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A MICRO-ECONOMIC ANALYSIS OF THE DETERMINANTS OF FERTILITY IN THAILAND

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PREFACE

The Survey of Fertility in Thailand (SOFT) was conducted in 1975 as a joint project of the Institute of Population Studies, Chulalongkorn University and the National Statistical Office as part of the World Fertility Survey, an international population research program in human fertility behavior. The project was undertaken with the financial support of the United Nations Fund for Population Activities and the technical assistance of the World Fertility Survey staff.

This report, A Micro-Economic Analysis of the Determinants of Fertility in Thailand, is the fifth in a series of publications presenting results of the Survey of Fertility in Thailand. The results of this report are based on the author's doctoral dissertation in economics at the University of Hawaii.

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A MICRO-ECONOMIC ANALYSIS OF THE DETERMINANTS OF FERTILITY IN THAILAND

SUMMARY OF THE FINDINGS

This study analyzes the determinants of fertility in Thailand by considering the actual fertility level in a family as determined by two basic elements: the desired completed family size and the ability of a couple to achieve the desired completed family size. Hence, the study is divided into two parts, the demand for children and the demand for contraceptive use. The first part analyzes factors which determine the couples' desired number of children while the second part analyzes factors which affect contraceptive utilization. The data collected in the 1975 Survey of Fertility in Thailand are employed. The data utilized consist of 2,042 sample households which were selected from the total number of households in the country.

The demand for children

The study of the demand for children is based on a micro-economic theory of fertility, which views child services as a commodity in the household produced with market goods and individuals' time. Two aspects of the demand for children — child-quality and child-quantity — are addressed, and are hypothesized to be determined simultaneously with other aspects of household decision making, such as the labor supply of the wife. The structural forms of the demand for child-quality and child-quantity are estimated by a two-stage least squares procedure by population groups. The population is classified according to the working characteristics of the wife, i.e., whether the wife works for wages and salaries, works in the family enterprise, or does not engage in any activity which is directly related to earning income. Basic characteristics of the groups vary widely. Wives who are working for wages and salaries are concentrated in municipal areas, have higher education and income, and demand more child-quality and less child-quantity. Wives who are working in family enterprises are mainly farmers, live in non-municipal areas, have lower education and demand less child-quality and more child-quantity. Non-working wives can be placed between the other groups with respect to the noted characteristics.

The demand for child-quality (measured in terms of the educational level which parents think is necessary for children) is consistently shown to be influenced by household income, the husband's educational level and his occupation. Households with higher income or households in which husbands have a higher educational level tend to demand higher child-quality, *ceteris paribus*. The occupation of the husbands is broadly classified into four groups: 1) professional, technical, administrative and clerical, 2) sales and services, 3) farmers and 4) skilled and unskilled workers. Farmers and skilled and unskilled workers tend to demand less child-quality. The demand for child-quality also varies with area of residence. Parents who live in municipal areas tend to demand more child-quality than parents who live in non-municipal areas. The relationship between the demand for child-quality and the demand for child-quantity varies among population groups. When statistically significant, the relationship is inverse, implying that child-quality and child-quantity are viewed by parents as substitute commodities. An insignificant relationship has been observed for the population group in which the wives are working for wages and salaries. These types of jobs are usually available in somewhat urbanized areas. The minimum level of education necessary for children in urban society is higher than that necessary for children in rural society. Since providing education for children is expensive and people who are working for wages and salaries generally constitute the low- and middle-income group, the observed desired level of education for children in this group will concentrate around the minimum level. Hence, the relationship between the demand for child-quality and child-quantity is not statistically significant.

Results of the estimated demand for child-quantity show that household income, the wage rate of the wife, the size of household enterprise and the availability of substitutes for child-care are statistically significant at least in some population groups. Household income exhibits a positive effect on the demand for child-quantity, which implies that children are a

normal good. An increase in the wage rate of the wife induces an increase in the demand for child-quantity if the wife's work and child care do not conflict with each other. If there is conflict between her work and child care, the substitution effect and the income effect induced by a change in her wage rate will cancel each other out. The size of the household enterprise is positively related to the demand for child-quantity. Since the productive role of children and wealth of the household vary directly with the size of the household enterprise, an increase in this variable will induce a decline in the cost of children to parents in addition to a positive wealth effect. Hence, the positive relationship between the size of the household enterprise and the demand for child-quantity is expected. The presence of other members in the household, whose time can be substituted in child care services, also decreases the cost of children to parents. Therefore, households with this traditional substitute for child care services tend to demand more child-quantity.

The demand for contraceptive use

The efficiency of the contraceptive technique employed is used as the dependent variable in the study of the demand for contraceptive use. This variable is hypothesized to be a function of the religion, the natural fecundability of the couple, the additional number of children desired, the educational level of the husband, the wife's breastfeeding practice, the age of the wife and the area of residence. Ordinary least squares and TOBIT procedures are utilized to estimate two forms of the demand for contraceptive use: a linear model and an interactive model. A linear model assumes that the effects of all variables on the demand for contraceptive use are linear and additive. An interactive model assumes that the effects of the natural fecundability of wives on the demand for contraceptive use interacts with the effect of all other variables.

Religion plays an important role in the acceptance of contraceptive use. The negative influence of the Islamic religion toward an acceptance of contraception is so large that it might prevent Islamic women from using contraception in almost all circumstances. Education tends to promote the utilization of contraception. It is the only factor whose positive influence on contraceptive use is strong enough to cancel out the negative effects of religion. Natural fecundability and breastfeeding, respectively, increase and decrease the expected gain from contraceptive use and thus increase or decrease the demand for its use. This implies that the use of contraception generally conforms to reasonable behavior. Besides these social and biological factors, the utilization of contraceptives depends on the additional number of children desired. The demand for contraception increases as the couple approaches the desired family size and stays at a constantly high level after the target family size has been reached.

INTRODUCTION

As is common in many other developing countries, the rate of population growth in Thailand has been quite high. Since a rapid increase in population is known to impede economic development of a country (Coale and Hoover 1958, Enke 1974, etc.), the Government of Thailand set as its target the reduction of the population growth rate from about 3 percent per annum in 1970 to 2.1 percent per annum by 1981 (National Economic and Social Development Board, 1976). To the extent that a high rate of population growth in Thailand is a result of high fertility combined with low mortality, the only satisfactory method of reducing the population growth rate is to reduce the fertility rate; large-scale international emigration is impractical while a rise in the death rate is undesirable.

This study attempts to analyze the determinants of fertility in Thailand. The basic framework of this study is to consider the actual fertility level in a family as being determined by two basic elements: the desired completed family size and the ability of a couple to achieve the desired completed family size. Although these two basic forces are not independent of each other, it is instructive to treat them separately. In societies where effective contraceptive techniques are not widely known or readily available, it might seem quite artificial to separate these two forces. In such societies, biological factors are the most important determinants of actual fertility, thus people may never seriously think about a "desired" family size. However, according to the 1975 Survey of Fertility in Thailand (Institute of Population Studies and The National Statistical Office, 1977), 96 percent of the women interviewed had heard of at least one efficient contraceptive technique, which makes the separation of these two forces more reasonable.

Hence, this study is divided into two parts, a study of the demand for children and a study of the demand for contraceptive use. The first part analyzes the determinants of the desired number of children. The second part analyzes factors which influence the use of contraception. Analyzing separately the determinants of these two basic elements in family formation helps to explain differences in fertility level among households, as being due to differences in the desired completed family size, and/or as due to differences in fertility control. Thus, the study may be useful for planners who would like to implement appropriate national population policies for the purpose of encouraging a decline in fertility rates in the future.

THE DEMAND FOR CHILDREN

Outline of the Willis Model

The theoretical framework adopted for the study of the demand for children is based on the works of R.J. Willis (1971, 1974). It is assumed in his model that a couple at the outset of marriage has a utility maximizing plan for its lifetime consumption. The couple's lifetime utility is assumed to be a function of "child-services" and non-child-commodities which include all other sources of household satisfaction that are unrelated to "child-services". There are two dimensions of "child-services", namely, "child-quality"and "child-quantity". Parents may increase the amount of "child-services" either via an increase in child-quantity or child-quality or both. "Child-services" is defined in the model as total child-quality which is the product of child-quantity and average child-quality.

Both child-services and non-child-commodities can be produced only within the household. The inputs used in producing these commodities are market goods and the wife's time available in home production. Thus, the amount of child-services and non-child-commodities which can be produced by the couple is constrained by the couple's lifetime income (which can be exchanged for market goods) and the time element available to them. The wife's time can be used directly in producing child-services and non-child-commodities or it can be exchanged into market goods before it is used in home production. The terms of trade between the wife's time and market goods are determined by the price index of market goods and the wife's wage rate which, in turn, is determined by her initial stock of human capital. Ultimately, the demand for child-services is determined by the couple's preference for child-services versus non-child-commodities, and the couple's initial endowments in terms of the husband's lifetime labor and non-labor income, the time available to the wife after marriage and her initial stock of human capital.

Necessity for a modified model

The Willis model described above was developed to study the demand for child-services in developed countries. Some assumptions in his model are not appropriate for developing countries. In order to make it more applicable to Thailand, additional elements, characteristic of a developing country such as the extended family type, self-employment and unpaid family workers and the productive role of children have been incorporated into the model used in this study. This modification of Willis' model will be discussed in the following sections.

The Willis model assumes that children are demanded as a source of utility in the same manner as a "consumption good." The motives of having children as a potential source of security to parents or as a productive agent are ignored in his model. Based on the 1970 Thai Census, 29.3 percent of agriculturally employed persons belong to the age group 11-19 years. The proportion was 15.8 percent for persons employed in non-agricultural occupations. This means that children and youth are an important source of labor, especially in the agricultural sector. To the extent that the productive roles of children are different among parents of different occupations, ignoring the motive of having children as a productive agent may lead to a misleading explanation of fertility behavior in Thailand.

