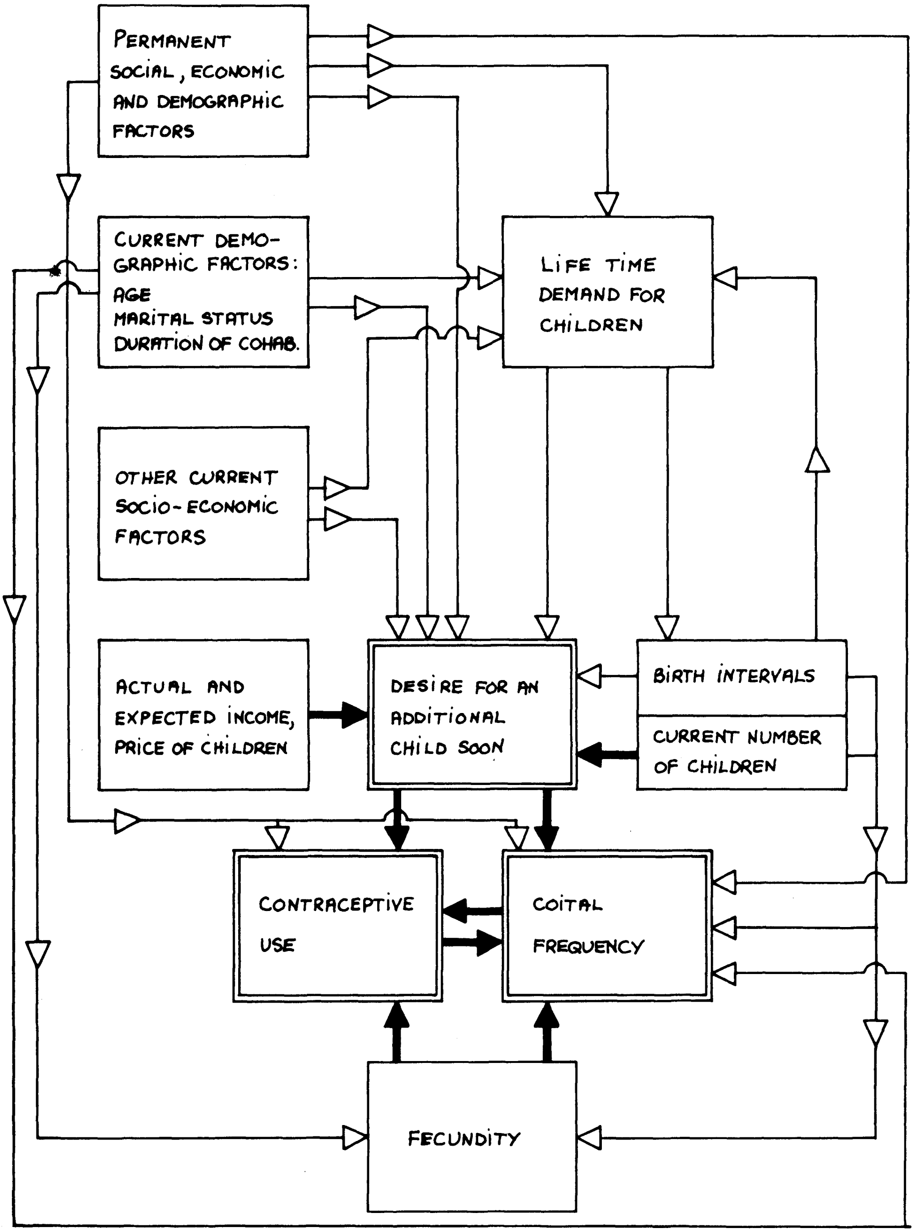
Old variables: None

Other possible variables: Age of both spouses, marital duration, marital satisfaction, length of birth intervals (in particular the open birth interval),

Figure 2.17 Path diagram of extended model.

Double frames: Endogenous variables of theoretical model

Thick lines: Causal relationships of theoretical model



education, occupation, labour force experience, number of siblings of both spouses and other family background factors, religious and political attitudes and practice, etc.

4 Variables having physiological and related effects

Old variables: Fecundity.

Other possible variables: Effects of age, parity and the open birth interval on fecundity, effects of age and marital duration on sexual desire, etc.

These four categories are not mutually exclusive. Some variables may work through several channels and appear in more than one category, e.g. parity, age and education. Other variables are difficult to classify. It may not be clear (and not very important either) whether a variable should be considered as an argument of the utility function or influencing the shape of it, as the length of the open birth interval.

Some readers may miss a fifth category, namely contextual variables, like urbanization and child-care opportunities. Such variables may be important, of course, but within the present framework we think of them as mainly affecting the form and perhaps also the arguments of the utility function.

It can be seen from figure 2.17 that we have distinguished between permanent and current factors. The permanent factors are constant - or change very little - throughout the reproductive cycle, and are believed to mostly affect the form of the utility function. Current factors are factors that are likely to change and they affect mainly the arguments of the utility function, but also the form of it, and the budget constraint, as well as having physiological effects. Note, e.g., that the life-time demand for children is influenced by current as well as permanent factors, and thus is classified as a current variable since it may change.

A survey of relevant permanent and current variables is given in the next section, together with their hypothesized effects on the endogenous variables.

2.10.2 Other Exogenous Variables and Their Effects

In this section we will discuss exogenous variables other than parity, income and price of children, and their hypothesized effects on the variables in the simplified theoretical model, see table 2.5. We will concentrate on the effects on the endogenous variables, i.e. desire for an additional child soon, contraceptive use and coital frequency, but also include effects on fecundity. In addition we will include effects on more traditional fertility measures, like children ever born, additional expected children and expected total family size, as we later also will estimate some traditional models of fertility for comparative purposes.

Table 2.5 lists the exogenous factors we are looking at and their hypothesized effects. Note that the first three variables - age, marriage duration and open birth interval - are all measures of elapsed time, namely time since birth, marriage and the woman's last delivery, respectively.

Note also that three of the exogenous variables are included in the theoretical model and as such were discussed in section 2.9: parity, income and price of children. The effects of these variables are given in table 2.4 but are included here as well. A possible effect of parity that was not captured by the theoretical model is also included, namely the direct effect on coital frequency.

Table 2.5 Hypothesized direct effects of exogenous variables

Exogenous factors	Desire for an additional child soon y 1	Coital frequency S 2	Contraceptive use M, e 3	Fecundity r 4	Children ever born CEB 5	Additional expec. fertility AEF 6	Total expected fertility TEF 7
Current demographic:							
A Age (of wife or husband)	∩	∩ or –	U or –	∩	+	–	+ ?
B Marriage duration	∩ or –	–	–?		+	–	+ ?
C Open birth interval	∩	∩ or +	+	+			
D Parity	–	–	+?	–			
Current socio-economic:							
E Income	+	+	–		+?	+?	+ ?
F "Price" of children (Woman's wage rate?)	–		+?		–	–	–
G Education	–?	+?	+		–	–	–
H Labour force participation	–				–	–	–
I Other activities	–				–	–	–
Ja Consumer aspirations	–				–	–	–
b Child quality standard ..	–				–	–	–
Permanent:							
K Family background							
a Number of siblings	+?				+		+
b Parent's education	–				–	–	–
c Mother's labour force participation	–				–	–	–
d Rural place of residence	+		–?		–	–	–
L Religiosity	+	–	–		+	+	+
Contextual:							
Ma Urbanization	–				–	–	–
b Child-care opportunities	–					–	–

U denotes U-shaped effect

∩ denotes an inverted U-shaped effect

Since we are interested in partial effects, it is often difficult to use results from other theoretical and empirical studies as hypotheses for the present analysis. Our y-variable, e.g., the desire for an additional child soon, has rarely been considered elsewhere, whereas children ever born and total expected fertility are frequently studied.

The hypothesized effect of a factor reported here is believed to be valid for individual couples, when all other factors are assumed to be constant (ceteris paribus). When data from a cross-section survey are used, however, the effects may be different across couples and cohorts.

All variables refer to the woman, if not otherwise stated.

Many of the variables and their hypothesized causal effects are given a rather cursory treatment, due to limitations of space and time. Instead, references are made to relevant literature.[1)]

A Age[2)]

Age is, besides gender, the most central demographic characteristic. It has well-known biological effects, and in addition it serves as an indicator of "social and cultural phenomena which influence an individual woman's fertility in a causal manner" (Pullum 1978:7). Age is a truly exogenous variable: nothing affects a person's age except the passing of time - when death is excluded. But the age of one person relative to another, e.g. the age of a woman's husband or her child, is influenced by a number of factors.

1) Since the work on this dissertation was began, several studies based on the Norwegian Fertility Survey have been published. We have not made any reference to these, however, since most of them appeared after the bulk of the dissertation was written, and also because we did not want to draw any hypotheses from the same sample as we were going to use for testing, see the discussion in section 5.1. For other results from the survey see Noack and Østby (1979, 1981), Østby (1982), and Central Bureau of Statistics (1981).

2) In the following discussion we discuss each of the exogenous factors in table 2.5 under the corresponding capital letter: A for Age, B for Marriage duration, etc. The effects on the various endogenous variables are discussed under the Arabic numerals in the columns in table 2.5. Thus, the effect of age on the desire to have an additional child soon is discussed in A1, etc.

A1 Desire to Have an Additional Child Soon

It seems reasonable to assume that this desire increases with age, ceteris paribus, to a maximum somewhere in the late 20's or early 30's and then goes down. Thus, we hypothesize that there is a curvilinear relation or an inverted u-shape. There may, of course, be exceptions to this. A woman may, e.g., approach the end of her child-bearing period and realize that she has not had as many children as she wants, with a resulting increase in y.

A2 Frequency of Intercourse

We believe that preferences for sex decline by the age of the woman for the ages we are interested in (above 18), perhaps with an initial increase.

Several sample surveys have found that coital frequency declines monotonically by age (James 1974, Westoff 1974, Leridon 1977, Trussell and Westoff 1980), whereas a maximum frequency between ages 25 and 35 are reported in other surveys (Zetterberg 1969, Hylland 1978). The problem with many of these results is that they do not control for the effects of other variables, like fecundity, duration of marriage, desire for additional children, and contraceptive use.

The negative association found by Westoff is retained when he controls for type of contraceptive method and fertility intentions, and marriage duration and age of husband (Westoff 1974, Trussell and Westoff 1980). He also looked at coital frequency by age of the <u>husband</u> and finds that it increases up to ages 20-24, and then declines. This relation persists when the wife is very young (below 20) but it becomes negative or irregular for older wives.[1] The irregulaties are probably due to small cell sizes.

Our conclusion is that empirical findings support our hypothesis about a negative relationship, and in some instances a curvilinear one, between the age of either the wife or the husband and coital frequency.

A3 Contraceptive Use, M and e

The direct effect of age on contraceptive technique and efficiency may work through several channels:

i) The woman may learn from her own and her spouse's experience with contraception, including contraceptive failures, health and other side effects. The higher the age the more reproductive and contraceptive experience she is likely to have had.

ii) Younger women may have had access to and information about other methods of contraception than older women when they were young and in an important learning stage, i.e. there is a cohort effect. An example is the introduction of the pill in the mid 1960's.

iii) Some methods have health or other side effects that make them less suitable for women of certain ages. Examples include the pill, which is not recommended for older women (particularly if they smoke), and the IUD which is not recommended for young women (particularly if they are nulliparous). (See Population Reports A-5 (1979) and B-3 (1979).)

It is not clear what the net effect of these age-effects is. The first point implies a negative relationship between age and contraceptive effectiveness, the second a positive relationship , whereas (iii) indicates a specific age-profile for each technique. The last point is supported by a number of sample surveys, see e.g. Westoff and Ryder (1977) and Grimsmo (1978). As mentioned previously, the problem

1) I am indebted to John Knodel for giving me copies of Westoff's unpublished tables and to Charles Westoff for allowing me to cite the results.

with such results is that they are usually not controlled for important variables, such as desire for more children and coital frequency.

A4 Fecundity

A number of studies show that female fecundity increases from puberty in the early teens to a maximum in the early twenties, and decreases afterward to zero in the late forties or early fifties (Leridon 1977). Thus, there is a curvilinear relation between age and fecundity. Although the age effect is strong there are considerable problems in estimating it. For methodology and estimates, see *inter alia* Sheps and Menken (1973), Bongaarts (1975), Leridon (1977), Bendel and Hua (1978).

A5 Children Ever Born

For a given woman, and for any cohort of women, there is a monotonically increasing relation between age and the number of children ever born. When we compare women from *different* cohorts, however, as in a cross-sectional survey, there may be exceptions to this pattern. If there has been a period of rapidly increasing fertility, e.g., younger women may have *more* children than somewhat older women.

A6 Additional Expected Fertility

The older a woman is the less additional children she expects to have, since she is more likely to have had the number of children she wants, and since there is less left of her reproductive period, and perhaps also because the desire for more children may decline because it becomes more strenuous to go through pregnancy, child-birth and child-care. Thus, this age-effect is partly a parity-effect and partly an effect of preferences about proper times for child-bearing.

A7 Total Expected Family Size

The effect of age on total expected fertility is ambiguous since it is a result of how many children a woman already has and how many more she expects to have. During a period of rapidly falling fertility, e.g., the relation with age may be positive. On the other hand, younger women may compensate for postponed childbirths by wanting more children than older women, thus arriving at more or less the same completed fertility.

B Marriage Duration

Duration of marriage (or cohabitation) and age are similar variables because they both measure elapsed time and because they have similar effects on many of the endogenous variables of the model, although they are conceptually very different, of course. It may be difficult to separate their effects since they are highly correlated. One difference between them is that marriage duration probably has no physiological effects *per se*. But the main reason why both variables are included is that everybody does not marry at the same age. Women who marry young, e.g., may share a quite different set of experiences than women who marry at an older age, both with regard to reproduction and otherwise. For a survey of issues and data on age at marriage and fertility see *Population Reports* M-4 (1979).

B1 Desire to Have an Additional Child Soon

It seems reasonable that this desire increases to a maximum some time after a couple marries or starts living together, and then declines. It may make a difference whether it is a first marriage or remarriage, but we believe that the duration effect is stronger in a first than in a later marriage, ceteris paribus.

B2 Frequency of Intercourse

The coital frequency is likely to be lower the longer a couple has lived together, since sex may become more of a routine and less of an exciting new experience. The quality of sex, however, may improve as the partners get to know each other better.

This negative relation with marriage duration is confirmed by results from the 1965, 1970 and 1975 U.S. National Fertility Studies (Trussell and Westoff 1980), although there are some irregularities when controlling for the age of the wife. This may be due to small cell sizes.

B3 Contraceptive Use

The pure duration effect on contraceptive use - as different from the age effect - may be that the longer a couple has been married the better they communicate. Thus, two partners who know each other very well may use traditional techniques like condom and rhythm with almost the same effectiveness as the pill and IUD. This should imply that the longer a couple has been married the less reliable method they would need to use, and that they would practice it more effectively. The net result on actual contraceptive effectiveness is unclear.

An effect related to marriage duration is the cohort effect mentioned previously. Women who married before or shortly after the modern methods of contraception were introduced did not have the same experience as women of the same birth cohort who married at an older age, for example.

B4 Fecundity

It is difficult to see how marriage duration *per se* can have any effect on fecundity, if we disregard voluntary sterilization.

B5-7 Actual, Additional and Total Expected Fertility

The effects of marriage duration on these variables are also similar to the age effects, and is primarily a parity-effect. The longer a couple has lived together the more children they have born, and the fewer additional children they expect, whereas the effect on total expected fertility is ambiguous.

However, women who married during the recent period of rapid fertility decline and were relatively old, have had fewer children than younger women who married at the same time, and they may also *expect* fewer additional children, resulting in a positive relation between duration and total expected fertility. Even if some of the decline was due to a postponement of births it is not likely that women who married late will catch up with the other women.

C Open Birth Interval

By the open birth interval we mean the time since the last child-birth. This is an important variable in the extended model, since our model is a short-horizon model where recent experience and current circumstances are important for decisions about the immediate future. Thus, we believe that it is primarily short open birth intervals that matter, i.e. less than, say, 5-6 years. Effects of long open birth intervals are difficult to distinguish from age and marriage duration effects.

C1 Desire for an Additional Child Soon

This desire is usually quite small right after a delivery, increases to a maximum between, say, 1 and 6 years, and declines thereafter. The desire may, of course, also decline monotonically after a child-birth, or remain constant, e.g. for couples that have made up their mind once and for all that they do not want any more children. For women who had their last child a long time ago an additional child would be much like having another first birth, with regard to the delivery in itself and since they are not able to take advantage of the economies of scale in childbearing.

C2 Frequency of Intercourse

It is recommended for medical reasons to abstain from intercourse for the first six weeks or so following a delivery. The frequency may also be relatively low for a longer period during infancy due to lack of sleep, privacy and time, and perhaps also due to hormonal and other changes associated with pregnancy, delivery, and breast-feeding.

C3-4 Contraceptive Use and Fecundity

Due to post-partum amenorrhea no contraception is necessary for some time after a delivery.[1)] The length of this period is highly variable, however. Thus, post-partum amenorrhea as a method of birth-control has a relatively low effectiveness that declines with time. It is well known, though, that the period of nonsusceptibility is greatly affected by breast feeding. Estimates of the mean duration of amenorrhea range from 1½ - 2 months for women who are not breast-feeding to as much as 2 years or more for long durations of breast-feeding (Leridon 1977). Once the nonsusceptible period is completed, the length of the open birth interval is not likely to have any effect on fecundity, since the age-variable should capture the effect of physiological ageing.

Thus, we hypothesize that there is a positive relation between the duration of the open birth interval on both fecundity and contraceptive use, at least for short durations, due to post-partum amenorrhea.

C5-7 Actual, Additional and Total Expected Fertility

The length of the open birth interval should have no separate effects on these three fertility measures when age and marriage duration are controlled for. There may be an exception to this, however, if there have been systematic changes in both spacing patterns and fertility over time.

D Parity

By a woman's parity, or number of children ever born, we mean the number of childbirths she has had. In a society where still

1) Sheps and Menken (1973:209) report a mean duration of 2-15 months of nonsusceptibility following a live birth.

births, infant and child deaths are relatively rare events, parity is practically the same as the actual number of children.

The effects of parity on the endogenous variables y, S and M, were discussed in section 2.9, see table 2.5. Parity is included here as well because there may be other effects that were not included in the model.

First, the number of children a couple has may affect the coital frequency via lack of time, energy and privacy.

Second, parity may have an effect on fecundity. We know, e.g., that intrauterine mortality increases with parity (Leridon 1977).

We now turn to variables of a less demographic and more economic and social character: income, price of children, education, labour force participation, family background etc. Let us first consider briefly the two variables discussed in section 2.9, income and the price of children.

E Income

In section 2.9 we showed that current family income has a positive effect on the desire for an additional child soon, and via this desire a positive effect on coital frequency and a negative effect on contraceptive effectiveness. Theoretical results such as these seem to be inconsistent with a number of empirical results, although there are also many examples of a positive or u-shaped income effect, see Andorka (1978). Several explanations have been suggested why negative income effects may be observed:

i) The negative price effect of the wage rate has not been taken into account.

ii) An inappropriate income concept has been used. Full life-time, permanent,or some relative income measure may be more appropriate than current income.

iii) Higher income is associated with higher education and a number of other factors that have a negative effect on the "tastes" for children

iv) The "price" of children is higher for high-income couples.

v) There may be differential information about contraceptive methods,as well as differentials in access, attitudes and use.

vi) Conclusions have been drawn from cross-section studies when longitudinal data should have been used.

vii) Income has been rising and fertility falling over time, but this relationship may be spurious.

Bearing these arguments in mind we should not be surprised to find negative income effects.

F Price of Children

By the price of children we mean the sum of direct and indirect money costs, including opportunity costs, implied by having children. There may be different "prices" of children in the same society, depending on people's standards for child quality. Parents may feel that they do not have much freedom in setting their own standards (See Blake 1968).

An important component of the price of children is the value of time. Since the traditional pattern is that the husband works full time whereas the wife works part time or not at all, it is the <u>wife's</u> actual or potential wage rate which is often used as a measure of the value of time, or the price of children. Empirical results (and theoretical as well) overwhelmingly show that the woman's wage rate is negatively related to both actual and intended fertility, see table 2.5.

On the other hand, we do not expect the woman's wage rate to have any direct effects on coital frequency and contraceptive use.

G Education

Education as a causal factor has a long tradition in both theoretical and empirical analyses of fertility. There are a number of problems with this variable, however:

First, the causality is not clear. There are a number of channels through which education may affect fertility. Cochrane (1979) argues in her excellent survey that individual education may have multiple effects via literacy (affecting access to information and a broader perspective); skills (affecting non-market efficiency and market opportunities); certificates (affecting status and non-market efficiency); socialization (affecting attitudes and behaviour patterns); the biological supply of children; the demand for children; and fertility regulation. Michael (1973) assumes that education influences fertility through money income; the value of time; proficiency of household production functions; indirect changes in relative prices; the utility function; and the length of the couple's time horizon. Schultz (1974b) argues that education of parents, notably that of the mother, may affect the choice of mate in marriage; parents' preferences for children; earnings of women who enter the labour market; the productivity of mothers in their household work including the rearing of their children; child mortality; and the ability to control the number of births.

Most of these effects point to a negative relation between education and fertility, and this conclusion is supported by numerous empirical results. There are, however, also examples of a u-shaped relation and even a few cases of a positive relation, see Andorka (1978). The problem with these findings is that they have not been controlled for variables that are positively correlated with the wife's education, like income, the husband's education and socio-economic status. In developing countries there may be an initial positive effect of education on fertility, due to better nutrition and health, see Cochrane (1979).

There are also other problems with the analysis of the relation between education and fertility. One important problem is that there is not always a unidirectional causal effect of education on fertility. Some women have little education because they started childbearing early, and consequently have many children. In the short run, however, as in our model, education can be taken as given.

Another problem is the definition and measurement of educational attainment. It is usually measured by duration of schooling. But education is not a one-dimensional variable. There are many kinds of education. The duration does not, e.g., take into account the quality of education. An important difference is between general and vocational education. Different types of education may have different bearings on reproductive attitudes and decisions.

A fourth problem is <u>whose</u> education is important in the fertility context: the woman's, the man's, or both? The education of the woman may have fertility implications that differ from the man's. Moreover, the education of the parents of the spouses may also be of importance.

Finally, not only individual education but also the community level of education may affect fertility, as pointed out by Cochrane (1979).

It falls outside the scope of this study to try to solve all these problems and separate all the different effects of education and the channels through which they work. We will only be concerned with the expected net effects on the endogenous variables of the model.

G1 Desire to Become Pregnant Soon

It is likely that there is a negative relation between education and this variable, because of the negative effects of education on fertility reported above. There may also be an additional effect in that more-educated couples may have preferences for shorter birth intervals. This should imply, ceteris paribus, a positive relation between education and y. But this effect is probably dominated by the negative effect via desired completed fertility. More-educated women are less likely to want more children at all, and consequenly less likely to want an additional child soon.

Thus, there seems to be one negative effect of education and one positive effect. The net effect on y is unclear, although we expect it to be negative and small. To study these effects it may be more appropriate to use education as an explanatory variable of expected completed family size and spacing patterns. Moreover, education is probably a more important determinant of contraceptive use and perhaps also of coital frequency, than of the desire for an additional child soon. We conclude that education should probably not be included as an explanatory variable of y.

G2 Coital Frequency

Excluding indirect effects, it is not obvious that education should have any effect on coital frequency. But there may be a positive effect of education since more-educated couples may communicate better about sexual matters.

G3 Contraceptive Use

There is overwhelming empirical evidence that more educated couples use contraception more extensively, and also that they use more effective methods. This is true for both developing and developed countries (Cochrane 1979, Michael 1973). The main reason for this is that more-educated couples have more information about and greater access to contraceptive methods and that they usually have more favourable attitudes towards birth control, *inter alia* because education improves communication between husband and wife.

Education may also affect the choice of specific techniques, not only the effectiveness and rate of use, because more-educated couples may be more knowledgeable and be more concerned about side-effects. In the U.S. for example, the diaphragm is mostly used by highly educated women.

G5-7 Actual, Additional and Total Expected Fertility

As mentioned above there is strong evidence for a negative effect of education on these three fertility measures. This effect is likely to be strengthened when cross-sectional data are used, since older women generally have less education than younger women.

Michael (1973) finds for the U.S. in 1965 a negative partial correlation between intended number of children and both the wife's and the husband's education. Examples of the negative relation between completed education and children ever born are common, including Rindfuss and Sweet (1977), Westoff and Ryder (1977) and Statistiska Centralbyrån (1979).

H Labour Force Participation

The relation between fertility and labour force participation is complicated to analyze, since both variables obviously affect each other. The classical question is: do women have few children because they want to work or do they work because they have few children? We are not going to attempt to answer this question here. In our short-horizon decision-making model this problem is less of a problem, since current labour-force participation can be treated as an exogenous variable. Decisions about future labour-activity depend on the outcome of current sexual and contraceptive behaviour.

There is abundant empirical evidence of a negative correlation between labour force participation and actual and intended fertility and we expect this to hold also for the desire to have an additional child soon.

I Other Activities

Other activities include non-market activities like reading, studying, sports, travelling, meetings, parties, etc. Since child rearing is very time-intensive it competes with these activities, and we expect a negative relation with actual fertility. Strong preferences for other activities may also be expected to have a negative effect on the desire to have an additional child soon as well as additional and total intended fertility.

J Consumption Aspirations and Child Quality Standards

These variables are measures of properties of the utility function. High aspirations for consumption means that consumption is given a lot of weight in the utility function, implying that relatively less utility is derived from children. Thus, consumer aspirations should have a negative effect on fertility (see e.g. Easterlin 1973).

However, as argued by many economists, there is a difference between the quantity and quality of children. (Becker 1960, Becker and Lewis 1973, Willis 1973). Couples with high child quality standards feel that children require large inputs of time, money, etc, and consequently they prefer a small number of children relative to couples with low standards. Becker (1960) argues that the income elasticity of child quantity is relatively small but positive and that the quality elasticity is positive and relatively large.

To sum up: We hypothesize that there is a negative association both between consumption aspirations and fertility and between child quality standards and fertility.[1)] We do not expect that these two variables have any direct effects on contraceptive use and coital frequency.

1) There are few empirical tests of these hypotheses. Thornton (1979) obtains rather mixed results. He found, *inter alia*, that child quality considerations which directly involve money are negatively associated while considerations which involve the mother's time are positively associated with family size. He also found that non-home consumption aspirations are negatively related to fertility whereas home aspirations are not.

K Family Background Variables

Family background and conditions while growing up are believed to be important for the formation of preferences. Easterlin (1973) argues for the influence of the material standard of living in the parent's home on later marital and reproductive behaviour. Others emphasize the number of siblings (Duncan et al. 1965); the education, occupation and labour force participation of the parents; and the childhood place of growing up, e.g. urban-rural (Westoff and Ryder 1977, Andorka 1978). Special attention has been devoted to the effects of growing up on a farm, which is shown to have a positive effect on fertility (Goldberg 1959, Duncan 1965).

The hypothesized effects of some background variables are given in table 2.5.

L Religion

Religious differentials in reproductive attitudes and behavior are well documented, see the references below. A number of theories have been proposed to explain these differentials, including pro-natalist doctrine, rejection of birth control, minority group membership including ethnocentrism, and cultural and socio-economic factors associated with belonging to a particular religious denomination. (Day 1968, Bouvier and Rao 1975, Chamie 1977, Westoff and Ryder 1977, Andorka 1978, Jones and Westoff 1979.)

In a country like Norway where 94 per cent of the population belongs to the protestant state church (Statistical Yearbook 1979:17), religious denomination cannot contribute much in explaining fertility differentials. There are, however, a number of small religious sects, and perhaps more important, there are great individual and regional differences in religious practice and the extent to which people identify with the church. Some parts of the country, particularly in south-western Norway, have long traditions in puritanic attitudes and life-style. The same region has also high fertility relative to the rest of the country (Berge 1978). Couples with such values may communicate less about reproductive matters. Moreover, use of contraception, and sex without intentions to have a child may be considered sinful.

Thus, we hypothesize that there is a positive relationship between religiosity, e.g. as measured by church attendance, and actual and expected fertility, and a negative association between religiosity and contraceptive use and coital frequency.

We hypothesize that there is a positive relation between religiosity, e.g. as measured by church attendance, and actual and intended fertility. Moreover, we expect a negative association between religiosity and contraceptive use and coital frequency.

M Contextual Variables

Contextual or community level variables may affect people's preferences for children, labour force participation, contraception, sex, etc. Examples include the general level of educational and cultural, religious and linguistic factors. (Cochrane 1979, Coale 1973).

A well-documented relationship is the negative effect of urbanization on fertility (Andorka 1978).

A factor that may be important for child-bearing decisions in Norway is child-care opportunities, which vary widely from county to county. The kindergarten enrollment ranges from 6 to 34 per cent of all children below 7 years of age (Statistical Yearbook 1979:337). Other childcare arrangements are expensive and often difficult to arrange.

The differences in kindergarten enrollment is both due to demand and supply. Oslo, for example, has the highest kindergarten enrollment in Norway, but the unmet demand may still be higher than in municipalities with considerably lower rates of enrollment. Therefore, we see no easy means of measuring child-care opportunities.

2.11 Does Uncertainty Matter? Concluding Remarks

The model presented in this chapter is based on the assumption that reproduction is a stochastic process. Couples usually cannot decide with certainty to have or not to have another child, they can only choose levels of coital frequency and contraceptive effectiveness which affect the probability of having a child. But is uncertainty really an important factor in decisions about sex and fertility?

What is the probability that a non-contracepting couple conceives, say, in one year? If we assume that the probability of conception in one month without any contraception is 0.2, the probability of conceiving within 12 months is as high as 0.93. Thus, a couple with normal fecundity who wants to conceive is almost certain to do so within a year. (The couple may not know their specific fecundity, however.)

Therefore, the model presented here may apply more to couples who do not want to become pregnant, than to couples who do. If a method with an effectiveness of 0.9 is being used, there is a chance of 0.22 of becoming pregnant within a year, which seems surprisingly high. If a method like the pill or the IUD is used, with effectiveness around 0.99, only 2 per cent of the couples would become pregnant in one year. But since couples using highly effective methods of contraception are more likely to have a higher frequency of intercourse (Westoff 1974), this percentage could increase to 5 per cent or more. Thus, even with very effective methods, the risk of becoming pregnant in one year is not insubstantial.

The risk of pregnancy increases with the length of the time period. Using a micro-simulation model, Hulka (1969) found that of 100 couples relying on diaphragm or condom after reaching a desired family size of 3 children, over 80 of them would have more children during the remaining 12 to 15 years period of fertile marriage. Even if a 99 per cent effective method was used, such as the pill or the IUD, about 30 of these couples would end up with more children than planned.

A factor that adds to the uncertainty in reproduction is foetal loss, which makes the probabilitiy of having a child smaller than the probability of conceiving. Cn the other hand, the possibility of induced abortion reduces the uncertainty in reproduction for couples not wanting to have a child soon. Introducing spontaneous and induced abortions into the model could be done using a multi-stage approach, but this would complicate the model substantially.

The conclusion of these illustrative calculations is that the risk of an undesired outcome can be high, but maybe more so for couples who do not wish to become pregnant than for chose who do. The resulting uncertainty may influence the timing and spacing of births, an aspect of fertility decision-making we have given little attention. Keyfitz (1977) argues that a good terminal contraceptive may shorten birth intervals, because when reproduction cannot be fully controlled any successful effort to lenghten intervals reduces the time at risk of unwanted births once a desired family size has been achieved.

In addition to the problems mentioned above, there are several more problems with the model, as discussed in the presentation, and undoubtedly a number of others as well.

We have had to make a number of simplifying assumptions, with varying degree of realism (some being quite unrealistic!) In spite of all this, the model seems to capture several important aspects of contraceptive and sexual behaviour as they are related to fertility decision-making. An indirect test of the realism of the model is the number of plausible implications that follow from it. Although the model perhaps is of the greatest interest from a theoretical point of view, it will be interesting to see how well it stands up when confronted with data (chapters 5 and 6), in spite of the problems with many of the variables used in the empirical analysis.

CHAPTER 3

DATA AND DESCRIPTIVE ANALYSIS

3.1 Introduction

To estimate and test the model presented in chapter 2 we use data from the Norwegian Fertility Survey 1977. This is the first national fertility survey in Norway[1]. The survey is part of the World Fertility Survey Programme, but the questionnaire is adapted for Norwegian conditions. Practically all questions recommended by the WFS are included, however.

The survey was carried out by the Central Bureau of Statistics and jointly financed by the Central Bureau of Statistics, the Norwegian Research Council for Science and the Humanities, and the Ministry for Administration and Consumer Affairs.

A random sample of about 5 000 women was drawn from the Central Population Register. The normal two-stage sampling procedure of the Central Bureau of Statistics was used. At the first stage a permanent set of 102 primary sampling areas was selected, with probabilities proportional to the population size in each area. At the second stage a sample of women (not households) was drawn from a register of all persons living in the primary sampling areas. The

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1) A fertility survey based on two counties only was carried out in 1972 on behalf of the Norwegian Family Planning Association, see Walløe et al.(1978).

selection probabilities in the second stage are constructed such that the sample becomes self-weighting. For details of the sampling procedure, see Central Bureau of Statistics (1977).

The sample was drawn from women born between 1 January 1933 and 30 September 1959, i.e. 18-44 years of age when the interviewing started in October, 1977. (Most of the interviews were obtained during October and November, 1977, but a few extended into 1978. The last interview was done in March, 1978). Both never married, currently married and previously married women were included.

Of the 5 047 women in the sample, interviews were obtained from 4 137, i.e. a response rate of 82 per cent. This is considered high for this type of survey in Norway (Noack and Østby 1981:50), especially since response rates have been declining in recent years (Thomsen and Siring 1980). A little more than half of the non-response (57 per cent) was due to refusals, whereas the rest was due to failure to find women at home or to locate women who had moved. All interviews were done by female interviewers.[1)]

A special effort was made to revisit respondents who were not interviewed at the first visit, which undoubtedly contributed to the relatively high response rate.

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1) For more information about the survey - design, interviewing, non-response etc. - see Noack and Østby (1981).

As in other surveys, the response rate varies according to characteristics like age and marital status, see Noack and Østby (1979). By matching population register and income data via the identification number, it was possible to study other characteristics of the non-respondents, see Thomsen and Siring (1980). It was found, e.g. that the mean number of live births is higher for respondents than for non-respondents, 1.57 and 1.19, respectively, 1.43 for the refusals. It was also found that the mean income is higher for respondents than for the non-respondents, 67 730 vs. 58 170 kroner.[1] Among the non-respondents, the mean income for refusals is 71 610 and for others 40 650. Refusals seem to be more similar to the rest of the population than the rest of the non-respondents.

Thus, not surprisingly, we see that non-response can cause seriously biased results. This is a reason for concern. There are methods to correct for this bias, but they still seem to be at an experimental stage, see Thomsen and Siring (1980)[2].