The Willis model is formulated under the assumptions that the employment of mothers strongly conflicts with her care for children. However, according to the 1970 Thai Population Census, the majority of women in Thailand engage in economic activities as self-employed or unpaid family workers. As a self-employed and unpaid family worker, it is possible for mothers to take care of children while working. In a situation where there is no conflict between women working and raising children at the same time, the shadow price[1/] of child-services faced by parents is lower than in the case where there is such conflict, *ceteris paribus*. By not allowing possible compatibility between the employment of the mother and her care for children may further lead to misinterpretation of fertility behavior in Thailand.

Finally, it is assumed in the Willis model that the couple base their decision on the demand for child-services on their own income and wealth. This assumption is quite reasonable in a developed country like the United States where almost every family is of the nuclear type, i.e., parents live with unmarried children. Although the nuclear family is becoming more and more popular, the extended family

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1/ Shadow price of child-services includes not only the actual cost of rearing children, but also the income forgone as a result of rearing children.

is still quite common in Thailand. Parents, in-laws, and relatives of the head of the household are often living in the same house. With the presence of these members in the household, it does not seems appropriate to define only the income and wealth of the husband and wife as the resource constraint on which they base their decisions, since there are many transfers of income and wealth within the household. The presence of other members in the household may increase or decrease the time available for the production of home-produced commodities. Therefore the value of the time of the wife used in home production is affected by the extended family, and in turn so are the shadow prices of home-produced commodities. Omitting the time of other members in the household may also bias the analysis.

Taking these three elements into consideration, a modified Willis model is derived. However, a formal formulation of the model will not be given in this paper.[2/] The discussion of the model will concentrate on the effects of exogeneous changes on the parents' demand for child-services as implied by the model.

Outline of a modified Willis Model

Similar to the Willis model, a couple at the outset of marriage is assumed to maximize utility which is a function of child-services and non-child-commodities. The inputs used in producing these commodities are market goods, the time available to each member in the house for home production. The implicit assumption adopted in the model is that every member in the household may contribute to household income which can be exchanged for market goods used in home production. In addition, the wife, other members in the household and children may all contribute their time directly to the production of home commodities. By assuming that the wife can spend her time in home production, family enterprise or in the labor market, the terms of trade between the wife's time and market goods are determined by the price index of market goods and the marginal product of her labor in family enterprise or the market wage rate, which in turn, are determined by the household stock of capital and the wife's initial stock of human capital. Similarly, by assuming that the children can spend their time directly in home production or in family enterprise, the terms of trade between the children's time and market goods are again determined by the price index of market goods and the marginal product of child labor in the family enterprise which is simply assumed to be a function of household stock of capital. Following this formulation and the couple's given preference for children, the demand for child-services is determined by household income (including the income of other members and children as well as that of the husband and wife), the time available to every member in the household, the wife's initial stock of human capital and household stock of capital. Each of these variables are assumed to be given exogeneously. The following section will analyze the effects of these exogeneous changes on the demand for child-services.

Husband's income and household non-labor income (H). An increase in H will increase the availability of market goods in the production of home commodities and should induce a positive income effect on the demand for child-services. However, in the case of a non-working wife, an increase in H while leaving the time factors of production constant will increase the availability of market goods without increasing the availability of time. Then if child-services are more time-intensive than non-child-commodities, the shadow price of child-services in terms of non-child-commodities increases.[3/] Therefore, an increase in H while leaving the time factors of production constant induces a negative substitution effect as well. Thus, an increase in H may either increase or decrease the demand for child-services.

In the case of a working wife, the positive income effect on child-services still remains, but there will be no negative substitution effect since the effective value of the wife's time which is measured by her market wage rate or the productivity of her labor in the family enterprise remains unchanged as does the shadow price of child-services. Hence the demand for child-services should increase.

Total time of other members available for home production (T_O). If the productivity of the time of other members in home production is positive, an

2/ A formal formulation of the model is given in the author's unpublished doctoral dissertation, Phananiramai (1979).

3/ This property is called Rybezynski's theorem, for further discussion, see Willis, 1974, p. 55.

increase in T_O will increase the availability of time resources in the production of home commodities. This should cause an increase in the demand for child-services and non-child-commodities. Its effect on the shadow prices of child-services depends on the relative productivity of other members in producing child-services and non-child-commodities. If the time of other members is a better substitute for the mother's time in producing child-services than in producing non-child-commodities, an increase in T_O will cause a decrease in the shadow price of child-services as measured by the amount of non-child-commodities forgone, and the parents' demand for child-services will increase. If the time of the other members is a better substitute for mother's time in producing non-child commodities than in producing child-services, there will be an increase in time resources as well as an increase in the shadow prices of child-services, and the direction of change in the demand for child-services is not clear.

Total time available to the wife after marriage (T_W). The effect of T_W on the demand for child-services will be similar to the effect of H discussed previously. An increase in either of them increases the availability of resources for home production, which induces a positive income effect on the demand for child-services. However, the effect on the shadow price of child-services will be in the opposite direction. An increase in T_W causes a positive income effect and also a decrease in the shadow price of child-services for a non-working wife if child-services are mother's time intensive, therefore the demand for child-services and T_W are unambigously positively related. For the working wife, the shadow price of child-services is unaffected by an increase in T_W. However, an increase in T_W will cause a decrease in the value of her time in home production which should induce her to allocate less of her time for such production. In this case, the relationship between T_W and the demand for child-services is not known *a priori.*

The average time available per child for home production (T_C). To the extent that the productivity of the time of children in home production is positive, an increase in T_C implies an increase in household resources for home production which should induce a positive income effect on the demand for child-services. Its effect on the demand for child-services via the substitution effect is more complicated. The marginal value of children's time can be measured by the added value of non-child-commodities produced by children. Therefore it can be deducted from the shadow price of child-services which is also measured in terms of non-child commodities forgone. The difference between the marginal value of children's time and the shadow price of child-services will represent the actual price of child-services. When the children are not productive in a household enterprise, the marginal value of their time is zero. When they do contribute to household income, the marginal value of the children's time is positive. Therefore in households where children contribute to production, parents face a lower price of child-services, *ceteris paribus.* If the marginal value of children's time for home production decreases as the total time available of chidren increases, then the shadow price of child-services increases as T_C increases even though the total added value of non-child-commodities produced may increase. An increase in the shadow price of child-services will induce a decrease in its demand. Hence, the combined income and substitution effect of an increase in T_C on the demand for child-services cannot be predicted *a priori.*

Initial stock of capital in the household (K). The initial stock of capital owned by the household (K) affects the productivity of the wife and children in the family enterprise. This will affect the allocation of the wife's time between alternative activities. An Optimal allocation of the wife's time requires that she equate the marginal value of her time in different activities. Since an increase in K makes her time in the family enterprise become more productive, she will allocate more of her time to working in the family enterprise. The increase in K will also induce an increase in the household resources for home production and thus have a positive income effect on the demand for both child-services and non-child-commodities. However, an increase in the marginal value of the wife's time in the family enterprise will also cause an increase in the shadow prices of child-services if child-services are intensive with respect to the mother's time and the wife is working for the family enterprise. An increase in the shadow prices of child-services will cause a negative substitution effect on its demand. Therefore, we can conclude only that as K increases, the wife will allocate more of her time to the family enterprise, but the net effect on the demand for child-services is not clear since it induces both positive income and negative substitution effects.

An increase in K also increases the value of the

children's time to the family enterprise, which should be deducted from the shadow price of child-services. Thus an increase in K will cause a substitution effect in favor of the demand for child-services. It is possible that, at times, the household enterprise will acquire new blocs of capital and, as a consequence, the value of the child's contribution to the family enterprise will be reduced. However, given the situation in Thailand where the majority of business firms are very small in scale, it is unlikely that the acquisition of capital will be in the form of large enough blocs to alter the conclusion that K and the demand for child-services should be positively related.

Since K affects the productivity of both the wife and the children in the family enterprise, and the effect on the demand for child-services is in the opposite direction, it is not possible to tell in advance which effect will dominate.

Initial stock of the wife's human capital (k). An increase in the initial stock of the wife's human capital will increase her market wage rate and her productivity in family enterprise, which will in turn increase the shadow price of child-services if child-services are intensive with respect to the wife's time. This will cause a negative substitution effect on the demand for child-services. The increase in the wife's initial stock of human capital and her earning ability will also increase household availability of market goods, which will cause a positive income effect on the demand for child-services. However, it can be expected that the effect of k on household resources will be weak, since the wife is generally not the major income earner of the house, it is therefore expected that the negative substitution effect will dominate.

Empirical analysis of the demand for children

The theoretical model as outlined previously was transformed into a model which can be empirically tested. The empirical model was tested with the data from the Survey of Fertility in Thailand (SOFT).[4/] The survey interviewed about 3,000 couples, however not all were used in the study. Households that had more than one eligible couple[5/] were excluded because it was not possible to allocate household income to each eligible couple non-arbitrarily. There were 242 couples who lived in multiple-couple households. Couples in which either partner had been married more than once, households with adopted children and incomplete interviews were also be excluded. The sample size to be analysed, therefore, consisted of 2,042 couples.

One major problem of testing the described model with this set of data is the selection of proxies for the value of time of the wife and children in the household. The wage rate of an individual is often used as a proxy for the value of his/her time if a person is working. However in Thailand, only a small percentage of wives are working for wages and salaries: the majority are either unpaid family workers in the household or are self-employed. The wage rates of these people are neither well-defined nor recorded, therefore other proxies had to be used. Different proxies for the value of wives' time for different population groups classified by the wives' working conditions were used. This method has some defects, as Willis points out, in that, by classifying families according to the wife's labor force participation, families have been classified by their taste for children since, *ceteris paribus*, those women who want more children are also less likely to work. Therefore it is not possible to compare the estimated results among groups because any differences among them may be due to differences in teaste. However, the results can be used to explain fertility behavior within groups.