The fertility survey includes questions on

residence and household,
migration,
marriage and cohabitation history,
pregnancy history,
sexual activity,
contraceptive use (past and current),
preference for children,

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1) The differences between the means of the respondents and non-respondents are all statistically significant at the 1 per cent level, since the sample means are normally distributed in large samples. See Kmenta (1971: 137) for the appropriate test-statistic.
2) Another of their interesting findings is that the characteristics of the respondents vary with the number of calls necessary to obtain an interview. The mean number of births, e.g., declines from 1.84 for women interviewed at the first call to 0.75 for the eight call.

child care arrangements,
labour force participation,
education,
income, and
political and religious activity.

There was some apprehension in advance about a government agency asking questions of a sensitive nature, but the survey was carried out without serious problems.

The survey is described in more detail in Central Bureau of Statistics (1981), which contains a larger number of tables from the survey. Results from the survey are also reported by Noack and Østby (1979, 1981). Evaluation of interviewing and questions is given by Noack and Østby (1980, 1981).

In the following sections we discuss the data that are used in the empirical analyses in chapters 6 and 7.[1)]

Only married women are included in the analysis. Single women were excluded because we wanted to study the attitude and behavior of couples. We could have included women who cohabit with a man without being married, but we believe that this group of women differs from married women in several respects. The group is too small to merit a separate analysis (only 206 out of 4 137 women). Data on cohabitation without marriage based on the 1977 survey are presented by Brunborg (1979).

As explained in section 5.1, the econometric analysis is carried out separately for one quarter and three quarters of the sample,

1) All question numbers refer to forms 1 (all respondents) and 2 (married and cohabiting women), see Central Bureau of Statistics (1981). The translation of the questions is taken from the translation from Norwegian by the ECE (United Nations Economic Commision for Europe), GE 77-51181.

respectively. In the present chapter, however, we describe the data for both the full sample and each subsample.

3.2 Education

3.2.1 General

There were several questions about education in the survey. The respondents were asked about their general education (Q.106); other courses or education lasting at least 5 months (Q.107 and 108); whether they were taking an educational course at the time of the interview or planning to do so (Q.109), and if so what type of education (Q.110 and 111). The respondents were also asked about the completed general or other education of their husbands (or cohabitants).

There were even questions about the education of the parents of the respondents: the general education of the father (Q.122) and the general or other education of the mother (Q123-125).

Table 3.1 presents data on the education of the married women and their husbands for the full sample of married women. The non-response is a bit higher for the husbands, and the quality of the answers is probably not as high as for the women themselves.

We may add that the questions about education seemed to be among the most sensitive questions in the survey, and not the questions on sexual activity, as expected by many.

Table 3.1 Distribution and duration of highest completed education. Full sample of married women and their husbands.1)

Educational category	Duration in years 2)	Women Absol. freq.	Women Cumul. freq. per cent	Husbands Absol. freq.	Husbands Cumul. freq. per cent
7-year primary school or less	7	241	8.2	302	10.6
1-year continuation school	8	329	19.5	229	18.6
1-year folk high school ..	8	63	21.6	27	19.5
2-year continuation school	9	76	24.2	43	21.0
9-year primary school	9	121	28.3	59	23.1
2-year folk high school ..	9	43	29.8	15	23.6
Secondary school, lower stage	10	117	33.8	92	26.9
Vocational education, level I (3)	11	1 157	73.3	674	50.5
Secondary school, upper stage	12	127	77.7	77	53.2
Vocational education, level II	13	183	83.9	633	75.3
University level I (5) ...	14	347	95.8	367	88.2
University level II (6) ..	16	90	98.8	131	92.8
University level III (7) and post-graduate (8)	18	34	100.0	207	100.0
Missing		9		81	
Total		2 937		2 937	

1) The table presents frequency figures for the highest completed education, based on questions 106-108 for women and 112-114 for men. The numbers in parentheses show the first digit of the Norwegian Standard Classification of Education (Central Bureau of Statistics 1973). The educational categories with numbers in parentheses have been coded on the basis of the replies to Q.108 and 114, respectively, whereas the other categories are identical to the categories in the questionnaire (Q.106 and 112).

2) The duration of education is assigned on the basis of the length of education for pupils/students who proceed according to the normal schedule, see subsection 3.2.2. See also the footnote on the next page.

3.2.2 Duration of Education

The survey only gives data on the type of education, and nothing about when the education was taken or how long the actual duration was. Thus, there is no detailed registration of the educational history.

For some purposes, however, we are also interested in the duration of education, and not only the type of education. To get a proxy for this we use the normal duration of each type of education, see table 3.1.[1)] Very few persons complete their education in less than the number of years given in the table, whereas the proportion using more time is probably quite substantial. There may be many reasons why some people do not follow the normal pattern, inter alia part-time employment, childbearing, and taking more than one kind of education at the same level, e.g. upper stage secondary school (examen artium) and teacher training for kindergarten teachers. (We could have looked at general and vocational education separately and assigned a duration to each of them separately, but this would have been complicated and cumbersome. Besides, we have poor information about the duration of many types of vocational education.)

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1) After the analysis was completed, Lars Østby pointed out that some of the assigned durations of education deviate a little from the duration given in Central Bureau of Statistics (1973: 11,18), where Vocational education levels I and II are reported with durations of 10 and 11-12 years, respectively. We do not believe, however, that these differences have any appreciable effects on the estimates of the relationships between education and wage rate, income, fertility, sex, and contraception, respectively, to be presented later. Moreover, if we interpret the duration as a rank measure instead of a measure of the amount or quality of education, the differences do not matter at all, although it is difficult to rank vocational and general education of similar duration. It is also difficult to rank the 6 first categories in table 3.1, since the educational system has changed substantially in the last 20 years, affecting the young and old respondents differently.

We do not have any data on the duration of schooling by type of education for Norway, but data on the age-distribution of students completing an education indicate that a large proportion follow the normal schedule.

The normal schedule in Norway since the early 1970's is that children begin primary school in the fall of the calendar year they become 7 years old and attend 9 (or sometimes 10) years of compulsory primary school. Those who proceed to senior (upper stage) secondary school usually spend three years before they graduate. The system was a little different in the 1950's and 1960's, when there was 7 years of primary school, 2 (or 3) years of junior (lower stage) secondary school, and 3 years of senior secondary school. The normal duration of the highest general education has been 12 years throughout.

Among students completing the upper stage of secondary school (examen artium or similar) in the school year 1977/78, only 2.5 per cent were 17 years of age or below at the end of 1976, 59 per cent were 18, 25 per cent were 19 and the rest, 13 per cent, 20 or older. (Source: Central Bureau of Statistics 1978a). About half of these students had their next birthday before they finished their exams in June 1977. The figures indicate that very few of these students have less than 12 years of schooling, and that the majority have 12 years. Some of the 19-year olds may have had 13 years of schooling, however.

We have also looked at the age distribution of students completing a university level education in the first half of 1971. Among those completing level I, about a third of the students were 21 or 22 at the beginning of the year, which implies that they had approximately 14 years of education. For level II, a little less than a third were 23 or 24 at the beginning of the year. Among those completing level III, a little more than half of the students were 25-29 years old. The figures are almost identical for men and women. (Source: Central Bureau of Statistics 1972:125).

We conclude that there seems to be some variation in the duration of education but that a substantial proportion follows the normal schedule. This proportion decreases as the (normal) duration of education becomes longer.

3.3 Work Experience

The fertility survey does not contain a complete labour force participation history. In particular, we do not know the total duration of work experience of each woman. It is, however, possible to estimate this on the basis of certain questions in the survey.

Each respondent was asked how many hours she worked last week (Q.66) and in the past 12 months (Q. 71 or 77); and how many years of gainful work she did after she married or started cohabiting for the first time (Q.85). She was also asked whether she worked before the birth of her first child (Q.86), between the births of the first and second child (Q.87), between the two last births (Q.88), and since the last birth (Q.89).

As a work experience measure we constructed a variable which equals the number of years worked after the first marriage or cohabitation started (Q.85)[1] plus the number of years worked between the normal age at completing the highest education (see 3.2.2.) and age at first marriage/cohabitation, assuming that all women who have completed their education and do not live with a man work.

This procedure results in a non-missing value for 89 per cent of the cases, with a mean of about 9 years of work experience.

3.4 Wage

3.4.1 Actual or Potential Wage

All employed respondents were asked about their current wage rate in kroner per hour (Q.139a). Women who did not respond to this were asked about their average gross monthly earnings (Q.139b) and how many hours per week they usually work (Q.139c).

On the basis of these questions, an actual wage variable was coded as the reply to Q.139a or their monthly earnings divided by four times their weekly hours of work[2], see line A in table 3.2.

1) This question was meant to cover the duration of labour force activity regardless of whether the woman worked part time or full time. Some respondents misunderstood this, however, and gave an estimate of the number of complete work-years instead. Some respondents replied the number of years they had worked since their first marriage and not since they started to live together with a man for the first time. (Noack and Østby, 1980:65). Women who had worked since their first marriage/ cohabitation but answered zero years, were assigned a value of 0.25 year, since women who had worked for 6 months or more probably answered one year. Women who had worked so little and so irregularly that no estimate could be given of the number of years were treated as missing.

2) Values were rounded to the nearest integer. Values greater than 96 kroner were set equal to 96 kroner.

Women who were not working at the time of the interview, were asked about their potential wage rate: "If your were to take up gainful work now, how much do you think you could earn per hour?" Women who did not answer this question were asked "Do you know how much you could earn per month in a full-time job?" (Q.80).

For these women we coded a potential wage variable as the hourly earnings or as the monthly earnings divided by 146 hours[1)], see line B in table 3.2.

This approach should avoid the Heckman-Gronau sample selection bias, namely the bias that arises when wage functions are estimated on non-randomly selected samples, e.g. when they do not include non-working women. (See Gronau 1974, Heckman 1979, and the papers in Smith 1980.) It would be possible to test whether this sample selection bias is avoided, but doing this properly would require estimation of the probability of working using the LOGIT or PROBIT methods, which were not available to us.

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1) 146 hours is the average number of hours worked per month in 1977 by government employees working full time (1 750 hours per year), including four weeks paid vacation, but not including lunch breaks. Some groups of employees work slightly more.

Table 3.2 Wage and income variables. Quarter and three-quarter samples

Variable	Quarter sample (734)		Three-quarter sample (2203)	
	Number of non-missing cases	Mean value (kroner)	Non-missing cases	Mean value
1. Wage of woman				
A. Actual wage	393	27,46	1 196	28.36
B. Potential wage	150	27,54	430	27.31
C. Observed wage (A orB).	543	27.48	1 626	28.08
D. Predicted wage as a function of education and work experience	651	27.39	1 972	27.66
E. Estimated wage (C or D)	705	27.11	2 102	27.61
2. Full income of woman				
F. Estimated wage (E) * 1 750	705	47 438	2 102	48 325
G. Full income (= E or maximum of E and income in 1976)	706	47 964	2 114	48 729
3. Income of husbands				
H. Actual income in 1976	592	66 290	1 790	68 026
I. Predicted income as a function of education and age	712	66 272	2 143	67 642
J. Estimated income (H or I)	726	66 133	2 184	67 677
4. Full income of couple				
K. Observed wife's wage * 1 750 + Actual income of husband (C·1 750 + H)	450	114 536	1 384	116 424
L. Estimated wife's wage * 1 750 + Estimated income of husband (E · 1 750 + J)	699	113 618	2 102	115 801
M. Maximum of L and couple's combined income in 1976	700	113 578	2 102	115 858

It is interesting to note that the means of the actual and potential wage rates are almost identical, see lines A and B in table 3.2.[1] This indicates that non-working women have a fairly realistic idea about how much they would earn if they were to work, and that the sample selection bias may be small.[2]

Since we want to analyse the fertility behaviour of all married women, regardless of whether they work at the time of the interview or not, we pool the working and non-working respondents. Line C in table 3.2 shows the mean value of the wage variable for each group and the two groups combined, as well as the number of non-missing cases for each group.

However, even after this pooling, the wage rate is still missing for 26 per cent of the respondents. This would cause more than a quarter of the cases to be deleted when the wage variable is included in a regression analysis, i.e. a substantial loss of efficiency.

This means that the variance of the estimators would be greater than if a larger sample were used, and that we would get more imprecise estimates of the relationships we are interested in.

Another problem with the missing observations is that there

1) The mean values of the actual and potential wage rates for the full sample are 28.14 and 27.37, respectively. These mean values are not significantly different at the 10 per cent level, assuming that the means are normally distributed and employing the test referred to in section 3.1 (test-statistic = 1.54, cf. Kmenta 1971: 137).
2) The range of wages is smaller for the potential than for the actual wage, however, 15-80 kroner and 1-96 kroner, respectively. The smallest and largest actual wage rates may be the result of the division of monthly earings by monthly hours worked. Teachers, e.g., get relatively high rates by this procedure.

may be a selection effect in that women with missing wage data are atypical with respect to fertility and other variables. Omitting the non-respondents from the analysis may introduce a bias into the results, but this bias depends on the effect of the omission on the dependent variables. If the distribution of the dependent variables is approximately unaffected by the omission, then there is no reason for a great concern.

One way of increasing the efficiency is to impute the wage rate for the missing cases, e.g. by estimating the wage rate as a function of education and labour force experience. On the other hand, replacing the missing wage values by imputed values may introduce another bias, see Kmenta (1979). We believe, however, that replacing the missing values by imputed proxies lead to a lesser bias than omitting the observations altogether. The respondents with missing wage values do not appear to be very different from the other respondents.[1] Although we do not have firm evidence about the magnitude of the biases introduced by omitting cases or by using imputed values, we believe that the improvement in efficiency[2] is important since the number of observations is relatively small for the quarter sample, especially when we study subgroups of the quarter-sample like only fecund women who expect more children. We will, however, estimate some relationships using

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1) One example of this is that the mean imputed wage for the quarter sample respondents with missing wage values is 25.87, which is only slightly lower than the mean observed wage of the other respondents, 27.48.

2) Kmenta (1979: 236) gives a formula for computing the loss of efficiency due to missing measurements. This involves an estimate of the variance-covariance matrix which was not available with our version of SPSS.

both approaches.[1)]

3.4.2 Wage as a Function of Education and Work Experience

The wage rate of a person depends on a number of factors, among which education and labour force experience are the most important, i.e.

$$W = f(E,X) + \varepsilon, \tag{3.1}$$

where W = wage rate,

E = educational attainment,

X = work experience, and

ε = an error term that is assumed to be normally distributed with zero expectation and constant variance.

It is generally believed that the higher the educational attainment and the longer the work experience, the higher is the wage rate. There may be non-linearities and interaction effects, however, and to allow for these we do a Taylor series expansion of (3.1) and keep the second-order terms:

$$W = a_0 + a_1E + a_2E^2 + a_3EX + a_4X + a_5X^2 + \varepsilon; \tag{3.2}$$

where the a's are constants.

1) Compare, e.g., tables 5.2 and 5.3 in chapter 5. When imputed values are included as in table 5.2 but not in table 5.3, observations increase by more than 50 per cent (from 352 to 541) and the standard errors of the coefficients decrease by 15-25 per cent. The estimates of the coefficients do not change much.

As a measure of educational attainment we use an estimate of the duration, see subsection 3.2.2. The construction of the work experience variable is explained in section 3.3.

The ordinary least squares estimates of equation (3.2) are presented in table 3.3 for both the quarter and the three-quarter samples, including both working and non-working respondents.[1] Looking at the results for both sub-samples we notice that all coefficients have the same signs, except the work experience variables, X and X^2. Moreover, all coefficients are significantly different from zero at the 1-per cent level, except X^2 and X, respectively.[2]

The estimates of the coefficients differ perhaps more than expected. We can test for the equality of the two regression equations by testing the null hypothesis that the coefficients are equal against the alternative that they are different, see Kmenta (1971: 373). To do this we need the sum of squares of the least squares residuals from the OLS regression of equation (3.2) with data from the quarter sample, the three-quarter sample, and the full sample, respectively. The test-statistic, which is F-distributed with 6 and 1973 degrees of freedom, is equal to 2.45, and the null hypothesis about equality is not rejected at the 10 per cent level. Thus, we conclude that the two equations are

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1) Since there are errors in the explanatory variables E and W, the OLS estimators of the coefficients are inconsistent (Kmenta 1971: 309).

2) Assuming homoskedasticity, it follows by the central limit theorem that the disturbance term is asymptotically normally distributed, and we may use the F-distribution or the t-distribtuion to test hypotheses about the coefficients, see Dhrymes (1970) and Theil (1971).

equal and that the two subsamples come from same population. The differences between the estimates may be due to multicollinearity. The correlation coefficient between E and E^2 is 0.99, and between X and X^2 0.95. The square terms should, therefore, perhaps have been deleted. It is, however, standard procedure to introduce square terms in an equation like (3.2), and multicollinearity is rarely mentioned at all.

Table 3.3 Regressions of woman's wage on education and work experience[1]. Quarter and three-quarter samples.

Explanatory variable	Quarter sample		Three-quarter sample	
	Coefficient	Stand.error	Coefficient	Stand.error
Constant	65.56		31.65	
E (Education) .	-8.87**	1.58	-3.50**	0.87
E^2	0.4429**	0.0594	0.2428**	0.0343
EX	0.1378**	0.0427	0.0326	0.0201
X (Experience)	-1.03*	0.62	0.40	0.29
X^2	0.0067	0.0122	-0.0164**	0.0067
Number of observ.	489		1 496	
R^2	0.354		0.309	
F-value	52.97**		133.00**	

1) OLS estimation of equation (3.1).
E = duration of education in years
X = work experience in years
*) Coefficient is significantly different from zero at 10 per cent level.
**) Significant at 1 % level.

Because of the non-linearities it is difficult to hypothesize about the sign of the coefficients. In table 3.4 we have computed the predicted wage, and the wage elasticities, for different combinations of the minimum, mean, and maximum values of education and work experience. The table is only calculated with the quarter sample results, since we first use the quarter sample for exploratory purposes. The results are quite similar for the three-quarter sample, however.

Table 3.4 Predicted wage and elasticities of wage (with respect to duration of education and work experience)[1]. Quarter sample of married women.

E	X	W	$El_E W$	$El_X W$
7	0	25.17	-0.74	0.00
7	8.8	29.79	-0.34	0.33
7	30.0	83.51	0.12	1.42
10.3	0	21.19	0.12	0.00
10.3	8.8	29.80	0.51	0.46
10.3	30	93.17	0.49	1.42
18	0	49.40	2.58	0.00
18	8.8	67.35	2.21	0.34
18	20	105.21	1.68	0.79
18	30	153.21	1.32	1.07

1) E = Duration of education, in years
X = Work experience, in years
W = Predicted wage rate, in kroner per hour

$El_E W = \frac{\partial W}{\partial E} \cdot \frac{E}{W} = (a_1 + 2a_2E + a_3X)\frac{E}{W}$: elasticity of wage with respect to duration of education.

$El_X W = \frac{\partial W}{\partial X} \cdot \frac{X}{W} = (a_4 + 2a_5X + a_3E)\frac{X}{W}$: elasticity of wage with respect to work experience.

The results should be interpreted with care, however, and particularly for extreme and unrealistic combinations of E and X. To repeat some of the problems with the regressions: there may be multicollinearity; neither E nor X are directly observed but imputed from other information;

the wage variable is partly based on actual and partly on potential values, and it is truncated at 96 kroner per hour.

We notice in table 3.4 that the wage elasticity with respect to education is negative for very low values of E and X. This is probably an artifact of the estimation, since such combinations of E and X are rare. Only older women in the sample have had as little as 7 years of schooling and it is quite unlikely that they have no work experience at all. Another unrealistic combination is 18 years of education and 30 years of work experience, since the oldest woman in the sample is only 44 years of age. (The longest a 44-year old woman with 18 years of education can have worked is about 20 years.)

The elasticity with respect to work experience is positive everywhere, and below unity except for women with very long work experience (30 years).

Which has the strongest effect on the wage rate, one additional year of education or one additional year of work experience? We see from table 3.4 that the answer to this depends on the amount of education and work experience the woman already has. Somewhat surprisingly, education has a considerably stronger effect than work experience at high levels of education, whereas the pattern is more irregular at lower levels of education.

3.4.3 Estimated Wage

In spite of the problems with estimation of the wage equation we conclude that it yields satisfactory results and that it is appropriate to use the results to predict the wage for women with missing wage data.

When we use the estimates in table 3.4 to impute the wage for all women with non-missing data on education and work experience, we get the values in line D in table 3.2[1]. These predicted wage rates are used for women with a missing observed wage rate (line D in table 3.2). This procedure reduces the proportion of missing cases from 26 to less than 5 per cent[2]. The mean value is only slightly reduced (line E in table 3.2).

3.5 Full Income of Women

The full income of women is set equal to the wage (actual, potential, or predicted) times 1 750[3], see line F in table 3.2. For women with missing wage data we use their reported 1976-income. If our estimate of the full income is lower than her 1976-income we use the 1976 income instead, to get a better measure of the income potential of the women.

This procedure yields a mean income of about 48 000 kroner per year (line G), ranging from 1 750 to 168 000 kroner.

3.6 Income of Husbands

3.6.1 Observed Income

Each respondent was asked the following question: "About how

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1) The lowest and highest predicted values for the quarter sample are 21.27 and 64.59 kroner, respectively. This range is, as expected, considerably smaller than the observed range, 1 to 96 kroner.
2) The cause of the remaining missing cases is that education and/ or work experience are missing for some women.
3) See the second footnote in subsection 3.4.2.

much was your net income in 1976 before tax?" (Q.136). She was also asked a similar question about her husband's/common-law husband's net income in 1976 (Q.137). Women whose income was jointly assessed with their husbands were asked about the couple's combined net income in 1976 (Q.138).

There are reasons to believe that the income questions were misinterpreted by many respondents and interviewers as gross income, i.e. income before deductions and taxes, and not as net income, i.e. income after deductions but before taxes, see Noack and Østby (1980) and Siring (1980). This is not a serious problem for our analysis, although net income probably is a better indicator of economic resources than gross income. The most important reason for the difference between the two income concepts is probably interest on housing loans, which is deductible.

3.6.2 Income as a Function of Education and Age

The income of the husbands of the respondents was reported for 81 per cent of the cases, see line H in table 3.2. To reduce the number of missing cases we estimate the income of the men as a function of educational attainment and age, in the same way as we estimate the women's wage (section 3.4). Age is used as a proxy for work experience since we have no data on this in the survey, and since it is relatively uncommon for men neither to work nor to be undertaking an education (except during the compulsory military or conscientious objection service)[1]. We could have used age minus duration of education minus seven (age at beginning of primary school) as a proxy for work experience, instead of age, but econometrically this would not have made any difference. (Substituting X=A-E-7 in equation 3.1 and expanding yield coefficients which are unique functions of the coefficients in equation 3.2.)

The results from the estimation of the quadratic form (3.2) are shown in table 3.4. The fit seems quite good, especially for the

Table 3.5 Regressions of husband's income on education and age[1]. Quarter and three-quarter samples.

Explanatory variable	Quarter sample		Three-quarter sample	
	Coefficient	Stand.error	Coefficient	Stand.error
Constant	50 780		50 707	
E (Education) ...	-10 397**	3 589	-11 197**	1 725
E^2	126	103	203**	53
EX	271**	56	254**	26
X (Age)	2 779*	1 366	2 839**	678
X^2	-68**	15	-65**	8
Number of observ.	578		1 749	
R^2	0,16		0.26	
F-value	21.0		122.5	

1) OLS estimation of equation (3.2), where
E = duration of education in years,
X = age in years.
*) Significant at 10 % level
**) Significant at 1 % level

1) Among the 2 937 husbands in the survey, only 87 did not have gainful work at the time of the interview. Among these men, the majority, 48, were students. Among the rest, 17 were drawing a pension (old age or disability), 9 were doing military service, 5 were unemployed and 4 were working at home.

three-quarter sample, where all coefficients are significant at the 1 % level. The estimated coefficients are very similar for the two subsamples, while the standard errors are much smaller for the larger sample, of course. (The equality of the two equations could be tested using the same test as in subsection 3.4.2)

Table 3.6 Predicted income and income elasticities of husbands with respect to duration of education and age. Quarter sample.

	E	A	I	$El_E I$	$El_A I$
	7	19	48 471	-0.50	-0.11
	7	35	64 535	0.09	-1.33
	7	64	4 911	12.42	-83.42
	11.2	19	36 061	-0.75	-0.30
	11.2	35	70 336	0.30	-1.36
	11.2	64	43 720	2.50	-9.79
	18	19	25 393	-0.50	-0.77
	18	35	89 153	0.73	-1.26
	18	64	115 978	1.78	-3.95
Observed values of quarter sample:					
Minimum	7	19	1 000		
Mean	11.2	35	66 290		
Maximum	18	64	300 000		

E = duration of husband's education, in years
A = age of husband, in years
I = income of husband, in kroner per year
The elasticities are explained in the footnote to table 3.4.

Table 3.6 presents the predicted income and the income elasticities for various combinations of education and age. Again, the results should be interpreted with care, especially for extreme values of E and A, and in particular high age. We see that the effect of age on income is positive except for high ages. The value of the elasticity with respect to age declines with age. The effect of education is positive except for low ages.

Using the predicted values for respondents with missing data on husband's income (but with non-missing data on his age and education) reduces the mean income slightly, and increases the number of observations substantially, see lines H-J in table 3.2.

3.7 Full Income of Couple

By full income of the couple we mean the income they would have if both worked full time, i.e. their maximum income potential. Since practically all men work full time, we define the full income variable as the full income of the woman plus the actual income of the husband.

If we only use cases with non-missing values on both these variables we get a value for only 60 per cent of the cases, see line K in table 3.2. If we include cases with predicted income values, the proportion of missing cases drops to only 5 per cent. Finally, we use the couple's combined reported income in 1976 if it is greater than the previous full income or if the full income is missing, see line M in table 3.2. This results in a full income variable with a mean value of about 115 000 kroner per year, ranging from 18 500 to 347 250.

3.8 Fecundity

All non-pregnant married women in the sample were asked about their fecundity: "Do you believe it is possible for you and your husband/common-law husband to have a child (children) now or later if you should so wish?" (Q.36), yielding the following distribution:

Table 3.7 Perceived fecundity. Full sample

	Absolute	Per cent
Yes/I believe it is possible	2 258	76.9
No/I do not believe it is possible	371	12.6
Do not know	116	3.9
Not stated	18	0.6
Question not asked (pregnant)	174	5.9
Total	2 937	100.0

This question is an attempt to measure the perceived or subjective fecundity of the respondents. As such it has certain weaknesses: there are too few response categories, in reality only "Yes" and "No". In addition there should have been alternatives expressing subfecundity or uncertainty, e.g. "Probably yes, but I am not quite sure" and "Probably no, but I am not quite sure".

Noack and Østby (1980:37-38) report that the fecundity question was misunderstood by some respondents as a question about desired or expected (additional) fertility, or as a question about whether they ought not to have more children (for health reasons).

All respondents who answered no to this question were unfortunately screened away from questions on the attitude towards becoming pregnant (see section 3.9) and current use of contraception.[1] It is

1) About half of the women who believe they cannot have (more) children are sterilized themselves or their husbands are sterilized.

evident from the questionnaires, however, that some of these respondents use contraception, either for medical reasons, or perhaps because they were uncertain about their infecundity. Some may have misunderstood the question.

These problems reduce the value of the fecundity question for our analysis. In the model developed in chapter 2, perceived fecundity is a continuous variable, whereas the survey yields a dichotomous variable with measurement errors. Moreover, the question is used to screen out some respondents that we would have liked to include in our analysis.

3.9 Actual and Expected Fertility

All pregnant or fecund respondents ("Yes" or "Do not know" to Q.36) were asked: "Do you expect to have a child (additional children)?" (Q.57), yielding this distribution:

Table 3.8 Expectations about additional children. Full sample

	Absolute	Per cent
Yes	810	27.6
No	1 357	46.2
Do not know	379	12.9
Not stated	20	0.7
Question not asked (infecund) ..	371	12.6
Total	2 937	100.0

Respondents who answered yes to this question were then asked: "How many children do you expect to have altogether?" (Q.59). The answer to this question is the total expected fertility variable, TEF, for fecund women. For other women, TEF is set equal to the number of live births, CEB (children ever born), as constructed from the pregnancy history (Q. 25-28). Subtracting CEB from TEF yields the additional expected fertility, AEF.

A dummy variable for child expectations is constructed by setting it equal to unity if the respondent expects to have more children and zero otherwise.

Table 3.9 Live children, children ever born, additional and total expected fertility. Full sample

Number of children	Absolute: Live children	Children ever born	Add. exp. fert.	Total exp. fert.	Relative (per cent): CEB	AEF	TEF
0	337	333	1 728	76	11.3	58.8	2.6
1	613	606	412	181	20.6	14.0	6.2
2	1 141	1 118	236	1 067	38.1	8.0	36.3
3	563	576	70	801	19.6	2.4	27.3
4	207	222	3	244	7.6	0.1	8.3
5	55	61	0	59	2.1	-	2.0
6	16	16	1	16	0.5	0.0	0.5
7	1	0	0	0	-	-	-
8	3	4	0	4	0.1	-	0.1
9	0	0	0	0	-	-	-
10	1	1	0	1	0.0	-	0.0
11	0	0	0	0	-	-	-
12	0	0	0	1	-	-	0.0
Missing	0	0	487	487	0.0	16.6	16.6
Total	2 937	2 937	2 937	2 937	100.0	100.0	100.0
Mean	1.98	2.01	0.45	2.51			
Stand.dev.	1.21	1.23	0.78	1.06			

The distribution of the fertility variables are shown in table 3.9. In addition to CEB, AEF and TEF, we have included the number of live children. We see that its distribution is very similar to live children ever born. The difference is due to child mortality. Adopted children are not included in the number of live children. We notice that very few women do not expect to have any children at all.

3.10 Attitude Towards Becoming Pregnant Next Month

This variable is crucial, as it is used as a proxy for the attitude towards becoming pregnant soon, y in chapter 2, and thus is used as a dependent variable in several regression analyses, see chapter 5 and 6.

Table 3.10 Attitude towards becoming pregnant next month. Full sample

	Assigned value[1)]	Frequencies Absolute	Per cent
I should be glad	+2	330	11.2
Should think it was all right	+1	346	11.8
I should have mixed feelings ..	0	847	28.8
I should regret it	-1	500	17.0
I should feel that it was a disaster	-2	262	8.9
Do not know	Missing	71	2.4
Refuse to answer	"	2	0.1
Not stated	"	34	1.2
Question not asked[2)]	"	545	18.6
Total	"	2 937	100.0

1) Value used in regression analysis
2) Pregnant (174) and infecund (371) respondents

As mentioned in section 3.8, all women who think they are fecund, or who do not know, were asked "How do you think you would feel if you should become pregnant in the course of the next month?" (Q.39).

There are several problems with this question. First, it yields an ordinal variable. This is primarily an econometric problem which will be discussed in chapter 4. Second, it is not certain that respondents giving the same answer to this question have equally strong feelings about their attitude towards becoming pregnant next month. This is a general problem of measurement theory that we can not go further into here. Third, the question is hypothetical and it is not obvious what it measures. Fourth, some respondents may have misunderstood the question. Experiences from the field work indicate that several respondents would apply to have an abortion if they were to become pregnant, and thus may have reported their attitude towards having an abortion instead, whereas women who were using the IUD or the pill may have been concerned about possible health effects on the baby from a pregnancy while using the method (Noack and Østby 1980). Fifth, some respondents may have had a time horizon that differs from one month.

In spite of these possibilities for misinterpretation, most respondents gave answers that are consistent with the replies to other questions, for example the question on additional fertility and desired next birth interval, which will be discussed below. Stating to be happy if pregnant next month is not the same as actually wanting to become pregnant and having another child. Some respondents reveal an ambivalent attitude towards having more children, see table 3.11.

Table 3.11 Attitude towards pregnancy next month by expectation about additional children. Per cent. Quarter sample

	n	Expect more	Do not expect more	Do not know	Missing expectations
Happy	78	33.9	2.6	14.0	0
All right	89	24.4	8.1	24.7	0
Mixed feelings ...	209	23.8	42.4	40.9	1
Regret	128	12.5	30.1	15.1	0
Disaster	66	5.4	16.8	5.4	0
Total	570	100.0	100.0	100.0	
n	570	168	309	93	
Missing pregnancy attitude		25	29	11	98

We see that 10.7 per cent of the women <u>not</u> expecting more children have positive feelings towards pregnancy, and fully 42.4 per cent have mixed feelings. (Remember that these women do not include women who think they are pemanently infecund.) This contradiction may be due to misunderstanding or misinterpretation of the question, or that some women find it unrealistic to have more children, e.g. because they are old, but that they would still feel positively about a pregnancy. On the other hand, there is no inconsistency between expecting more children and having negative feelings about becoming pregnant next month, as 18 per cent of them do, since many women do not want the next child so soon. Only 22 per cent of those expecting more children want it within one year (and 41 per cent in 1-2 years), see table 3.12.

Table 3.12 Attitude towards pregnancy next month by desired next birth interval for women expecting more children. Per cent. Quarter sample

	n	Within a year	1-2 years	3-4 years	5 or more	No plans
Happy	57	73.2	32.9	7.9	0.0	9.1
All right	41	26.8	27.1	21.1	0.0	27.3
Mixed feelings	40	0.0	30.0	31.6	25.0	45.5
Regret	21	0.0	8.6	23.7	50.0	18.2
Disaster	9	0.0	1.4	15.8	25.0	0.0
Total	168	100.0	100.0	100.1	100.0	100.1
n	168	41	70	38	8	11

The table shows that there is a high degree of consistency between when women want their next child and their attitude towards becoming pregnant. Positive feelings towards a pregnancy next month are observed among all women preferring to have their next child within a year and among nobody of those preferring it in 5 years or more.

There is some inconsistency between the pregnancy attitude and contraceptive use, in that some respondents who answered that they had positive feelings towards becoming pregnant next month, nevertheless used contraception, see subsection 5.5.4 (table 5.14).

Our conclusion is that the question about the attitude towards becoming pregnant next month seems to have worked fairly well, and that it may be used as an indicator of the attitude towards becoming pregnant soon.

3.11 Frequency of Intercourse

There were several questions in the survey about sexual activity:

1) whether the respondent has any experience of sexual intercourse (Q. 35),
2) age at first intercourse (Q. 36),
3) whether the respondent has had intercourse within the past four weeks (Q. 37), and
4) the number of intercourses within the past four weeks (Q. 38).

Some respondents were not asked about sexual activity to avoid unnecessary questions: The first question above was not directed to women who were currently living with a man or had done so previously (married or not). Pregnant women were only asked the second and not the last two questions, since they were not under risk of becoming pregnant.

The main reasons for including questions about sexual activity were to identify the population under risk of becoming pregnant and who are potential users of contraception.

Few national fertility surveys to date have included questions about sexual activity. There was a lot of discussion about this when the Norwegian survey was planned. There was concern that such questions were too private and sensitive, and that their inclusion could cause damage to both the fertility survey and perhaps also to other interview surveys carried out by the Central Bureau of Statistics. The skeptics were proven to be wrong on this point, however. There were few negative reactions to these questions among the respondents and the interviewers, and there was practically no publicity about them in the mass media.

The proportion declining to answer one of the questions on sexual activity varied from 1.9 to 5.7 per cent. For further comments, see Noack and Østby (1980).