The contribution of children to household income is another problem in using this set of data to test the model. Although household income can be estimated from the survey, it cannot be allocated among the husband, wife, children and the capital. Different proxies for the value of children's time have been examined, but none of them is without deficiencies. The survey asked whether children help in the family enterprise or whether parents receive any financial aid from their children, etc. This set of questions is expected to indicate the parents' perceived benefits of children. Based on this set of questions an index can be created, and this index was the first choice as a proxy for the value of children's time. However, this index measures the existing as well as the perceived benefits of children, and is therefore highly correlated with the actual number of children a respondent already had at the time of the survey. If this index is used as an explanatory variable of the desired number of children,

4/ A more detailed description of the data can be found in Institute of Population Studies and National Statistical Office (1977).

5/ An eligible couple is defined as a couple in which the husband was a usual resident of the household and had a wife under 50 years of age who had slept in the household the night before the interview.

it is equivalent to explaining the demand for children by the actual number of children that a couple already has. The actual number of children and the demand for children are expected to be highly correlated, but the actual number of children should be the result, rather than the cause, of the demand for children. Including the actual number of children as an explanatory variable will cloud the effects of wage rate, income and other variables, which, according to economic theory, are major determinants of the demand for children. Hence, this index was dropped. One might argue that the number of children a couple has will influence the desired number of children. If this is the case, the model is characterized by a mis-specification for excluding relevant independent variables, which will cause the estimated coefficients to be biased and inconsistent. One satisfactory method of capturing the effect of the number of children born on the desired number of children is to turn to a sequential model. A sequential model allows the couple to revise the desired family size according to their past experience. But this type of model and data to test such a model do not exist. Therefore, we have to be content with a one-step decision process and ignore the possible feedback of the number of children born on the desired number of children. Since differences between the actual and the desired number of children can frequently be observed in both directions, we hope that the bias caused by this mis-specification in the model is not too serious.

The size of the stock of capital owned by the household can affect the productive role of children. However there are also drawbacks in using it as a proxy for the value of children's time. The size of the stock of capital affects not only the marginal product of children, but affects the value of the wife's time as well, if she is working for the family enterprise. Therefore the two effects will be confounded in the estimated coefficient of the stock of capital and its interpretation will be quite difficult. For wives who are engaged only in home production or are working for wages and salaries for other people, such a problem does not arise. Because no other better proxy exists, the size of the stock of capital owned by the household was used as a measure of the value of the productive role of children in the house.

Model Specification

Population group 1. Population group 1 consists of couples in which the wives are working for wages and salaries. Data on their wage rates are available from the survey and were used as a measure of the value of the wife's time. The structural forms of a demand function for child-quality and a demand function for children-quantity were estimated from the following equations.

$$1)\ E(Q) = a_0 + a_1\,HIR + a_2\,NCD + a_3\,HED + a_4\,HOC2 + a_5\,HOC3 + a_6\,HOC4 + a_7\,MUN$$

$$2)\ E(NCD) = b_0 + b_1\,HIR + b_2\,Q + b_3\,WR + b_4\,SE + b_5\,MUN + b_6\,D1 + b_7\,WR \times D1 + b_8\,D2 + b_9\,WR \times D2$$

(Definitions of these variables are given in table 1)

The average number of years of education perceived by the husband as necessary for boys and girls "to get along in the world these days" is used as a proxy of the demand for child-quality (Q). It is expected that child-quality will depend on household income and taste regarding child-quality and child-quantity. Household income (HIR) should be positively related to Q if Q is a normal good. The sign of the coefficient of the desired number of children will tell whether child-quality and child-quantity are substitutes or complementary goods. A positive relation means that child-quality and child-quantity are complementary, while a negative relation indicates that child-quality and child-quantity are substitutes. We expect that education will change parents' tastes in favor of more child-quality. The education of the husband (HED) represents this phenomenon, and will be included in the equation[6/]. Dummy variables for the occupation of the husband and areas of residence are also included in the equation.

The answer to the question "If you could choose exactly the number of children to have in your whole life, how many children would that be?" will be used as the dependent variable in the demand

6/ At first, the educational levels of both the husband and wife were included in the equation for child-quality. However, it turns out that the educational level of the wife is insignificant, therefore this variable has been excluded. The husband is the respondent for this question which asked about the demand for child-quality (Q), therefore the educational level of the husband should be more closely related to Q than the relationship between the educational level of the wife and Q.

Table 1

Definitions and Notations of Variables in the Equations of the Demand for Children

Variable	Notation	Definition
Wife's wage rate	WR	Average wage rate per month (in real terms).
Child-quality	Q	Average number of years of education perceived by the husband as necessary for boys and girls to get along in the world these days.
Number of children desired	NCD	The number of children that the husband would like to have during his whole life if he could choose exactly that number.
Wife's education	WED	Number of years which is necessary to attain her educational level.
Wife's occupation	WOC	Occupation is broadly classified into four groups: Group 1 : Professional, technical, administrative and clerical Group 2 : Sales and services Group 3 : Farmers Group 4 : Skilled and unskilled workers WOC_i = 1 if respondent belongs to occupation group i, i = 1, 2, 3, 4 = 0 if otherwise.
Municipality	MUN	MUN = 1 if respondent lives in municipal area = 0 if otherwise.
Household total income, excluding wife's wage income	HWIR	in real terms.
Wife's total wage income	WWIR	in real terms.
Household total income	HIR	HIR = HWIR + WWIR.
Husband's education	HED	Number of years which is necessary to attain husband's educational level.
Husband's occupation	HOC	HOC1, HOC2, HOC3, HOC4 have the same definitions as WOC1, WOC2, WOC3, WOC4, respectively, for husbands, except that HOC1 includes a small percentage of husbands who are not working.
Availability of substitute for mother's child care	D1	A dummy variable to distinguish whether other sources of child care exist besides the mother. D1 = 1 if there is a substitute for child care = 0 if otherwise.
Compatability of the nature of the wife's work and child care	D2	A dummy variable to distinguish whether there is incompability between the nature of the wife's work and child care, D2 = 1 if there is conflict = 0 if there is no conflict.
Size of family enterprise	SE	See calculation of SE in Appendix I.

equation for child-quantity. The variable will be called NCD; the number of children desired. HIR is used as a proxy for household permanent income. Child-quality is included in the regression, which means that b_1, the coefficient of HIR, measures the effect of HIR on NCD by holding Q constant. Therefore b_1 should be positive if child-quantity is a normal good. The wife's wage rate (WR) is used as a proxy for the value of her time. The size of family enterprise (SE) is an index calculated from the size of total land area for farming, farm equipment, the number of employees and the amount of capital goods used for family enterprises, such as trucks, cars, etc. (Details of the calculation of this index are given in Appendix I). This index is used as a proxy for the capital owned by the household(K). For this population group, there will be no problem about the confounding effect between the value of the wife's time and the productive role of children in the variable for size of family enterprise(SE), since the value of the wife's time can be accounted for in the wife's wage rate variable(WR). Therefore, SE and NCD should be positively related if the size of capital owned by the household does increase the productive role of children as hypothesized.

Almost every previous study about fertility in Thailand emphasizes differences between municipal and non-municipal areas, therefore a dummy variable MUN, which distinguishes area of residence, is included in the equation to account for influences which cannot be accounted for by other variables. The dummy variables D1 (substitute for mother's child care), D2 (compatability between child care and the nature of the work of the wife) and the interaction terms between WR (wage rate of the wife) and D1 and D2 are included in the model to see whether they cause a change in the intercept or a change in the effect of WR on NCD in the demand function.

It should be noted that D1, which will be termed here the existence of a traditional substitute for child care, will be set equal to one in the presence of relatives and (older) children who might take care of younger children. Therefore D1 cannot be independent of the demand for children. Thus, although we would like to account for the effect of the availability of time for child care on the demand for children, we cannot separate the possible feedback of the actual number of children, which depends on the demand for children, on the availability of time for child care. Thus D1 will partially reflect the influence of the productive role of children in the production of household commodities (taking care of younger children). It also reflects the influence of a decrease in the cost of children as time elements in the production of children become more abundant. Both effects tend to reinforce each other and cause an upward shift in the demand for children.

Incompatability between the nature of the work of the wife and child care will increase the cost of children. Therefore we expect D2 (incompatability) to decrease the demand for children. Moreover, the negative effect should increase with the wage rate of the wife.

Population group 2. Population group 2 consists of couples in which wives are reported as working, but their wage rates are not available. This group is constituted mainly of the wives who are working for family enterprises. Specifications of the demand function for child-quality will be the same as in population group 1. Since the wife's wage rate, which is the measure of the value of wife's time, is not available for this population group, her educational level (WED) will be used as a proxy. Therefore the specification of the demand for child-quantity for this population group becomes.

$$3)\quad E(NCD) = c_0 + c_1HIR + c_2Q + c_3WED + c_4SE + c_5MUN + c_6D1 + c_7WED \times D1 + c_8D2 + c_9WED \times D2$$

Although this equation is the same as equation (2), except that WED is used in the place of WR, the interpretation of c_4 is quite different from that of b_4. In equation (2), SE affects NCD by decreasing the shadow price of child-services via an increase in the productive role of children. However, for this population group, where wives are working in family enterprises, the value of their time is also affected by the size of household enterprises. Therefore SE affects NCD by changing the value of the wife's time and by changing the value of the productive role of children. Since the effects on NCD through these two channels are opposite in direction, one should expect a weaker relationship between NCD and SE for population group 2 than in population group 1 and population group 3 which will be specified below.

Population group 3. Population group 3 consists of couples in which the wives engage only in

home production. Again education of the wife (WED) will be used as a proxy for the value of her time. Since she does not engage in any family enterprise, the value of her time will not depend on the size of those household enterprises (SE). Therefore SE should account only for the effect of changes in the value of the productive role of children. Although the two demand equations which will be estimated for population group 3 are exactly the same as those in population group 2, the interpretation of the coefficient for SE will be different.

Estimation Procedure

Two-stage least squares is used to estimate the equations specified above. The procedure is to regress each endogeneous variable on all exogeneous variables, then use the predicted endogeneous variables as the respective instrumental variables. For population group 1, the endogeneous variables are WR, Q, NCD and HIR. The exogeneous variables are WED, WOC2, WOC3, WOC4, HWIR, HED, HOC2, HOC3, HOC4, SE and MUN. For population group 2, the endogeneous variables are Q, NCD and HIR. The exogeneous variables are those which are defined in population group 1. For population group 3, the endogeneous variables are Q and NCD, and the exogeneous variables are HOC2, HOC3, HOC4, HWIR (=HIR), WED, HED, SE and MUN.

Some Characteristics of the Population by Groups

Table 2 gives the means and standard deviations of the variables by population group, which will be discussed in this section. It can be seen that population group 1 consists of only 6.5 percent of total population, the largest is population group 2 which constitutes 75.8 percent of the total, while the remaining 17.7 percent form population group 3. For the total population, over 60 percent are farmers. The average education of husbands is 4.6 years. The average education of wives is 3.7 years. On the average, people would like to have 3.8 children and the desired educational level for their children is 9.7 years. About half of these couples said that there were other members in the household who could take care of the children while the mothers are working. Only about one-fourth of them said that mothers could take care of their children while working. The size of household enterprises ranges from 0 to 24 on the index scale, a larger size corresponds to a higher number. The average size of household enterprises is 3.9 (on the index scale). Thirteen percent of the sample households live in municipal areas.

Although municipal residents constitute only 13 percent of the total, they constitute almost one-half of population group 1. This means that the wives who work in the formal labor market tend to concentrate in municipal areas. The majority of both the husbands and wives in population group 1 work as professional, technical, administrative or clerical workers. The next largest group is skilled and unskilled workers who constitute about one third of the total. There is a smaller percentage of farmers or sales and services workers. On the average, population group 1 have higher education and income. The average size of household enterprises is 0.5 (on the index scale).

Population groups 2 are mostly non-municipal residents and 80 percent of them are farmers. On the average, they have the lowest education among the three groups, but they own the largest sized family enterprises. Population group 2 can be considered as typical of the rural population in Thailand. The characteristics of population group 3 seem to lie in between those of groups 1 and 2 in almost all aspects, except that their income is the lowest. About 30 percent of population group 3 live in municipal areas.

Empirical results and interpretations

Since these equations are estimated by the two-stage least squares technique, R^2 cannot be interpreted as the proportion of total variation explained by the independent variables in the model, rather it is the square of the correlation coefficient between the actual and the predicted dependent variable. The distribution of the estimated coefficients will coverge to normal if the sample size is large. Because the sample size of the data used in this study can be considered as "large", tests for significance of the coefficients will be performed based on a normal distribution.

Population group 1. Estimates of the equations for the demand for child-quality and child-quantity are shown in Table 3. Each equation will be discussed separately.

In the demand for child-quality, R^2 is .454 and the household income, husband's education and husband's occupation are significant. The coefficients

Table 2

Means and Standard Deviations of Selected Variables by Population Group

Sample Size	Total 2,042		Group 1 133		Group 2 1,534		Group 3 375	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Endogeneous Variables								
Q	9.7	3.6	11.9	3.8	9.3	3.4	10.7	3.7
NCD	3.8	1.6	3.2	1.4	3.9	1.7	3.8	1.5
HIR*	227	209	338	297	220	194	—	—
WR*	—	—	13	14	—	—	—	—
Exogeneous Variables								
% of HOC1	7.2	—	36.8	—	3.1	—	13.9	—
HOC2	8.3	—	14.3	—	6.1	—	14.9	—
HOC3	67.4	—	13.5	—	80.8	—	31.7	—
HOC4	16.2	—	32.3	—	9.8	—	37.1	—
% not working	0.9	—	3.1	—	0.2	—	2.4	—
HED	4.6	3.1	7.9	5.0	4.0	2.4	5.6	3.9
% of WOC1	3.2	—	40.6	—	0.8	—	—	—
WOC2	8.1	—	13.5	—	9.6	—	—	—
WOC3	63.8	—	18.8	—	83.3	—	—	—
WOC4	6.5	—	27.1	—	6.3	—	—	—
% not working	18.4	—	0.0	—	0.0	—	100.	—
WED	3.7	2.5	7.0	5.0	3.3	1.9	3.8	2.6
SE	3.9	2.5	0.5	1.3	4.5	2.0	2.3	2.9
% of MUN	13.1	—	48.9	—	5.7	—	30.7	—
HWIR*	218	199	234	222	218	191	216	221
% of D1	51.1	—	37.6	—	55.1	—	39.2	—
% of D2	77.2	—	89.5	—	73.4	—	88.0	—

* in hundred Baht.

of HOC3 and HOC4 are negative and significant which means that, if the husband is a farmer, skilled or unskilled worker, he tends to demand less child-quality in terms of the children's education, than he would if he were in occupation group 1. One explanation is that children tend to take up the same occupation as their parents. If parents also anticipate that this will happen and think that working as a farmer, a skilled or unskilled worker does not require a high level of education, then parents in these two occupational groups will demand less child-quality in terms of education. The coefficient for husband's education is positive and significant. This seems to confirm the hypothesis that education tends to change parents' tastes in favor of more child-quality and less child-quantity. Household income and child-quality are positively related which implies that child-quality is a normal good. It should be noted that child-quantity is not a significant determinant of child-quality or vice versa. This surely weakens the argument that people can substitute child-quality for child-quantity. The result seems to indicate that for this population group, child-quality and child-quantity are determined by other factors and deci-

Table 3 Population Group 1

ß — coefficients †, 'z' Value and Elasticity at the Mean

Independent Variables	Dependent Variables					
	Q R^2 = .454			NCD R^2 = .134		
	ß	'z'	elasticity	ß	'z'	elasticity
Intercept	8.682**	2.81		4.104**	3.38	
HIR	0.003@	1.94	0.0008	—0.001	—0.77	
NCD	0.386	0.48				
HED	0.194**	2.83	0.13			
HOC2	—0.398	—0.47				
HOC3	—3.421**	—3.51				
HOC4	—1.250@	—1.70				
MUN	0.642	1.04		0.476	1.55	
Q				—0.124	—0.91	
WR				0.329*	2.17	
SE				0.056@	1.88	0.009
D1				—0.392	—1.53	
WR x D1				0.001	0.02	
D2				—0.041	—0.11	
WR x D2				—0.300*	—2.31	

† A ß— coefficient estimates the partial effect of the corresponding independent variable on the dependent variable, keeping all other independent variables constant. An independent variable is said to be significant at a 100(1-α)% confidence level if $P[|Z| > z] < \frac{\alpha}{2}$ and Z is distributed in a standard normal distribution.

** significance at a 99% confidence level, two-sided test,
* " 95% "
@ " 90% "

sions for one will not affect decisions for the other.

In the equation for the demand for child-quantity, R^2 is .134 and the wage rate of the wife (WR), interaction terms between the wage rate of the wife and the dummy variable for compatability of her work with child care (WP x D2) and the size of household enterprises (SE) are significant determinants of the demand for children. It should be noted that household income (HIR) is not a significant determinant of NCD. Since this variable is significant in other population groups, the insignificant relationship between the demand for child-quantity and household income for population group 1 deserves additional explanation. First, the sample size which constitutes population groups 1 is small relative to the sample size which constitute population groups 2 and 3. Second, household income (HIR) and the wage rate of the wife (WR) are both included in the model for population group 1; and it is expected that wage rate and household income should be related. Since the wage rate of the wife has partially accounted for the household income effect when the nature of her work does not conflict with child-care services, HIR is not significant for this group, considering the small sample size.

As explained earlier, an increase in the wage rate of the wife will induce both a positive income effect (because household potential-income increases) and a negative substitution effect (because the shadow price of children increases). However, one tends to

expect that the negative substitution effect will dominate since the wife is usually not the major income earner of the household. A positive relationship between WR and NCD for population group 1 of this study implies that the income effect is dominant. While this was contrary to expectation, it might, however, be explained by the fact that, for this population group, the wife alone contributes about 30% of total income in the typical household. However, the positive relationship between WR and NCD holds only for the group for wives whose work does not conflict with their child-care services. For wives whose work conflicts with these services, income and substitution effects of a change in WR seem to cancel each other out and leave WR as an insignificant determinant of NCD.

The size of household enterprises (SE) is a proxy for the stock of capital which households own. It is hypothesized that SE should increase the value of the children's time in household enterprise and thus reduce the shadow price of children. The result is significant and positive as expected. This positive relationship is also explained by the fact that the size of household enterprises is positively related to household wealth. To the extent that child-quantity is a normal good, the positive coefficient of this variable should be anticipated. It should also be noted that area of residence is not a significant determinant of the demand for children if economic variables such as wage rate, income and SE have been included in the estimated equation.

Population Group 2. Estimates of the demand for child-quality and child-quantity for population group 2 are given in Table 4. All of the variables included in the equation for the demand for child-quality are significant and R^2 is .148. Household income is again positively related to the demand for child-quality. As in population group 1, the demand for child-quality of farming, skilled and unskilled fathers is lower than the demand for child-quality of fathers in occupation group 1, ceteris paribus and parents with a higher educational level tend

Table 4 Population Group 2

ß — coefficient, 'z' Value and Elasticity at the Mean †

Independent Variables	Dependent Variables					
	Q R^2 = .148			NCD R^2 = .042		
	ß	'z'	elasticity	ß	'z'	elasticity
Intercept	15.861**	7.31		5.116**	13.10	
HIR	0.003**	6.11	.07	.001**	3.27	.06
NCD	−1.611**	−3.34	−.69			
HED	0.167**	2.79	.07			
HOC2	−0.199	−0.34				
HOC3	−1.950**	−3.71				
HOC4	−1.701**	−2.70				
MUN	1.103**	2.71		.430*	2.00	
Q				−.170**	−3.39	−.41
WED				−.021	−0.40	
SE				.041	1.58	
D1				.474**	2.63	
WED × D1				.015	0.32	
D2				−.452**	−2.03	
WED × D2				.026	0.46	

† see footnote under Table 3

to demand more child-quality. Area of residence (MUN) is significant and positive in this equation, which means that, for this population group, fathers who live in municipal areas place more weight on the education of their children. It should be noted that this variable (MUN) is not significant is population group 1. MUN has been included in the equation as a dummy variable, therefore different degrees of urbanization which are grouped under a broad category of non-municipal areas cannot be distinguished. Population group 1 consists of couples in which wives are working for wages and salaries, and these types of jobs are usually available in somewhat urbanized areas. Thus, the degree of difference between municipal and non-municipal areas for population group 1 might be smaller than that for population groups 2 and 3, which would account for the insignificant effect for this variable in population group 1.