Table 3.13 shows the distribution of coital frequency during the four weeks preceeding the interview, by marital and cohabitational status. As expected, women living with a man have intercourse more often than women living alone. Nine out of ten women who live with a man had intercourse at least once, whereas only half of the "single" women had intercourse in the preceding four weeks.

Cohabiting non-married women appear to have a somewhat higher sexual activity than married women (51 per cent versus 33 per cent with more than 6 intercourses), but this may be an effect of age, duration of marriage/cohabitation and other factors.

Table 3.13 Number of intercourses last four weeks. Full sample including non-married women. Per cent.

	Value used in analysis	All women	Married women[1)]	Not married cohabiting women[2)]	Not married women living alone[2)]
0 time......	0	16.4	7.4	7.8	49.1
1 time	1	4.8	4.3	1.0	7.5
2 times	2	9.0	9.2	6.2	9.3
3-6 times ..	4.5	40.3	46.3	34.2	21.3
7-11 times..	9.0	22.3	25.4	34.2	8.5
12 or more	16.0	7.2	7.4	16.6	4.2
Total		100.0	100.0	100.0	100.0
Missing		637	385[3)]	13[3)]	239[4)]
Number of observations		4137	2937	206	994

1) All married women live together with their husbands.
2) Includes never married and previously married women.
3) Pregnant, declined to answer, do not remember, or missing for other reasons.
4) Never had intercourse or as in footnote 3.

To study this more closely, and to simplify further analyses, we assigned a continuous value to each of the response categories, see the first column. We assigned the midpoint values to respondents who answered 3-6 or 7-11 times and 16 to those who replied 12 or more.

Table 3.14 shows the mean coital frequency by age for different marital and cohabitational groups. The pattern from table 3.13 is repeated when we look at each age group separately, bearing the greater uncertainty in mind: The coital frequency is highest for non-married cohabiting women (except for the age group 20-24), somewhat lower for married women, and considerably lower for women who do not live with a man. We also notice that the frequency seems to decline by age above 20-24 years, and that there is a small increase from the late

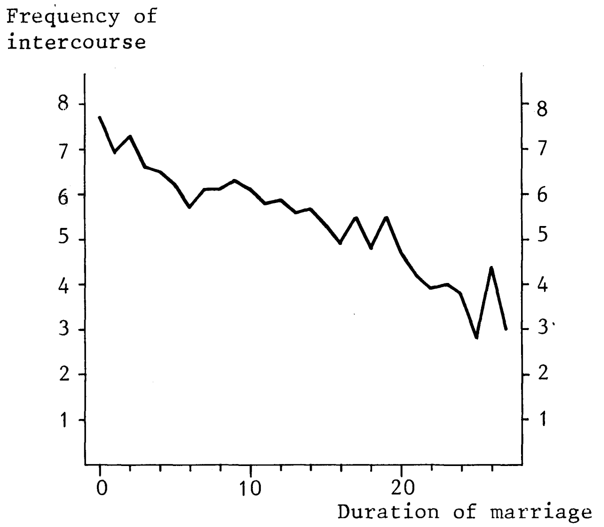
Table 3.14 Mean coital frequency last four weeks by age and marital/-cohabitational status. Full sample.

	Age in years							
	18-44	18-19	20-24	25-29	30-34	35-39	40-44	N
ALL WOMEN	5.2	3.2	5.7	5.7	5.7	5.0	4.1	3500
Married and other cohabiting women	5.9	6.3	7.5	6.2	6.0	5.4	4.3	2754
Married	5.8	4.7	7.6	6.2	5.9	5.3	4.2	2552
Not married1)......	7.4	8.1	7.2	6.9	8.5	(7.1)	(9.1)	193
Women not living with a man	2.7	2.5	3.2	2.5	2.7	1.5	1.7	755

1) Never or previously married women living with a man.
( ) Based on less than 20 observations.

Figure 3.1 Mean coital frequency last four weeks by age of woman and age of husband. Full sample

Figure 3.2 Mean coital frequency of women last four weeks by duration of marriage. Full sample



teenages to the early twenties . See figure 3.1, which also shows that the pattern is about the same when we look at the age of the husbands, that is men married to women 18-44 years of age.[1)2)]

As discussed in section 2.10, however, the coital frequency may also vary with the duration of marriage. Our hypothesis is that it is lower the longer a couple has been married, assuming that routine, lack of novelty, etc. has a negative effect on sexual activity. But the possibility of a positive effect should not be excluded: the better a woman and a man know each other, their relationship may be more intimate and their pleasure from sex greater.

The first column in table 3.15 shows a strong negative association between coital frequency and marriage duration. When we standardize for age, however, the picture becomes less clear. This may partly be due to small cell sizes, but the general trend is still that the frequency of intercourse declines by the duration of marriage.[3)]

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1) The curves are based on 1-year age groups, which leaves few observations for some ages and particularly for the youngest. There are, e.g., only 3 married women at age 18 and 17 at age 19. The reason why these women have so low frequencies may be that many of them have just borne a child, since marriage among teenagers is strongly associated with pregnancy. 73 per cent of the women in the survey who married as teenagers had their first child within 7 months of the marriage (Noack and Østby 1981:144).

2) The U.S. National Fertility Studies 1965, 1970 and 1975 all find that the coital frequency declines monotonically when the age of the wife increases from "below 19" to 44 (Trussell and Westoff 1980). As here, the coital frequency increases when the age of the husband increases from "below 20" to 20-24, however, and declines thereafter. (Source: Unpublished tables kindly provided by Charles Westoff).

3) The same slightly irregular pattern was found in the U.S. National Fertility Studies 1965 and 1970. (Source: unpublished tables as mentioned in the previous footnote).

Table 3.15 Mean coital frequency last four weeks by age of woman and duration of marriage. Full sample

Marriage duration in years	Age in years						
	18-44	18-19	20-24	25-29	30-34	35-39	40-44
0- 4	6.7	4.7	7.8	5.6	6.0	7.2	4.5
5- 9	6.1		6.5	6.4	5.7	4.5	5.4
10-14	5.8			6.4	6.0	5.6	3.6
15-19	5.0				6.0	5.3	4.4
20-24	4.1					4.0	4.1
All durations	5.8	4.7	7.6	6.2	5.9	5.3	4.2

3.12 Contraception

One of the principal purposes of the Norwegian Fertility Survey 1977 was to obtain information about the use of contraception in Norway. There was very little information about this before 1977, only contraceptive sales data, a non-national interview survey (Walløe et al. 1978), and surveys of women visiting hospitals or clinics to obtain information about contraception or to apply to have an abortion (inter alia Abort eller prevensjon, 1975).

To obtain information both about current and past use of contraception, the respondents were asked which method(s) of contraception, if any, they used within the past four weeks (Q. 40), which methods they have used for at least three months (Q. 44), and the years in which they used them (Q. 45 - Q.49). They were also asked if they practiced contraception when they had their last sexual intercourse (Q. 41), and if not, the reason for this (Q. 42), as well as the reasons for not practicing contraception during the past four weeks 0.43).

Noack and Østby (1980) report that very few respondents declined to answer the questions about contraceptive practice, but that there were different views about what constitutes a contraceptive method. The authors think that some respondents obviously did not consider withdrawal and rhythm (safe periods) to be contraceptive methods. Also, some women seem to have misunderstood the length of the time period (past four weeks).

A more important problem, however, is that there were no questions about how often each method was used, and when the use of several methods were reported, whether they were used sequentially or simultaneously. This causes problems for our analysis of contraceptive use, since we need to assign an effectiveness value to each method: When more than one method is used, should we assign some intermediate value (e.g. the mean), or a higher value on the assumption that two methods used together reduce the probability of contraception more than when each method is used on separate occasions? On the other hand, even when only one method is used, we do not know if it was used all the time or irregularly. Moreover, some couples may use more effective methods during the ovulatory period and less effective methods (or nothing) during the rest of the menstrual cycle.

For some combinations of methods it is fairly obvious that they must have been used consecutively (e.g. pill and IUD), for other combinations it is likely but not certain that the methods were used together (e.g. diaphragm and spermicides), and for other combinations it is unclear (e.g. withdrawal and safe periods).

Table 3.16 Contraceptive use last four weeks. Full sample (2937 married women)

Method	Women using method only or in combination	Women using method only	Women using method in combination with other methods	Number of different combinations of methods
Withdrawal.......	226	107	119	9
Safe periods.....	138	33	105	9
Spermicides	29	8	21	8
Condom	494	358	136	10
Diaphragm	33	17	16	8
Pill	368	354	14	4
IUD	811	801	10	5
Other methods ...	1	1	0	0
Total		1679	199[1)]	22[2)]
No method		291		
Not stated		63		
Question not asked:				
Pregnant....................		174		
Infecund....................		371		
Fecund and no intercourse[3)]		160		

1) Total number of women using two or more methods.
2) Total number of different combinations.
3) An additional 29 infecund women did not have intercourse.

Table 3.16 shows the number of women using each method separately and in combination with other methods. Of the 2169 women who answered the question about use of contraception, 13.4 per cent (291) used nothing, 77.4 per cent (1679) used one method only, and 9.2 per cent (199) used two or more methods. 177 respondents used two methods, 21 used three and one woman used four. Table 3.17 shows the most common combinations. The most frequently used method in combination with other methods is condom, which is used in 10 of the 22 different combinations, and by 136 of the 199 women using more than one method. The most common combination is condom and withdrawal (52 respondents). Our guess is that these couples used condom at some intercourses and withdrawal at others, but we cannot be sure that they were not used simultaneously, of course. The other most common combinations are withdrawal and safe periods (46), condom and safe periods (40), and condom and withdrawal and safe periods (13).[1] Again, we think that the most likely interpretation of these combinations is that withdrawal or condom is used on susceptible days and that nothing is used during the rest of the period. (The interviewers were instructed that "safe periods" means that nothing is used on non-susceptible days and that there is no intercourse on susceptible days.)

Since we have so little firm knowledge about this, and sequential use seems more likely than simultaneous use for most of the combinations, we decided to assign the mean effectiveness of the methods when more than one method was used. The estimates of effectiveness are based on Michael (1973) and shown in table 2.1 and 3.17. We also experimented with estimates based on Bongaarts (1978:112), which are very similar and yield similar results both for combinations of methods and in the econometric analysis presented in chapter 5.

As discussed in chapter 2, we hypothesize that there is a positive relationship between coital frequency and contraceptive effectiveness: the higher the effectiveness the higher the frequency. In table 3.17 we also show the mean frequency of intercourse by method of contraception for methods with 15 or more users. The figures support our

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1) Since it may be of some interest we report the other combinations with more than one user: condom and spermicides 9 users, condom and pill 8, condom and IUD 5, condom and diaphragm 4, diaphragm and spermicidies 4, condom and diaphragm and spermicides 3, withdrawal and pill 3, pill and IUD 2. In addition there were 10 different combinations mentioned by only one respondent.

Table 3.17 Mean frequency of intercourse by method of contraception.1)2) Full sample

Method	Assigned effectiveness	Mean frequency of intercourse	Number of observations
No method	0.0	6.0	267
Rhythm (safe periods)*	0.8396	5.0	104
Rhythm and withdrawal	0.8848	5.5	46
Rhythm and condom	0.8911	5.9	50
Withdrawal*	0.9300	3.9	31
Withdrawal and condom	0.9363	6.3	40
Diaphragm*	0.9400	4.4	15
Condom*	0.9425	5.8	332
IUD*	0.9896	6.7	753
Pill*	0.9958	7.3	329
All users of contraception	0.9600	6.4	1766
All respondents, including no method	0.8339	6.4	2033

*) Only one method is used.
1) Only methods or combinations of methods with 15 or more users are included in the table.
2) Non-pregnant fecund married women.

hypothesis about a positive relationship, particularly if we disregard women using no method since many of them want to become pregnant. If we also disregard combinations of methods since their assigned effectiveness may be somewhat unrealistic the trend is even more convincing, with rhythm as the only exception. These mean values of coitus are affected by factors like age and attitude towards becoming pregnant, so we have to do a multivariate analysis to study the relationship more closely, see chapter 5.

CHAPTER 4

ESTIMATING THE MODEL

4.1 Introduction

In chapter 2 we showed how the two-stage maximization procedure (when contraception is treated as a discrete variable), or the simultaneous equilibrium conditions (when contraception is treated as a continuous variable), implicity define three different sets of demand equations, as in equations (2.31) & (2.32) and (2.36) & (2.37):

(4.1) $S = S(N,\Pi,I_1,I_2;Z_S)$,

(4.2) $M = M(N,\Pi,I_1,I_2;Z_M)$,

where, to repeat, S is the number of intercourses last four weeks, M is a measure of contraceptive use, N is the number of children in the first period, Π is the "price" of children, I_i is income in period $i(i=1,2)$, and Z_S and Z_M are vectors of other exogenous variables.

Alternatively, we may introduce the intermediate variable y, which is a measure of the desire to become pregnant soon, and implicitly define the demand for y, S, and M as in equations (2.33)-(2.35) and (2.58)-(2.60):

(4.3) $y = y(N,\Pi,I_1,I_2;Z_y)$,

(4.4) $S = S(M,r,y;Z_S)$,

(4.5) $M = M(S,r,y;Z_M)$.

If the two last equations can be solved explicitly for the two endogenous variables S and M , M and S will not appear on the right hand sides of (4.4) and (4.5), respectively.

A common approach when analyzing relationships between variables such as these, is to write the demand functions as linear functions of the right-hand side variables:

$$(4.6) \qquad y = a_0+a_1N+a_2\Pi+a_3I_1+a_4I_2+a_5r+\sum_{i=6}^{m} a_iZ_{yi}+u_y,$$

$$(4.7) \qquad S = b_0+b_1M+b_2y+b_3r+\sum_{i=4}^{n} b_iZ_{Si}+u_S,$$

$$(4.8) \qquad M = c_0+c_1S+c_2y+c_3r+\sum_{i=4}^{q} c_iZ_{Mi}+u_M,$$

where the a_i, b_i, and c_i are constant parameters, the Z's are other exogenous (or predetermined) variables, and the u's are disturbance terms. (These equations apply to all couples t, t=1,2,..., but we drop the subscript t here to simplify the notation.) It is usually assumed that the disturbance terms are normally distributed with zero expectation and constant variance.

The parameters in equations such as these are often estimated by the ordinary least squares (OLS) regression method on each linear equation separately. There are several problems with this, however: First, the disturbance terms of (4.4) and (4.5) may be correlated with each other, which is likely if the endogenous variable appear on the right-hand side. If this is the case, OLS will yield inconsistent esimators. Second, important non-linearities may have been left out, which lead to biased estimators by OLS.

Another problem is that estimates of the parameters of linear function like (4.6)-(4.8) tell us very little about the properties of the utility functions discussed in sections 2.4 and 4.2, although we could learn something about the effects of other exogenous factors.

There are, however, other approaches. If we have some a priori knowledge about the utility function, we may introduce this by assuming a specific functional form for the utility function, and derive explicit expressions for the demand equations.

This approach has become fairly common when estimating production-functions, see e.g. Zeller, Kmenta and Drèze (1966), but is more rare when utility functions are estimated; see Christensen, Jorgenson and Lau (1975) and Rosen (1978) for some examples. Rosenweig and Wolpin (1980) let a random shift parameter be an argument of the utility function, but they do not assume any specific functional form. There are several examples in the literature of theoretical discussions of specific functional forms for the utility function, see e.g. Phelps (1962), Stiglitz (1969), Zabel (1977), and Russell and Seo (1978), but none of these introduce any stochastic disturbance, nor do they do any estimation.

In recent years it has become more common to assume specific functional forms for indirect utility functions and the corresponding demand functions, rather than for direct utility functions as here, see e.g. Caves and Christensen (1980). An indirect utility function indicates the maximum utility attainable given any set of prices and income, and "is generally more attractive for empirical application" (Caves and Christensen 1980). Duality theory (see Lau 1970) applies to situations where we have a constrained maximization problem subject to a budget constraint. The (direct) demand functions are derived by partial differentiation of the indirect utility function, using Roy's identity. Our case is different, however, in that we have an unconstrained problem, i.e. maximizing the expected utility function V (eq. 2.15) with respect to S and e. Also, our (expected) utility function is not monotonically increasing in the variable S, which is one of the conditions for a one-to-one correspondence between the direct and indirect utility function (Caves and Christensen 1980).

The problem with use of specific functional forms is that we have only limited a priori knowledge about the form for the utility function, and that our results may rely too heavily on the specific functional form we choose. Moreover, it is not easy to find a functional form that satisfies all the properties discussed in chapter 2, and that is also tractable mathematically and econometrically. We have tried to keep the function(s) as simple as possible while at the same time retaining all desirable theoretical properties[1]. The choice of utility function(s) will be discussed in the next section before we derive the specific demand functions in 4.3, discuss the error structure in 4.4, the estimation of the y-equation in 4.5, the assumptions about contraceptive use in 4.6, and the estimation of the demand functions for sex and contraception in 4.7.

Even if we forget about the specific functional forms, there are several other problems with the estimation of linear functions like (4.6)-(4.8), as mentioned in the previous chapter: y is an ordi-

1) More flexible but also more complicated functional forms than those suggested here have been proposed, see Christensen, Jorgensen and Lau (1975) and Caves and Christensen (1980) for examples.

nal variable, M is a discrete variable, S is discrete and limited (greater than or equal to zero), r (fecundity) is the same for all couples with non-missing observations of S and M, etc. These problems will be discussed later.

4.2 Specific Utility Functions

The considerations we make when looking for specific functional forms are:

i) Realism: the function should capture the main characteristics of the function we have in mind with regard to curvature and range, i.e. it should satisfy certain properties of the first and second partial derivatives and assume certain values for special values of the arguments, e.g. when one or more of them approach zero or infinity.

ii) Generality: the function should be as general and flexible as possible and include more special functions as special cases. A quadratic function, for example, is more general than a linear function, and includes the latter as a special case.

iii) Simplicity: the function should be simple enough to make mathematical and econometric analysis possible. We do not want too many degrees of freedom. Any functional form we want could be achieved by a polynomial of high enough degree, e.g.

Before we discuss the specific functional forms, we will assume that the utility function of children and consumption is completely separable in the arguments,[1)] i.e.

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1) An example of a non-additive utility function is the translog function proposed by Christensen, Jorgensen and Lau (1975), but this function does not allow for negative marginal utility of children, see subsection 4.2.1.

$$(4.9) \quad f(N_1,N_2,X_1,X_2) = k_1(N_1)+k_2(N_2)+h_1(X_1)+h_2(X_2).$$

This is a fairly strong assumption which implies cardinality, but it is not as restrictive as it may seem, since an additive utility function such as this can be derived from a multiplicative utility function by doing a monotonic transformation, e.g. by taking the logarithm of a Cobb-Douglas function. Most properties of the utility function are preserved by such monotonic transformations.

Second, we assume that the utility functions of children and consumption, respectively, are the same for each period, i.e.

$$k_1=k_2=k \text{ and } h_1=h_2 = h$$

This means that the parameters of the k and h functions are the same for each period. We make this assumption because we have no a priori reasons for hypothesizing that the functional form and the parameters change over such short time-periods, although it would have been interesting to test this empirically. Moreover, it can be shown that the parameters cannot be identified if we assume period-specific parameters, e.g. as in this simple linear version:

$$f(N_1,N_2,X_1,X_2) = a_1N_1+a_2N_2+b_1X_1+b_2X_2.$$

Bearing these two restictrive assumptions in mind, we can discuss the specific functional forms for the utility of children and consumption, respectively.

4.2.1 Utility of Children

The specific functional form of the utility of children, k(N), should satisfy the following conditions:

i) k(N) must exist and be defined for all non-negative values of N.

ii) k(0) = 0, i.e. there is no utility of children if there are no children.

iii) The marginal utility of children, dk/dN, may be positive for low values of N, zero for some value $N = \tilde{N}$, and negative for higher values, i.e., k(N) should be a strictly concave function.[1] These assumptions imply that k(N) may become zero or negative for large values of N, i.e. some couples may feel worse having many children than not having any.

Since we want to allow for the possibility of first increasing and later decreasing utility of children as in (iii), all monotonic functions are excluded, in particular the linear, logarithmic, exponential, and Box-Cox[2] functions. However, a relatively simple function that satisfies conditions (i) - (iii) is the quadratic utility function

$$(4.10) \quad k(N) = a_1N^2 + a_2N,$$

where the constant term is set equal to zero, the parameter a_1 is negative and a_2 is positive.

Another property that characterizes the quadratic utility function is that it has strictly increasing absolute and relative risk

1) Since children come in whole numbers, N is an integer. It is treated as a continuous variable here, however, to simplify the analysis, see the first footnote in subsection 2.9.4.

2) See Kmenta (1971:467)

aversion (Pratt 1964:130).[1] In our case, risk aversion means that the couple would be happier with the expected utility of children and consumption etc, than with the utility of the expected values of children and consumption. The interpretation of increasing risk aversion here is that the more children a couple has the less likely it is to gamble with respect to children, which implies that the couple would use more effective contraception if they contracept, or perhaps have less sex.

4.2.2 Utility of Consumption

The utility of consumption, $h(x)$, should also be zero when x is zero, and increasing for $x>0$, but it seems less reasonable that the marginal utility of consumption may become negative for realistic values of x. Moreover, increasing risk aversion which seems reasonable in the case of children seems unrealistic in the case of consumption and contrary to the common assumption about decreasing risk aversion with respect to wealth. Therefore, the quadratic utility function does not seem to be a good candidate. We could choose a linear function, of course, but this would imply constant marginal utility of consumption, which is not very realistic either.

Other possible forms are the logarithmic function and the Box-Cox form

$$(4.11)\quad h(x) = b(x^c-1)/c,$$

1) The definitions of absolute and relative risk aversion, are $-U''/U'$ and $-xU''/U'$, respectively, where the utility function $U=U(x)$, and U' and U'' are the first and second partial derivatives with respect to x.

which includes the logarithmic, exponential, and linear functions as special cases, see Kmenta (1971:467). The problem with the Box-Cox form is that it is relatively complicated to estimate.

With these assumptions, (4.10) and (4.11), substituted into (4.9), the utility function f of children and consumption over the two periods becomes

$$(4.12) \quad f(N_1,N_2,X_1,X_2) = a_1(N_1^2+N_2^2) + a_2(N_1+N_2) + b(X_1^c+X_2^c-2)/c.$$

4.2.3 Utility of Sex and Contraception

The general shape of the function g(S,M) is indicated in figures 2.1 - 2.9 (for constant M) and figure 2.10 (for constant S and continuous M=e). Several properties of the g-function are mentioned in chapter 2. To summarize:

i) $g(0,M) < g(0,0)$ for $M>0$,

i.e. there is a loss in utility using contraception when S=0.

ii) There exists a "satiation" value of $S = \tilde{S}$, such that

$$\frac{dg(S,\bar{M})}{dS} \begin{cases} >0 \text{ for } S<\tilde{S} \\ =0 \text{ for } S=\tilde{S} \\ <0 \text{ for } S>\tilde{S}, \end{cases}$$

iii) $\dfrac{\partial^2 g(S,\bar{M})}{\partial S^2} < 0$ for all S,

i.e. the function $g(S,\bar{M})$ is strictly concave for given contraception $M=\bar{M}$.

A simple functional form that satisfies conditions (i) - (iii) is the quadratic utility function

$$g(S,0) = d_1S^2+d_2S,$$

where the parameter d_1 is negative and d_2 is positive.

Furthermore, there may be both fixed and/or variable utility costs of contraceptions, which implies the following conditions:

iv) Fixed costs:

$$g(S,M) = g(S,0) + \phi(M),$$

where $\phi(M)$ is a utility loss that does not depend on S.

v) Variable costs:

$$g(S,M) = g(S,0) + q(S,M)$$

where $q(S,M)$ depends on S such that the partial derivatives of $q(S,M)$ with respect to S and M are negative. This means that the utility of sex and contraception is lower (or the disutility of contraception is higher) the "more" contraception is used, and the greater the coital frequency.

vi) $\dfrac{\partial^2 g(S,M)}{\partial M^2} < 0$, because of the second-order condition for utility maximum (2.35).

Introducing the contraceptive cost function $q(S,M)$ is more difficult. We obviously need an interaction term that includes both S and M. The simple product SM only does not satisfy the second-order condition (vi), so we need to include the quadratic factor M^2 as well:

$$q(S,M) = d_3SM^2 + d_4M^2 + d_6SM.$$

The factor M^2 is included twice to ensure that the second-order condition is met both when there are only variable costs of contraception (d_4=0), and when there are only fixed costs of contraception (d_3=0). Our hypothesis is that parameters d_3 and d_4 are negative or zero, but both need not be negative at the same time. The term d_6SM is included to allow for a more general functional form. We do not have any <u>a priori</u> hypothesis about the sign of d_6, although it is likely that it is negative to ensure negative partial derivatives of h with respect to S and M.

We mentioned in subsection 2.4.2 that some couples may enjoy sex <u>more</u> when they contracept than when they do not if they do not want another child in the next period, i.e. there is a direct "relaxtion" effect. To allow for this possibility, we include two interaction terms, d_5SMy and d_7SMy^2, in the function $g(S,M)$[1]. The last term is included to allow for a more general interaction effect. We expect the parameter d_5 to be negative, which would make the term d_5My positive when y is negative. The sign of d_7 is uncertain, but it is likely to be positive, since the "relaxation" effect $d_5SMy + d_7SMy^2$ is assumed to be positive. Moreover, a negative d_5 and a positive d_7 would make the differential of this effect with respect to M positive and with respect to y negative. I.e., the "relaxation" effect on the utility is greater the "more" contraception is used and the less negative the attitude towards becoming pregnant soon is.

Thus, the suggested utility function of sex and contraception is

$$(4.13) \quad g(S,M) = d_1S^2+d_2S+d_3SM^2+d_4M^2+d_5SMy+d_6SM+d_7SMy^2.$$

---

1) Inclusion of these two terms containing y imply that the utility function is no longer separable as assumed in section 2.4 (eq. 2.5), but this does not cause any problems.

Our *a priori* hypotheses about the signs of the parameters are summarized in table 5.19.

4.3 Derivation of Demand Equations

With the functional forms we assumed in the previous section, we can derive explicit demand equations.

Substituting the utility function for children and consumption (4.12) into expressions (2.16) for f^o and (2.17) for y yields

$$f^o = 2a_1N^2+2a_2N+2b[(I-\Pi N)^c-1]/c,$$

and

$$(4.14) \quad y = a_1+a_2+2a_1N+b((I-(N+1)\Pi)^c - (I-N\Pi)^c)/c,$$

where we have set $I_1=I_2=I$, since we do not have any data about actual or expected income for period 2. Moreover, changes in I_1 have no effect on the pregnancy attitude, as derived in subsection 2.9.4. The I-variable can be interpreted as a measure of permanent full income.

As mentioned in chapter 2, the variable y can be treated in several different ways: First, y can be treated as an unobserved intermediate variable. In this case, we substitute the expression (4.14) for y into the demand equations for sex and contraception to be derived later. Second, y can be treated as an intermediate *observed* variable, since several variables in the survey can be used as proxies for y, in particular the attitude towards becoming pregnant next month, see section 3.10. In this case, y is an endogenous variable in the system of equations (4.3) - (4.5). It can be treated as a predetermined variable in the S and M equations, (4.4) and (4.5).

Now let us look at the demand for sex. Differentiating the specific function (4.13) for g(S,M) with respect to S gives

$$(4.15)\quad g_S = 2d_1S+d_2+d_3M^2+d_5My+d_6M+d_7My^2 .$$

Substituting this into the first-order condition (2.21) (with $g_{S1}=g_S$) and solving for S yields

$$(4.16)\quad S = -(d_2+(1-e)ry+d_3M^2+d_5My+d_6M+d_7My^2)/2d_1 .$$

This is the optimal value of S for given contraceptive use M with effectiveness e .

As mentioned in chapter 2, however, coital frequency and contraceptive use are determined simultaneously. To derive the explicit demand function for contraceptive use, we need to assume something about the variable M . As mentioned in chapter 2, M can be treated in three different ways: as dichotomous, as polytomous, and as continuous. Before we discuss this we need to say something about the error structure.

4.4 Stochastic Specification

So far we have discussed deterministic utility functions and not said anything about the possibility of errors in the model.

We assume that each couple t knows its own utility function, i.e. the couple knows how happy each possible combination of children, goods, sex and contraception would make them, and they can rank the different combinations. This means that for each couple the only uncertainty is the fertility outcome in the second period, which makes N_2 and X_2 stochastic variables for each couple. As discussed in chapter 2, the couple takes this uncertainty into account by maximizing their expected utility.

However, couples may attach different weights to how happy certain combinations of sex, children, goods, and contraception make them, i.e. there are so-called "taste" variations. In addition there are a number of random disturbances that affect the behaviour of each couple. A way of taking this unobserved heterogenity into account is to assume that it can be represented by linear and additive disturbance terms u_y, u_S and u_M, as we have done in the system of linear equations (4.6) - (4.7), and as we do in the following system of non-linear equations based on the specific demand equations (from 4.14 and and 4.16):[1)]

$$(4.17) \quad y_t = a_2 + a_1(1+2N_t) + b((I_t-(N_t+1)\Pi_t)^c - (I_t-N_t\Pi_t)^c)/c + \sum_{i=4} a_i Z_{it} + u_{yt}$$

$$(4.18) \quad S_t = -(d_2+(1-e_t)ry+d_3M_t^2+d_5M_ty_t+d_6M_t+d_7M_ty_t^2)/2d_1 + \sum_{i=8} d_i Z_{it} + u_{St}.$$

---

1) Other ways of incorporating unobserved heterogenity are:
   (1) Including additive stochastic disturbances directly in the utility functions.
   (2) Assuming that the parameters in the f and g utility functions are random with unknown means and variances.
   (3) Assuming that random parameters of the utility functions are functions of exogenous variables and an error term.

   It is not obvious from a methodological/philosophical point of view that any of these approaches is better than the one we have chosen. Besides, these approaches lead to more complicated estimation procedures.

The specification of the demand function for contraception depends on the treatment of M, so we write it in general form here:

$$(4.19) \quad M_t = M(S_t, y_t, Z_{Mt}; U_{St}) + u_{Mt}.$$

Z_M is a vector of other exogenous variables influencing the behaviour of the couples: age, marriage duration, education etc., as discussed in section 2.10. We assume that the effects of these factors are additive. The Z-variables are not the same in each equation.

It seems reasonable to assume that the disturbance term u_y is uncorrelated with the two other disturbance terms, u_S and u_M, since the endogenous variables S and M do not appear in the y-equation, i.e. we have a partly recursive system of equations. Thus, the parameters of equation (4.6) can be estimated independently of the others, using a single-equation method, e.g. OLS, which would yield consistent estimators.

The disturbances u_S and u_M, on the other hand, cannot generally be assumed to be uncorrelated, since explicit solutions for S and M depend on both disturbance terms. OLS single-equation estimation of (4.7) and (4.8) (or 4.18 and 4.19), would, therefore, yield inconsistent estimators of the parameters. To get consistent estimators we could use maximum likelihood estimation or a two-stage procedure.

Moreover, the estimation of (4.7) and (4.8) depend on our assumptions about contraceptive use, which will be discussed in section 4.6.

4.5 Desire for an Additional Child Soon

We explained in the previous section why the pregnancy-attitude equation (4.17) can be estimated independently of the coital frequency and contraceptive use equations.

There are other problems with this equation, however, since it is non-linear both in some variables (N,I,Π) and in some parameters (a_1,b,c). The first non-linearity is not really a problem at all, whereas the second non-linearity is difficult to handle, in particular because of the exponent c . Estimation of this requires a search procedure, or a non-linear estimation procedure, such as non-linear least squares or maximum likelihood estimation. Programs that do this are not readily available, however, and special programming is complicated and time-consuming.

Instead of attempting to do a complicated non-linear estimation, we could resort to estimating a linear approximation of equation (4.17), to get approximate estimates of the magnitude and direction of the effect of the exogenous variables on y .

Linearizing equation (4.17) in terms of parameters b and c proves to be quite difficult, however. We tried to do a binomial expansion of the two non-linear terms in (4.17) and thereby managed to eliminate one of the terms. But this was of little help, since we could not simplify the resulting infinite series by dropping terms that approach zero, as there were no such terms. We also did a Taylor series expansion of (4.17) which resulted in a complex but manageable linear function of the unknown parameters. The drawback with this is that the expansion has to be done around a set of fixed values of the parameters, and our *a priori* knowledge about the parameters is very limited. We only know that a_1 should be negative, a_2 and b positive, and c between zero and unity, see section 4.2. (Since the expansion is done with regard to parameters and not variables, we cannot compute sample means to be used in the expansion.) One way of solving these problems would be to search over different values of the parameters, but this would be time-consuming and complicated since there are several unknown parameters.

Thus, there does not seem to be a simple linear road to estimating the b, c, and a-parameters. It is not, however, of vital importance to obtain estimates of the b and c -parameters.

As mentioned previously, we are also interested in testing if the explanatory variables in equation (4.17) have any significant influence on the dependent variable y. The expected signs of these effects were derived in section 2.9 and summarized in subsection 2.9.6.

A simple linear-in-parameter additive approximation of equation (4.17) is

$$(4.20)\quad y = \alpha_0+\alpha_1 N+\alpha_2 I+\alpha_3 \Pi+\Sigma\alpha_i Z_{yi}+u_y,$$

where we have deleted the subscript t for each individual to simplify the notation.

To account for the obvious non-linear influences of N and Π we will also include the terms N^2 and $N\Pi$:

$$(4.21)\quad y = \alpha_0+\alpha_1 N+\alpha_2 I+\alpha_3 \Pi+\alpha_4 N^2+\alpha_5 N\Pi+\sum_{i=6}\alpha_i Z_{yi}+u_y.$$

Non-linear functions of the Z-variables may also be included. Possible interactions will be discussed later. Equations (4.20) and (4.21) are the linear-in-parameter equations we want to estimate, and the results from this are reported in sections 5.3 and 6.2.

The price of children, Π , is not observed in our survey. We can treat Π as either a constant, i.e. the "price" of children is the same for all couples, or as an observed stochastic variable, i.e. there is variation in the "price" of children across couples. An important component of Π is the costs of time devoted to child care. This can be measured by the actual or potential wage rate of the woman (and also of the man), which is in fact observed in our survey. We will, therefore, use the wage rate of the woman as a proxy for the price of children. This variable is discussed in section 3.4. The I-variable, full family income, or the income the couple would have if both spouses worked full time, is discussed in section 3.7.

As a measure of y we will primarily use the attitude towards becoming pregnant next month which seems to be a fairly good proxy, although there are some problems with it, see section 3.10. The most serious problem in this context is that it is an ordinal variable, taking five different values. An obvious solution to this would be to do the analysis as if y were a categorical and not an ordered variable, but this would imply a serious loss of information. Another approach would be to use a multinomial LOGIT or PROBIT model, taking into account that the responses to the pregnancy attitude question are ordered, see McFadden (1976). It does not seem worth the trouble to use such complicated methods, however, in view of the other problems with y , the non-linearities, etc. Thus, we conclude that we will treat y as a continuous variable, and use OLS to estimate equations (4.20) and (4.21).

4.6 Assumptions About Contraceptive Use

As shown in chapter 2, the demand functions for sex and contraception depend on our assumption about the contraceptive use variable M, i.e. whether we treat it as a dichotomous, polytomous, or continuous variable.

Methods to estimate models with qualitative dependent variables are well-known, and include the binomial and multinomous LOGIT and PROBIT models, see Domencich and McFadden (1975). We cannot use these methods to estimate our model, however, at least not without modifications, since the disturbance terms u_S and u_e are dependent. Methods to estimate the parameters of structural models with categorical and continuous variables have been developed, see Schmidt and Strauss (1975), Heckman (1978), Schmidt (1978), Warren and Strauss (1979) and Manski and McFadden (1981).

We are, however, not certain that the methods discussed by these authors can easily be extended to allow for the non-linearities and other special features of our model. Estimation of our model would require special programming or sophisticated soft-ware packages that are not easily available. Moreover, even if we had access to such programs, they would be complicated, time-consuming, and expensive to use. To save time we have limited our analysis to the case where contraception is treated as a continuous variable (with a few exceptions), i.e. we assume that contraceptive use is measured by its effectiveness, or M=e.

In the next section we develop the demand functions for sex and contraception based on this assumption.

4.7 Continuous Contraception

4.7.1 Single-equation Estimation

As in section 2.9 we assume that each contraceptive method is characterized only by its effectiveness, e, which is the measure of the "amount" of contraception being used. Setting M = e in the utility function (4.13) of sex and contraception g(S,M), yields:

$$(4.22)\quad g(S,e) = d_1S^2 + d_2S + d_3Se^2 + d_4e^2 + d_5Sey + d_6Se + d_7Sey^2,$$

which can be substituted into expression (2.15) for expected utility:

$$V = f^o + Sr(1-e)y + g(S,e),$$

where f^o is a function of consumption X_1 and X_2, and the current number of children, N.

The values of S and e maximizing expected utility are found by differentiating V with respect to S and e and solving for the endogenous variables S and e:

$$(4.23)\quad S = -(d_2 + ry + d_6e + d_3e^2 -(r - d_5)\ ey + d_7ey^2)/2d_1$$

and

$$(4.24)\quad e = ((r - d_5)\ y - d_7y^2 - d_6))\ S/(2d_3S + 2d_4).$$

Equations (4.23) and 4.24) are not pure demand equations, however, since S and e are not functions only of the exogenous variables (y and r), but also functions of each other. In principle it is possible to find explicit solutions for S and e as functions of y and r only, but these would be very complicated since we would have to solve two cubic equations in S and e.

Equations (4.23) and (4.24) are deterministic. We know that sexual activity and contraceptive use are influenced by many other factors as well: age, marriage duration, education etc., as discussed in section 2.10. We assume that the effects of these exogenous factors, $Z_1, \ldots, Z_k$, are linear and additive and that there are no other interaction effects than those shown in equations (4.23) and (4.24). In addition to these factors there are a number of random disturbances that affect behaviour. These effects are taken care of by the disturbance terms u_s and u_e. With these assumptions, the equations become

$$(4.25) \quad S_t = -0.5d_2/d_1 - 0.5(r/d_1)y_t + 0.5(d_6/d_1)e_t - 0.5(d_3/d_1)d_t^2 - 0.5((r-d_5)/d_1)e_t y_t - 0.5(d_7/e_t)y_t^2 + \Sigma\, b_i Z_{Sit} + u_{st},$$

$$(4.26) \quad e_t = [(r - d_5)\, y_t - d_7 y^2 - d_6]\, S_t / [2d_3 S_t + 2d_4] + \Sigma\, a_i Z_{eit} + u_{et},$$

where t stands for couple number t. The fecundity variable, r, is treated as a constant parameter since we can only do the estimation for couples who believe they are fecund.

Equations (4.25) and (4.26) form a simultaneous equation system which is non-linear in both variables and parameters. Moreover, most parameters appear in both equations. Thus, we have a number of econometric problems to tackle. Solutions of some of these problems have been suggested in the literature, and we will later use them to estimate the equations (Kelejian and Oates 1981, Goldfeld and Quandt 1972). Before we attempt to do this, however, we will for practical and experimental reasons use ordinary least squares estimation on linear versions of each equation separately. This will result in inconsistent estimators because the endogenous variables on the right-hand sides are correlated with the disturbance terms u_s and u_e, since the explicit solutions of (4.25) and (4.26) with respect to S and y depend on both error terms.

We see from (4.25) that there is a one-to-one correspondence between the d_i-paramters in (4.25) and the b_i-coefficients in the linear-in-parameters equation

$$S_t = b_0 + b_1 y_t + b_2 e_t + b_3 e_t^2 + b_4 e_t y_t + b_5 e_t y_t^2 + \sum_{i=6}^{k} b_i Z_{Sit} + u_{st}. \tag{4.27}$$

The d's as functions of the b's are:

$$\begin{aligned}
d_1 &= -0.5r/b_1 && < 0\\
d_2 &= rb_0/b_1 && > 0\\
d_3 &= rb_3/b_1 && \leq (?)\\
d_5 &= r\ (1 + b_4/b_1) && \leq 0\\
d_6 &= rb_2/b_1 && \leq 0\ (?)\\
d_7 &= rb_5/b_1 && \geq 0,
\end{aligned} \tag{4.28a}$$

where we have indicated the expected signs of each parameter, according to the arguments in subsection 4.2.3.

If the $\hat{b}_i$ are consistent estimators of b_i, so will $\hat{d}_i = f(\hat{b}_i)$ be consistent estimators of d_i, according to the Slutsky theorem (see e.g. Kmenta 1971:166). The $\hat{d}_i$ will only be asymptotically consistent, however, since they are non-linear functions of the $\hat{b}_i$. To test hypotheses about the estimates of d_i we would need estimates of the variances of $\hat{d}_i$. It is not simple to estimate these variances, however, because of the non-linearities. An approximation formula exists (Kmenta 1971:444), which requires an estimate of the variance - covariance matrix of the least squares estimators of b_i. If this is available it is possible but cumbersome to calculate the estimates of var $\hat{d}_i$.

The only exception is var $\hat{d}_1$, for which it is relatively simple to calculate an approximation. Application of the above-mentioned approximation formula to $\hat{d}_1 = -0.5/b_1$ for the large-sample variance of d_1 yields.

(4.28b) $\widehat{\text{var}}\ \hat{d}_1 \approx \widehat{\text{var}}\ \hat{b}_1/4\hat{b}_1^{\,4}$.

It is easy to show that this approximation yields the same F-ratio for $\hat{d}_1$ as for $\hat{b}_1$, namely

$$F(\hat{d}_1) = F(\hat{b}_1) = \hat{b}_1^{\,2}/\widehat{\text{var}\ \hat{b}_1}.$$

Thus, we can use the F-ratio calculated for $\hat{b}_1$ to test hypotheses about $\hat{d}_1$, as both estimators can be assumed to be normally distributed for large samples.

However, although the variance - covariance matrix is unknown, we can calculate an estimate of the upper bound of the variances of the other d_i's. Most of the relationships between the b's and the d's in (4.28a) are of the form d = a/b. Applying the same approximation formula as above yields

$$\mathrm{var}\ \hat{d} = \frac{\hat{a}^2}{\hat{b}^2} \left[\frac{1}{\hat{a}^2}\ \widehat{\mathrm{var}\ \hat{a}} + \frac{1}{\hat{b}^2}\ \widehat{\mathrm{var}\ \hat{b}} - \frac{2}{\hat{a}\hat{b}}\ \widehat{\mathrm{cov}(\hat{a},\hat{b})}\right].$$

We can calculate an estimate of the upper bound of this variance by substituting $\sqrt{\mathrm{var}\ \hat{a}\cdot\mathrm{var}\ \hat{b}}$ for $\widehat{\mathrm{cov}(\hat{a},\hat{b})}$ and taking the absolute value of the last term:

$$(4.28c)\quad \overline{\mathrm{var}\ \hat{d}} = \frac{\hat{a}^2}{\hat{b}^2} \left(\frac{1}{\hat{a}^2}\ \widehat{\mathrm{var}\ \hat{a}} + \frac{1}{\hat{b}^2}\ \widehat{\mathrm{var}\ \hat{b}} + \left| \frac{2}{\hat{a}\hat{b}} \sqrt{\mathrm{var}\ \hat{a}\cdot\mathrm{var}\ \hat{b}} \right| \right).$$

This estimate can be used to calculate the lower bound of the standard t-and F-ratios that are used in hypothesis testing. If $\underline{t} = \hat{d}/\overline{\mathrm{var}\ \hat{d}}$ is greater than 1.645, e.g., we can reject the null hypothesis that d=0, with a probability of 10 per cent of being wrong.

The fecundity variable r appears multiplicatively in all expressions in (4.28a). Since we do not know the value of r for each couple, and all d-parameters are proportional to r and b, we will arbitrarily set r equal to 1 when we estimate the parameters. Estimates of the d-parameters are presented in sections 5.8 and 6.7.

The only d-parameter which cannot be estimated from OLS-estimation of (4.27) is d_4. The estimation of this will be discussed shortly.

Turning now to the contraception equation (4.26), we notice that it is, as mentioned already, non-linear in both variables and parameters so we cannot use OLS to estimate it. It is not possible to simplify the equation by doing a Taylor series expansion of it, but we can use a general linear approximation:

$$(4.29) \quad e_t = a_0 + a_1 y_t + a_2 S_t + a_3 y_t S_t + a_4 y_t^2 + a_5 S_t^2 + \Sigma\, a_i Z_{eit} + u_{et}$$

Estimation of this equation will not yield estimates of any of the d-parameters, but it will give us a rough idea about the effects of the explanatory variables, their magnitudes and variances.

Another approach would be to first estimate (4.27) and derive estimates of $d_1 - d_3$ and $d_5 - d_7$ via (4.28a). Thus, we only lack an estimate of d_4. To obtain this we can substitute the estimates of d_3 and $d_5 - d_7$ into (4.26), omitting the additional explanatory factors, Z_i, to simplify:

$$(4.30) \quad e_t = [(r-\hat{d}_5)\, y_t - \hat{d}_7 y_t^2 - \hat{d}_6]\; S_t/[2\hat{d}_3 S_t + 2d_4] + u_{et}.$$

Thus, e_t is a non-linear function of the exogenous variable y_t, the endogenous variable S_t, one unknown parameter d_4, four known parameter estimates, and the disturbance term u_{et}. This equation can, for positive values of S and e be transformed into

$$(4.31) \quad W_t = cX_t + u_{Wt},$$

where

$$(4.32) \quad W_t = ((r - \hat{d}_5)\, y_t - \hat{d}_7 y_t^2 - \hat{d}_6)/e_t - 2\hat{d}_3,$$

$c = 2d_4$,

$X_t = 1/S_t$, and

$u_{wt} = u_{et}\ (2\hat{d}_3 + 2d_4)$.

This transformation is based on the fact that E $(1/e_t)$ asymptotically approaches 1/E (e_t).

If S is an exogenous non-stochastic variable, which it unfortunately is not, an estimator of parameter $d_4 = c/2$ can be found by OLS estimation of equation (4.31). This equation does not contain any intercept, however, so we cannot use a regular OLS program without modification. The OLS estimator of c is

(4.33) $\hat{c} = \Sigma\, W_i X_i / \Sigma\, X_i^2$,

with estimated variance

(4.34) $\text{var}\ \hat{c} = \hat{\sigma}_C^2 = \frac{1}{n-1} \sum_{i=1}^{n} (W_i - \hat{b}X_i)^2 / \Sigma\, X_i^2$,

where n is the number of observations.

Estimators of c and var c can be calculated from OLS estimation of the corresponding equation <u>with</u> intercept,

(4.35) $W_t = a + bX_t + u_t$.

Finally, $\hat{d}_4$ is estimated by

$$\hat{d}_4 = 0.5\ \hat{c},$$

and

$$\text{var}\ \hat{d}_4 = 0.25\ \text{var}\ \hat{c}.$$

Hypotheses about $\hat{d}_4$ can be tested using the test-statistic

$$t = \hat{d}_4/(\widehat{\text{var}\ \hat{d}_4})^{1/2},$$

which is t-distributed with n - 1 degrees of freedom, if u_t is normally distributed with zero mean and constant variance.

The value of the coefficient of determination, R^2, is higher for the unrestricted sample regression line, i.e. with intercept, than for the restricted one, since unrestricted OLS estimation leads to the maximum value of R^2 so that any departure from it must result in a decrease (Kmenta 1971:433). It is, however, not meaningful to calculate R^2 for the restricted case since it compares the sum of squares of deviations from the regression line with the sum of squares of deviations from the mean value of W_t, $\bar{W}$, and the restricted regression line does not pass through $(\bar{X},\bar{W})$. The ordinary R^2 could even assume negative values when there is no intercept. Setting $\bar{X} = 0$ and $\bar{W} = 0$ in the formula for R^2 is not meaningful either. Better measures of the goodness of fit are the F- or t-statistics.

Estimates of $\hat{d}_4$ using this method are presented in sections 5.8 and 6.7.

There are many problems with the OLS procedure described above for estimating the parameters: First, since (4.25) and (4.26) is a simultaneous equations system, where the endogenous variables also appear on the right-hand side of the equations, the estimators will be inconsistent. Second, when we calculate parameters $d_1 - d_3$ and $d_5 - d_7$ from the OLS regression of (4.25) we do not use the information that some of these parameters are also parameters in (4.26). A non-linear regression of (4.26) would surely yield different estimates of d_3, d_5, d_6 and d_7. Third, estimating d_4 from the OLS-regression of (4.31) can only be done for positive values of S and e, and S is not exogenous.

We will estimate demand equations (4.27) and 4.29), and parameter d_4 (4.31), by OLS (sections 5.5 - 5.7 and 6.5 - 6.7), in spite of the problems mentioned above. We do this because it is simple to use OLS to find out which additional explanatory variables we should include, and also to compare the OLS results with results from the more rigorous procedure presented in the next subsection.

4.7.2 Two-stage Least Squares Estimation

Writing the simultaneous equations system (4.25) and (4.26) in terms of the b_i-coefficients instead of the d_i-parameters, as in (4.27), yields

$$(4.27)\quad S_t = b_0 + b_1 y_t + b_2 e_t + b_3 e_t^2 + b_4 e_t y_t + b_5 e_t y_t^2 + \sum_{i=6}^{k} b_t Z_{Sit} + u_{st}$$

and

$$(4.36)\quad e_t = -b_2 S_t/(2b_3 S_t + b_1 c) - b_4 y_t S_t/(2b_3 S_t + b_1 c)$$
$$- b_5 y_t^2 S_t/(2b_3 S_t + b_1 c) + \Sigma\, b_i Z_{eit} + u_{et},$$

where

$$c = 2d_4/r$$

The first equation which is non-linear in variables but linear in parameters, can be estimated by the two-stage least-squares

(TSLS) procedure suggested by Kelejian (1971) and explained in more detail by Kelejian and Oates (1981). The second equation, which is non-linear in both variables and parameters can be estimated by the non-linear two-stage least squares (NLTSLS) procedure suggested by Amemiya (1974), which is also described by Kelejian and Oates (1981).

Kelejian and Oates distinguish between basic endogenous variables (here S and e), and additional endogenous variables, which are functions of the basic endogenous variables and the predetermined variables. The additional endogenous variables in the first equation are e^2, ey and ey^2, and in the second $S/(2b_3S + b_1c)$, $yS/(2b_3S + b_1c)$ and $y^2S/(2b_3S + b_1c)$. The predetermined variables are the pregnancy attitude, y, and the Z-variables discussed in section 2.11.

The necessary condition for identification of each equation is

$A_{1i} \geq A_{2i}$,

where A_{2i} is the number of basic endogenous variables appearing on the right-hand side of the i'th equation and A_{1i} is the number of predetermined variables and additional endogenous variables appearing in the model but not appearing in the i'th equation (Kelejian and Oates 1981: 294-295).

We find for the first equation above that $A_{21} = 1$ and $A_{11} = 3$, and for the second equation that $A_{22} = 0$ and $A_{12} = 4$, when we only include one predetermined variable, namely y. (Inclusion of other predetermined variables would not affect the identification condition here). Thus, the necessary conditions for identification are met. The additional conditions that must be satisfied in non-linear models to guarantee identification of a given equation are difficult to determine and rarely considered in practice (Kelejian and Oates 1981:295).

As mentioned above, the problem with our equations is that some right-hand side variables are correlated with the disturbance terms. The regular two-stage least square procedure, which consists of substituting the dependent variables with their predicted values, would not be feasible here, because it is too complicated to find the reduced-form equation with endogenous variables on the left-hand side only[1]. The Kelejian procedure overcomes this problem by regressing the basic and additional endogenous variables in each equation on all predetermined values and perhaps their squares etc., and replacing them by their predicted values, and finally estimating the unknown parameters by the ordinary least squares method. Thus, this is an instrumental variable technique. It can be shown that under reasonable conditions, these parameter estimators are consistent.

The basic endogenous variable on the right-hand side in the first equation (4.27) is e, and the additional endogenous variables are e^2, ey, and ey^2. The first stage of the two-stage procedure consists of regressing these variables on the predetermined variables and on powers of them, i.e. on y, y^2, and the additional explanatory factors: age, age squared, age of husband, age of husband squared, etc.[2] The second stage consists of calculating the predicted values of e, e^2, ey and ey^2, and using them in the least squares

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1) In principle there are three different solutions for S and e of the model (4.27) and (4.36), since substitution of S from (4.27) into (4.36) yields a cubic equation. We assume, however, as Kelejian and Oates (1981:285) also do, that if the model's equations define more than one solution, all but one of them are ruled out by restrictions on the variables, e.g. that S cannot be negative and that e is between zero and one.

2) The first-stage regression of e on the predetermined variables is identical to a regression of the reduced-form equation for the demand for sex.

regression of (4.27). The results from this are presented in sections 5.9 and 6.5.2 (tables 5.21 and 6.5).

Kelejian and Oates (1981:301) note that using the square of the predicted value of e, $(\hat{e})^2$, instead of the predicted value of e^2, $\widehat{e^2}$, would yield inconsistent second-stage estimators. Similarly for ey and ey^2. Moreover, for each equation the same set of predetermined variables has to be used as first-stage regressors to obtain all predicted variables to be used in the second stage.

The second-stage regression will not yield consistent estimators of the variances of the coefficients of the basic and additional variables, however, since they are correlated with the disturbance terms. But Kelejian and Oates (1981:249, 305) propose a method which will yield consistent estimators. A consistent estimator of the variance of $\hat{b}_2$ in (4.27) is

$$(4.37) \quad \widehat{\text{var}\,(\hat{b}_2)} = \hat{\sigma}_s^2 / \Sigma\, \hat{q}_t^2,$$

where $\hat{\sigma}_s^2$ is a consistent estimator of the variance of u_{st}, i.e.

$$(4.38) \quad \hat{\sigma}_s^2 = \sum_{t=1}^{n} (S_t - \hat{b}_o - \hat{b}_1 y_t - \hat{b}_2 e_t - \hat{b}_3 e_t^2 - \hat{b}_4 e_t y_t - \hat{b}_5 e_t y_t^2 - \hat{b}_6 Z_{6t} \ldots)/(n-d),$$

where n is the number of observations and d is the total number of explanatory variables including the constant, and $\hat{q}_t$ is the $t^{\underline{th}}$ residual in the regression of $\hat{e}_t$ on the other right-hand side variables in (4.27), i.e. on the predicted values of the additional endogenous variables and the predetermined variables:

$$(4.39) \quad \hat{q}_t = \hat{e}_t - \hat{a}_0 - \hat{a}_1 y_t - \hat{a}_2 e_t^2 - \hat{a}_3\, e_t y_t - \hat{a}_4 e_t y_t^2 - \hat{a}_5 Z_{6t} \ldots$$

The sums of squared residuals in (4.38) can be obtained from OLS single-equation estimation of (4.27), i.e. with no correction for the simultaneity bias. This is done in section 5.7.

Since the sample is quite large, we can assume that $(\hat{b}_2 - b_2)/\sqrt{(\text{var } \hat{b}_2)}$ is a standard normal variable, and use this to make inferences about $\hat{b}_2$. Formula (4.37) would be strictly correct only if the sample size were infinite, but since our sample is relatively large we may safely use it as an approximation. (Even the quarter sample should be large enough, in most cases we are using 500 or more observations).

The estimates of the variances of b_3, b_4, and b_5 are found in the same way as for b_2.

Since the predetermined variables y, Z_6, Z_7 etc. are uncorrelated with the disturbance terms, the ordinary second-stage estimators of the variances of their coefficients are consistent.

We cannot use the two-stage procedure described above to estimate the second equation (4.36) in the simultaneous-equations system, since it is non-linear in the parameters as well. The non-linear method suggested by Amemiya (1974) could be used to do this, although this method does not take into consideration the fact that some parameters appear in both equations. If we applied the Amemiya approach to the second equation, we would almost certainly get different estimates of the parameters appearing in both equations, and we would not know which of the estimates would be the correct ones, if any.

A modified approach would be to replace the unknown parameters $(b_0, \ldots, b_5)$ in the second equation with the estimates obtained from the TSTL estimates of the first equation, yielding

$$(4.40) \quad e_t = -(\hat{b}_2 + \hat{b}_4 y_t + \hat{b}_5 y_t^2) S_t / (2\hat{b}_3 S_t + \hat{b}_1 c) + \sum_{i=6} b_i Z_{eit} + u_{et},$$

which contains only one unknown parameter, c, in addition to the linear parameters b_6, b_7 ....[1]. These parameters can be estimated by the non-linear two-stage least squares (NLTSLS) method suggested by Amemiya (1974)[1].

This method consists of five steps, according to the outline presented by Kelejian and Oates (1981):

1. We express equation (4.40) in the form

$$(4.41) \quad F_t = u_{et},$$

where F_t equals e_t minus the right-hand side of (4.40) except the disturbance term:

$$(4.42) \quad F_t = e_t + (\hat{b}_2 + \hat{b}_4 y_t + \hat{b}_5 \hat{y}_t^2)\ S_t / (2\hat{b}_3 S_t + \hat{b}_1 c) + \sum_{i=6} b_i Z_{eit}$$

2. We determine an approximate value of F_t, denoted F_t^a, by selecting a set of values of parameters c and b_6, b_7, ...

3. We regress F_t^a on the exogenous variables and possibly their polynomials: y, y^2, age, age^2, etc.

4. We use the first-stage regressors in step 3 to calculate predicted values of F_t^a, denoted $\hat{F}_t^a$.

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1) This method differs from the method to estimate d_4 explained in subsection 4.7.1 (eg. 4.31) in that we here have a non-linear equation, it includes additional explanatory variables, the estimation can be done including cases with no intercourse and/ or no use of contraception, and we do not have to assume that S is exogenous.

5. We search over possible parameter values of c, b_6, b_7, ... to find the set of values that minimizes the sum of squares

$$(4.43)\quad W = \sum_{t-1}^{n} (\hat{F}_t^a)^2/n,$$

where n is the number of observations.

Any OLS program can be used to implement steps 1-4, e.g. SPSS. The fifth step requires non-linear estimation and is more complicated. This may be done doing OLS regressions for different parameter values, particularly if we only need to estimate c. The linear-approximation estimates of (4.29) described in section 4.7.1 can be used as estimates of the other coefficient b_6, b_7, ... It is feasible but very cumbersome to use a program like SPSS to search over only one parameter.

Alternatively, we may use a program containing non-linear estimation as an option, as e.g. TROLL does, to do step number 5 and perhaps the other steps as well.

CHAPTER 5

ANALYSIS OF QUARTER SAMPLE

5.1 Introduction. Why Quarter Sample?

In chapter 4 we derived the equations to be estimated, on the assumption that contraception is treated as a continuous variable. Thus, "all" that remains to be done should - in principle - be to estimate each equation once. But this is no simple task, since we have non-linear simultaneous equations including categorical and limited dependent variables.

In practice, however, it is normally not enough to estimate the equations only once, even if they had been linear and stochastically independent of each other.

It is usually necessary to experiment and try out different measures of the variables and perhaps also different functional forms. Moreover, there may be problems with the available computer programs. For these reasons the first empirical analysis will always be of a somewhat exploratory nature, even when the equations to be estimated are derived from an explicit theoretical model.

Since we knew in advance that we would have to do some exploratory data analysis, we decided to start it by utilizing only a subset of the full sample.

If the full sample had been used from the beginning, we could in principle only have estimated each equation once, as the results in further estimations would be conditionally dependent on the first results. This would violate standard statistical tests for significance.

There is always a chance that the results obtained only hold for the sample that is being studied. If we use only a part of the full sample to explore the data and relationships and to aid us in generating hypotheses, we can later test the hypotheses on the rest of the sample - provided that the two samples are statistically independent of each other.

We desided to use one quarter of the full sample of married women for the exploratory analysis. One quarter was chosen because this seems large enough (approximately 700) to permit meaningful statistical analysis, and because the remainder of the sample (approximately 2 200) seems sufficiently large to permit statistical estimation and hypothesis testing. An additional advantage of using only a quarter of the sample is that the computer work is faster and less expensive.

Since estimation of the system of non-linear equations is complicated and requires computer programs not easily available, we have mostly resorted to ordinary least squares estimation of linear-in-parameter approximations of each equation separately. This is done to get approximate estimates and to become acquainted with the data. This procedure does not generally yield consistent estimates, however. Most of this chapter will consist of a report on the findings from estimation of linear equations with the quarter sample data.[1)] Although this analysis was intended to be only preparatory and exploratory, the results were found to be of sufficient interest to justify presentation.

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1) All results presented here are obtained by SPSS versions 7 and 8 (Statistical Package for the Social Sciences, see Nie et al. 1975 and Hull and Nie 1979) on the Honeywell-Bull L66/60P computer of the Norwegian Government Computer Centre.

In addition to estimating linear versions of our derived demand equations (sections 5.3-5.6), we have also analyzed some traditional fertility measures (section 5.4), and done a two-stage least squares estimation of the demand for sex (section 5.7).

The experimental aspects of the quarter sample estimation of the linear-in-parameter equations (4.27) and (4.29) include

1) trying different Z-variables, see section 2.11,
2) including interaction terms and non-linear terms, e.g. quadratic terms,
3) trying different measures of the same variable, e.g. income and the desire to have an additional child soon, as it is not obvious from the theory how all variables should be measured, and as the available measures do not always correspond well to our variables,
4) trying different ways of solving problems like the ordinal nature of the y-variable and the categorical nature of the contraception variable.

Although the primary purpose of the analysis of the three-quarter sample is to test hypotheses about the effects of the exogenous variables, we will do some hypothesis testing in this chapter as well, mainly as part of the investigation to find out which variables we should include and which we should omit when we use the three-quarter sample. When we say that a variable is significant, or rather that the estimate of its coefficient is significantly different from zero, this should be interpreted as meaning that the standard error is less than the estimated coefficient divided by 1.645 (10 per cent level) or 2.576 (1 per cent level). The same is the case for other tests.

The theoretical analysis of chapter 2 (sections 2.6 -2.9) indicates that the empirical analysis should be done separately for couples whishing to or being indifferent to having an additional child soon, and for couples not wishing so. But as shown in section 2.9, the effects of S and e of an increase in y are practically the same for all realistic situations and consequently do not depend on the sign or value of y (columns 1, 3 and 4 in table 2.2).

The effects of an increase in fecundity, r, on the other hand, depend on the sign of y. As mentioned in chapter 3, however, the measurement of perceived fecundity is inappropriate for our model. Therefore, we have to exclude couples that think they are infecund from our empirical analysis, and drop fecundity r as an explanatory variable.

Thus, we conclude that we can in principle estimate the demand equations for all couples at the same time, whether or not they want an additional child soon. Still, it may be worth experimenting with separate estimation to see if the results differ much.

Before the estimation results are presented (sections 5.3-5.7), a brief description of the quarter sample is given.

5.2 Description of Quarter Sample

The subsample is drawn by first selecting all married women and then selecting every fourth of these, starting with the first one. This should give a random subsample of the full sample. (The respondents in the full sample are ordered successively according to geographical area but the order is otherwise arbitrary.

The full sample consists of 4 137 women, of which 2 937 are married. Thus, the quarter sample consists of 734 women and the three-quarter sample of 2 203 women. There are, however, missing data for most of the variables. Table 5.1 gives the number of non-missing cases and some descriptive statistics for the variables that are used in the analysis of the quarter sample.

5.3 Desire for an Additional Child Soon, y

5.3.1 Attitude Towards Pregnancy Next Month as a Measure of y

We do not have any direct measure of the desire for an additional child soon. But as discussed in sections 3.10 and 4.5, the attitude towards becoming pregnant soon seems to be a fairly good measure of it.

Other measures of y that we will try are desired next birth interval, whether the woman wants more children or not, and additional expected fertility.

The results of the regression analyses of y are presented in tables 5.2-5.5[1].

The first regression equation is the simple linear and additive approximation (4.20) of the "pure" theoretical model, i.e. without inclusions of any exogenous z-variables. The explanatory variables are current full family income (I), the woman's actual or potential wage rate as a proxy for the price of children (Π), and children ever born (N), see regression 1 in table 5.2.

---

1) The number of observations (cases) is less than the size of the quarter sample, 734, and not the same in each regression, due to missing observations.

Table 5.1 Descriptive statistics of quarter sample of married women

Variable	Number of non-missing cases	Minimum	Maximum	Mean	Standard deviation
Pregnancy attitude (y)[2]	571	-2	2	-0.03	1.18
Perceived fecundity (r)[1]	701	0	1	0.86	0.34
Coital frequency last 4 weeks (S)[3]	646	0	12+	6.0	4.0
Used contraception last 4 weeks (M)[1]	537	0	1	0.857	0.351
Contraceptive effectiveness (e)	537	0.0	0.996	0.825	0.340
Full income of couple, kr/yr (I)	450	18 500	347 250	114 536	34 811
Wage of woman (actual potential), Kr/hr (π)	543	1	96	27.48	11.22
Full income of couple, Kr/yr(I)[4]	700	18 500	347 250	113 578	32 766
Wage of woman (actual or potential), Kr/hr(π)[4]	705	1	96	27.11	10.13
Number of live children (N)	734	0	8	1.98	1.20
Children ever born	734	0	8	2.01	1.21
Additional ecpected fertility	606	0	4	0.44	0.79
Total expected fertility	606	0	8	2.50	1.02
Having children[1]	734	0	1	0.888	0.315
Expecting more children[1]	730	0	1	0.264	0.441
Duration of marriage and cohabitation, months	733	2	326	128.8	73.3
Youngest child less than two years[1]	734	0	1	0.19	0.39
Desired interval of next birth, years[3]	173	<1	5+	2.37	1.50
Want another child within a year[1]	734	0	1	0.056	0.008
Relative economic position[2]	730	1	5	3.45	0.65
Index of durable consumption goods	734	0	5	2.71	0.91
Ownership of house/apartment[1]	734	0	1	0.710	0.454
Saving for house/apartment[1]	734	0	1	0.138	0.345
Political activity (meetings per year)[3]	733	0	70+	0.6	3.8
Religious activity (meetings per year)[3]	734	0	70+	4.3	12.6
Strong religious feelings[1]	733	0	1	0.08	0.26
Number of siblings	734	0	11	2.49	1.89
Growing up in a rural place[1]	712	0	1	0.41	0.49
Living in a rural place[1]	734	0	1	0.21	0.41
Having gainful work[1]	734	0	1	0.62	0.49
Education of woman, years	733	7	18	10.3	2.3
Age of woman	734	18	44	32.0	6.3
Age of husband	733	19	64	34.9	7.7
Education of husband, years	713	7	18	11.2	2.9
Education of father, years	610	7	12	7.8	1.5
Education of mother, years	671	7	12	7.6	1.2
Mother had gainful work[1]	610	0	1	0.46	0.50

1) Binary variable (0,1). The mean value equals the proportion of cases where the variable equals one.

2) Ordinal variable, see ch. 3 for assigning of values.

3) Interval variable recoded to a continuous variable by assigning the midpoint of each interval. The maximum value is the value assigned to the open interval.

4) Partly based on estimated values, see sections 3.4-3.7.

We notice first that the three variables combined have a significant effect on y. This is seen from the value of the F-statistic at the bottom of the table, which is a measure of the goodness of fit, just as the multiple correlation coefficient, R, is.1) As shown in the table we expect a positive income effect but get a negative coefficient. Its standard error is too large to draw any conclusions, however.2) As discussed in subsection 2.10.2 a negative income effect contradicts theory but is frequently observed in practice. The wage effect is also not significant, although the estimate has a negative sign as predicted by theory and confirmed by numerous other analyses. The standard error is not exceedingly large, which indicates that other runs may yield significant results (as in runs 7 and 8), or when the larger three-quarter sample is used.

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1) The F-statistic can be used to test the hypothesis that none of the explanatory variables have any influence on the mean of the dependent variable. A starred F-statistic in the table means that the null-hypothesis that all coefficient are zero is rejected at a significance level of 10%, whereas two stars correspond to 1%. The F-statistic is F-distributed with K-1 and n-K degrees of freedom under the null hypothesis, where K is the number of explanatory variables including the constant, and n is the number of observations, see Kmenta (1971:366). The relationship between F and R^2 is $F(K-1, n-K) = \frac{n-K}{K-1}\frac{R^2}{1-R^2}$

2) Because we expect the income coefficient to be positive,see section 2.10, we use a one-sided test to test the null-hypothesis that the income coefficient is less than or equal to zero. By using a t-test we find that the null-hypothesis cannot be rejected (test-statistic -0.524). On the other hand, many empirical studies yield a <u>negative</u> income coefficient. Because of the uncertainty of the sign of the income coefficient, we also test the null-hypothesis that it is zero against the alternative that it is different from zero. This null-hypothesis cannot be rejected either.

Thus, the only significant variable is the number of live children, which has a negative and quite strong effect on the desire to become pregnant soon, as expected. The two economic variables do not have a combined significant effect either, as shown by an F-test for the relevance of additional explanatory variables[1)2)].

The effect of the "price" of children, or rather the woman's wage, may be quite different for women with and without children. In a regression not shown here, we included a variable that is set equal to the wage if the woman has children and zero otherwise. This did not yield a significant wage effect either. In still another regression not presented here we estimated equation (4.21) without the Z-variables, i.e. the same as regression 1 in table 5.2, but with the non-linear explanatory factors N^2 and N x wage in addition. We find that the N^2-coefficient is significantly positive, whereas the interaction coefficient is not significant. Consequently, we include N^2 but exclude N x wage from further regressions.

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1) This F-test is used to test the null-hypothesis that all coefficients of a set of additional variables are zero against the alternative that at least one of them is different from zero. The test-statistic can be computed as

$$F\ (Q-K,\ n-Q) \quad = \quad [(R_Q^2 - R_K^2)/(1-R_Q^2)] \cdot [(n-Q/(Q-K)]$$

which represents the F-distribution with Q-K and n-Q degrees of freedom if the null hypothesis is true. The original equation has K explanatory variables, including the constant, yielding a multiple correlation coefficient R_K^2 , whereas the extended equation has Q explanatory variables, yielding R_Q^2. Thus, Q-K additional variables have been included. See Kmenta (1971:370).

2) The test-statistic is 1.77, which is smaller than the 10 % fractile of the F-distribution with 3-1 and 541-3 degrees of freedom, and the null-hypothesis that the economic variables have no influence cannot be rejected.

Table 5.2 Regressions of attitude towards pregnancy next month. Partly imputed wage and income variables

OLS estimates of coefficients. Standard errors in parentheses.