The demand for child-quantity (NCD) does have a significant effect on the demand for child-quality for this population group. Since the coefficient is negative, it implies that child-quality and child-quantity are substitute commodities. This result is different from the result for population group 1. Suppose, if one considers that child-quality has a required minimum level which is determined by society, then parents should not have freedom to choose any level of child-quality below that level, but will have the freedom to choose any higher level. Then, one possible explanation for the discrepancy shown between group 1 and 2 is that population group 1 characterizes an urban society where job competition seems to be higher, in addition to the fact that people who are working for wages and salaries generally constitute the low- and middle-income groups. Therefore, for population group 1, only the level of education which is the minimum required in urban society has been observed. By contrast, population group 2 characterizes a rural society where education does not play such an important role in making a living. The required minimum level of education in a rural society is much lower, so that various levels of demand for child quality are observed according to parents' tastes. For this population group, substitution between child-quality and child-quantity is possible.

In the demand for child-quantity (NCD), R^2 is .042, significant variables are household income (HIR), child quality (Q), dummy variables for the presence of traditional substitution for child care (D1), dummy variables for compatability of the mother's roles (D2) and area of residence (MUN). HIR is positively related to NCD, which means that children are a normal good. Child-quality is negatively related to child-quantity, which is consistent with the result in the equation for the demand for child-quality. D1 causes an increase in the demand for child-services while D2 causes a decrease in its demand. Thus incompatability between the work of the wife and her child care services tends to reduce the demand for children while the existence of a substitute for child care services tends to increase the demand for children, *ceteris paribus*.

Problems might arise concerning the result that D1 is significant in this case and not so in population group 1. A possible explanation is that the majority of population group 2 are farmers and living in rural areas. Most of them have traditional substitutes for mother's time in child-care services, and/or can take care of children while working. In these areas, a formal market for child-care service in the form of nurseries, kindergartens, etc, as is usually observed in urban areas, either does not exist or exists on a very small scale. It can be posited that the people are quite homogeneous in terms of their occupations, such that specialization in child-care services does not occur, or the demand for child-care is not significant enough to foster a supply, or the ability to pay for such services is too low. Therefore the constraint on time for child-care is more directly related to the demand for children. Moreover, children in these areas attend school for a shorter period, therefore their contribution to taking care of younger children can be greater than urban children who tend to stay in school for a longer period of time. Given that D1 is a dummy variable, taking only a value 0 or 1, it cannot account for the differences in the degree of contribution made by these children in home production. This again reinforces the positive effect of D1 on the demand for children in this population group.

The wife's education (WED) is not a significant determinant of the demand for children. WED is included as a proxy of her initial stock of human capital, which presumably affects the value of her time. However, the majority of the wives in this population group are sales workers or farmers' wives who work in their own family enterprises. Education does not seem to be a good measure of the value of their time, therefore WED is not significant. The size of household enterprises (SE) may be a better measure of the value of her time. But, the size of

household enterprises also affects the value of children by increasing their productive role, (this hypothesis is confirmed by a significant positive relationship between SE and NCD for population groups 1 and 3). Therefore, the effect of increasing the size of the family enterprise increases the value of both the wife's and children's time, which seem to cancel each other out, thus SE becomes insignificant.

Population group 3. Population group 3 consists of couples in which wives are full-time home-commodity producers. The characteristics of this group lie in between those of population groups 1 and 2. Estimates of the demand for child-quality and child-quantity are given in Table 5. The R^2 is .344 for the estimated equation of the demand for child-quality. Most variables in this equation are significant and are of the expected direction. People living in municipal areas require higher education for their children. Substitution between child-quality and child-quantity is still possible.

In the equation of the demand for child-quantity, R^2 is .172 and household income (HIR), child-quality(Q), size of household enterprises(SE), D1 and WED x D1 are significant. Wife's education(WED) is again not significant, which means that for non-working wives, the value of their time cannot be well represented by the level of education. Moreover, the value of their time does not depend on the size of household enterprise either, therefore the effect of SE on NCD is only via the productive role of children, so that SE is positively related to NCD and significant as expected. The presence of substitutes for child care services shifts the demand for child-quantity upward. This is similar to the explanation given for population group 2. The education of the wife tends to decrease the effect of D1 on NCD.

Conclusion concerning the demand for children

Utilizing the data collected in the 1975 Survey of Fertility in Thailand, two forms of the demand for

Table 5 Population Group 3

ß — coefficients, 'z' Value and Elasticity at the Mean †

Independent Variables	Dependent Variables					
	Q $R^2 = 0.344$			NCD $R^2 = 0.172$		
	ß	'z'	elasticity	ß	'z'	elasticity
Intercept	9.605**	3.14		4.064**	5.57	
HIR	0.002*	2.40	0.04	0.001*	2.22	0.06
NCD	0.122	0.17				
HED	0.257**	3.06	0.13			
HOC2	−0.420	−0.72				
HOC3	−3.120**	−5.21				
HOC4	−1.311*	−2.42				
MUN	0.870*	2.22		0.087	0.47	
Q				−0.099@	−1.94	−0.29
WED				−0.053	−0.35	
SE				0.030*	2.09	0.02
D1				1.443**	5.27	
WED x D1				−0.231**	−3.69	
D2				0.159	0.26	
WED x D2				0.040	0.26	

† see footnote under Table 3

children of individual couples, namely, the demand for child-quality and the demand for child-quantity, are investigated. Each demand equation has been estimated separately by population group classified according to the working characteristics of the wife, i.e., whether the wife works for wages and salaries, works in the family enterprise or does not engage in any activity which is directly related to earning income. The study yields the following results.

The demand for child-quality (measured in terms of the educational level which parents think is necessary for children) is consistently shown to be influenced by household income, the husband's educational level and his occupation. Households with higher income or households in which husbands have a higher educational level, tend to demand higher child-quality, *ceteris paribus*. The occupation of the husband also plays an important role; farmers and skilled and unskilled workers tend to demand less child-quality. Moreover, parents who live in municipal areas tend to demand more child-quality than parents who live in non-municipal areas. The relationship between the demand for child-quality and the demand for child-quantity varies among population groups. When statistically significant, the relationship is inverse, implying that child-quality and child-quantity are substitutes. An insignificant relationship has been observed for the population group in which wives are working for wages and salaries. Since these types of jobs are usually available in somewhat urbanized areas, an insignificant relationship may be explained by the higher required minimum level of education which is determined by society. To the extent that people who are working for wages and salaries generally constitute the low- and middle-income groups, only the level of education which is the minimum required in urban society has been observed. Hence the relationship between the demand for child-quality and the demand for child-quantity is not statistically significant.

Household income has a positive effect on the demand for child-quantity, which implies that children are a normal good. An increase in the wage rate of the wife induces an increase in the demand for child-quantity, if the wife's work and child care do not conflict. If there is conflict between her work and child care, the substitution effect and the income effect induced by a change in her wage rate will cancel each other out. The size of the household enterprise is positively related to the demand for child-quantity. Since the productive role of children and wealth of the household vary directly with the size of the household enterprise, an increase in this variable will induce a decline in the cost of children to parents in addition to a positive wealth effect. Hence, the positive relationship between the size of the household enterprise and the demand for child-quantity is expected. The presence of other members in the household, whose time can be substituted in child care services, also decreases the cost of children to parents. Therefore, households with this traditional substitute for child care services tend to demand more child-quantity.

In conclusion, because human fertility behavior is very complicated, economic variables cannot be expected to account for all or even most of the total variation in desired family size among different couples. Moreover, many variables specified in the theoretical model of fertility behavior, such as household potential income, the value of time of each individual member, etc., are not observable. Hence variables which can be measured must be used instead as proxies. Due to limitations of the existing data, some proxies used in this study are not a good representative of the variables specified in the theoretical model. However, in spite of these limitations, most of the variables suggested in the model proved to be significant determinants of the demand for child-quality and child-quantity.

THE DEMAND FOR CONTRACEPTIVE USE

Factors which determine the demand for children are investigated in previous sections. However, it is the actual number of children born which affects the age structure and growth of a population, influences household expenditures and savings, raises or lowers the supply of labor, etc. The demand for children is important only to the extent that people actually realize their desired family size.

The number of children born to a couple is ultimately constrained by the fact that reproduction is a stochastic, biological process. The outcome of this stochastic process depends on many factors such as age when a woman first marries, the couple's natural fecundability, the couple's practice of contraception, child mortality and the length of breastfeeding etc. Some of these factors are a matter of individual choice while others are purely biological

or cultural. This section attempts to explain one type of voluntary behavior, namely the choice of contraceptive use which affects the probability of conception. A theoretical model of the demand for contraceptive use will be discussed. The logic provided in the theoretical model will be used to specify the determinants of the demand for contraceptive use. Finally, the specified equations will be tested with the Survey of Fertility in Thailand (SOFT) data and the results will be interpreted.

A theoretical model

At the current state of the art, a theoretical model of the demand for contraceptive use has not yet fully developed. The difficulties of developing a theoretical model which also provide empirical test are due to the nature of this decision-making process. The use of contraception is the result of sequential decision making. The utilization of contraception in any period depends on the outcome of fertility performance in previous periods which is a stochastic event. Hence, a model which describes the demand for contraceptive use should be a stochastic dynamic programming model. Yet, a model of this nature does not easily yield testable hypotheses.