	Hypothesized effect	1	2	3	4	5	6	7	8
Constant		1.02	-3.18	-3.25	-0.71	-0.16	-1.28	-0.64	-0.76
Full income (I),in 100 000 kr	+	-0.099	-0.061	-0.047	-0.062	-0.074	-0.081	0.057	-0.082
		(0.188)	(0.186)	(0.187)	(0.186)	(0.184)	(0.200)	(0.268)	(0.186)
Wage of woman (r),in 100 kroner	−	-0.610	-0.836(*)	-0.917(*)	-0.802(*)	-0.649	-0.526	-1.502*	-0.582
		(0.605)	(0.597)	(0.609)	(0.607)	(0.601)	(0.623)	(0.858)	(0.614)
Live children (N).......................	−	-0.386**	-0.780**	-0.767**	-0.879**	-0.683**	-0.634**	-0.826**	-0.646**
		(0.045)	(0.136)	(0.137)	(0.142)	(0.150)	(0.153)	(0.189)	(0.150)
Live children squared (N^2).............	+		0.093**	0.092**	0.113**	0.088**	0.074(**)	0.126**	0.077**
			(0.028)	(0.028)	(0.028)	(0.029)	(0.029)	(0.037)	(0.029)
Age	+		0.308**	0.310**	0.119	0.100	0.161(*)	0.167(*)	0.138(*)
			(0.080)	(-0.080)	(0.105)	(0.104)	(0.107)	(0.131)	(0.105)
Age squared	−		-0.0050**	-0.0049**	-0.0020	-0.0017	-0.0028*	-0.0027(*)	-0.0024(*)
			(0.0012)	(0.0012)	(0.0017)	(0.0016)	(0.0017)	(0.0020)	(0.0016)
Marriage duration, in years	+			-0.013	0.111*	0.054	0.035	0.042	0.037
				(0.020)	(0.048)	(0.050)	(0.051)	(0.062)	(0.051)
Marriage duration squared	−				-0.0052**	-0.0036**	-0.0027(*)	-0.0030(*)	-0.0028(*)
					(0.0019)	(0.0019)	(0.0019)	(0.0023)	(0.0019)
Youngest child less than two years.......	−					-0.500**	-0.497**	-0.621**	-0.487**
						(0.134)	(0.137)	(0.168)	(0.133)
Relative economic position	+						0.0052		
							(0.0788)		
Durable consumption goods	−						-0.025		
							(0.059)		
Ownership of house/apartment[1]	+						0.094		
							(0.142)		
Saving for house/apartment[1]	+						0.242(*)		
							(0.175)		
Political activity(meetings per year)...	−						-0.0045		
							(0.0160)		
Religious activity (meetings per year)...	−						0.0097*		0.0087*
							(0.0058)		(0.0038)
Strong religious feelings[1]	+						-0.084		
							(0.270)		
Number of siblings	+						0.013		
							(0.027)		
Growing up in a rural place[1]	+						0.262*		0.320**
							(0.105)		(0.097)
Living in a rural place[1]	+						0.115		
							(0.124)		
Having gainful work[1]	−						0.048		
							(0.103)		
Education of woman	−							0.011	
								(0.034)	
Age of husband	−							-0.012	
								(0.018)	
Education of husband	−							-0.013	
								(0.024)	
Education of father	−?							0.097*	
								(0.054)	
Education of mother	−							-0.080	
								(0.065)	
Mother worked[1]	−							-0.099	
								(0.117)	
Number of cases		541	541	541	541	541	524	370	526
F-statistic		26.7**	18.4**	15.8**	15.0**	15.2**	8.1**	7.4**	14.5**
R^2		0.130	0.171	0.172	0.184	0.205	0.244	0.238	0.236

1) Dummy variable. For explanation of stars see table 5.3, page 228.

In the rest of the regressions, most of the exogenous variables discussed in section 2.10 are introduced successively. They have only been included additively, on the assumption that they only affect the intercept and not the slope of any of the other variables, i.e. there are no interaction effects.[1)]

All regression runs show that both the number of children and its square have strong and significant effects on the desire for an additional child soon. The N-coefficient is negative and the N^2-coefficient positive, which means that the relationship is U-shaped. The estimated coefficients can be used to calculate the family size at which the attitude towards becoming pregnant soon is the least positive[2)]. This may be interpreted as the parity the couple is the most happy with, since they have the least desire to change it, at least in the short run. We get values of the "optimal" number of children ranging from 4.3 (regression 6) to 3.3 (regression 7). These values may seem a bit high,

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1) Multicollinearity does not seem to cause any problems. Among the explanatory variables in table 5.2, only variables that are functions of each other have correlation coefficients exceeding 0.90, ranging from 0.94 for N and N^2, to 0.994 for age and age squared. The other pairs of variables that are most highly correlated are age and marriage duration (corr.coeff.=0.89), and mother's and father's education (corr.coeff.=0.64). Thus, the only problematic variables seem to be age and age squared, which are highly but not perfectly correlated. This should not affect the results for any of the other variables, but indicates that the estimates of the coefficients of age and age squared may be somewhat random. As long as the variances are small we should be on safe ground, however. Moreover, if the three-quarter sample yields estimates that are not too different from these results, we should be fairly certain that there is no multicollinearity problem. This is, in fact, the case, which we see by comparing the estimates in reg. 8 in table 5.2 and reg. 2 in table 6.1. The age-estimates are virtually identical.

2) Let $y = a_0 + a_1N + a_2N^2 + \ldots$. Setting the derivative of y with respect to N equal to zero yields $\tilde{N} = -a_1/2a_2$.

compared to the mean total desired number of children in the sample, which is 2.5 children. They may not be so unrealistic, however, considering that parity is only one of the factors determining the attitude towards pregnancy soon, and that other factors may have a stronger and more decisive negative effect. Women might be happy having a lot more children than they actually have and also say they want, had it not been for a number of factors which make it difficult to have many children. In fact, the "optimal" number of children is generally lower the more explanatory variables are included, (it varies from 4.2 in run 2, to 3.3 in run 7, with run 6 as an exception), but this may be a coincidence.

The relatively high values for the optimal number of children, 3.3-4.3, may also be indicative of the somewhat hypothetical and unrealistic nature of the pregnancy attitude variable, as discussed in section 3.10.

As an experiment we included a dummy variable for child expectations (=1 if woman expects more children, 0 otherwise) as an explanatory variable in some regressions not shown here. The variable has a strong and highly significant effect on the attitude towards pregnancy next month, but it is also changing the size and significance of most of the other coefficients. It is doubtful, however, that this life-time variable really belongs in a short-horizon model.

Let us now look at the relationship between age and the attitude towards pregnancy soon, which was hypothesized to be an inverted U-shape (subsection 2.11.2). Both age and age squared come out significantly in regressions 2 and 3. Similarly to what we did for parity, we can calculate the age where the attitude towards pregnancy is the most positive. We get values ranging from 28.7 years (run 8) to 31.6 years (run 3), which seem like reasonable results. This means that the attitude towards pregnancy becomes increasingly positive up to around 30 years of age and decreases afterwards, when other variables are controlled. The attitude does not change much by age between 20 and 40, but it increases rapidly for teenagers and decreases fast for women above 40.

In regression 3 we have included the duration of marriage (plus any cohabitation before marriage with the husband-to-be), which we believe is important for the desire to become pregnant. Marriage duration alone is not significant. As discussed in section 2.10, however, increasing marriage duration may have a positive effect on y for short durations, implying that the square of the duration should also be included. When this is done, as in regression 4, we get a strong and highly significant effect. As for age we can calculate the duration of marriage where the attitude towards pregnancy soon is the most positive. We get values ranging from 5 years (run 8) to 11 years (run 4). On the other hand, the introduction of marriage duration reduces the magnitude of the age effect. We see from run 4 that the two age coefficients are no longer significantly different from zero. But taken together, age and age squared have a significant effect at the 1 per cent level, as shown by the F-test mentioned previously (test-statistic 10.7).

The importance of marriage duration is reduced, however, when a dummy variable for the length of the open birth variable is introduced, as in regression 5.[1)] The marriage duration is only significant in combination with its square.

We see from table 5.2 that having had a child less than two years ago has a strong negative and significant effect on the desire to become pregnant, as expected.[2)]

So far we have looked at the effects on y of the "original" economic and demographic variables, and in addition some central demographic variables: Age, marriage duration and length of open birth interval. In regressions 6 and 7 in table 5.2 we include a number of social and economic current and permanent factors, to test the effects hypothesized in section 2.10.

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1) As argued in 2.10.2 it is primarily short open birth intervals that should affect the desire to have an additional child soon. To account for this we use a dummy variable with a value of 1 if the youngest live child is less than two years old, and zero otherwise. (Including women with no children). Since infant mortality is so low in Norway, the time since last delivery would have yielded practically the same results as the age of the youngest child.

2) As an experiment we also included the open birth interval and its square as continuous variables in a regression not shown in table 5.2, and found a significant and inverted U-shape effect. The desire to have an additional child soon increases for open intervals less than 8 years and decreases thereafter. But as discussed in 2.10.2, long open birth intervals should not, really, have any effects that are not captured by age and marriage duration. To avoid the polluting effects on age and marriage duration, only a binary variable for short open intervals is included, as in regressions 5-8. The correlation coefficients between the length of the open birth interval and age and marriage duration are 0.64 and 0.71, respectively.

As explained in section 2.10, differences in reproductive attitudes and behaviour may also be due to differences in the "tastes" for children. Easterlin (1973) argues, e.g., for the importance of the standard of living of young adults relative to their parents while growing up. A more general interpretation of the well-known Easterlin hypothesis is that the feeling of economic well-being relative to other groups, like people of the same age, education and social status, friends, colleagues and neighbours, is important for the fertility. Different versions of the Easterlin-hypothesis have been tested by Freedman (1963) Thornton (1979), and others, but with mixed results.

The respondents in the survey were asked about their economic position compared to friends and acquaintances (Q.140), and values from 1 (very poor) to 5 (very good) were assigned. We expect this variable to have a positive effect on the attitude towards pregnancy. Regression 6 shows that the standard error is very large, yielding no support for the relative income hypothesis. This is no surprise since this hypothesis probably has the greatest validity for life-time decisions.

Some questions to try to measure consumer aspirations were also included in the survey (Q.134). For each of six items - house/apartment, holiday house, automobile, colour television, dishwasher, and washing machine - the respondent was asked if she and her husband owned one or not, if she considered it important to get one, and if she was saving to get one. We constructed an index for the five last goods, i.e. excluding house ownership which is analysed separately, with the value of the index being equal to the number of durable consumption goods owned by the respondent and her husband. Regression 6 indicates that this index does not have any effect on the pregnancy attitude.

Owning a house/apartment and saving to get one are entered separately as explanatory factors of y. Here, however, we do not expect any conflict with childbearing. On the contrary, couples owning a house (and particularly if they are planning to get one as indicated by their savings behaviour), are more likely to want an additional child soon, but it may also be the other way around: couples who are planning to have another child may be saving to get larger accomodation. It is perhaps more appropriate to say that both variables are caused by a common set of factors, of which the stage of family building is an important one. Regression 6 shows that only the savings variable has a significant positive effect on y.

Finally, we use the F-test to see if the four consumption aspirations variables in regression 6 (relative economic position, durable consumption goods, ownership and saving for house/apartment), combined have any effect on the attitude towards pregnancy soon. The test-statistic is only 0.81 and we cannot reject the null-hypothesis that they have no influence.

In section 2.10 we discussed the importance of time-use and competing activities for fertility behaviour. In regression 6 we have included a couple of variables as proxies for such activities, namely political and religious activity, as measured by the number of meetings attended in the past 12 months (Q.131).[1] We find that political activity is not significant, whereas religious activity has a positive effect on the pregnancy attitude, as expected. It is likely, however, that religious activity is a better measure of religiosity than of time use.[2] It is not surprising that religiosity has a positive effect on fertility attitudes. We have also included another measure of religiosity, religious feelings, in regression 6, but this is not significant. This variable is probably not a good measure, however. It is constructed as a dummy variable from the answers to the question "Would you say that your religious feelings are strong, average or weak, or are you indifferent to religion?" (Q.133). Only 7.5 per cent replied that they have strong religious feelings.

There are still striking regional differences in fertility in Norway, although they have diminished considerably in the last decade.[3] These differences may partly be due to differences in population density and rurality. As mentioned in 2.10 many studies show a strong relationship between rural background and fertility behaviour. In regression 6 we have included two dummy variables as measures of the rurality of the

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1) The response alternatives were given as categories: 0, 1-2, 3-5, 6-9, 10-19, 20-39, 40-59 and 60+ meetings. We constructed a variable with the midpoint value of each category (0, 1.5, 4, etc.) and 70 for the open interval. The majority of the women did not attend any meetings at all: only 9 per cent had attended a political meeting and 41 per cent a religious meeting or been to church.

2) The zero-order partial correlation coefficient between religious activity and religious feelings is quite high, 0.76, but only 0.06 between religious and political activity.

3) In 1968, the total fertility rate ranged from 1.67 in Oslo to 3.40 in Finnmark, whereas it in 1977 only ranged from 1.39 in Oslo to 2.12 in Sogn og Fjordane. (Source: Central Bureau of Statistics, 1978b, and unpublished data.)

place the woman grow up in and her current place of residence, respectively.[1)] Only "growing up in a rural area" has a significant positive effect. It is interesting to notice that the character of the place where the woman grew up has a greater effect on the pregnancy attitude, and a smaller standard error, than the place where she currently lives. This may be an example of a family background factor that influences fertility "tastes", i.e. the shape of the preference function, or the fertility norms as sociologists would put it.

Own family size is also often believed to be important for fertility attitudes, as discussed in section 2.10. In regression 6 we included the number of siblings of the woman, but got a large standard error. We should have included the family size of the husband as well, but this item was not collected in the survey.

Finally, we test whether the activity and rurality variables in regression 6 combined have any significant influence on the pregnancy attitude, and conclude that they do not (test-statistic 2.65).

In regression 7 we have included some characteristics of the husband and the parents, together with the woman's own education. We notice that neither her own nor her husband's education have significant effects, which is no surprise in view of the discussion in section 2.10.2 (G1). Some of the effects of education may have been captured through the wage and income variables, however. The education of the father has a significant positive effect, whereas the mother's education

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1) Each variable is set equal to one if the place is sparsely populated (spredtbygd), and zero otherwise. Table 5.1 shows that 41 % of the respondents grew up in a rural place. The zero-order correlation coefficient between the two dummy variables is 0.33.

is not significant.[1] The combined effect of the education variables is not significant either.

It is difficult to see the reason why the attitude towards becoming pregnant soon should be greater the more education the woman's father has. Moreover, inclusion of this variable makes the effect of the woman's wage stronger. By running regressions similar to number 6 but without the father's education as an explanatory variable, we find that the strong and significant wage effect is a selection bias due to exclusion of cases when the father's education is included, and not the effect of father's education *per se*[2].

We hypothesize that having grown up with a mother who had gainful work may have weakened family values and strengthened preferences for a work carreer, implying a negative effect on the pregnancy attitude, *ceteris paribus*. The "mother worked" coefficient is negative as expected, but not significantly so.

We have also tested whether all the additional education and background variables in regression 7 combined have any influence on the desire to become pregnant. The test-statistic is 0.9, and we cannot conclude that this may be the case.

In regressions 6 and 7 we introduced a number of additional variables. Most of them turned out to affect the pregnancy attitude in the expected direction, but only a few of them have coefficients that

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1) All education variables discussed here are coded in the way described in section 3.2, that is by assigning the normal duration of the highest completed education. Only 29 per cent of the mothers and 31 per cent of the fathers have more than 7 years of primary school, when the missing cases are excluded. For the parents we have only included general education. Information about additional education of the mother was obtained in the survey, but not used here.

2) Education of the father is missing for fully 17 per cent of the cases. Inclusion of it in regression no. 6 reduces the number of cases from 416 to 370.

are significantly different from zero: saving for house/apartment, religious activity, rurality of place of growing up, and father's education. As discussed above, there are problems with the first and last variables, however, so we decided to exclude them from further analyses. In regression 8 we have included the two other variables, in addition to the variables that are derived from the theoretical model and the central demographic variables (see regression 5). Both religious activity and rurality retain their signs and significance.

Comparing regressions 8 and 5 we see that inclusion of these two additional variables increases the square of the multiple correlation coefficient from 0.205 to 0.236, while not changing the size of the coefficients and their standard errors much.

5.3.1.1 Use of Observed Income and Wage Variables

The income and wage variables used as explanatory variables in regressions 1-8 are partly based on estimated (imputed) data to reduce the number of missing cases, as discussed in sections 3.4-3.7 (lines E and M in table 3.2). To study the effects of this we ran the regressions in table 5.2 again, but with the observed and not the imputed wage and income variables, i.e. lines C and K in table 3.2, see table 5.3 where some of the results are shown. The main effect is, as expected, that the number of cases is considerably reduced (from 541 to 352, i.e. by 35 per cent). Otherwise the regression results are quite similar. The signs of the coefficients are identical and their values not very different, but the standard errors are larger without the imputed data due to the smaller number of cases. Still, the results are practically identical as far as hypothesis testing is concerned. The multiple correlation coefficients are also almost equal.

As explained in sections 3.4-3.7 the imputed values are predicted on the basis of education and work experience for women, and education and age for men. Instead of doing this prediction we may include these four variables directly as explanatory variables, see regression 6 in table 5.3, which should be compared to regression 5 in table 5.2 (and regression 2 in table 5.3). Only the age of the husband has a significant effect (negative) on the attitude towards pregnancy soon. The greatest difference between the two regressions is that the wage coefficient changes from positive to negative, but it is still not significantly different from zero. The standard errors, which are not shown in table 5.3 to simplify the presentation, are also larger. Thus, we do not seem to gain anything by this.

We conclude that use of observed and imputed wage and income variables yield similar results. We will continue to use imputed variables when observations are missing to get more cases and higher efficiency.

5.3.2 Other Measures of the Desire for an Additional Child Soon

As mentioned previously, there are several problems with the pregnancy attitude variable. It would, therefore, be interesting to try some other measures of the desire for an additional child. Two other items in the survey seem relevant for this: desired time to next birth and additional expected number of children.[1)] Both variables can be interpreted as continuous proxies for the desire to have an addi-

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1) "About when would you prefer to have your first (next) child?" (Q.64). The response categories were: Within a year, 1-2 years, 3-4 years, 5 years or more, and Have made no plans. The additional expected children variable was discussed in section 3.9.

Table 5.3 Regressions of attitude towards pregnancy next month. Observed wage and income variables

	Hypothesized effect	OLS estimates of coefficients					
		1	2	3	4	5	6
Constant........................		0.99	-0.50	-2.03	-0.28	-1.34	-0.80
Full income (I), in 100 000 kr...	+	-0.037	-0.056	-0.10	0.01	-0.09	-0.10
Wage of woman (π), in 100 kr....	-	-0.602	-0.496	-0.402	-1.321	0.389	0.189
Live children (N)...............	-	-0.419**	-0.602**	-0.540**	-0.863**	-0.570**	-0.632**
Live children squared (N^2).......	+		0.067*	0.055(*)	0.124(**)	0.062	0.076*
Age............................	+		0.113	0.185(*)	0.122	0.171(*)	0.194(*)
Age squared.....................	-		-0.0017	-0.0029(*)	-0.0019	-0.0027(*)	-0.0023
Marriage duration, in years.......	+		0.022	0.0007	0.060	-0.002	0.019
Marriage duration squared........	-		-0.0024	-0.0016	-0.0031	-0.0014	-0.0027
Youngest child less than two years 1)	-		-0.652**	-0.647**	-0.612**	-0.618**	-0.672**
Relative economic position.......	+			0.028			
Durable consumption goods........	-			0.029			
Ownership of house/apartment 1)...	+			0.107			
Saving for house/apartment 1).....	-			0.334(*)			
Political activity (meetings per year)	-			-0.001			
Religious activity (meetings per year)	-			0.001		0.003	
Strong religious feelings 1)..........	+			0.035			
Number of siblings..................	+			0.034			
Growing up in a rural place 1)........	+			0.204			
Living in a rural place 1)...........	+			0.187(*)		0.276*	
Having gainful work 1)...............	-			0.078			
Education of woman..................	-				0.015		-0.033
Labour force experience of woman.....	-						-0.019
Education of husband................	-				-0.017		-0.015
Age of husband......................	-				-0.019		-0.028(*)
Education of father.................	-?				0.159*		
Education of mother.................	-				-0.098		
Mother worked 1)....................	-				-0.166		
Number of cases.....................		352	352	341	242	342	312
F-statistic.........................		18.3**	8.9**	4.9*	5.0*	8.5**	6.2*
R^2		.136	.205	.235	.249	.221	.212

1) Dummy variable

*) Significantly different from zero at ten per cent level (two-sided test)

**) Significantly different from zero at one per cent level (two-sided test)

(*) Significantly greater (or less) than zero at ten per cent level (one-sided test)

(**) Significantly greater (or less) than zero at one per cent level (one-sided test)

tional child soon: the shorter the desired time to the next birth and the more additional children the woman wants, the more likely she is to want an additional child soon.

These two variables, and two binary versions of them, are used as dependent variables in the regressions presented in table 5.4.

The first regression has desired time to next birth as dependent variable. We notice that only the index of durable consumption goods, and not the explanatory variables combined, has any significant effect. This is probably due to the small sample size, which here only consists of women who want another child and report when they want it. It is somewhat surprising that not even having had a child less than two years ago has any significant effect on when the woman wants her next child.

The desired time to the next birth is a rather poor proxy for the desire for an additional child soon, however, and partly because of the way it was measured. The response to the question was recorded as an ordered and not a continuous variable. In addition there are probably non-linearities that are not taken care of in regression 1 in table 5.4.

Women who answer that they want their next child within a year, however, can surely be said to want their next child soon. We constructed a dummy variable with value one if the woman wants her next

Table 5.4 Regressions of other measures of the desire for an additional child soon

	Hypothesized effect in 2-4	Desired time to next birth 1 coeff.	st. err.	Wanting next child within one year 2 coeff.	st. err.	Additional expected fertility 3 coeff.	st. err.	Expecting more children 4 coeff.	st. err
Constant........................		5.65		0.07		3.46		2.18	
Full income (I), in 100 000 kr.[2]...	+	0.441	0.456	0.020	0.038	-0.018	0.090	0.016	0.057
Wage of woman (π), in 100 kr.[2]....	-	-0.532	1.848	-0.184(*)	0.124	-0.461(*)	0.292	-0.221	0.183
Live children (N)...............	-	0.325	0.495	-0.091**	0.023	-0.348**	0.056	-0.141**	0.034
Live children squared (N^2).......	+	0.036	0.163	0.013**	0.004	0.050**	0.010	0.019**	0.006
Age.............................	+	-0.209	0.456	0.024	0.019	-0.080*	0.046	-0.059*	0.029
Age squared.....................	-	0.0016	0.0087	-0.0004(*)	0.0003	0.0007	0.0007	0.0006	0.0004
Marriage duration, in years.......	+	-0.0510	0.1757	-0.0137	0.0089	-0.1567**	0.022	-0.0658**	0.0130
Marriage duration squared........	-	0.0031	0.0135	0.0004	0.0003	0.0051**	0.0007	0.0021	0.0005
Youngest child less than two years[1]	-	0.483	0.335	-0.072**	0.026	-0.279**	0.064	-0.070*	0.038
Relative economic position.......	+	0.066	0.193	-0.027*	0.015	-0.013	0.035	-0.023	0.022
Durable consumption goods........	-	-0.223*	0.152	0.008	0.010	-0.015	0.025	0.004	0.015
Ownership of house/apartment[1]...	+	0.153	0.332	0.005	0.026	-0.027	0.060	-0.010	0.038
Saving for house/apartment[1].....	-	-0.227	0.341	0.066*	0.033	0.141*	0.079	0.029	0.048
Religious activity (meetings per year)	-	-0.010	0.010	0.001	0.001	0.006**	0.002	0.001	0.001
Number of siblings..................	+	-0.074	0.083	-0.004	0.005	0.003	0.011	-0.009	0.007
Growing up in a rural place[1]........	+	0.098	0.268	-0.030	0.019	0.036	0.045	0.003	0.028
Living in a rural place[1]............	+	-0.206	0.333	0.045*	0.022	0.094*	0.055	0.067*	0.033
Having gainful work[1]................	-	-0.207	0.282	0.034*	0.019	0.086	0.046	0.038	0.028
Education of woman..................	-	0.090	0.068	-0.008(*)	0.005	0.029**	0.011	0.004	0.007
Number of cases.....................		160		674		557		670	
F-statistic.........................		1.76		5.74*		52.3**		31.5**	
R^2		0.193		0.143		0.649		0.480	
Adjusted R^2..........................		0.083		0.118		0.637		0.464	

1) Dummy variable 2) Partly based on estimated values, see sections 3.4-3.7.

*) Significantly different from zero at ten per cent level (two-sided test)

**) Significantly different from zero at one per cent level (two-sided test)

(*) Significantly greater (or less) than zero at ten per cent level (one-sided test)

(**) Significantly greater (or less) than zero at one per cent level (one-sided test)

child within a year and zero otherwise, as in regression 2.[1] This increases the sample size and improves the results substantially, with a large number of significant coefficients. We notice, for example, that the wage of the woman has a significant and negative effect on the desire to have another child within a year, as expected. The same is the case for the education of the woman, having a child of less than two years of age, and growing up in a rural place.

It is, however, not appropriate to use the ordinary least squares method when the dependent variable is dichotomous as in regression 2, and for several reasons: (1) the disturbance is not normally distributed and is heteroskedastic, (2) the OLS estimators of the coefficients are not normally distributed and the classical tests of significance do not apply, and (3) the predicted value of the dependent variable may fall outside the interval from 0 to 1 (Kmenta 1971: 425-427). More appropriate estimation methods include the LOGIT and PROBIT methods. In spite of the shortcomings of the OLS method we use it at this preliminary stage to get approximate results. Moreover, several studies find that OLS yields almost the same results as more sopisticated methods, particularly when the dependent variable is evenly distributed between 0 and 1[2]. This is not the case here, unfortunately, as only 6 per cent of the women want another child within a year. The results in regression 2 are, therefore, quite tentative.

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1) In a regression not shown here we set the dummy variable equal to zero only for women who want another child in more than a year, and missing for other women. This did not yield any better results. The only significant variable was the number of children.

2) Lansing and Morgan (1971) suggest that OLS estimates are most reliable when the average value of the dependent variable falls between 0.2 and 0.8.

We now turn to the expected number of additional children, AEF. The results from a regression with this as the dependent variable are presented in column 3 of table 5.4. We first notice the high values of the F-statistic and the coefficient of determination: R^2 is 0.65 which is unusually high for a cross-section analysis of micro data. We do not, however, consider the value of R^2 to be an important criterion for the performance of a regression model. Next we see that all the demographic variables have strong and highly significant effects. Both the number of live shildren and the marriage duration have a u-shaped relation to additional expected fertility, with a minimum effect at 3.4 children, and 15 years, respectively, whereas the age effect is negative throughout the childbearing ages.

We do not see the reason, however, why women who have more than 3-4 children and have been married for more than 15 years should expect <u>more</u> additional children the more children they have already and the longer they have been married. This may be the result of pooling different cohorts together in the analysis.

Having had a child less than two years ago reduces the number of additional expected children by more than a quarter of a child. This may not only be a spacing effect, however, since women who just had a child have already had a large proportion of the children they expect to have altogether.

Turning to the non-demographic variables we see that the wage of the woman has a significant and negative effect on additional expected fertility as hypothesized, whereas the income effect is not significant. The elasticity of additional children with respect to wage is -0.28 (for the mean values of AEF and wage). Both having gainful work and the woman's education have significant effects, but they are positive which is contrary to the hypothesis. This may be a timing effect, however. Women with more education participate more often in the labour market, and have their children later, and this may be the reason why they want more children than women with less education. Even if the number of children the woman has already is included as an explanatory factor, there may be interaction effects that the linear and additive regression model does not take into account.

Finally, we ran a regression with a dummy variable for additional births as a dependent variable, assigning the value one if the woman expects to have more children and zero otherwise, see column 4 in table 5.4. The problems with the least squares method mentioned previously are still valid, but we get about the same results as with the continuous version in regression 3.[1)]

Our conclusion from the use of desired time to next birth and additional expected children as proxies for the desire to have an additional child soon, is that we get a good fit for additional fertility with relatively small standard errors of the coefficients, whereas the time to next birth does not seem to work so well, although this may partly be due to the low number of observations. We do not seem to gain anything by using binary versions of these variables. We also found that economic factors seem to be more important in explaining additional expected fertility than desired time to next birth and the

1) This dichotomous variable is more evenly distributed than the one in regression 2, as 26 per cent of the women expect to have another child (or more).

attitude towards pregnancy next month.

5.3.3 Birth-order Analysis

The analysis so far shows a strong and non-linear relationship between the number of live children and the attitudes towards pregnancy and having more children. It may, however, also be of interest to perform some of the regressions separately for each parity, to see if there are any parity-specific effects, and to compare with results from other empirical analyses.[1)] We are particularly interested in the attitudes of women with one or two children, as their decisions are pivotal for the development of fertility. Almost all women in Norway want to have children according to the fertility survey: only 1-2 per cent of respondents 18-29 years of age do not expect to have children at all, and only 2 per cent of women 18-24 expect to have only one child. (Central Bureau of Statistics 1981:76). The important question is whether Norwegian women want to have <u>more</u> than two children. To ensure replacement-level fertility, i.e. 2.1 children per woman, a sizeable proportion needs to have three (or more) children. (Around 25 per cent, assuming the following distribution of the other parities: 7 per cent childless, 10 per cent with one child, 53 per cent with two children, and 5 per cent with four or more children. This hypothetical distribution is based on data from the fertility survey about proportions expecting 0 or 1 child among respondents 35-44 years old, and proportion expecting 4 or more children among respondents 18-19 years old.)

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1) Lightbourne and MacDonald (1982) argue that the proportion wanting no more children depends on how successful women are at stopping at their desired parity. This may cause international comparisons to be misleading, but should not violate comparison of parity-specific results for a given country, particularly for Norway where the proportion being unsuccessful in stopping childbearing at a desired parity is relatively low.

Table 5.5 shows that the attitude towards becoming pregnant soon becomes increasingly negative the more children the women have already. The same is the case for the expectations about having more children. Fully two thirds of childless women (which includes infecund respondents) expect to have children, whereas only 5 per cent of those who have 3 or 4 children expect to have more.

Table 5.5 Attitude towards pregnancy next month and expectation about more children by number of live children. Per cent

		Number of live children						
	Total n	0	1	2	3	4	5	6+
Happy	78	52.1	24.4	7.1	2.0	8.8	0.0	
All right	89	18.8	17.1	17.0	14.1	2.9	7.1	
Mixed feelings	210	14.6	31.7	45.1	35.4	29.4	35.7	
Regret	128	10.4	16.3	22.9	30.3	38.2	14.3	
Disaster	66	4.2	10.6	7.9	18.2	20.6	42.9	
Total	571	100.0	100.0	100.0	100.0	100.0	100.0	
Number of cases	571	48	123	253	99	34	14	0
Missing	163	34	31	38	33	21	4	2
Expect more children	193	67.1	60.1	12.4	5.3	5.5	0.0	0.0
Do not expect more children......	537	32.9	39.9	87.6	94.7	94.5	100.0	100.0
Total..............	730	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of cases....	730	82	153	290	131	55	0	2

The results from the parity-specific analyses of the attitude towards becoming pregnant next month are presented in table 5.6.[1]) Only a few variables have significant effects, probably due to the small number of cases. Not surprisingly, having had a child less than two years ago has a strong negative effect for both parities, and particularly for women with only one child. It is interesting to notice that none of the other demographic factors are significant. Thus, when we do the analysis separately for each parity, the open birth interval dominates the other factors. On the other hand, economic and social variables have larger coefficients than in previous analyses, but they are still not significant.

It is worth noting the significant effects of house ownership and saving for a house. Both factors have negative effects for parity one and the opposite for parity two. This may reflect the different stages in the life cycle couples with one or two children are at. The causal directions are not clear, however. Couples may be planning and saving to get another and usually larger dwelling because they are expecting to have more children. Since the savings variable may be endogenous it should perhaps not be included in the analysis.

Education has a significant (positive) relation with the pregnancy attitude only for women with two children. This result seems to contradict the common finding that education is negatively correlated

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1) The equation was also estimated for parities 0 and 3, but only for a few cases, due to missing observations of pregnancy attitude (47 and 89 observations, respectively). Age has a strong non-linear positive effect for both parities and marriage duration a negative effect for parity three, but otherwise there were no significant effects exept for a positive effect of religious activity and, interestingly, of full family income, for respondents with three children.

Table 5.6 Regressions of attitude towards pregnancy next month by number of live children (N)

		N=1		N=2	
		coeff.	st.err.	coeff.	st.err.
Constant........................		2.04		-1.20	
Full income (I), in 100 000 kr.[2]...	+	0.366	0.499	-0.430	0.296
Wage of woman (π), in 100 kr.[2]....	-	-1.815	1.616	-0.246	1.022
Age............................	+	-0.008	0.210	0.087	0.203
Age squared.....................	-	-0.0005	0.0034	-0.0018	0.0032
Marriage duration, in years.......	+	-0.0264	0.1096	0.0596	0.0906
Marriage duration squared........	-	-0.0026	0.0043	-0.0024	0.0036
Youngest child less than one year[1]	-	-1.361**	0.293	-0.319(*)	0.206
Relative economic position.......	+	0.285(*)	0.179	-0.125	0.113
Durable consumption goods........	-	-0.093	0.149	-0.104	0.081
Ownership of house/apartment[1]...	+	-0.556*	0.283	0.395*	0.201
Saving for house/apartment[1].....	-	-0.836*	0.346	0.464(*)	0.283
Religious activity (meetings per year)	+	-0.006	0.009	0.004	0.003
Number of siblings..................	+	0.033	0.069	-0.008	0.041
Growing up in a rural place[1]........	+	0.460*	0.246	0.268*	0.150
Living in a rural place[1]............	+	0.628*	0.356	-0.029	0.174
Having gainful work[1]................	-	-0.061	0.257	0.111	0.141
Education of woman..................	-	-0.048	0.056	0.075*	0.039
Number of cases in regression.........		114		232	
Number of missing cases..............		40		59	
F-statistic..........................		4.24*		1.89	
R^2..................................		0.429		0.131	
Adjusted R^2..........................		0.328		0.062	

1) Dummy variable 2) Partly based on estimated values, see sections 3.4-3.7

*) Significantly different from zero at ten per cent level (two-sided test)

**) Significantly different from zero at one per cent level (two-sided test)

(*) Significantly greater (or less) than zero at ten per cent level (one-sided test)

(**) Significantly greater (or less) than zero at one per cent level (one-sided test)

with fertility, but it is probably due to a timing effect.[1] Women with more education start childbearing later and have, consequently, a more positive attitude towards becoming pregnant soon.