Heckman and Willis (1976) developed a model that views couples, at any period (month) as choosing a contraceptive strategy which maximizes their expected lifetime utility, given their past fertility outcomes. Thus a couple with n children at the beginning of month t will consider the expected life time utility associated with two possible alternative states at the beginning of month t+1. In the first state, the woman conceives during month t, hence she is pregnant with an n+1 th child at the beginning of month t+1. The expected life time utility corresponding to this state will be denoted by $V_{t+1}(b_{n+1})$. In the second state, the woman does not conceive during month t. The expected lifetime utility corresponding to this state will be denoted by $V_{t+1}(b_{n+1})$. If the couple chooses a contraceptive efficiency e_t, the probability of conception during month t is $p_t^*(1-e_t)$ where p_t^* is the couple's natural fecundability.[7/] Then the expected utility of the couple with n children is

$$V_{nt} = P_t^* (1-e_t) V_{t+1}(b_{n+1}) + (1-P_t^*(1-e_t)) V_{t+1}(b_{n+1}) - f(e_t)$$

where $f(e_t)$ is the monthly cost of using contraceptive efficiency e_t. The costs of contraceptive use are defined as utility loss due to resources forgone and psychic costs. Heckman and Willis's model hypothesizes that the couple will choose a contraceptive strategy with efficiency e_t^* which maximizes V_{nt}.

Although the approach taken by Heckman and Willis to contraception appears promising, the model cannot be easily transformed into a testable model. Thus, the subsequent empirical analysis is not a formal test of the Heckman and Willis model. However, we will compare it with several plausible hypotheses suggested by the model.

First, we might plausibly characterize the time pattern of contraception using the model. For a couple with a given stock of children, we should think the expected gain from not conceiving would be large and positive immediately following the birth of a child. Among other possible reasons, it is well established that short birth intervals adversely affect both maternal and child health. As time passes a decline in health problems should be reflected in a decline in the expected gain from non-conception. This would also be reinforced by a decline in the probability of excess fertility as the expected remaining childbearing span declined. Hence, contraceptive efficiency should decline until it reaches zero — the case if the expected gain from using contraception becomes negative — or until conception occurs.

Second, a corresponding relationship exists between the current stock of children and the expected gains from current non-conception. As the current stock of children approaches the desired completed stock of children, the expected gains from current non-conception should increase, *ceteris paribus*, and contraceptive efficiency should rise.

Third, contraceptive use will depend upon the couple's natural fecundability, p_t^*. During sterile periods due to pregnancy or postpartum anovulation, p_t^* is zero, therefore, the expected gain to contraception is zero and no contraception should be employed. The general relationship between fecundability and contraceptive use is more complex. Suppose that the expected gains to non-conception and contraceptive costs were equal for two couples, then the more fecund couple would demand

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7/ Natural fecundability is defined as the probability of conception if the couple do not employ any contraception.

a more efficient contraceptive. However, the expected gain to current non-conception depends on future fecundability which is clearly not independent of current fecundability. Of course, couples with relatively high current fecundability would, in general, have relatively high future fecundability. This should reinforce the simple relationship between current contraception and current fecundability. It is expected that more fecund couples will use more effective contraception.

Fourth, contraceptive use will depend on the marginal cost of contraception. (It should be kept in mind that marginal cost may vary widely from couple to couple because of the importance of psychic costs.) As is the case for fecundability, the relationship between marginal cost and current contraceptive use is complex, because the expected gain from current non-conception is not independent of future costs. Consider a couple for which the marginal cost of a very efficient contraceptive is quite high. The couple has an incentive to apply a less efficient contraceptive throughout their childbearing span. On the other hand, if the marginal cost of a highly efficient contraceptive is low, the couple may use no contraception during some periods and very effective contraception during other. This possibility is a plausible explanation of the concentration and occasional increase in childbearing among young women which has accompanied large general declines in fertility in countries such as Taiwan (Tung, 1978).

Model Specification

The model described above reduces the choice of contraceptive efficiency to three major elements: (1) the expected gain to non-conception; (2) natural fecundability and, (3) the marginal cost of contraceptive efficiency. Of course, neither contraceptive efficiency nor the three determinants can be measured directly and we must be content with analysis of measurable and available variables which are related to one or more of the above factors.

First, we turn to the dependent variable in the model, contraceptive efficiency (CE). The level of contraceptive efficiency depends not only on the particular contraceptive technique employed by the couple, but also, upon the care and intensity of use and on characteristics of the user. The requisite data is not available and contraceptive efficiency will be measured as the average efficiency of the contraceptive technique used by the couple at the time of the survey. The estimated efficiency of each contraceptive technique is provided in Table 6.

The independent variables employed in the analysis are additional desired children (AD), age of wife (WA), religion (R2), husband's education (HED), whether the wife is breastfeeding (BRES), residential area (MUN) and the wife's predicted natural fecundability (NF). The definitions of these variables are given in Table 7. The rationale for including these variables and their expected signs is given below.

Additional Desired Children (AD). This variable is the difference between the desired completed family size and the current number of children. For those who are willing to use the contraceptive techniques with (presumably) perfect protection, such as abstinence or sterilization, there should be no reason for the couple to use any contraception until the desired completed family size has been achieved, (except in the case of using contraception for child-spacing, which should be irrelevant to AD). However, the many couples, these techniques are not acceptable due to their costs (especially psychic costs). Therefore, for these people who are not willing to use contraceptive techniques with absolute efficiency, there are reasons to believe that contraceptives might be employed even before the couples reach the desired completed family size.

First, as the number of children born approaches the desired number, the probability of not achieving the desired family size declines, and the probability of bearing an excess number of children rises. Therefore, the couple might start to use contraception for child-spacing in order to reduce the period of risk of excess births after the desired completed family size has been achieved. Second, in addition to uncertainty with regard to contraceptive use, there is also uncertainty with regard to the desired number of children. In response to the question in the survey which asks about the ideal family size, the couple bases their answer on the information available to them at that time. However, the couple should also realize that there is uncertainty with regard to future income. Together with the fact that the number of children, once born, cannot be reduced except through child mortality, it is quite conceivable that parents would postpone the births of the later children which may be desired. For example, a couple who desires three children as an ideal may

postpone the birth of the third child in order to attain better knowledge of future uncertainties and income. The couple will have no incentive to postpone the birth of the first two children if they decide to have at least two children under any circumstances.

For these reasons, we expect that the demand for contraceptive use increases as the actual family size approaches the desired family size. Once desired family size is achieved (AD = 0), one would expect couples to use the most effective contraceptive available if it were available at negligible cost. Hence, for families with excess fertility there would be no relationship between AD and contraceptive efficiency. Therefore, the estimated model uses a piecewise linear function for AD. The coefficient of AD gives the partial derivative for AD when AD is less than zero. The sum of the coefficients for AD and AD × DUM (see Table 7 for definition of dummy variable: DUM) gives the partial derivative for AD when AD is greater than zero, which is anticipated to be negative.

Age of Wife (WA). The age of the wife may affect contraceptive use in a variety of ways. First, maternal and child health problems increase with the mother's age and may raise the expected gain from non-conception which should increase the demand for contraceptive efficiency. Second, the probability of achieving or exceeding a given desired additional number of births declines as the wife's age increases. This reduces the expected gain from non-conception and the demand for contraceptive efficiency. Third, the development, spread and governmental support for family planning are fairly recent phenomena in Thailand. It may well be that acceptance and knowledge of contraceptive techniques is less widespread among older than younger women. In other words, the marginal (psychic) cost of contraceptive efficiency may be greater among older women. Because of the variety of

Table 6

Contraceptive Efficiency (CE) (1)

Method (i)	Efficiency (CE_i)
Abstinence, Ligation, Vasectomy	1.000
Pill	0.9958
Injection	0.9927 (2)
IUD	0.9896
Condom	0.9425
Withdrawal	0.9300
Vagina Spermicide	0.9156 (3)
Rhythm	0.8396
Douche	0.8321
No method or non-scientific method	0.0000

(1) Contraceptive efficiency is defined by

$$P = NF(1 - CE)$$

where NF is the probability of monthly conception in the absence of any contraceptive use and P is the probability of conception if CE is chosen. Efficiency of each contraceptive method in this table (except the efficiency of injection) is taken from Table 1 in Michael (1974).

(2) The efficiency of injections is calculated as the average efficiency of pill and IUD. This method of calculation was suggested to the author by Dr. Suporn Koetsawang M.D. Family Planning Research Unit, Department of Obstetrics and Gynecology, Faculty of Medicine, Siriraj Hospital, Bangkok.

(3) The efficiency of the methods classified under vagina spermicide is the average efficiency of the jelly, cream and foam tablet methods.

Table 7

Definitions of Variables in the Equation of the Demand for Contraceptive use

CE	Contraceptive efficiency of the technique used at the time of the survey; its values are given in Table 6.
NF	Monthly probability of conception at the time of the survey; it is used as a proxy for natural fecundability p^*. The estimating procedure is given in Appendix II.
AD	Additional desired children; it is the difference between the number of children desired (NCD) and the number of children that the couple already has (C).
DUM	A dummy variable to distinguish whether couples want additional children; DUM = 1 if AD > 0, = 0 otherwise.
WA	Age of the wife.
R2	A dummy variable to distinguish Islamic from non-Islamic; R2 = 1 if the respondent is Islamic, = 0 if otherwise.
HED	Education of husband measured by years of schooling.
BRES	A dummy variable to distinguish whether or not the wife is breastfeeding her child at the time of the survey; BRES = 1 if the wife is breastfeeding, = 0 if otherwise.
MUN	A dummy variable to distinguish municipal and non-municipal residents; MUN = 1 if the respondent lives in municipal areas, = 0 if otherwise.

factors involved, we have no *a priori* expectations regarding the effect of the wife's age on contraceptive efficiency.

Religion (R2). R2 is a dummy variable which equals one for Islamic couples.[8/] It is anticipated that Islamic couples will, on average, use less contraception because they face higher psychic marginal costs.

Husband's Education (HED). Education is also employed to capture variations in the psychic costs of contraceptive efficiency among couples. Individuals with lower educational attainment may be less knowledgeable about contraception and/or less receptive to change. Therefore, the husband's education (which is highly correlated with the wife's education) is expected to be positively related to contraceptive efficiency.