In table 5.7 we present the results from the analysis of another fertility attitude measure, expectations about additional children[2]. The dependent variable is the same as in subsection 5.4.2. It is equal to one if the woman expects to have more children and zero otherwise, the last category including both fecund and infecund women. The problems with OLS analysis of a dichotomous dependent variable have been mentioned previously. Table 5.5 shows that the distribution of the dependent variable is not so far from a 50-50 split between the two categories of 0 and 1 for parities 0 and 1, but quite far away from it for parities 2 and 3. Thus, the analyses of the two first birth orders should yield the least biased estimates.[3]

Although only one income coefficient is significant, the results suggest a negative income effect which increases monotonically with parity. This is consistent with diminishing marginal utility of children, but contrary to the results of some other empirical analyses (Namboodiri 1974, Simon 1975b, Snyder 1975).

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1) Cochrane (1979) reports many findings of a positive relation between education and fertility, but these apply mainly to developing countries, where education is associated with better nutrition and less breast-feeding.

2) We also did some other parity-specific analyses of pregnancy attitude variables not published here. In a regression of "desired time to next birth" there were too few cases (only 28). In a regression of "wanting next child within a year" there were just a few significant results (youngest child less than two years, and education of the woman for parity 1; and age, and religious activity for parity 2). Not even combined do all the explanatory variables have any significant effect.

3) Unbiased estimates of the standard errors of the coefficients can be obtained by the generalized least squares procedure suggested by Goldberger (1964).

Table 5.7 Regressions of child expectation [1] by number of live children

	N=0		N=1		N=2		N=3	
	coeff.	st.err.	coeff.	st.err.	coeff.	st.err.	coeff.	st.err.
Constant......................	1.74		1.65		0.77		0.51	
Full income (I), in 100 000 kr.	-0.242	0.194	-0.067	0.156	0.034	0.088	0.255**	0.075
Wage of woman (π), in 100 kr...	0.738	0.514	0.141	0.490	-0.581*	0.297	-0.637*	0.270
Education of woman............	0.003	0.022	0.017	0.018	-0.003	0.011	-0.021*	0.012
Relative economic position.....	-0.063	0.061	-0.016	0.058	0.004	0.033	-0.029	0.035
Having gainful work[1].........	0.054	0.101	-0.048	0.076	0.066	0.041	0.096*	0.042
Ownership of house/apartment[1].	-0.116	0.105	-0.122*	0.072	0.098*	0.047	0.034	0.053
Age.........................	-0.023*	0.012	-0.035**	0.012	-0.015*	0.008	-0.009	0.008
Marriage duration	-0.038*	0.015	-0.011	0.014	-0.009	0.008	-0.003	0.008
Number of siblings............	-0.012	0.022	-0.001	0.021	-0.019	0.012	-0.005	0.010
Growing up at a rural place[1]..	-0.042	0.096	0.070	0.077	-0.021	0.043	-0.069*	0.041
Living at a rural place[1]......	0.192*	0.115	0.082	0.110	0.069(*)	0.052	0.097*	0.044
Number of cases in regression..	77		141		266		117	
Number of missing cases........	5		13		25		14	
F-statistic...................	8.38**		9.82**		4.16*		2.56	
R^2...........................	0.586		0.456		0.153		0.212	
Adjusted R^2....................	0.516		0.409		0.116		0.129	

1) Dummy variable. For explanation of stars see table 5.6

The wage effect is significant for parities 2 and 3 and indicates the opposite effect: it declines monotonically from positive to negative values. This result differs also somewhat from the results of Simon (1975b) and Snyder (1975), but seems to be more consistent with economic theory, since the wage of the woman can be interpreted as a measure of the value of her time. Namboodiri's results have been criticized by Rosenzweig and Seiver (1975), however, who find effects of income and education that are similar to ours. Simon and Snyder explain the negative income effect across birth-orders by differential contraceptive efficiency and that income may be correlated with other variables which have a different effect on fertility. But the different results may also be explained by differences in variables and statistical methods. The dependent variable studied by Simon and Snyder is <u>actual</u> birth-order probabilities, whereas Namboodiri, Rosenzweig and Seiver, and we use <u>expected</u> birth probabilities. Namboodiri's and Simon's income measure is husband's current income, whereas the other analyses use some measure of permanent or potential income. Moreover, the other regressors included vary somewhat from study to study. Some of the analyses were performed separately for different age and education categories, e.g., whereas other analyses include these as explanatory variables. Finally, the data are different: our sample consists of Norwegian women 18-44 years of age interviewed in 1977, whereas the other samples consist of women in the USA obtained in the 1960s.

As mentioned before, the education of the wife may affect birth-order probabilities through several channels, including contraceptive efficiency, home productivity, and tastes. The education effect also changes with parity, but it is significant only for women with three children.

Relative economic position, which should have a positive effect according to the cross-section version of the Easterlin-hypothesis, has no significant coefficients.

The age effect is significant and negative for all birth-orders except for the highest, whereas the marriage duration effect is significant and negative only for childless women, which may be due to infecundity. The older a childless woman is and the longer she has been married, the more certain she may be that she is unable to have children.

Of the other variables, only "living in a rural place", has a systematic significant effect across most birth-orders. This variable is included both as a taste variable and as a price variable on the assumption that the costs of children are lower in rural areas. The positive effect of this is confirmed, as was the case when all parities were included in the analysis (table 5.2).

Snyder (1975) notes that the influence of education may not be linear and additive, so he applies the model separately to wives with 8 years of education, and wives with more than 8 years, and finds that the parity-specific effects of education depend on the level of education. He also finds that the wage has a stronger negative effect for more educated wives, and that the income effects depend on the educational level and the age of the woman. Because our sample is so small we cannot subdivide it further, but we have included some additional factors to account for the non-linear effects mentioned by Snyder: Education squared, Education x wage, Income x age, and Income x age. These factors do not seem to have any systematic effects.

We conclude from this parity-specific analysis that economic factors seem to have stronger effects at higher parities than at lower ones, while the opposite seems to be true for demographic factors.[1)] This is the same conclusion as Namboodiri (1974) drew from his birth-order analysis (which has been criticized by Rosenzweig and Seiver 1975). An important change seems to take place between parities 1 and 2: The effects of income, wage, education, and house ownership change sign, the wage effect becomes significant (and the income effect for birth-order three), and the effects of age and marriage duration become much smaller. (The age effect ceases to be significant at parity three and the marriage duration at parity 1.) Thus, two children may be a threshold level.

It will be interesting to see if these tentative findings are confirmed by the analysis of the three-quarter sample. If they are confirmed they may have important population policy implications: They indicate that it may be more effective to use economic incentives to stimulate couples with two or three children to have more children, than couples with zero or one child, if the aim is to increase fertility. Almost everybody wants to have two children, perhaps because of social pressures whereas the benefits and costs of a third or fourth child are considered more carefully. This finding also supports the economic theory of fertility in general: people do seem to balance the advantages and disadvantages of another child against each other, at least when they have two or more children already.

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1) The coefficient of determination, R^2, is substantially higher for parities 0 and 1 than for parities 2 and 3, but we cannot conclude anything from this, as R^2 depends on the number of observations and the variances of the independent variables. The variance of the age variable, e.g., is smaller for parities 2 and 3 than for parities 0 and 1.

5.3.4 Conclusions

This exercise in linear regression of the determinants of the desire to become pregnant soon indicates:

a) Of the three variables in the original theoretical model - full income, wage and parity - only parity has a consistent significant effect, which is u-shaped. Wage has a significant negative effect as predicted by theory. The income effect is not significant, and mostly negative, which is contrary to theory but consistent with other empirical results.

b) Several variables in addition to the three "original" variables have strong and significant effects and improve the predictive power of the model considerably.

c) Demographic factors seem to be more important determinants of the attitude towards pregnancy next month than economic and other factors, which mostly have effects in the right direction, but many of them are weak and not significantly different from zero. This is perhaps a little disappointing but no real surprise. It remains to be seen if the expected effects are confirmed by the three-quarter analysis.

d) In addition to parity, the most important demographic factors are age and marriage duration, both with an inverted u-shape relationship to pregnancy attitude, and having had a child less than two years ago, which has a strong negative effect. It is no surprise that the last variable is so important in a short-horizon model. The two variables age and marriage duration measure more or less the same thing, namely elapsed time. The regression results show that they have similar effects.

e) Religious activity and rurality of the place the woman grew up in, seem to be the non-demographic variables with the strongest effects, and both with signs as hypothesized.

f) The use of observed wage and income variables yields almost the same results as when we use partly imputed variables.

g) Of the five different measures of the desire to become pregnant soon, additional expected fertility yields the best fit, but this variable is for other reasons not the best measure of the desire to become pregnant soon.

h) Our conclusion from the parity-specific analysis is that economic factors seem to have stronger effects on child expectations at high (2 and 3) than at low birth-orders (0 and 1), whereas the opposite is true for demographic characteristics.

The results in this section should not be taken as a refutation (or confirmation) of either the model presented in chapter 2 in particular or of the economic theory of fertility in general, since they are based on a small subsample and the analysis is exploratory. Moreover, there are problems with the dependent variable and several of the explanatory variables. Reliance on only ordinary least squares estimation may also have affected the results. But the analysis gives a good background for doing the confirmatory analysis of the three-quarter sample.

5.4 Traditional Fertility Measures: Children Ever Born, Additional Expected Fertility, and Total Expected Fertility

The analysis in this section is not directly based on the theory presented in chapter 2,[1)] but is done for two reasons: First,

1) Still, this empirical analysis may be interpreted as an analysis of the determinants of the life-time demand for children in figure 2.17.

there is considerable interest in Norway in the influence of economic and other factors on actual and expected fertility. Second, analyses of these fertility measures have been done in many countries and it would be valuable to have comparable results.

Table 5.8 shows that all three regressions yield high F-statistics and multiple correlation coefficients, in particular children ever born (CEB)[1)] and additional expected fertility (AEF).[2)] The third variable, total expected fertility (TEF) is the sum of the first two, and it is interesting to note that the fit is better for CEB and AEF separately, than for the sum of them.[3)] The interpretation of this is that the women in the sample all expect to have more or less the same number of children, whereas there is considerably more variation in the number of children they have had already, due to differences in timing, and consequently, in the additional number of children they expect to have.[4)]

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1) We use children ever born here, whereas we have used the number of live children as an explanatory variable in previous regressions. These two variables denote different concepts, but as noted before, there is very little difference between them, see table 3.9.

2) The regression of AEF is the same as regression 3 in table 5.4 without live children, N and N^2, as explanatory variables.

3) The statistical reason for a better fit when using two separate regressions than when using an aggregate one is that the latter imposes constraints which almost always diminishes R^2. (This was pointed out by Jan Kmenta.)

4) The zero-order partial correlation coefficient between CEB and AEF is -0.56. The standard deviation for CEB, AEF, and TEF is 1.21, 0.79, and 1.02, respectively. But when we divide the standard deviation by the mean to get more comparable figures we get 1.67, 1.78 and 0.41, respectively, which supports the explanation given above.

Table 5.8 Regressions of children ever born, additional expected children, and total expected fertility

	Children ever born			Additional expected children			Total expected fertility		
Explanatory variables	Hyp. eff.	Coefficient	Standard error	Hyp. eff.	Coefficient	Standard error	Hyp. eff.	Coefficient	Standard error
Constant..........................		-1.83			3.73			1.90	
Full income (I), in 100 000 kr...	+	0.310*	0.164	+	-0.063	0.093	+	0.247	0.175
Wage of woman (π), in 100 kr....	-	-0.833(*)	0.528	-	-0.260	0.300	-	-1.093*	0.564
Age..............................	+	0.183*	0.082	-	-0.110*	0.047	+?	0.073	0.088
Age squared......................	-	-0.0033**	0.0012	+?	0.0013*	0.001	-?	-0.0020	0.0013
Marriage duration, in years.......	+	0.2218**	0.0353	-	-0.2107**	0.0201	+?	0.0111	0.0378
Marriage duration squared........	-	-0.0026*	0.0013	+?	0.0064**	0.0007	-?	0.0038**	0.0014
Youngest child less than one year[1]	+?	0.654**	0.109	-	-0.408**	0.062	-?	0.246*	0.117
Relative economic position.......	+	-0.135*	0.063	+	0.010	0.036	+	-0.125*	0.067
Durable consumption goods........	-?	-0.010	0.046	-?	-0.022	0.026	-	-0.032	0.049
Ownership of house/apartment[1]...	+?	-0.069	0.110	-?	-0.021	0.062	+?	-0.090	0.118
Saving for house/apartment[1].....	-?	-0.060	0.143	+	0.154*	0.081	+?	0.094	0.153
Religious activity (meetings per year)	+?	0.006*	0.003	+	0.006*	0.002	+	0.011**	0.004
Number of siblings...................	+	0.052*	0.021	+?	0.000	0.012	+	0.052*	0.022
Growing up at a rural place[1]........	+	0.048	0.082	+	0.039	0.047	+	0.087	0.088
Living at a rural place[1]............	+	0.370**	0.099	+	0.057	0.056	+	0.427**	0.106
Having gainful work[1]...............	-	-0.223**	0.082	-	-0.124**	0.047	-	-0.099	0.088
Education of woman..................	-	-0.034*	0.021	+	0.032**	0.012	-	-0.002	0.022
Number of cases......................		557			557			557	
F-statistic..........................		34.6**			52.5**			8.8**	
R^2		0.522			0.623			0.216	

1) Dummy variable 2) Partly based on estimated values; see sections 3.4-3.7.
*) Significantly different from zero at ten per cent level (two-sided test)
**) Significantly different from zero at one per cent level (two-sided test)
(*) Significantly greater (or less) than zero at ten per cent level (one-sided test)
(**) Significantly greater (or less) than zero at one per cent level (one-sided test)

We get a negative wage effect in all three regressions, as hypothesized, although only two of them are significant. The wage (or price) elasticities of CEB, AEF and TEF are -0.11, -0.15 and -0.12, respectively, for the mean values of the cases included in the regressions. We also notice with interest the significant positive income effect in the regression of CEB, with an income elasticity of 0.17. This yields support to the Becker-type micro-economic fertility models. Among the other economic variables, relative economic position has a significant effect on CEB and TEF, but it is negative which is contrary to the relative income hypothesis.

The demographic variables age and marriage duration have significant effects on CEB and AEF but not on TEF, which is further evidence that people want more or less the same number of children altogether.[1] The effects of age and marriage duration are not linear, since the coefficients of the square-terms are significant, except for the square of age in the regression of TEF. The relations are not u-shaped, however, since most of the "optimum" ages and durations fall outside or at the end of the age and marriage duration ranges. Children ever born increases by age up to 28 years, i.e. for women born in 1949, and declines thereafter,[2] whereas it increases non-linearly by

1) The total expected fertility by age for the women in the quarter sample is 2.44 for women who are 18-19 years of age, declines to 2.38 for women 20-24, and increases to 2.78 for women 40-44, i.e. a range of only 0.4 children.

2) 28 is the age of maximum CEB when we control for all the variables that are included in the regression. When we only look at the partial relationship between age and CEB, CEB increases monotonically, from 0.7 for women 18-19 years to 2.8 for women 40-44 years.

marriage duration. The number of additional expected children declines by age and by marriage duration throughout the actual range (maximum at 44 and 16 years, respectively), whereas total fertility increases by both age and marriage duration.

We notice with interest that the number of siblings of the woman has a positive and significant effect both on CEB and TEF. Having gainful work (at the time of the interview) has a negative effect on all three fertility measures, whereas the effect of education varies. It has a negative and significant effect on children ever born, a positive effect on expected additional children, and no effect on total expected fertility. All these effects are consistent with differences in timing associated with education. Women with higher education start childbearing at a considerably higher age than other women.[1)]

Our conclusion from the analysis of these three fertility measures is that it yields strong and interesting results. They are perhaps more convincing than the results from the analysis of the pregnancy attitude in the previous section.

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1) The mean age at first live birth for all married and previously married women in the sample who have given live birth before or in first marriage is 21.5 years for women with the first stage of secondary school or less, 22.5 years for women with second stage of secondary school, and fully 25.6 years for women with university education (Central Bureau of Statistics 1981: table 106).

5.5 Frequency of Intercourse

5.5.1 Fecund Women Only

The equations to be estimated were presented in section 4.7. We mentioned that our first approach to the simultaneous equations (4.25) and (4.26) (or 4.27 and 4.36) would be to estimate them separately by the ordinary least squares method. In chapter 3 it was pointed out that we have observations on the attitude towards pregnancy next month and the contraceptive use last four weeks only for fecund women, that is women who believe it is possible for them to have another child. Consequently, the major part of the analysis has to be done for fecund women only. We will, however, also present a limited analysis of the sexual behaviour of infecund women in subsection 5.5.3.

One problem we have to resolve before we can estimate the model is what we should do with repondents who replied that they had not had intercourse during the past four weeks. They were for obvious reasons not asked about their use of contraception in this period, which increases the number of missing observations. It does not seem quite right to exclude these respondents from the analysis of the relationship between contraceptive use and coital frequency, since some of them may have avoided intercourse for fear of becoming pregnant.

It is, however, unlikely that abstinence is a common method of contraception among married couples in Norway to-day, with the widespread knowledge and availability of good methods of contraception. Other reasons than fear of pregnancy may have been more important for not having intercourse, e.g., absence of husband, poor emotional relationship between spouses, illness of one of the spouses, etc. Knowledge about the reasons for not having intercourse would have helped us in treating these respondents correctly, but there were no questions about this in the survey.

There are four possible ways of treating respondents with no intercourse in the analysis:

1) Excluding them, i.e. setting e=missing.

2) Setting e=0, since they in fact did not use any contraception. This seems to be the best solution according to the theory, see 2.9.3.3, section A.

3) Setting e=1, since abstinence may be considered a perfect method of contraception.

4) Setting e equal to some intermediate value, e.g. 0.8, i.e. the same effectiveness as relatively poor methods of contraception like safe periods and withdrawal, since abstinence, or rather attempted abstinence, is unlikely to be very effective in the long run.

Ordinary least squares estimates of equation (4.27) (with no additional explanatory variables) for these four alternatives are shown in table 5.9. The results give support to our theoretical model. All variables derived from the model (y, e, and functions of y and e) have coefficients that are significantly different from zero, and mostly at the one per cent level, with only one exception (ey^2). Since the standard error of the ey^2-coefficient is so large, we have deleted it from further analyses.

Most of the results are surprisingly similar, all coefficients and their standard errors are of the same magnitude in all four regressions. The third regression, where we assigned perfect contraception (e=1), deviates most from the other regressions, and the overall fit is also the poorest. The best overall fit is achieved when e is set equal to 0.8. Nevertheless, it is not obvious which solution we should

Table 5.9 Regressions of coital frequency by treatment of respondents with no intercourse

Explanatory variables	Hypothesized sign	Value of e when S=0							
		e =missing		e =0		e =1		e =0.8	
		Coeff.	St.error	Coeff.	St.error	Coeff.	St.error	Coeff.	St.error
0 Constant		5.4469		3.5678		5.4999		5.3306	
1 y (pregnancy attitude)	+	1.2304**	0.4074	1.8942**	0.2505	1.1749**	0.4385	1.3227**	0.3959
2 e (contraceptive effectiveness)	-?	-16.085**	4.804	-12.017**	4.660	-4.490	5.047	-30.241**	3.496
3 e^2	-	17.797**	4.808	15.604**	4.752	5.385	5.033	32.447**	3.396
4 ey	-	-1.2402**	0.4582	-1.9302**	0.3132	-0.9403*	-0.4876	-1.2606**	0.4494
5 ey^2	+ or 0	0.0839	0.1296	0.0822	0.1291	-0.0922	0.1306	0.0691	0.1223
F-statistic		5.15*		20.92**		2.74*		24.76**	
R^2		0.050		0.166		0.025		0.191	
Adjusted R^2		0.041		0.158		0.016		0.183	
Number of cases		493		532		532		532	

* Significant at 10 per cent level ** Significant at 1 per cent level

choose. Assigning values of 0, 0.8, or 1, when S=0, introduces a relationship that may not exist. Since we have little knowledge about the reason for not having intercourse, the safest solution would perhaps be to exclude these respondents from the analysis, i.e. treating e as missing.

As mentioned above, however, there are theoretical arguments for setting e=0 for respondents with no intercourse. Moreover, table 5.9 and other empirical analyses where we have tried both solutions 1 and 2, show that the second solution yields the best fit. Most of the standard errors of the coefficients are smaller and the overall fit as measured by R^2 and the F-statistic is greater. Therefore, the analyses presented in the next sections and in chapter 6 are based only on this solution. I.e., we are assuming that respondents with no intercourse in the last four-week period did not use any contraception.

Table 5.10 shows results from regression analyses of coital frequency excluding the term ey^2, and with additional explanatory variables, as discussed in section 2.10.

Substituting the estimates of the first regression in table 5.10 into the demand equation (4.27) yields

$$(5.1) \qquad \hat{S} = 3.57 + 1.895y - 11.75e + 15.43e^2 - 1.14ey.$$

The effect of y, which is exogenous in this equation, is

$$\partial S/\partial y = 1.895 - 1.94e,$$

which is positive except for values of e close to 1 (e > 0.9774), i.e., the greater the desire to have another child soon, the higher the

Table 5.10 Regressions of coital frequency including additional explanatory variables[1)2)]

Explanatory variables	Hypothesized sign	Estimates (1) Coeff.	(1) St.error	(2) Coeff.	(2) St.error	(3) Coeff.	(3) St.error
Constant	+	3.5674**	0.3714	9.73		15.04	
1 y (pregnancy attitude)	+	1.8950**	0.2503	1.5328**	0.2789	1.5946**	0.2879
2 e (contraceptive effectiveness)	-?	-11.7546*	4.6387	-11.0649*	4.7842	-11.1627*	4.8799
3 e^2	-	15.4334**	4.7422	14.5376**	4.9143	14.6154**	5.0162
4 ey	-	-1.9388**	0.3127	-1.7496**	0.3230	-1.8154**	0.3302
6 Age of woman	- or { +			-0.1657*	0.0707	-0.1478	0.4111
7 Age of woman squared	-					-0.0002	0.0063
8 Age of husband	- or { +			-0.0456	0.0483	-0.4442$^{(*)}$	0.2885
9 Age of husband squared	-					0.0053$^{(*)}$	0.0038
10 Marriage duration	- or { +			0.1326*	0.0718	0.2225	0.1857
11 Marriage duration squared	-					-0.0028	0.0069
12 Youngest child less than 2 years	-			-1.0923*	0.4667	-1.1380*	0.4811
13 N (live children)	-			-0.2040	0.2055	-0.1360	0.2230
14 Full income/100 000	+?					-0.1673	0.6640
15 Wage/100	-					-0.0142	2.2344
16 Education of woman	+					0.1012	0.0870
17 Religious activity	-					-0.0003	0.0139
F-statistic		26.08**		13.92**		8.04**	
R^2		0.166		0.201		0.208	
Adjusted R^2		0.158		0.187		0.182	
Number of cases				508		508	

1) For explanation of stars see table 5.6.

2) We have set e=0 when S=0.

frequency of intercourse. This corresponds well with the theoretically derived results in section 2.9, see table 2.2. We cannot say that the value e=0.9774 is significantly different from 1, however, since the null-hypothesis that the coefficients of y and -ey are equal (estimates 1.895 and 1.94), is not rejected using the test in Kmenta (1971: 371-372).[1]

Although e is an endogenous variable, and the optimal values of S and e are determined simultaneously, it may be of interest to look at the direct partial effect of a change in effectiveness on coital frequency[2]. We find from table 5.10 that

$$\partial S/\partial e = -11.75 + 30.86e - 1.94y,$$

which is greater than zero for values of e greater than ca. 0.4, i.e. for all common methods of contraception. This partial effect is as expected: the higher the contraceptive effectiveness the higher the frequency of intercourse. For very low levels of e and for non-users of contraception (e=0), the effect may be negative, which is in accordance with the theoretical results in section 2.9 (table 2.2).

---

1) This test requires an estimate of variance - covariance matrix, which was not available when the econometric dissertation work was done. After this was completed, however, a new version of SPSS has become available to us, and some of the regressions have been reestimated, yielding the variance - covariance matrix, the standard error of the constant, etc.

2) There is a subtle problem with conceptualizing the term $\partial S/\partial e$ since both S and e are endogenous. I.e., their values are jointly determined by the values of the exogenous variables and of the disturbances. That is, S does not change in response to changes in e; rather both S and e change in response to changes in the exogenous variables and their distributions. We can interpret $\partial S/\partial e$ as the change in S associated with a simultaneous change in e, but not caused by a change in e. $\partial S/\partial E(e)$ has an easier interpretation, though, i.e. the change in S caused by a change in the expected value of e. (Pointed out by Jan Kmenta.)

For the mean values of the quarter sample the direct elasticity of S with respect to e is positive: 1.5 when y=0 and 2.0 when y=-2.

Now a few comments on the inclusion of additional explanatory variables as in the two last regressions in table 5.10. In the second we have included a few traditional demographic variables: ages of the spouses, duration of the marriage, number of live children, and a dummy variable for the length of the open birth interval, which equals unity if the woman has a child below two years of age and zero otherwise. These five variables combined have a significant effect on S, and all but parity have significant separate effects. All of them have signs as hypothesized, except marriage duration which has a <u>positive</u> and significant coefficient (c.f. 2.10.2).

The last result may be due to covariation between marriage duration and age. The zero-order correlation coefficient is 0.896, which is high, but not so high as to cause unstable results because of multicollinearity. The effect of marriage duration is also positive in the third regression, although insignificant, and in the regressions in tables 5.11 - 5.13. This indicates that the positive marriage effect may be substantive and not only an artifact. We look forward to the 3/4-analysis to confirm this.

As shown in section 3.11 (table 3.15), the coital frequency declines with the duration of marriage although the picture becomes less clear when we look at each age group separately. Moreover, the zero-order correlation coefficient between marriage duration and coital frequency is negative (-0.16). The multivariate analysis, however, indicates that when we control for the effects of age, the attitude towards pregnancy soon, contraceptive use, and other factors, marriage duration may have a <u>positive</u> effect on sexual activity. This is not an unreasonable effect, as mentioned in paragraph B2 in subsection 2.10.2: the longer a couple has been married, the better they know each other and the stronger their feelings may be. Another possible reason is that reduced fear of pregnancy may make women enjoy sex more, because of lower fecundity, sterilization, or more efficient use of contraceptive methods. It should also be remembered that the women (and most husbands) in the sample are relatively young, below 45 years of age, and that few of them have been married for a long time (10.2 years on average, only 10 per cent for 20 or more years).

In a regression not shown here we included an interaction term (marriage duration times age of woman), to see if there is any special effect on the frequency of intercourse of being newly married and having a high age, but did not get a significant result.

The negative effect of age on sexual activity is no surprise, however. The coital frequency declines by almost 1 (intercourse per four weeks) for every 5 years of age. The age of the husband also has a negative effect, but it is not significant and much smaller in absolute value.

In the "pure" model the parity of the woman is assumed to affect sexual and contraceptive behaviour only through y, the desire to become pregnant soon. The number of live children is included in regressions 2 and 3 of table 5.10 to see if parity has an additional effect on sexual activity, e.g. because of lack of privacy and time and because it is tiring to have children. The regression results show that the parity coefficient is negative as expected, but that the estimated standard error is quite large.

In the third regression in table 5.10 we have included three square terms to allow for non-linear effects of age and marriage duration. Only the square of the husband's age is significant, but the woman's age and the marriage duration are no longer significant, probably due to high correlation between these variables, so we delete all square terms in further analyses of coital frequency.

In this regression we have also included four socio-economic variables. Like parity, the two economic variables full income and wage of woman are assumed to effect coital frequency through y, see section 5.3, but are also included here to see if they have separate effects, which the table shows that they do not - the standard errors being very large. Finally, we included two social variables that we thought might be indicators of attitudes toward sex, namely education of the woman, and religious activity as a measure of religiosity, but neither of them seemed to have any significant effect, not even combined. It is somewhat surprising that only the "original" variables, pregnancy attitude and contraceptive effectiveness, and some demographic variables have significant effects, and none of the socio-economic factors.

5.5.2 Analysis by Attitude Towards Further Child-bearing

We found in the previous section that some of the derived results depend on the value of y, i.e. whether the attitude towards becoming pregnant soon is positive or negative. The theoretical analysis in section 2.9 shows that most of the results, but not all, are the same for positive and negative values of y, see table 2.2. To investigate this further, we performed some analyses separately for positive and negative values of y, respectively, see table 5.11. (Cases with y=0 and

$y>0$ are combined because the expected results are the same, see table 2.2.) We included only those variables which were found to have significant effects in table 5.10.

Most of the results in table 5.11 are consistent with the theory and with the results in table 5.10. The effect of y on S is positive for all y (between -2 and +2), except for values of e close to 1 when y is positive[1]. The effect of e on S is positive for both negative and positive values of y, except for low values of e (less than ca. 0.5).

It is, however, surprising that the pregnancy attitude (via the factors y and ey) does not have any significant effect on the coital frequency S for respondents with negative values of y[2]. We would perhaps expect the effect of y on S to be more important for negative than for positive values of y, but table 5.11 shows that the opposite is the case. The explanation for this may be that almost all couples who do not want to become pregnant soon contracept, and that they consider the probability of conception so low that their sexual behaviour is independent of the strength of their desire to avoid pregnancy. (Only 4 per cent of women with a negative pregnancy attitude did not use contraceptions in the four-week period.) After all, most couples use a method of contraception with a very high effectiveness (0.96 on the average; 60 per cent of the users used a method with an effectiveness greater than 0.95).

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1) According to the theory women with a positive attitude towards becoming pregnant soon should not have any reason for using contraception. Nevertheless, there are quite a few respondents with a positive value of y who used contraception in the four-week period. The possible reasons for this are discussed in subsection 5.5.4.

2) The same is the case if respondents with values of y equal to zero are included.

Table 5.11 Regressions of coital frequency by pregnancy attitude and child expectations[1)]

	Pregnancy attitude, y				Expecting more children?			
	y<0		y≥0		No		Yes	
Explanatory variables	Coeff.	St.error	Coeff.	St.error	Coeff.	St.error	Coeff.	St.error
0 Constant	12.80**	3.46	6.75**	2.14	8.70**	1.93	11.53**	3.20
1 y (pregnancy attitude)	1.34	1.41	2.40**	0.50	1.46**	0.38	1.81**	0.50
2 e (contraceptive effectiveness)	-8.17	8.56	-6.81	5.80	-9.25*	5.61	-5.14	8.67
3 e^2	12.10	8.22	11.22*	5.90	12.55*	5.75	9.64	8.86
4 ey	-0.98	1.61	-2.45**	0.59	-1.60**	0.45	-2.43**	0.58
6 Age of woman	-0.250*	0.115	-0.120	0.088	-0.232**	0.083	0.013	0.130
8 Age of husband	-0.095	0.071	-0.017	0.065	0.023	0.056	-0.268**	0.089
10 Marriage duration	0.248*	0.114	0.038	0.085	0.153*	0.076	0.044	0.150
12 Youngest child less than 2 years	-1.267*	0.746	-1.198*	0.563	-0.328	0.563	-3.037**	0.719
F-statistic	14.75**							
R^2	0.305		0.146		0.180		0.307	
Adjusted R^2	0.273		0.126		0.161		0.270	
Number of cases	184		346		371		158	

1) For explanation of stars, see table 5.6.

Besides the attitude towards becoming pregnant soon, another important criterion in the present context is the expectation about having more children altogether, i.e. sooner or later. In the second half of table 5.11 we have done the analysis separately for women expecting and women not expecting to have more children. The results are very similar to the first half of the table. As mentioned before we would expect the model to be more appropriate for couples not wanting more children (soon), than for those who do, but table 5.11 shows that even the sexual behaviour of couples wanting to have another child (sooner or later) is influenced by factors like attitude towards pregnancy soon, a short open birth interval, and age.

Table 5.11 shows a curious finding about the effect of age: the age of the woman has a negative and significant effect in the third regression and similary for the age of the husband in the fourth, but otherwise the age effects are zero. This means that ageing of the woman has no effect on her sexual behaviour if she expects to have another child and a negative effect if she does not expect so. The role of the husband's age is exactly the opposite. This indicates an area of marital conflict, which we unfortunately do not have any data to analyze further. It will be interesting to see if these results are confirmed by the three-quarter sample.

One interpretation of these results is that husbands get tired of sex as they get older (unless they do not expect to have more children). Another interpretation is that women are less interested in having intercourse with older husbands, and a third that the desire to become pregnant is the most important motivation for women's sexual activity.

The effect of contraceptive effectiveness on sexual activity for couples with negative attitudes to having more children (sooner or later), may perhaps be more due to the fact that these couples use contraception than to the effectiveness of the methods per se, as mentioned earlier. To investigate this further, we did a regression analysis with a dummy variable for contraceptive use instead of a continuous variable, see the second regression in table 5.12, which includes the same explanatory variables as in table 5.11, except that the square term had to be deleted to avoid getting a singular matrix. After all, our continuous variable may be a poor measure since it is based on assigned values. The results from the first two regressions in table 5.12 are almost identical as measured by the F-statistic, R^2, and the values of the coefficients. The results in table 5.12 imply that the partial effect of contraceptive use on coital frequency is positive, except for women with very positive attitudes towards becoming pregnant soon and who are unlikely to use contraception anyway.

The two first regressions in table 5.12 do not tell us what the most important determinant of coital frequency is, contraceptive use or contraceptive effectiveness. The third regression includes only users of contraception, however, and shows that contraceptive effectiveness is indeed significantly related to the frequency of intercourse, and not only as a proxy for contraceptive use. The non-significance of the pregnancy attitude in this regression is consistent with our explanation for the lack of significant results in regression 1 in table 5.11.

Finally, the last regression in table 5.12 includes only nonusers of contraception, i.e. $e = 0$. Nevertheless, the pregnancy attitude is positively related to the frequency of intercourse.

Table 5.12 Regressions of coital frequency by use of contraception[1)][3)]

	All women $0 \leq e < 1$		Dummy variable for contraceptive use[2)] $e = 0$ or 1		Only users of contraception $0 < e < 1$		Only non-users of contraception $e = 0$	
	Coeff.	St.error	Coeff.	St.error	Coeff.	St.error	Coeff.	St.error
Constant	10.57**	1.55	10.92**	1.55	0.37	4.84	8.91**	2.98
y (pregnancy attitude)	1.53**	0.28	1.50**	0.27	2.49	3.60	1.55**	0.32
e (effectiveness)	2.98**	0.43	2.75**	0.42	13.24**	4.37		
ey	-1.80**	0.31	-1.70**	0.30	-2.77	3.74		
Age of woman	-0.185**	0.069	-0.189**	0.069	-0.215**	0.081	-0.023	0.130
Age of husband	-0.061(*)	0.048	-0.065(*)	0.048	-0.021	0.056	-0.154*	0.088
Marriage duration	0.129*	0.067	0.131*	0.067	0.113(*)	0.078	0.123	0.134
Youngest child less than 2 years	-1.377**	0.445	-1.402**	0.447	-1.27**	0.49	-2.158*	1.163
F-statistic	17.58**		16.82**		5.21*		14.82**	
R^2	0.191		0.184		0.081		0.418	
Adjusted R^2	0.180		0.173		0.066		0.390	
Number of cases	530		530		421		109	

1) For explanation of stars, see table 5.6.

2) $e = 1$ if the respondent used contraception in the four-week period and $e = 0$ if she did not.

3) e and e^2 cannot both be included as explanatory factors because they are highly correlated when e is 0 or 1, and when e is greater than zero.

The role of the ages of the spouses for users vs. non-users of contraception seems to be the same as for couples expecting vs. couples not expecting to have more children, as in table 5.11. Having had a child less than two years ago reduces the coital frequency by about 1.5 per 4 weeks for women who use contraception and by about 2 for women who do not.

5.5.3 Infecund Respondents

As mentioned previously, the analyses in the two previous subsections do not include infecund women (or wives of infecund men), because they were not asked about pregnancy attitude and contraceptive use last four weeks. The infecund respondents were, however, asked about their coital frequency and may be included in a partial analysis of sexual activity.

The infecund respondents have on average a lower coital frequency than the fecund respondent (5.1 vs. 6.1), but this may partly be due to differences in age and other characteristics. They are on average 6.3 years older than the fecund women (37.4 vs. 31.1 years), with the uncertain respondents in between (33.7). To remove the effects of other factors we need to do a multivariate analysis.

A large number of the infecund respondents or their husbands are sterilized, although we do not know whether they were sterilized for contraceptive or other purposes. Unless the sterilization by coincidence was done in the four-week period in which the interview took place, it was not a matter of current choice, like other methods of contraception. Their "method" of contraception and its effectiveness is given, i.e. e = 1. Infecund couples need not be concerned about the possibility of becoming pregnant, and consequently they should have a coital frequency corresponding to a marginal utility of zero, which is what we have called the "satiation level of sex". (The spouses may have different opinions about this level, however. We cannot go into how such conflicts are resolved.)

Since we do not know the attitude towards pregnancy next month for infecund women, we set y = 0 in equation (4.27), which becomes

$$(5.2) \qquad S = b_0 + b_3e^2 + \Sigma b_jZ_j + u_s.$$

The results from OLS estimation of this equation are presented in table 5.13. The first regression includes both fecund and infecund couples, the second only fecund couples to enable comparison, and the third only infecund couples. The results in the two first regressions are similar to those in the second regression in table 5.10. Interestingly, both the age of the woman and the age of her husband have significant negative effects on the coital frequency when infecund couples are included. Comparison of the second regression in tables 5.13 and 5.10, respectively, shows that the effects of contraceptive effectiveness and other explanatory variables are about the same whether or not the pregnancy attitude y is included, which should be comforting to people who do not like the measure of y employed in this section.

In the regression including only infecund couples, only the age of the husband has a significant effect. Moreover, we cannot even reject the hypothesis that none of the explanatory variables has an influence on S. The number of cases is quite small, however.

The results in this subsection are not strong enough to warrant analysis of infecund respondent with the three-quarter sample.

Table 5.13 Regressions of coital frequency by perceived fecundity[1)]

Explanatory variables	Fecund and infecund couples[2)] Coeff.	St.error	Fecund couples Coeff.	St.error	Infecund couples Coeff.	St.error
0 Constant	10.15**	1.43	11.33**	1.61	7.21*	3.34
2 e (contraceptive effectiveness	-7.93(*)	4.88	-6.28	4.73		
3 e^2	9.92*	4.79	9.56*	4.84		
4 er	1.317**	0.509				
6 Age of woman	-0.106*	0.064	-0.173*	0.072	0.153	0.145
8 Age of husband	-0.091*	0.043	-0.079(*)	0.050	-0.146*	0.085
10 Marriage duration	0.048	0.060	0.101	0.070	-0.118	0.115
12 Youngest child less than 2 years	-1.808**	0.419	-1.861**	0.435	-1.208	1.967
F-statistic	15.64**		16.81**		1.61	
R^2	0.153		0.163		0.071	
Adjusted R^2	0.143		0.153		0.027	
Number of cases	614		525		89	

1) For explanation of stars, see table 5.6.

2) e=1 for infecund couples.

5.5.4 Why Contraception When the Pregnancy Attitude is Positive?

As mentioned previously we found some puzzling results for contraceptive use and coital frequency for couples with a positive attitude towards becoming pregnant soon, since they should in principle not have any reason for using contraception, as shown in chapter 2. Nevertheless, a sizable proportion (67 per cent) used contraception among the respondents who answered "Happy" or "All right" to the question about their feelings if they became pregnant next month, see table 5.14.

This inconsistency indicates that some respondents have misunderstood the question as discussed in section 3.10, or that they are uncertain or ambivalent about becoming pregnant next month. Some women would, perhaps, prefer to have another child some time in the future and not so soon, e.g. because of economic reasons, housing conditions, employment, education or marital relationship, but they would nevertheless not be unhappy, or rather happy, if they by chance or

Table 5.14 Women by contraceptive use and attitude towards becoming pregnant next month

	Used contraception	Did not use contraception	Total
Happy..............	40	35	75
All right..........	67	17	84
Mixed feelings.....	175	17	192
Regret.............	112	4	116
Disaster...........	48	2	50
Total	442	75	517

accident were to become pregnant in the next month. Using contraception which is not 100 per cent effective in a way leaves the decision about future child-bearing to the fate. Finally, some respondents may feel that it is not socially acceptable to express negative attitudes towards pregnancy and motherhood. One thing is what they say, another thing is how they would actually feel if they were to become pregnant.

There is, on the other hand, no inconsistency between having a negative attitude towards becoming pregnant next month and the use of contraception, as almost all of them (96.4 per cent) used contraception, see table 5.14.

5.5.5 Concluding Remarks

In the three previous subsections we have analyzed the determinants of sexual activity on the basis of the theoretical model presented i chapter 2. The model seems to stand up well against the confrontation with empirical data. All the "original" variables from the theoretical model have significant effects and signs as expected, with only one exception. Moreover, the inclusion of terms that are non-linear functions of these variables seems justified. In fact, when these non-linear terms are excluded, not even the linear terms are significant.

Of the additional explanatory factors included, most of the demographic factors have significant coefficients, in particular the age of the women, and for some subgroups the age of the husband, the marriage duration (in most cases), and the length of the open birth interval, whereas none of the socio-economic variables seem to be significant.[1)] Our analysis indicates that there is considerable

1) Trussell and Westoff (1980) find roughly the same for the 1970 National Fertility Study.

variation in sexual activity according to the attitude towards becoming pregnant soon, contraceptive use, and demographic characteristics.

The present exploratory OLS single-equation analyses of the quarter sample seem promising for further analyses.

5.6 Contraceptive Use

In section 4.7 we explained why our first approach to estimating the complicated non-linear equation (4.26) would be to estimate the second-order approximation of it:

$$(5.3) \qquad M = a_0+a_1y+a_2S+a_3Sy+a_4y^2+a_5S^2+u,$$

where M is a variable for contraceptive use.

In this section we will mostly treat M as a continuous variable and use contraceptive effectiveness as a measure of M, where e is the effectiveness of the method used, according to the estimates presented in section 3.11.

As discussed at the beginning of subsection 5.5.2, respondents with no intercourse cause a problem for our analysis since we do not know anything about their use of contraception during the last four weeks. In table 5.15 we have analyzed contraceptive effectiveness according to the same four alternatives as in table 5.9. The results in regressions 1, 3 and 4 are fairly similar. The overall fit is the best in the second regression (e=0 when S=0) and most of the relative standard errors are the smallest, with the notable difference that the pregnancy attitude is not significant and the coital frequency significant only in this regression. (Since y and S affect e through

Table 5.15 Regressions of contraceptive effectiveness by treatment of respondents with no intercourse 1) 2)

Explanatory variables	Hypothesized sign	Value assigned to e for cases where S=0							
		e=missing		e=0		e=1		e=0.8	
		Coeff.	St.error	Coeff.	St.error	Coeff.	St.error	Coeff.	St.error
0 Constant.............		84.60		47.13		93.46		84.19	
1 y (pregnancy attitude)	-	-6.3028*	2.5562	-0.8714	2.3448	-6.6034**	2.1105	-5.4570**	2.0955
2 S (coital frequency)..	+	1.0162	1.3666	10.8088**	1.1208	-1.3935(*)	1.0088	1.0469	1.0016
3 yS...................		-0.5229(*)	0.3228	-1.1872**	0.3093	-0.4837*	0.2784	-0.6244*	0.2764
4 y^2...................		-4.4790**	0.9132	-5.4728**	0.9369	-3.9414**	0.8433	-4.2477**	0.8373
5 S^2...................		-0.0391	0.0766	-0.5324**	0.0671	-0.0817(*)	0.0604	-0.0411	0.0599
F-statistic		22.33**		41.86**		24.24**		23.64**	
R^2		0.187		0.285		0.187		0.183	
Adjusted R^2		0.178		0.278		0.180		0.176	
Number of cases		493		532		532		532	

1) The effectiveness values have been multiplied by 100.

2) See tables 5.6 or 5.22 for explanation of stars.

several factors we ran the regression with and without these factors, i.e. y, y^2 and yS; and S, S^2 and yS; respectively, and employed the test of additional explanatory factors mentioned in section 5.3.)

Based on the theoretical arguments in 5.2.2 and these empirical results we conclude again that the best solution seems to be to include respondents without intercourse and assume that they did not use any contraception. The rest of the regressions presented in this section are based on this assumption.

The partial effect of y on e, $\partial e/\partial y$, holding S constant, should be negative according to the theory with some exceptions, in particular when the so-called "substitution effect" is large and when we have a corner solution (see subsection 2.9.3.3, part A):

$$(5.4) \quad \partial(100e)/\partial y = -0.87 - 1.19S - 10.94y$$

Expression (5.4) is negative as expected for all non-negative values of y. For negative values of y the expression is only negative when S is large (S greater than 8 when y=-1 and greater than 17 when y=-2). The last result may seem disturbing, but indicates that there may be a corner solution, as discussed in section 2.9.

The partial effect of S on e is

$$(5.5) \quad \partial(100e)/\partial S = 10.81 - 1.19y - 1.06S$$

which is positive as predicted by the theory, except for large values of S (S greater than ca. 10).

Since the results concerning the effect of y on e (5.4) are somewhat contrary to our expectations, we estimated the model (5.1) again separately for negative and positive values of y, see table 5.16. (The factor y^2 had to be omitted from the first regression because of perfect collinearity, remember that y can only assume two different values here, -2 and -1.) The estimates are quite similar for both negative and non-negative values of y, and also similar to the second regression in table 5.15. The greatest difference is that the standard error of the y coefficient is smaller, especially when y is negative. (Omitting the square term y^2 in tables 5.15 and 5.16 <u>increases</u> the relative standard error of y, so we conclude that y^2 belongs in the model.)

Table 5.16. Regressions of contraceptive effectiveness by attitude towards pregnancy next month

Explanatory variables	Estimates			
	$y<0$		$y\geq 0$	
	Coeff.	St.error	Coeff.	St.error
0 Constant	47.61**	10.39	49.65**	6.19
1 y (pregnancy attitude)	12.74*	6.53	10.24	9.79
2 S (coital frequency)	13.93**	1.93	8.87**	1.65
3 yS	-1.28*	0.94	-2.03**	0.65
4 y^2			-8.27*	4.79
5 S^2	-0.77**	0.08	-0.36**	0.10
F-statistic	46.87**		17.98**	
R^2	0.517		0.208	
Adjusted R^2	0.506		0.197	
Number of cases	184		348	

* Significant at 10 per cent level.

** Significant at 1 per cent level.

Other explanatory variables are introduced in table 5.17. The regressions in the table do not include variables which had large standard errors in previous regressions, like the square of the ages of the spouses, having a child less than two years of age, the age of the woman, her religious activity, and the rurality of the place she grew up in.

Most of the remaining variables have effects as expected, inter alia the negative effects of the ages of the spouses. The effectiveness of contraception increases non-linearly with the duration of marriage, but with a small decline for durations of more than 15 years. Couples who have been married for 15 years use contraception which is 21 percentage points more effective than the contraception used by newly wedded couples, ceteris paribus. This positive effect is contrary to our expectations, see section 3.1, but not unreasonable. The explanation may be that most couples have their children at the beginning of their marriage, and consequently that their need for contraception increases after that. The pregnancy attitude variable and the number of live children should control for some of this, but evidently have not done so completely.

The number of children has a strong positive and significant effect on the use of contraception. The explanation for this is obviously that Norwegian couples want few children and that they need to limit further child-bearing when they have had them. This is consistent

Table 5.17 Regressions of contraceptive effectiveness including additional explanatory variables[1)2)]

Explanatory variables	Hypothesized sign	Estimates 1: All y — Coeff.	Estimates 1: All y — St.error	Estimates 2: y<0 — Coeff.	Estimates 2: y<0 — St.error	Estimates 3: y≥0 — Coeff.	Estimates 3: y≥0 — St.error
0 Constant		55.05		16.61		79.16	
1 y (pregnancy attitude)....	-	-1.5926	2.4215	5.6834	6.8947	9.9676	9.6577
2 S (coital frequency)......	+	10.0486**	1.1414	14.4252**	1.9911	8.0190**	1.6449
3 yS.......................		-1.0144**	0.3109	-0.5908	0.9592	-1.8612**	0.6329
4 y^2.......................		-5.1964**	0.9505			-7.9484*	4.7253
5 S^2.......................		-0.5018**	0.0676	-0.7667**	0.0836	-0.3285**	0.0951
6 Age of woman.............	-	-0.6953	0.6503	1.2618	0.8333	-1.5739*	0.8962
7 Age of woman squared......	+						
8 Age of husband...........	-	-0.6011(*)	0.4276	-0.4677	0.4909	-1.0209(*)	0.6302
9 Age of husband squared....	+						
10 Marriage duration.........	-?	2.2602*	1.2324	2.6715(*)?	1.7203	2.2712(*)	1.6528
11 Marriage duration squared.	+?	-0.0719*	0.0418	-0.1487**	0.0537	-0.0364	0.0597
12 Youngest child less than 2 years.....................	+						
13 N (live children).........	+?	5.869**	1.794	-1.002	2.246	9.072**	2.507
14 Full income/100 000.......	-	-9.839*	4.705	-6.338	6.315	-7.241	6.334
15 Wage/100.................	+?						
16 Education of woman........	+	2.2900**	0.7244	0.4033	1.0193	2.9060**	0.9529
17 Religious activity........	-						
F-statistic		20.16**		17.24**		11.02*	
R^2		0.328		0.536		0.293	
Adjusted R^2		0.312		0.505		0.267	
Number of cases		508		176		332	

1) The effectiveness values have been multiplied by 100.

2) See tables 5.6 or 5.22 for explanation of stars.

with the finding in section 5.3 that the attitude towards pregnancy is less positive the more children a couple has.

Having had a child recently, on the other hand, does not seem to have any effect on contraceptive behaviour. Perhaps this is due to lower coital frequency during the post-partum period? This effect should have been covered by the S-variable, however.

The education of the woman has a strong positive effect on contraceptive use: more educated women use more effective methods. We do not know which of the many possible effects of education this is due to (see section 2.10). Do, e.g., more educated women have more knowledge about effective contraceptive methods, is their optimal contraceptive effectiveness higher than for other women, or do their perceptions of the side-effects etc. of each method differ?

We notice with interest the strong negative effect of family income on contraceptive use, especially in view of the relatively weak income effects found in previous sections of this chapter.

The two other regressions reported in table 5.17 show that the effects of y and S on e depend on the value of y. Both effects are positive for relatively large values of S (greater than 10) when y is negative. Thus, only one of the partial effects is as hypothesized at the time. When y is positive, however, both effects are as expected for "normal" values of y.

In two regressions not shown here, we did the analysis separately for women who expected and who did not expect to have more children, respectively, just as we did in the analysis of coital frequency (table 5.11). The results are fairly similar to the results in table 5.17, but with one noticeable difference: For couples expecting to have more children the woman's age has a significant negative effect on contraceptive use and the husband's age has an insignificant effect, whereas the opposite is the case for couples _not_ expecting to have more children, just as we found in the analysis of coital frequency. The reasons for this are probably related to those discussed in section 5.5.

We also did a corresponding regression not shown here including users of contraception only (setting e=0 when S=0), and found that most coefficients have the same signs as in table 5.17, although the overall fit is, as expected, not as good (F-statistic = 5.27, R^2 = 0.139, n=404). This indicates that our model not only is capable of explaining why some couples contracept and some do not, but also why some couples choose more effective methods than other couples.

It will be interesting to see if the tentative results presented in this section will be confirmed by the analysis of the larger three-quarter sample. The analysis by pregnancy attitude does not seem to yield much additional insight, so we conclude that the only results that need to be confirmed by the three-quarter sample are the effects of the selected explanatory variables, as in the first regression in table 5.17.

5.7 Two-stage Least Squares Regression of Coital Frequency

We explained in section 4.7 why single-equation ordinary least squares regression of coital frequency (equation 4.27) would yield inconsistent estimators of the parameters and how a two-stage least square procedure suggested by Kelejian (1971) could be used to get consistent estimators.

Following the steps outlined by Kelejian and Oates (1981:299) the parameters are estimated in the following way:

Step 1. Predicted values of the basic endogenous variable e (contraceptive effectiveness) are obtained by regressing e on the predetermined variables y, y^2, age of the woman, age of the woman squared, age of the husband, age of the husband squared, marriage duration, marriage duration squared, education of woman, number of live children, and full income of the couple, that is variables that were found to have significant effects on contraceptive effectiveness in section 5.6, see table 5.17.[1)]

Step 2. The predicted values of the additional endogenous variables in equation (4.27), e^2, ey, and ey^2, are obtained in the same way, using the same predetermined variables as in step 1.

Step 3. The basic and additional endogenous variables are replaced with their predicted values, and the b_i-parameters (i=0,...,5) are estimated by OLS. The results from this are shown in table 5.18. As in section 5.5 we tried different sets of explanatory variables: with and without ey^2, and with and without the additional demographic and social explanatory factors. We concentrated on the variables that were found to have significant effects in section 5.5 (table 5.10).

---

1) The analysis in this section is done with inclusion of respondents with no intercourse last four weeks and assuming that they did not use any contraception, i.e. e=0, cf. the second regression in tables 5.9 and 5.15, and tables 5.10 and 5.17.

Table 5.18 Two-stage least squares regressions of coital frequency[1) 2)]

Explanatory variables	Hypothesized sign.	Estimates (1) Coeff.	(1) St.error	(2) Coeff.	(2) St.error	(3) Coeff.	(3) St.error	(4) Coeff.	(4) St.err
0 Constant	+	2.8069		4.1962		12.1017		-0.9292	
1 y (pregnancy attitude)	+	2.2501*	0.8815	2.6687**	0.8217	1.0350	0.9941	10.0547*	5.951
2 $\hat{e}$ (contraceptive effectiveness)	-?	-33.938	31.961	-57.177*	27.151	16.955	39.952	-258.50(*)	162.6
3 $\widehat{e^2}$	-	38.929	31.356	61.451*	26.756	-14.969	40.230	279.17(*)	173.1
4 $\widehat{ey}$	-	-2.2693*	1.2205	-3.0670**	1.0773	-1.1943	1.2617	12.2471*	6.882
5 $\widehat{ey^2}$	?	0.3392	0.2445						
6 Age of woman	- or +					-0.2114*	0.0874	0.9888	0.862
7 Age of woman squared	-							-0.0107	0.009
8 Age of husband	- or +					-0.0693	0.0552	-1.0596*	0.531
9 Age of husband squared	-							0.0163*	0.008
10 Marriage duration	- or +					0.1293	0.0800	-1.0585	0.860
11 Marriage duration squared	-							0.0448	0.032
12 Youngest child less than 2 years	-					-1.5270**	0.5016	-1.4735**	0.510
13 N (live children)	-							-0.6473(*)	0.481
F-statistic		6.29*		7.42**		6.11*		4.38*	
R^2		0.059		0.056		0.089		0.096	
Adjusted R^2		0.049		0.048		0.074		0.074	
Number of cases		509		509		509		509	

1) See table 5.8 for explanation of stars.
2) See tables 5.6 or 5.22 for explanation of stars.

The standard errors of the coefficients are estimated using expression (4.37), see subsection 4.7.2[1]. This procedure yields estimates of the standard errors that are only slightly smaller (3.6 to 6.3 per cent) than the ordinary estimates of the standard errors calculated by the SPSS regression program in the OLS second-stage regression in step 3. For the first regression in table 5.18 the estimated standard errors are, with the "ordinary" estimates in parentheses, e:31.961 (33.904), e^2:31.356 (32.255), ey:1.2205 (1.299), and ey^2:0.2445 (0.2598).

The differences being so small we conclude that it is not really worth the trouble to go through the procedure described in subsection 4.7.2 to estimate the variances. The "ordinary" estimates may just as well be used since the variances are not very precisely estimated anyway, in view of all the approximations we have had to make, problems with measurement of the variables, etc.

The standard errors in the first regression in table 5.18 are relatively large, so we ran the model again but without the term ey^2, getting smaller standard errors, which made the remaining factors significant. The signs of all coefficients are the same as in the OLS results reported in table 5.9.

Introduction of additional explanatory factors as in the two last regressions in table 5.18 have considerable effects on the estimates. When we include the same explanatory variables as in the second regression in table 5.10, the signs of the e and e^2 coefficients b_2 and b_3 change, but their standard errors are too large to conclude anything.

---

1) The regression to calculate the sum of squared residuals in (4.38) had to be run again, to get the same number of observations when calculating the residuals in (4.38) and (4.39).

The signs of the other coefficients are the same as in table 5.10. When quadratic terms and a dummy variable for the open birth interval are included, cf. regression 3 in table 5.10, the relative standard errors of the theoretical variables become much smaller and the signs of b_2 and b_3 do not change.[1)]

As in section 5.5, the partial effect of y on S, $\partial S/\partial y$, is positive in all regressions in table 5.18, except for values of e close to one (above 0.99, 0.87, 0.88 and 0.82, respectively), but these values need not be significantly different from zero. The direct partial effect of e on S, $\partial S/\partial e$, is positive for all values of e greater than ca. 0.45, except in the third regression where the standard errors are very large.

5.8 Conclusions

In this chapter we have presented the results from experiments with ordinary least squares estimation of linear approximations of the demand functions, as well as a two-stage method, using a random quarter sample of the full sample of married women. The purpose of the quarter sample analysis was to experiment with the data and the econometric methods so that we could estimate relationships and test hypotheses using the rest of the sample. This purpose has been achieved, but the

---

1) Regression results not presented here show that the estimate of b_2 changes sign from negative to positive when the age of the woman is included in addition to the "basic" variables (e, e^2, ey, and y). The sign does not change when the age of the husband, the marriage duration and the dummy variable for the open birth interval also are included, but changes back to negative when the squares of the three demographic variables age of woman, age of husband, and marriage duration, are included. We do not understand the reasons for this, which most probably is a statistical artifact and of no substantive interest.

analysis has also yielded many results that are of substantive interest in themselves. Before we summarize these, we will present our conclusions regarding a number of methodological problems mentioned previously. The solutions we suggest are those we are going to employ in the analysis of the three-quarter sample.

Econometric methods: A number of econometric problems have been pointed out. One of these problems seems to be solved using the two-stage least squares method in section 5.7, although the results from this are quite similar to the ordinary least squares results. In fact, the treatment of respondents with no intercourse, and the number of additional explanatory variables included, seem to be more important for the estimates of the coefficients. Some of the other econometric problems can also be solved using more sophisticated techniques, e.g. the non-linear two-stage least squares method described in subsection 4.7.2, but it is not certain that this would yield sufficiently different results to justify it.

Respondents with no intercourse: Most of the analyses have been done including respondents with no intercourse and treating them as if they did not use any contraception (e=0). This solution seems to be the best one, both because there are theoretical arguments for it, because it excludes less observations, and because the results are generally somewhat stronger than for the other solutions.

Use of imputed wage and income variables: The analyses in subsection 5.3.1.1 show that it does not affect the results much whether or not we use observed, or observed plus imputed wage and income variables. We have decided to stick with the last solution since it implies a larger number of observations, in spite of the possible danger of biased estimates.

Attitude towards becoming pregnant soon: We tried several measures of the pregnancy attitude variable in subsection 5.3.2, but we conclude that the attitude towards becoming pregnant next month seems to be acceptable, in spite of the problems with it. We have not attempted to improve on these, the most important being that the dependent variable is ordinal, except by doing the analyses separately for respondents with positive and negative attitudes towards becoming pregnant soon.

Contraceptive use: Our measure for contraceptive use in this chapter has been use-effectiveness based on estimates from Michael (1973). Estimates from other sources yield almost identical results. We also did a few analyses treating contraceptive use as a binary variable. To limit the work we have not analyzed the determinants of each method separately, e.g. using the LOGIT or PROBIT methods as mentioned in section 5.1, although this might have given new insight.

Results: The main effects on the three endogenous variables are summarized in table 5.19.

Analysis of three-quarter sample: As mentioned before, the analysis in this chapter is experimental and exploratory. The outcome of it is a set of equations to be estimated with the three-quarter sample, so that we can test the hypotheses based on the theory in chapter 2 and some of the tentative findings in this chapter. Ideally, we should reestimate only one equation for each dependent variable, i.e. pregnancy attitude, contraceptive use and coital frequency. We have decided, however, to reestimate two equations for each dependent variable: the equation based on the "pure" theoretical model and the "best" equation including additional explanatory variables, based on the analyses in this chapter. The regressions of coital frequency will be done both with

Table 5.19 Summary of effects on pregnancy attitude, coital frequency, and contraceptive effectiveness

	Pregnancy attitude y	Coital frequency S	Contraceptive effectiveness e
y....................................		*	*
S			*
e....................................		*	
Age of woman..........................	∩	-"	-"
Age of husband........................	-"	-"	(+)-"
Marriage duration.....................	∩	+"	/"
Youngest child less than 2 years..........	-	-	(+)
Number of live children...................	\	(-)	+
Full income of couple.....................	(-)	(-)	-
Wage rate of woman........................	-"	(-)	(+)
Having gainful work.......................	(+)		
Labour force experience...................	(-)		
Education of woman........................	(+-)	(+)	+
Relative economic position................	(+)		
Number of durable consumption goods.......	(+-)		
Ownership of house/apartment..............	(+)		
Saving for house/apartment	+		
Political activity........................	(-)		
Religious activity........................	+"	(-)	(+)
Religious feelings........................	(+-)		
Number of siblings........................	(+)		
Growing up at a rural place...............	+"		
Living at a rural place...................	+"		(-)
Education of husband......................	(-)		
Education of father.......................	+"		
Education of mother.......................	(-)		
Mother worked.............................	(-)		

* Significant effect, complicated relationship

" Significant in some but not all regressions

( ) Coefficient not significantly different from zero

(+-) Positive effect in some regressions and negative in others.

∪ U-shaped effect

∩ Hill-shaped effect (inverted U-shape)

/ Positive non-linear effect

\ Negative non-linear effect

Blank Effect not investigated

ordinary least squares and two-stage least squares to enable comparison. In addition to this we will do the parity-specific analyses and the analyses of traditional fertility measures.

The analyses by pregnancy attitude (tables 5.11, 5.16 and 5.17), use of contraception (table 5.12) and fecundity (table 5.13) did not give much additional insight and do not have to be repeated. The same is the case for the analyses where we have used only observed instead of partly imputed wage and income variables (table 5.3).

We conclude that the following regressions seem promising and should be reestimated with the three-quarter sample for confirmatory purposes:

1) Analyses of pregnancy attitude:
   Reg. 1 and 8 in table 5.2
   Reg. 1-4 in table 5.7 (parity-specific analyses)
2) Analyses of coital frequency:
   Reg. 1 and 3, table 5.10, only including significant variables
   Reg. 2 and 4, table 5.18 (two-stage least squares)
3) Analyses of contraceptive effectiveness:
   Reg. 1, table 5.17
4) Analyses of traditional fertility measures:
   Reg. 1-3 in table 5.7.

CHAPTER 6

ANALYSIS OF THREE-QUARTER SAMPLE

6.1 Introduction

The previous chapter was devoted to experimental analyses of a subsample of the full sample, to become acquainted with the data and to experiment with variables and functional forms. On the basis of these experiments we drew a number of conclusions and identified a set of equations to be estimated with the rest of the full sample, see section 5.10. The three-quarter sample analysis will be fairly limited, since the philosophy behind our approach was to use the 1/4 sample for experimental purposes and to test our findings from this with data from the 3/4 sample.

Most of what we said about data, estimation problems, and interpretation of results from the 1/4 analysis are also valid for the 3/4 sample. Repetition of this would be tedious, so we will limit our comments.

As mentioned before the two sub-samples are assumed to be statistically independent and drawn from the same population. Thus, the expected values of the estimates of the regression coefficients and parameters are the same. The major difference between the two subsamples is that the three quarter sample is larger than the quarter sample. This implies that estimation of the same regression model with both subsamples will usually yield smaller estimates of the variances of the coefficients for the 3/4 than for the 1/4 sample (on the average $\sqrt{3} = 1.73$ smaller), a greater F-statistic for the whole regression and a smaller coefficient of determination, R^2.

6.2 Desire for an Additional Child Soon

In section 5.3 we presented an extensive analysis of the desire for an additional child soon. We concluded that the attitude towards becoming pregnant next month seems to be a fairly good measure of this variable. In this section we limit the analysis to OLS regressions of equations (4.20) and (4.21), without the interaction term N x wage, which did not have any significant effect in the quarter sample analysis.

The first regression in table 6.1 shows the results from estimation of the same regression model, namely equation (4.20) without the non-linear terms and the additional explanatory Z-factors. The results are very similar to the results in table 5.2, except for the absolute value of the wage coefficient which is only half as large for the 3/4 sample as for the 1/4 sample, but not significantly different from zero in both cases.

It seems appropriate to ask again if the two samples really come from the same population, just as we did in chapter 3. This can be tested by employing the F-test described in subsection 3.4.2 (see Kmenta 1971:373). The F-statistic is only 0.09, which means that we cannot reject the null-hypothesis that the coefficients are equal, so we conclude again that the two samples represent the same population. We have also done the same test based on the other regression in table 6.1, with the same conclusion (test-statistic 1.23).

Table 6.1 Regressions of attitude towards pregnancy next month

	Hypothesized effect	OLS estimates of coefficients. Standard errors in parentheses. 1	2
Constant..............		1.00	-0.69
Full income (I), in 100 000 kr............	+	-0.150 (0.114)	0.059 (0.116)
Wage of woman (π), in 100 kroner............	-	-0.289 (0.380)	-0.664* (0.382)
Live children (N)......	-	-0.377** (0.025)	-7.600** (0.070)
Live children squared (N^2)..................	+		0.099** (0.012)
Interaction N·π........			
Age....................	+		0.134* (0.058)
Age squared...........	-		-0.0022 (*) (0.0009)
Marriage duration, in years.................	+		-0.016 0.029
Marriage duration squared................	-		-0.0004 (0.0011)
Youngest child less than two years.........	-		-0.169* (0.076)
Religious activity (meetings per year)...	-		0.0092* (0.0022)
Growing up in a rural place................	+		0.143* (0.056)
F-statistic..........		80.90**	36.18**
R^2....................		0.131	0.203
Adjusted R^2...........		0.129	0.197
Number of cases.......		1620	1574

*) Significant at 10 per cent level **) Significant at 1 per cent level

The second regression in table 6.1 shows that the effects of the additional explanatory factors are also very much the same as for the quarter sample. The major differences are that wage is significant and marriage duration not significant when the larger sample is used.

Table 6.1 shows that the analysis of the three-quarter sample confirms the following results: The attitude towards becoming pregnant soon is negatively and non-linearly affected by the number of children, positively and non-linearly affected by the age of the woman, negatively affected by having had a child less than two years ago, and positively affected by the woman's religious activity and having grown up in a rural place. The age with the most positive attitude to becoming pregnant soon is around 30 years, *ceteris paribus*. We notice with interest that the negative wage effect is confirmed, whereas the income effect is zero as for the quarter-sample analysis. Marriage duration does not seem to have any significant effect either.

6.3 Birth-order Analysis of Child Expectations

In subsection 5.3.3 we showed how the determinants of the attitude towards becoming pregnant soon as well as the expectation about additional children vary with the number of children the couple has already (tables 5.6 and 5.7). The most interesting finding is perhaps that economic factors seem to play a greater role for the attitudes towards having more children at high than at low parities, whereas the opposite is true for demographic characteristics.

To test this and other tentative findings we ran the regressions in table 5.7 again, see table 6.2. The quarter-sample results are only partly confirmed, however.

Table 6.2 Regressions of child expectation [1] by number of live children

	N=0		N=1		N=2		N=3	
	coeff.	st.err.	coeff.	st.err.	coeff.	st.err.	coeff.	st.err.
Constant......................	1.27		1.42		0.78		0.27	
Full income (I), in 100 000 kr.	-0.118	0.081	-0.081	0.095	-0.035	0.061	-0.007	0.047
Wage of woman (π), in 100 kr...	-0.066	0.441	0.277	0.279	-0.114	0.197	0.048	0.147
Education of woman............	0.012	0.013	0.004	0.011	-0.005	0.007	-0.005	0.006
Relative economic position.....	0.049(*)	0.032	0.038	0.030	0.012	0.021	-0.000	0.018
Having gainful work[1]..........	0.009	0.062	-0.006	0.042	0.033	0.029	0.001	0.023
Ownership of house/apartment[1].	0.029	0.048	-0.000	0.043	-0.065*	0.030	0.033	0.033
Age..........................	-0.022**	0.008	-0.026**	0.007	-0.010*	0.005	-0.005	0.004
Marriage duration	-0.038**	0.009	-0.028**	0.008	-0.017**	0.005	-0.005	0.005
Number of siblings............	-0.004	0.014	-0.028*	0.012	0.016*	0.007	0.015**	0.005
Growing up in a rural place[1]..	0.007	0.051	0.017	0.044	-0.069*	0.029	0.025	0.024
Living in a rural place[1]......	0.035	0.063	-0.010	0.055	0.085*	0.033	0.013	0.027
Number of cases in regression..	243		416		775		383	
F-statistic...................	19.57**		21.04**		14.04**		3.41*	
R^2............................	0.482		0.364		0.168		0.092	
Adjusted R^2....................	0.458		0.347		0.156		0.065	

1) Dummy variable *) Significant at 10 per cent level **) Significant at 1 per cent level

(*) One-sided test

The economic variables, wage and full income, are not significant at any parity and do not exhibit the same pattern across parities. The value of the income coefficient increases by parity as in table 5.7, but it does not change from negative to positive for parities 0 to 3. The wage coefficient oscillates between negative and positive values and does not decline monotonically from positive to negative values as in table 5.7. The effect of education is also not significant for all parities.

The demographic characteristics age and marriage duration have strong negative and significant effects at low parities (0-2), and weak and not significant effects at high parities (3-4). Several of the other variables have significant effects only for parity 3 (house ownership and growing up and living in a rural place).

One interesting finding from the 3/4 sample is the strong and significant effect of the number of siblings of the respondent on child expectations. For high parities, 2 and 3, this effect is positive as expected, whereas it is negative for lower parities. We do not see why women with one child should be less willing to have more children the more siblings they have themselves, when the opposite is the case for women with 2 and 3 children. Women who have grown up in large families may, of course, have both positive and negative experiences from this. Our results indicate that the positive aspects of this may be the most important for the desires to have many children.

These results confirm that there may be a threshold level at three children, but that demographic factors and background factors may be more important than economic factors for passing this threshold.

Finally, we notice that the fit of each equation decreases with parity. This is also the case if we include a regression of women with four children (F-statistic = 1.20, R^2=0.101, adjusted R^2=0.017, n=129).