Municipal Area (MUN). A municipal area in Thailand is a legal unit established for administrative purposes. To qualify, a locality must meet certain urban characteristics and provide a minimal level of services, such as lighting, piped water supply, a market, streets, sewage, health and education (Economic and Social Commission for Asia and the Pacific, 1976). Thus, in general, one would expect that people in municipal areas have better access to modern contraceptive methods at lower cost. However, the family planning program in Thailand tends to emphasize non-municipal areas. Hence,

8/ A better classification would be to group Islams and Catholics together since both Islamic and Catholic respondents may have higher psychic costs of contraceptive use than others. But the data used does not subclassify Christian into Catholic and non-Catholic respondents, therefore such classification is not possible. However, according to the 1970 Census only 0.6 percent of the Thai population are Christian. This mis-classification should not cause serious error.

the effects of municipal areas may not be strong and may even become insignificant.

Breastfeeding (BRES). Breastfeeding is known to postpone the resumption of ovulation after birth. However the effect is not indefinite, which means that it is possible for a woman to conceive (but with lower probability) even though she is breastfeeding. Since the actual effect of breastfeeding on the probability of conception is not known, the effect of breastfeeding is entered into the model simply by a dummy variable BRES. The expected relationship is that breastfeeding reduces the probability of conception per month, therefore it reduces the benefits of contraceptive use and thus decreases its demand.

Natural Fecundability (NF). Natural fecundability is assumed to be a function of the age of the wife. This variable is estimated from the average waiting time between the fecund-non-pregnant state and passage to the pregnant state for those women who have never used any contraception. Detailed calculation of NF is shown in Appendix II. Natural fecundability is expected to bear a direct relationship to contraceptive use.

In this study, two different functional forms of contraceptive efficiency are estimated. The first assumes that all variables are linearly related, i.e.,

$$\begin{aligned} E(CE) &= a_0 + a_1NF + a_2AD + a_3AD \times DUM + \\ &\quad a_4WA + a_5R2 + a_6HED + a_7BRES + \\ &\quad a_8MUN \qquad \text{if fecund} \\ &= 0 \qquad \text{if infecund.} \end{aligned}$$

The second form estimated assumes that NF interacts with all other variables in the model, i.e.,

$$\begin{aligned} E(CE) &= b_0 + (b_1 + b_2AD + b_3AD \times DUM + \\ &\quad b_4WA + b_5R2 + b_6HED + b_7BRES + \\ &\quad b_8MUN)NF \qquad \text{if fecund} \\ &= 0 \qquad \text{if infecund.} \end{aligned}$$

There are two aspects of these specifications requiring comment. First, the predicted value of contraceptive efficiency is restricted to zero for women who report themselves or their husbands to be infecund or who were pregnant at the time of the survey. This is in accord with *a priori* expectations. Although this hypothesis could be tested in principle, all women falling into this category were not using any contraception.

The interactive model is estimated because it is more consistent with the theoretical model described above. This specification essentially 'weights' expected gains from non-conception by the probability of conception for fecund women. For example, consider two couples desiring an equal number of additional children over a given time period. We would expect that a birth will increase contraceptive efficiency of both couples. However, the more fecund couple faces a greater risk of excess childbearing and should be expected to use a more efficient form of contraception. This relationship is imposed on the data through the interactive model.

Estimation Procedure

The dependent variable CE, contraceptive efficiency, can only take a value from zero to one, and we expect to observe many zeros which correspond to non-users of contraception. This gives rise to three estimation problems. First, the fact that CE can only take a value from zero to one seems to violate the normality assumption in the ordinary least squares estimation. Although violation of the normality assumption does not change the property of OLS as the best consistent linear unbiased estimator, it renders statistical tests on the estimated coefficients not possible for small sample sizes. Second, the error terms associated with a high level of CE seems to have larger variances than error terms associated with a low level of CE which means that the assumption of homoscedasticity is violated. This violation again does not affect the best consistent linear unbiased property of the OLS estimator, but it makes the estimated coefficients inefficient, i.e., the variances of the estimates are not minimized. Third, because CE tends to concentrate either at zero or almost one, a straight line estimated by the OLS procedure will not fit the data well. As shown in Figure 1, a kinked line such as OBC gives a better fit for the data. Fitting a straight line, such as DE, will underestimate the actual slope represented by the slope of BC. This problem arises because there is a wide range of difference among those women who are non-users of contraception. There are some women at the margin who might employ a method of contraception if the cost of contraceptive use was reduced by just a small amount. There are also some women whose distaste for contraceptive use is so high that only a drastic change in the price could induce them to

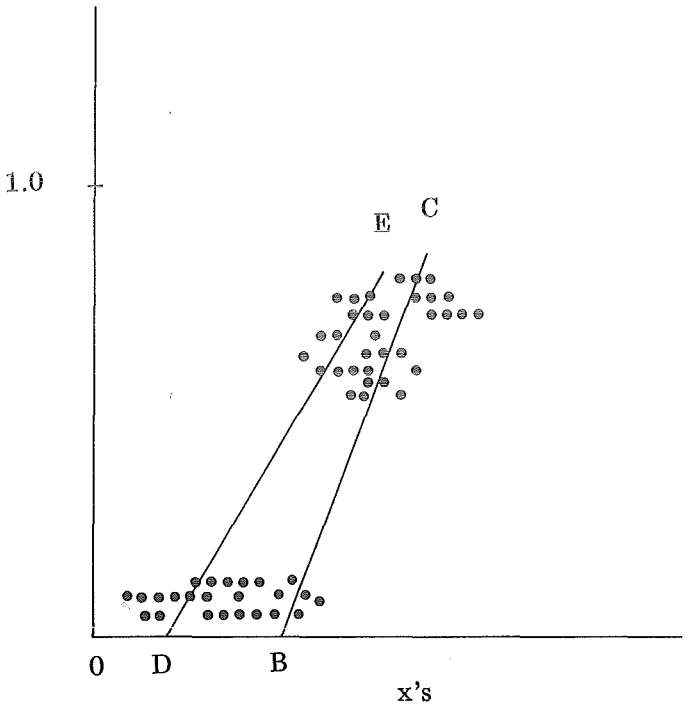

Figure 1. Fitting a scatter diagram by OLS and TOBIT Procedures.

use contraception. The survey results cannot distinguish these women since both of them are simply recorded as non-users of contraception.

For the reasons mentioned above, OLS is not an appropriate procedure for this study. Tobin has developed an estimation procedure known as the TOBIT procedure (Tobin, 1958) to deal with this type of limited dependent variable. Hence, the TOBIT procedure will be used to estimate the model presented above. Unfortunately, as far as the author knows, no existing computer package produces information that can be used to test the coefficients estimated by this procedure.[9/] Therefore, estimation of the coefficients by OLS will also be given and the discussion of the significance of each variable will be based on the information of the OLS procedure.

9/ Testing of the coefficients estimated by the TOBIT procedure can be done by likelihood ratio tests (Tobin, 1958). SHAZAM, a computer package developed by Professor White of North Carolina, can be used to test the significance of the coefficients if it is run several times by excluding each explanatory variable on alternative runs. However, each TOBIT run is very expensive in terms of computer time. Hence, testing of the coefficients has not been performed.

Source of Data

In addition to collecting information on the number of children desired, and social and economic variables which are used in the study of the demand for children, the SOFT (The Survey of Fertility in Thailand) also has information on the existing number of children, knowledge and practice of contraception, maternity history, breastfeeding, social and demographic variables such as couples' religious beliefs, age of the wife, age at first marriage, etc. This set of data will also be employed in this study of the demand for contraceptive use.

The means, standard deviations, and maximum and minimum values of the variables used in this model are given in Table 8. The age of wives responding ranges from 15 to 50, with an average of 33 years. About 2 percent of the couples are Islamic. Contraceptive efficiency, which is the proportional reduction in the monthly probability of conception, ranges from zero to one, and the average efficiency is .37. Natural fecundability, which is the estimated probability of conception per month if the couple does not use any contraception, ranges from 0.026 to 0.054. The average monthly probability of conception is 0.048, which means that if the monthly probability of conception is constant at this level, the waiting time for a woman to conceive is 21 months on the average. About 33 percent of the wives in this sample set were breastfeeding their children at the time of the survey. In 9.5 percent of the couples the wives were pregnant, and 13.4 percent of couples thought they were infecund. The expected CE for these two groups of couples, which constitutes about 23 percent of the total, is set at zero. The difference between the desired and the actual number of children varies from −10 to 11. About 57 percent of the couples already have an excess stock of children and 43 percent either have exactly the desired number of children or want additional children.

Empirical Results

Estimation of equations 1 and 2 by OLS and TOBIT are shown in Table 9. The first two regressions are estimates of the linear model while the third and the fourth regressions are estimates of the interactive model by OLS and TOBIT respectively.

Each regression can explain about 28 percent or 29 percent of the total variation in the contra-

Table 8

Basic Statistics for the Variables in the Equation of the Demand for Contraceptive Use.

Variables	Mean	S.D.	Minimum	Maximum
WA	33.25	8.26	15	50
R2	2.3%			
CE	.372	.479	0	1
NF	.048	.006	.026	.054
BRES	33.6%			
PREGNENT	9.5%			
INFECUND	13.4%			
AD	.2	2.2	−10	11
DUM	43.1%			
HED	4.6	3.1	0	16
MUN	13.1%			

S.D. = Standard deviation

ceptive efficiency employed. Natural fecundability (NF), interaction between the variables for additional desired children and the dummy variable DUM (AD x DUM), religion (R2), education of husband (HED) and breastfeeding (BRES) have significant coefficients at the 99 percent confidence level. All of these variables are of the expected sign and the signs agree in all four equations. Within each model, the magnitude of each coefficient estimated by the TOBIT procedure is larger than the corresponding coefficient by the OLS procedure. This is also anticipated as illustrated in Figure 1. The magnitude of each significant variable estimated in the linear model is approximately the magnitude of the corresponding coefficient estimated in the interactive model multiplied by 0.048 which is the mean value of natural fecundability. This means that for an average fecund women, the linear model and the interactive model predict approximately the same level of contraceptive efficiency used for any values of other independent variables. As a whole, the results from these four regressions seem to conform with each other.