We conclude from this that there are very few women who want a fourth and fifth child (5 and 0.8 per cent, respectively), and that this desire is due to random factors not captured by our model. For married women with 0, 1 or 2 children the most important determinants of child expectations are their age and marriage duration. For women with 2 or 3 children, living in a rural area and having many siblings are associated with expectations about more children.

6.4 Traditional Fertility Measures

In chapter 5 (table 5.8) we presented results from analyses of three traditional measures, children ever born (CEB), additional expected fertility (AEF), and total expected fertility (TEF), because there is considerable interest in the determinants of these variables. We found *inter alia* that there is a positive effect on CEB of full family income and a negative effect of the wage of the woman, as hypothesized. Moreover, background variables like the number of siblings, living in a rural place, and the education of the woman seem to be important for actual and expected fertility.

The regressions presented in table 5.8 are repeated in table 6.3. Some but not all of the findings from the quarter sample are confirmed.

The wage of the woman has a negative effect both on actual and total expected fertility. The elasticities of CEB and TEF with respect to wage are quite small, however, -0.08 and -0.06, respectively. The

Table 6.3 Regressions of children ever born, additional expected children, and total expected fertility

Explanatory variables	Children ever born: Hyp. eff.	Coeffi- cient	Standard error	Additional expected children: Hyp. eff.	Coeffi- cient	Standard error	Total expected fertility: Hyp. eff.	Coeffi- cient	Standard error
Constant...........................		-0.30			2.07			1.77	
Full income (1), in 100 000 kr.......	+	0.078	0.100	+	-0.063	0.059	+	0.015	0.108
Wage of woman (π), in 100 kr.........	-	-0.590*	0.328	-	0.006	0.194	-	-0.584(*)	0.355
Age................................	+	0.089*	0.048	-	-0.019	0.028	+?	0.070(*)	0.051
Age squared.........................	-	-0.0017*	0.0007	+?	0.0001	0.0004	-?	-0.016(*)	0.0008
Marriage duration, in years..........	+	0.2472**	0.0217	-	-0.2580**	0.0128	+?	-0.0108	0.0235
Marriage duration squared............	-	-0.0045**	0.0008	+?	0.0079**	0.0005	-?	0.0034**	0.0009
Youngest child less than one year[1]..	+?	0.660**	0.065	-	-0.164**	0.038	-?	0.497**	0.070
Relative economic position..........	+	-0.204**	0.036	+	0.070**	0.021	+	-0.134**	0.039
Durable consumption goods...........	-?	-0.022	0.026	-?	0.020(*)	0.015	-	-0.042(*)	0.028
Ownership of house/apartment[1].......	+?	0.164*	0.067	-?	0.049	0.040	+?	0.213**	0.073
Saving for house/apartment[1].........	-?	-0.025	0.084	+	0.033	0.049	+?	0.008	0.090
Religious activity (meetings per year)	+?	0.001	0.002	+	0.004**	0.001	+	0.005**	0.002
Number of siblings..................	+	0.046**	0.013	+?	0.002	0.008	+	0.049**	0.014
Growing up in a rural place[1]........	+	0.054	0.050	+	0.013	0.030	+	0.067	0.054
Living in a rural place[1]...........	+	0.091(*)	0.059	+	-0.006	0.035	+	0.085(*)	0.064
Having gainful work[1]...............	-	-0.252**	0.050	-	0.109**	0.030	-	-0.142(**)	0.055
Education of woman..................	-	-0.008	0.013	+	0.019**	0.007	-	0.011	0.014
F-statistic.........................		84.6**			128.0**			16.3**	
R^2................................		0.463			0.566			0.142	
Adjusted R^2.........................		0.457			0.561			0.134	
Number of cases.....................		1689			1689			1689	

1) Dummy variable

*) Significant at ten per cent level

**) Significant at one per cent level

(*) One-sided test

effect of income is not significantly different from zero. Relative economic position is significant in all three regressions, but the effect is positive as hypothesized only on AEF.

The effect of durable consumption goods is significantly less than zero on AEF and TEF, which confirms our hypothesis about competition between durable consumption goods and children. House ownership, which may be interpreted as a wealth measure, has a positive effect on fertility, and significantly so on CEB and TEF.

The effect of education is confirmed by the 3/4 sample analysis: The more education a woman has, the more additional children she expects to have, due to later child-bearing, whereas her total expected fertility is the same as for other women, *ceteris paribus*.

Moreover, women who have gainful employment at the time of the interview have on the average 0.25 fewer children than other women, and expect more children in addition but fewer altogether, with all three effects being significantly different from zero at the one per cent level. The positive coefficient for AEF is probably the result of later child-bearing among working women, just as for women with more education. On the other hand, we see that these women also expect to have fewer children altogether, which we could not conclude for more educated women.

The relationships between the three fertility measures and age and marriage duration are about the same as we described in section 5.4. A minor difference is that age has a significant U-shaped relationship with total expected fertility, with a minimum at 22.6 years, and not a monotonically increasing effect from 18 years as for the 1/4 sample.

We conclude that both demographic, economic and social factors are important for actual and expected fertility.

6.5 Frequency of Intercourse

In chapter 5 we experimented with regression analyses of the demand function for sex, using both ordinary least squares and two-stage least squares methods. The methods yielded fairly similar results, although there were some differences. Since so much of the analysis in chapter 5 was done using the OLS-results, we decided to do the confirmatory analysis of the 3/4 sample for both methods to enable comparison. Only the TSLS results will be used in the analysis of the utility function in section 6.7, however.

In table 6.4 we have repeated two of the linear regressions of the demand for sex reported in table 5.10 (1 and 2), i.e. the "pure" theoretical model and the model including additional explanatory variables, respectively.

The first regression confirms the quarter sample results. All coefficients are significantly different from zero and have the same signs, although their magnitudes differ somewhat between tables 5.10 and 6.4. We see that the effect of a change in the attitude towards pregnancy soon is $\partial S/\partial y = 1.21 - 1.05e$, which is positive except for values of e close to 1 ($e > 0.8651$). (The value is significantly different from 1 since the two coefficients with estimates 1.21 and 1.05 are significantly different from each other, employing the test in Kmenta (1971:371-372), with test-statistic 1.652.)

There may be several substantive reasons why there is a small region of e close to 1 where there is a negative effect of y on S, in addition to measurement errors and a possible bias from single-equation estimation. First, users of highly effective methods of contraception may feel virtually certain that they cannot become pregnant, which

Table 6.4 Regressions of coital frequency[1)]

Explanatory variables	Hypothesized sign.	Estimates (1) Coeff.	(1) St. error	(2) Coeff.	(2) St. error
Constant	+	2.98**	0.23	7.10**	0.78
y (pregnancy attitude)	+	1.2139**	0.1503	0.9624**	0.1537
e (contraceptive effectiveness)	-?	-6.0597*	2.6206	-2.1210	2.6677
e^2	-	9.9199**	2.6730	5.6599*	2.7306
ey	-	-1.0502**	0.1848	-0.9438**	0.1834
Age of woman	- or +			-0.1137**	0.0371
Age of husband	- or +			-0.0125	0.0254
Marriage duration	- or +			0.0168	0.0347
Youngest child less than 2 years	-			-0.7495**	0.2459
F-statistic		54.88**		34.18**	
R^2		0.121		0.147	
Adjusted R^2		0.119		0.143	
Number of cases		1593		1592	

1) Respondents with no intercourse are assumed to use no contraception. *) Significant at 10 per cent level. **) Significant at 1 per cent level.

Table 6.5 Two-stage least squares regressions of coital frequency[1)]

Explanatory variables	Hypothesized sign	Estimates (1) Coeff.	(1) St. error	(2) Coeff.	(2) St. error
Constant	+	0.8056		7.3650	
y (pregnancy attitude)	+	3.1994**	0.9814	0.7796	1.1853
$\hat{e}$ (contraceptive effectiveness)	-?	9.5378**	1.3443	3.9507	2.4716
e^2	-	-2.6302**	0.6123	-0.2149	1.1882
$\hat{e}y$	-	-3.8944**	1.3224	-0.7046	1.5842
ey^2	?				
Age of woman	-			-0.1206**	0.0425
Age of husband	-			-0.0129	0.0291
Youngest child less than 2 years	-			-1.1303**	0.2652
F-statistic		20.05**		15.70**	
R^2		0.050		0.068	
Adjusted R^2		0.048		0.063	
Number of cases		1519		1519	

1) Respondents with no intercourse are assumed to use no contraception.
*) Significant at 10 per cent level.
**) Significant at 1 per cent level.
(*) One-sided test.

means that their subjective contraceptive effectiveness is 1, i.e. a corner solution. They should, therefore, already be at the satiation level of sex, and an increase in y would not have any positive effect on S. The only possible effect would be that an increase in y could lower the optimal e and thus decrease S. Another possible explanation is that the use of modern methods of contraception increases the desire for sex in itself, as discussed in subsections 2.4.2 and 4.2.3. Finally, users of modern methods of contraception may also differ in other ways than in their choice of contraception, e.g. with respect to age, marriage duration, and education.

A surprising finding in chapter 5 was that marriage duration seems to affect coital frequency positively when other factors are controlled for (tables 5.8-5.10). This result is not confirmed by the analysis of the 3/4 sample, but on the other hand it is not rejected either. Table 6.4 shows that the coefficients of both marriage duration and its square are positive but not significant. The same is the case if we omit the square term (as in table 5.10). If we do the analysis separately for respondents with negative and positive attitudes towards further child-bearing, respectively, as in table 5.11, we also get insignificant results (negative for $y < 0$ and for women not expecting more children, and positive for $y \geq 0$ and for women expecting more children).

Just as with the 1/4 sample we notice that having had a child less than two years ago has a much stronger negative effect on coital frequency for couples expecting more children than for couples not expecting so. The reason for this may be that couples expecting more children have on the average a higher coital frequency than other couples (7.4 vs. 6.0 times per four weeks).

The two-stage least squares results are presented in table 6.5. This table corresponds to table 5.18 except that we have not repeated estimation of the model including the term ey^2, since this was not found to have a significant effect in any of the analyses of the quarter sample. Another minor difference is that marriage duration is not included as an explanatory variable in table 6.5 since it was rejected by the SPSS regression program ("F-level or tolerance-level insufficient for further computation"), probably because marriage duration is highly correlated with the ages of the spouses (zero-order correlation coefficients 0.88 and 0.81, respectively), and also with the predicted value of e^2 (correlation coefficient 0.78).

We have not gone through the elaborate procedure of calculating the proper TSLS standard errors as we did for table 5.18, since we found in section 5.7 that these estimates are only a few per cent lower than the second-stage "OLS" estimates.

Comparison of regression 1 in table 6.5 and regression 2 in table 5.18 shows that the signs of the effects of the four "theoretical" variables are confirmed by the 3/4 analysis with one exception, although the magnitudes differ somewhat. With the 1/4 sample all coefficients have signs as predicted by theory except b_3, and the same is the case for the 3/4 sample but with b_2 as the exception. The OLS estimation, on the other hand, yields the same signs of the coefficients for both subsamples, compare tables 5.10 and 6.4. We will later (section 6.7) see how the TSLS results affect the estimates of the d-parameters of the utility function for sex and contraception.

The effects of the other explanatory variables are about the same for both subsamples, the most important being the negative effects of the age of the woman and having a child less than two years of age.

As in all other regressions the estimate of the coefficient for the age of the husband is negative, but it is not significantly different from zero, so we cannot conclude anything about the direction of the effect.

6.6 Contraceptive Effectiveness

The quarter-sample results in section 5.6 indicate that both pregnancy attitude and coital frequency have strong non-linear relationships with contraceptive use (table 5.17). Among other variables, there seems to be a negative effect of the age of the husband; a hill-shaped effect of marriage duration; a strong positive effect of the number of children and the education of the woman; and a negative income effect. The effect of the woman's own age is negative as expected, but not significant.

The analyses by positive and negative pregnancy attitude, respectively, yielded similar but less strong results.

Table 6.6 shows a regression including the above-mentioned variables. Most of the tentative quarter-sample results are confirmed, but not all. Coital frequency has about the same non-linear relation with contraceptive effectiveness. The effect of the pregnancy attitude is a little different, however. The strong negative effect of y^2 is confirmed. But the y-coefficient is significant and the yS-coefficient not significant, whereas the opposite was the case for the quarter-sample.

Linear approximations would probably have yielded the same effects for both sub-samples, however. We conclude that the attitude towards becoming pregnant soon also affects the use of contraception.

Amont the other variables, the age of the woman is still not significant. We included it in the 3/4 analysis in spite of the inconclusive 1/4 sample results because we did not quite believe that contraceptive is unrelated to the age of the woman, both as a life-cycle variable and as a measure of the effect of the introduction of modern methods of contraception, which occurred when the women in our sample were at different stages in their reproductive career.

The negative effect of the age of the husband, on the other hand, is confirmed. The elasticity of contraceptive effectiveness with respect to the husband's age is about -0.2. Having a ten-year older husband decreases the effectiveness by about six percentage points, ceteris paribus.

The positive effect of children is also confirmed. Having one more child increases the effectiveness of contraception by about six percentage points. The same is the case for the education of the woman. Five more years of education increases the contraceptive effectiveness by eight percentage points, ceteris paribus.

The negative income effect is not confirmed, however. (Negative but not significant coefficient.)

The overall explanatory power of the regression equation is also quite strong (F-statistic = 65.2, R^2 = 0.34).

We conclude that our model seems to explain an important portion of married couples' contraceptive behaviour. Both the attitude towards becoming pregnant soon, the coital frequency, the age of the husband, the number of children, and the education of the woman are related to the use of contraception.

Table 6.6 Regression of contraceptive effectiveness[1)2)]

Explanatory variables	Hypothesized sign	Coeff.	St.error
Constant		46.97	
y (pregnancy attitude) ..	-	- 6.1609**	1.2022
S (coital frequency)	+	11.1498**	0.6231
yS		- 0.2310	0.1711
y^2		- 4.9714**	0.5116
S^2		- 0.5499**	0.0375
Age of woman	-	- 0.3666	0.3446
Age of husband	-	- 0.5525*	0.2216
Marriage duration	-?	0.3171	0.6564
Marriage duration squared	+?	- 0.0016	0.0225
N (live children)	+?	6.3187**	0.9627
Full income/100 000	-	- 1.6095	2.7448
Education of woman	+	1.6662**	0.4064

F-statistic	65.16**
R^2	0.344
Adjusted R^2	0.339
Number of cases	1504

1) Respondents with no intercourse are assumed to use no contraception. *) Significant at 10 per cent level. **) Significant at 1 per cent level. (*) One-sided test. 2) The effectiveness values have been multiplied by 100.

6.7 The Utility Function of Sex and Contraception

The forms of the demand equations for S and e (equations 4.23 and 4.24) are determined by the specific functional forms of the utility functions presented in section 4.2. The estimates in tables 6.4-6.6 can be used to estimate most of the parameters of these functions, since there is a one-to-one relationship between the d-parameters of the utility function of sex and contraception and the b-coefficients of (4.27), as shown in section 4.7 (eq. 4.28a). The only exception is d_4, which does not appear in the demand function for sex, but which can be estimated by the method discussed in subsection 4.7.1.

Table 6.7 shows the estimates of the d-parameters of the utility function of sex and contraception. There is no estimate of d_7, which is implicitly assumed to be zero, since we have omitted the term ey^2. There are two sets of estimates, based on OLS and TSLS regressions, respectively. We are only presenting results based on the "pure" theoretical model not including additional explanatory variables, since these seem to be the strongest.[1)]

For both sets of estimates, at least four parameters (d_1, d_3, d_4 and d_6) are significantly different from zero. Among these, only one sign differs from the expected sign in each set. We used the method described in section 4.7 to estimate the variances or their upper bounds, see formula (4.27c), since the variance-covariance matrix was not available. A large upper bound of the variance of a d-parameter

1) The original version of the dissertation also contains estimates of the parameters based on the quarter sample including d_7, and on regressions including additional explanatory variables.

Table 6.7 Estimates of parameters of utility function of sex and contraception[1)]

	d_i as a function of b_i [2)]	Expected sign of d_i	Variable in utility function	Estimates of d_i-parameters[3)] 1	2
1	$-1/2b_1$	-	S^2	-0.4119** (0.0510)	-0.1563* (0.0479)
2	b_0/b_1	+	S	2.4549	0.2518
3	b_3/b_1	-?	e^2S	8.1719 ((3.2138))*	-0.8221 ((0.4436))*
4		-?	e^2	-14.3669** (0.3286)	-2.2107** (0.0764)
5	$1+b_4/b_1$	-	eSy	0.1349 ((0.2594))	-0.2171 ((0.7867))
6	b_2/b_1	-?	eS	-4.9919 ((2.7769))*	2.9811 ((1.3343))*
	Satiation level of sex[4)] for e= 0.0			3.0	0.8
	Satiation level of sex[4)] for e= 0.5			2.4	5.1
	Satiation level of sex[4)] for e= 1.0			6.7	8.2
	Source of the estimates of b_i			T. 6.4 reg. 1	T. 6.5 reg. 1
	Estimation method			OLS	TSLS

1) Respondents with no intercourse are assumed to use no contraception.
2) The multiplicative factor r (fecundability) has been set equal to one.
3) Figures in single parentheses are estimates of the standard errors of the parameters. Figures in double parentheses are estimates of the upper bound of the standard error, according to formula (4.28c). A starred double-parenthesis means that the relationship between the estimate of the parameter and its upper bound is greater than 1.645, i.e. a significance level of 10 per cent. A double star corresponds to a "t-ratio" of 2.576, i.e. a significance level of 1 per cent.
4) Calculated for y=-1.

does not imply that we can conclude that the parameter is not significantly different from zero, only that we cannot conclude anything at all, which is the case for $\hat{d}_5$.

Since TSLS avoids the bias we get when we use OLS, we conclude that the second column in table 6.7 represents the best estimates of the parameters, and we are going to use these in the following discussion. The only problem with these estimates seems to be the low value of $\hat{d}_2$, and consequently the low satiation level of sex when e = 0 ($\tilde{S}$=0.8). On the other hand, such a low level may not be so unrealistic for couples not wanting a child soon and who are not using any contraception. For contracepting couples, the satiation level assumes higher and more realistic values. (The satiation level was discussed in section 2.4. It is equal to the regression constant b_0 when e=0.)

Table 6.7 also shows the satiation level of sex estimated for different values of contraceptive effectiveness. (The levels have been calculated for y=-1. Setting y=-2 yields almost identical results.) We notice that the satiation level of sex declines as e declines from 0 to around 0.5, and increases thereafter. This is an interesting and plausible result. The satiation level of sex, which is defined as the frequency of intercourse where the marginal utility of sex is zero, declines with e when ineffective methods of contraception are used, and increases when highly effective methods are used.

As mentioned in section 4.2, parameters d_3, d_4, and d_6 are included in the utility function to allow the "costs" of contraception to increase with the number of intercourses and the effectiveness of contraception, possibly in a non-linear fashion. If there are fixed costs, d_4 is different from zero. If the costs are strictly proportional to the number of intercourses, d_6=0. If there are variable costs, d_3 is different from zero. The results in table 6.7 show that there are both fixed and variables costs of contraception.

The parameters d_5 and d_7 were introduced in section 4.2.3 to allow for the possibility of a direct positive utility effect of contraceptive use for couples not wanting a child soon, the so-called "relaxation" effect. The estimate of d_5 is negative as expected, although we cannot conclude that it is significantly different from zero.

Substitution of these estimates into the utility function (4.22), with $d_7 = 0$, yields

$$(6.1) \quad g(S,e) = -0.16S^2 + 0.25S - 0.82Se^2 - 2.21e^2 - 0.22eSy + 2.98eS.$$

What about the properties of the utility function discussed in section 4.2.3, do they hold when confronted with data? Most of them do except for some subsets of the admissible values of e, S and y. (The admissible values are $e\varepsilon[0,1]$, $S\varepsilon[0,\infty>$, $y\varepsilon[-2,2]$.)

i) $g(0,e) = -2.21e^2 < g(0,0) = 0$

ii) The satiation level of sex is positive ($\tilde{S}=0.8$).

iii) The function $g(S,\bar{e})$ for given contraception is strictly concave ($g_{ss} = -0.3 < 0$).

iv&v) There are both fixed ($\hat{d}_3 = -0.82 \neq 0$) and variable costs of contraception ($\hat{d}_4 = -2.21 \neq 0$).

vi) The second-order differential with respect to e, $g_{ee} = -1.62S - 4.42$, is negative for all $S \geq 0$.

vii) The cross-partial differential, g_{es}, is negative as expected only for S=0 when e is positive and y negative.

Thus, all desirable properties except the last one are satisfied.

The most troublesome result, however, may be that the determinant $D=g_{ss}g_{ee}-(g_{se}-ry)^2$ is positive only for very low values of S (0 and 1), which implies that the second-order condition (2.46) is generally not fulfilled. This may imply that the solution derived in section 2.9 is not unique or that we have a corner solution.

The estimates of the d-parameters can be used to find the numerical solutions for the optimal values of S and e, for a given value of y. This can be done in two different ways:

The first method consists of differentiating the expected utility function V with respect to S and e, setting these equal to zero and solving the resulting cubic equation in e by a numerical algorithm. This method may give solutions outside the admissible range ($0 \leq e \leq 1$, $0 \leq S$), which would imply that there are corner solutions.

The second method is a search procedure consisting of calculating the total expected utility V (eq. 2.15), with the specific utility function (4.13) substituted for g (S,e), for different values of y, S and e belonging to the admissible set. The values of S and e that yield the highest value of V is the optimal solution, assuming that the utility of children and consumption when the number of children is the same in the two periods, f_0, does not depend on y, S and e. This method will give corner solutions if there are any.

The first method yielded both interior and "exterior" solution of S and e, depending on the value of y. To find the corner solutions we used the search procedure, which gave values of e equal to zero or one, and approximate values of S. When e is given, however, we can substitute this value into the first-order equilibrium condition (2.41), and derive the optimal value of S:

$$(6.2) \qquad S = -0.5\ (d_2+d_3e^2+d_5ey+d_6e+d_7ey^2+ry\ (1-e))/d_1$$

We applied this procedure to values of y ranging from -2 to +2, see table 6.8. We see that we have a corner solution with e=1 when y is negative or zero. As y becomes positive, we get interior solutions. It is consistent with the theory that the optimal level of e declines with increasing y. On the other hand, we proved in section 2.6 that women who are indifferent or positive to becoming pregnant soon will never use contraception (Theorem 2.2). Therefore, we set e=0 and use (6.2) to calculate the corresponding optimal value of S, see the figures in parentheses in the table.

Table 6.8 Estimated optimal values of contraceptive effectiveness and sex by pregnancy attitude[1)2)]

y	Optimal values[3)]		Satiation value[4)]
	e	S	$\tilde{S}$
-2	1.0	9.1	8.9
-1	1.0	8.4	8.2
0	1.0	7.7	7.5
	(0.0)	(0.8)	(0.8)
+1	0.77	7.0	5.9
	(0.0)	(4.0)	(0.8)
+2	0.26	7.5	2.7
	(0.0)	(8.1)	(0.8)

1) e = effectiveness of contraception.
   S = frequency of intercourse (per four weeks).
   y = attitude towards becoming pregnant soon (desire for an additional child soon).

2) Numbers in parentheses show the optimal solutions of S and e when we have set e=0 for $y \geq 0$.

3) Values that maximize the expected utility V.

4) Values where the marginal value of sex, g_s, is zero.

The table also shows that when there is a corner solution with e=1, the optimal value of S decreases with y, as hypothesized. When there is a shift in e from 1 to 0, the optimal S declines. The expected utility V is higher the higher y is. These findings are consistent with the results in section 2.9 (table 2.2).

We also see from the table that the optimal value of S is practically equal to the satiation level when y is negative or zero (e=1), and greater than this level when y is positive and e is less than unity, as predicted by the theory (section 2.7).

6.8 Summary of Results

The main results concerning the effects of the exogenous variables are summarized in table 6.9. Comparison with table 5.19 shows that most of the quarter-sample results are confirmed by the analysis of the three-quarter sample.

Table 6.9 Summary of effects on pregnancy attitude, coital frequency, and contraceptive effectiveness

	Pregnancy attitude y	Coital frequency S	Contraceptive effectiveness e
y		*	*
S			*
e		*	
Age of woman	∩	(-)	(-)
Age of husband		(-)	-
Marriage duration	(-)	(+)	(∩)
Youngest child less than 2 years	-	-	
Number of live children	U	(-)	+
Full income of couple	(-)	(-)	(-)
Wage rate of woman	-	+	
Education of woman		(-)	
Religious activity		(-)	
Growing up in a rural place..	+		

* Significant effect, complicated relationship

( ) Coefficient not significantly different from zero

U U-shaped effect

∩ Hill-shaped effect (inverted U-shape)

Blank Effect not investigated

CHAPTER 7

SUMMARY AND CONCLUDING REMARKS

7.1 Theory

The theoretical and empirical analysis presented in this dissertation has focused on a few aspects of reproductive behaviour. The model is a short-horizon model based on a sequential decision-making approach. As pointed out in the introduction, the model is not a general model of fertility decision-making, but it focuses on some aspects of it.

As mentioned in chapter 2, there are a number of problems with the model, inter alia that it is not fully dynamic, and that the gestation period and the possibility of legal abortion are not incorporated. There is no time budget and no labour force participation; no direct quality-quantity of children trade-off; no allowance for the fact that couples who want to have a child may concentrate their sexual activity on susceptible days and vice versa for couples not wanting so; and no wife - husband interaction. Moreover we have assumed that the utility function is partly separable, that there are no time and money costs of contraception and sex, and that the probability of conception is proportional to the number of intercourses. We have not been able to incorporate the characteristics of various contraceptive methods.

The theoretical analysis in section 2.9 indicated several apparently counterintuitive results e.g. that the optimal coital frequency declines as the attitude towards becoming pregnant soon becomes less negative, but we showed why this could be the case if there is a corner solution. The empirical analysis confirms this, as most of the optimal solutions for contraceptive effectiveness are corner solutions, i.e. either no contraception or perfect contraception. This is a plausible result, as the modern methods of contraception, the pill and the IUD (and sterilization as well), are highly effective and may be considered 100 per cent effective by most users. To find out why some couples still use imperfect methods like withdrawal and condom would have merited a method-specific analysis, and not, as here, an analysis of contraceptive use as measured only by its effectiveness.

7.2 Data

With regard to the measures we have used there are also problems: The pregnancy attitude variable (y) is ordinal, but we are treating it as a continuous variable; sexual activity is reported in categories whereas we assigned the midpoint value to each category and a somewhat arbitrary value to the open interval; as a measure of contraceptive use we used effectiveness of contraception based on other studies; respondents who reported more than one method were assigned the average effectiveness; the wage and income variables are partly imputed (but use of observed variables only yields almost identical results); as a measure of education we have used normal duration of highest completed education and not the actual duration, and we have not included more than one category of education; as a measure of the price of children we have used the actual or potential wage rate of the woman.

In addition to these and undoubtedly many other problems are errors in recording the responses, memory problems, non-random selectivity and non-response, etc.

7.3 Estimation Methods

To make estimation of the model feasible we have had to make a number of simplifying assumptions:

We have, with a few exceptions, treated all three endogenous variables as continuous, whereas the pregnancy attitude variable (y) is ordinal, the effectiveness of contraception (e) is limited (between 0 and 1), and the coital frequency (S) is discrete and limited (greater than or equal to zero). Most of the estimation is done using the ordinary least squares method although we have not been able to take account of all non-linearities, and in some of the analyses we have used OLS when the dependent variable is categorical and/or limited. OLS seems to give satisfactory results compared to TSLS results where this approach is appropriate, however, as judged by the estimates of the coefficients and the implications for the specific utility function of sex and contraception.

7.4 Use of Subsamples

The econometric analysis was done in two steps: the first step consisted of experimental analyses of a quarter of the sample of married women, whereas the second was a confirmatory analysis of the rest of the sample. As expected, most of the results are quite similar for the two subsamples, but with some important differences. We learn from this that it may be risky to draw conclusions from the econometric analysis of a small sample, even when it consists of several hundred cases, and also that it is risky to draw conclusions from the analysis of only one sample, whether it is a subsample or a full sample.

More specifically, one of the purposes of the quarter sample analysis was to derive the variables to be included in the analysis of the larger subsample. The criteria for selecting variables for the 3/4 analysis were that they belonged to or were derived from the theoretical model in chapter 2; that they were found to be important in empirical analyses of other data sets (section 2.10); that the signs of the estimates are consistent with the hypotheses presented in chapter 2; and finally that the estimates of the coefficients were found to be significantly different from zero.

In retrospect, it seems dangerous to put much weight on the last criterion, since estimation with a larger sample will usually yield smaller estimates of the variances of the coefficients. A variable that is omitted because it is not significantly different from zero with the 1/4 sample might be significant with the larger 3/4 sample. Therefore, the criterion for selecting variables for the 3/4 analysis should be different, e.g. by using a significance level that is a function of the relationship between the sizes of the two samples. (This is more or less what we did in practice, but without a specific numerical value of the test criterion). Thus, the smaller subsample should be used to weed out variables with very large estimates of the variances. Even so, there is no guarantee that we would not delete a variable that would have a significant effect with the larger 3/4 sample. We should keep variables even if they have large variances if we have strong *a priori* reasons for believing that they are important.

Was it really necessary to do the analysis in two steps, first using the quarter and then the rest of the sample? For the main results, e.g. the relationship between contraception and coital frequency, the conclusions would have been the same if we had used only a subsample, or only the full sample. But for other conclusions repetition of the analysis seems necessary. We found in section 5.5, e.g., that marriage duration has a positive effect on coital frequency when we control for other factors. This result may be a coincidence, since it is not confirmed by the three-quarter analysis (but not rejected either). The same is the case for the role of economic factors for child expectations for women with many versus few children (sections 5.3.3 and 6.3).

7.5 Results

Most of the empirical results are plausible and consistent with the theory. In view of the problems concerning theory, data, and estimation methods, the results should be interpreted with caution, however.

The results from the quarter-sample analysis are summarized in several sections: 5.3.4, 5.5.5 and 5.10. Most of these results are confirmed by the analysis of the three-quarter sample, compare tables 5.19 and 6.9. We will not repeat all results mentioned previously, but only summarize the main results and conclusions:

Model. All "original" variables, and combinations of variables, from the theoretical model have significant effects on the endogenous variables and signs as expected, with only one exception.

Coital frequency and contraceptive use. The analysis shows that these variables affect each other strongly and non-linearly, particularly when combined with the attitude towards becoming pregnant soon. Couples using very effective methods have intercourse more often, and vice versa. This is comforting, as the theory developed in chapter 2 is based on the hypothesis that there exists such a relationship.

Parameters of the utility function: The parameters of the specific utility function of sex and contraception have signs as expected, with a few exceptions. Our analysis shows that the optimal solutions of coital frequency and contraceptive effectiveness mostly are corner solutions and not interior solutions. As the attitude towards becoming pregnant soon increases from negative to positive, the optimal frequency of intercourse increases, and there is usually a switch from no use of contraception to perfect contraception, i.e. with 100 per cent effectiveness. These findings are consistent with the theoretical results in section 2.9. It is somewhat puzzling that there are only corner solutions, and that there seems to be a discrete and not a continous change in the use of contraception as the attitude towards becoming pregnant soon changes from negative to positive. This may be due to the assumptions about the utility function, the estimation methods, or the data.

Among the exogenous variables, demographic factors (ages of spouses, marriage duration, age of youngest child, and number of live children) seem to be the most important determinants of the three endogenous variables (pregnancy attitude, coital frequency, and contraceptive effectiveness), and with a few exceptions, more important than economic and other factors.

Of the economic variables, the wage rate of the woman has a significant negative effect on the attitude towards becoming pregnant soon, a mixed effect on coital frequency and a positive but insignificant effect on contraceptive effectiveness, as expected. The full income of the couple has a negative and insignificant effect on all three endogenous variables, whereas the theory predicted a positive effect on the pregnancy attitude. There is a positive (but insignificant) income effect on other fertility measures, however, e.g. on children ever born and total expected fertility. The Easterlin-inspired variable, relative income, has a positive effect as expected, but it is not significantly different from zero. Saving and/or owning the house or apartment have positive effects on fertility variables in several instances, but it is difficult to interpret these results, as the causal direction is unclear.

Only a few of the background variables have significant effects on one or more of the endogenous variables, namely growing up or living in a rural place, number of siblings, and religious activity.

Frequency of intercourse is negatively affected by the ages of both spouses. Somewhat surprisingly, the frequency increases with the marriage duration when we control for other factors. This effect is not found to be significantly different from zero with the three-quarter sample, however. As expected, having had a child recently (less than two years ago) has a strong negative effect on coital frequency. Religious activity, which is a measure of religiosity, also has a negative effect but this is not found to be significant.

Contraceptive use, as measured by effectiveness of contraception, is also negatively affected by the ages of the spouses. Having had a child recently and the number of live children have strong positive effects on contraceptive effectiveness, as expected.

Desire for an additional child soon. As a measure of this endogenous variable we tried several variables, see section 5.3, but conclude that the attitude towards becoming pregnant next month is the most valid measure. Demographic factors seem to be more important determinants of the attitude towards pregnancy next month than economic and other factors, which mostly have effects in the right direction, but many of them are weak and insignificant. Of the three variables in the original theoretical model, parity has a significant u-shaped effect, wage a significant negative effect as predicted by theory, whereas full income mostly has a negative but insignificant effect, which is contrary to theory but consistent with other empirical results.

In addition to parity, the most important demographic factors are age and marriage duration, both with an inverted u-shape relationship to pregnancy attitude, and having had a child less than two years ago, which has a strong negative effect. It is no surprise that the last variable is so important in a short-horizon model. Two of the most important non-demographic effects are religious activity and having grown up in a rural place, both being positive as hypothesized.

Parity-specific analysis. Some of the effects on the attitude towards becoming pregnant soon and the expectation about more children are parity-specific, for example the effects of wage and income, relative economic position, house ownership, number of siblings, and growing up or living in a rural place. These results indicate that certain economic and social conditions may be more important for attitudes towards having a third or fourth child than for having a first or second child. A majority of the respondents with one child expect a second (60 per cent), whereas only a minority expect a third (12 per cent) or a fourth child (5 per cent). (Around 96 per cent of the respondents expect to have one or more children.) These findings may have important population policy implications: resources should rather be devoted to stimulating couples to have a third than to have a second child, if the aim is to increase fertility.

Traditional fertility measures. The analysis of the three traditional fertility measures, children ever born (CEB), additional expected fertility (AEF), and total expected fertility (TEF) shows that fertility is indeed affected by economic factors. There is a positive income effect on CEB, a consistent negative wage effect on all three fertility measures, and the same is the case for labour force participation. On the other hand, the effect of relative economic position is significant but negative, which is contrary to our expectations. The education of the woman has a negative effect on CEB and TEF as expected. Furthermore, we notice the positive fertility effects of religious activity, which should be interpreted as a proxy for religiosity, number of siblings, having grown up in and living in a rural place, and the number of durable consumption goods. Saving for house/apartment has a positive effect on expected fertility, but the causal relationship may be the other way around: The more children couples expect to have in addition and in total, the more likely they are to save to get new larger housing.

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