Some explanations of the demand for contraceptive use can be derived from these empirical results. First, the two variables which have the most significant negative effects on contraceptive use are religion and breastfeeding. The magnitude of these two coefficients is so large that it might prevent Islamic women or women who are currently breastfeeding from using contraception in almost all circumstances. A rough calculation[10/] indicates that on the average, even the most fecund women will not contracept if she is Islamic and will rarely contracept if she is currently breastfeeding.

Second, the two variables which have the most significant positive effects on contraceptive use are natural fecundability and education of the husband. As mentional earlier, the expected gain from nonconception is weighted by natural fecundability, therefore the expected gain from contraceptive use is larger, which will cause highly fecund women to demand more contraceptive use. Education plays a very important role in the receptiveness of contraceptive use. In fact it is the only variable for which the positive effect is strong enough to cancel the negative effect of religion. Thus we expect that, of Islamic couples, only the highly educated would consider using contraception.

Third, given these biological and social variables: religion, natural fecundability, breastfeeding and education, the demand for contraceptive use will depend on the couple's desire for additional children (AD). According to regression 4, the re-

10/ Assume that AD = 0, WA = 33, HED = 4, MUN = 1, NF = 0.054, then estimated CE is negative if R2 = 1 and BRES = 0, and is 0.135 if R2 = 0 and BRES = 1.

Table 9

Regression Estimates by OLS and TOBIT for the Equation of the Demand for Contraceptive Use. Dependent Variable, CE, (sample size: 2042 couples)

Independent Variables	Linear Model				Interactive Model			
	OLS R^2 = 0.29 F = 104.97		TOBIT R^2 = 0.28 S.D. = .84515		OLS R^2 = 0.29 F = 106.07		TOBIT R^2 = 0.29 S.D. = .84401	
	ß	t	ß	S.E.	ß	t	ß	S.E.
Constant	.007	0.37	−1.950	0.140	.003	0.19	−1.861	0.122
NE	12.958*	13.04	41.811	2.984	14.568*	10.66	45.987	3.723
AD	−.001	−.12	−0.006	0.021	−.058	−.30	−.416	0.451
AD x DUM	−0.076*	−5.66	−0.143	0.033	−1.637*	−5.77	−2.910	0.682
WA	−.001	−.97	0.007	0.003	−0.065	−1.77	−0.014	0.087
R2	−.294*	−4.56	−0.772	0.190	−6.593*	−4.94	−17.130	3.942
HED	0.010*	2.94	0.023	0.008	0.181*	2.59	0.358	0.157
BRES	−.278*	−12.53	−.549	0.054	−5.715*	−12.81	−11.702	1.068
MUN	0.035	1.11	0.084	0.071	0.680	1.05	1.712	1.447

S.D. = standard error of estimate
S.E. = (standard error of estimate) X (standard error of the normalized coefficient)
(*) = significant at 99% confidence level.

lationship between contraceptive use and additional desired children (AD) can be illustrated in Figure 2. A couple whose desired number of children is, say, five at the time of marriage may decide not to contracept until the first or second child is born. As the number of children increases, the probability of achieving the desired family size increases, as does the risk of having excess children. This should induce the couple to demand higher contraceptive efficiency as they approach their desired family size. As is expected, once the couple achieves their desired family size, thereafter they will use the most efficient contraceptive technique which is feasible for them. Therefore additional desired children (AD) is no longer a determining factor in the demand for contraceptive use. Thus the line representing the relation between CE and AD has a negative slope for positive AD, and a slope of zero (approximately) for negative AD.

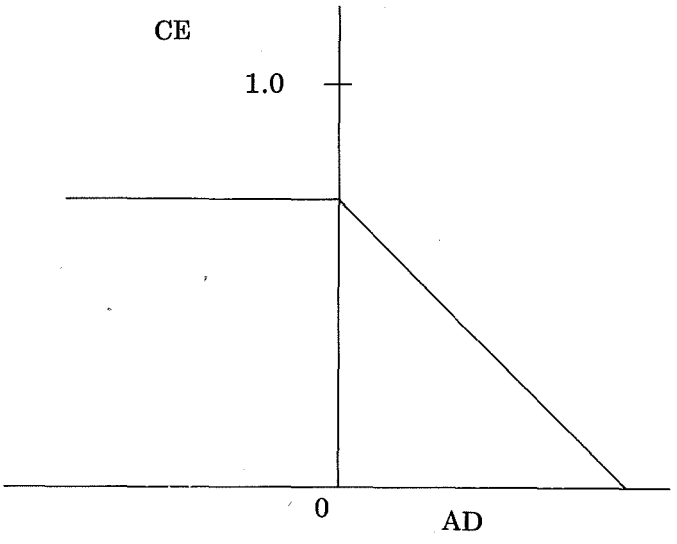

Figure 2 Relationship between the demand for contraceptive use (CE) and the additional number of chidren desired (AD).

A few remarks will serve to conclude this section. First, a comparison between contraceptive use among municipal and non-municipal areas shows a higher percentage of users in municipal than in non-

municipal areas, (Knodel and Pitaktepsombati, 1973). However this study shows that living in municipal areas in and of itself does not significantly affect the demand for contraceptive use. As mentioned earlier, the relative advantage of living in municipal areas in terms of a better access to modern contraceptive techniques seem to be reduced by the emphasis of the family planning program in non-municipal areas. The different rates observed between users in municipal and non-municipal areas can most likely be explained by the fact that municipal residents tend to be more educated and breast-feed for a shorter length of time, therefore when these two variables are accounted for in the model, MUN is not significant. Second, age of the wife is expected to affect contraceptive use in many ways and in different directions. The insignificant effect of the age of the wife in this study can either mean that age is in fact irrelevant to contraceptive use or that many effects were compounded in this variable and they cancel each other out. Therefore nothing can be inferred from this variable.

Conclusion concerning the Demand for Contraceptive Use

The demand for contraceptive use should be a consequence of a sequential decision process in which demand at any time depends on both the timing and past fertility outcomes. Heckman and Willis (1976) have formulated this type of model, but their model is not yet in a testable form. However, in an attempt to identify factors which affect the demand for contraceptive use, the model suggests several plausible hypotheses. These hypotheses were tested with Thai data and yielded the following results.

Social and biological factors are important in the receptiveness to contraceptive use. Islamic belief seems to discourage, while education seems to promote contraceptive use. Natural fecundability and breastfeeding are two factors which, respectively, increase and decrease the expected gain from contraceptive use and thus have a strong positive and negative influence on its utilization. Additional desired children (AD) is another significant variable which determines the demand for contraceptive use. As the couple approaches the desired family size, the demand for contraceptive use increases. After the desired family size is achieved, contraceptive use no longer depends on additional desired children (AD), hence its demand will remain at a constantly high level if other things are equal.

POLICY IMPLICATIONS

Historical studies show that, although the timing and pattern of modern economic growth and fertility declines can be quite different in various countries, a low fertility rate signals a high development level. The development process can usually be characterized by 1) an increase in per capita income, 2) industrialization, which means the movement of labor and capital from the agricultural to the industrial sector, 3) a massive internal migration which tends to break the extended family type, 5) urbanization and 6) an increase in levels of formal education and formal training (Kuznets, 1974). All these changes combined cause a decline in fertility level. This development process, to a certain extent, repeats itself in developing countries today. Modern economic growth has already started in Thailand, as has some decline in the fertility rate, although the rates of growth and decline may be quite low. Since a decline in the population growth rate will accelerate modern economic growth, the subsidiary effects of any economic development plan on the population growth rate should not be overlooked.

This study indicates that an increase in the levels of formal education, a shift from family enterprise to large scale productive processes and a dissolution of extended family type are particularly important in inducing a decline in the desired completed family size in Thailand. Increases in income and urbanization by and of themselves do not seem to be as important in inducing such a decline. As suggested by history, in the development process, an increase in levels of formal education, changes from family enterprises to large scale enterprises, and the dissolution of extended family types are bound to happen. However, at their own pace, these changes in the development process occur too slowly compared to the urgent problems of population, therefore the government might wish to implement policies which will accelerate fertility declines.

As hypothesized previously, the actual fertility level in a family is determined by both the demand side (the desired completed family size) and the supply side (the ability to control fertility

level). In order to accelerate fertility declines, policies can be designed to influence either the demand or the supply side or both. A guideline for such policies is suggested below.

Policies should be geared at providing a better opportunity for higher education for young adults, and the number of years of compulsory education for children should be increased. Not only is higher education considered as desirable in itself, but it seems to create an atmosphere which will accelerate a decline in birth rates for the following reasons: 1) An increase in the educational level of young adults tends to increase their demand for child-quality when they become parents. For the majority of couples, child-quality and child-quantity can be considered as substitute commodities, thus the demand for child-quantity of these young adults should decrease. 2) By increasing the educational level of the parents (which presumably causes an increase in the value of their time) and the demand for child-quality, the cost of children increases. This should further reduce the demand for child-quantity. 3) An increase in the number of years of compulsory education for children will keep children in school longer, which will reduce the availability of time children can expend in home production or for income earning. This in turn will increase the cost of children and decrease their demand. However, this policy of drawing child labor from present production to (presumably higher) furture production may not be feasible, unless there is a policy which encourages capital-intensive techniques of production, especially in the agricultural sector. Of course, these policies must be implemented with care in order to avoid other problems such as unemployment.

Within each group, farmers tend to demand less child-quality than people in other occupations. Between groups, population group 2, which consists mainly of farmers, demands less child-quality and more child-quantity. Thus, industrialization which will decrease the proportion of farmers should, on the national average, increase the demand for child-quality and decrease the demand for child-quantity.

Along with a shift from family enterprises to large scale enterprises, attempts should be made to increase the opportunity for female employment in the formal labor market. When the opportunity and the returns from spending one's time in market activities increase, some women who were originally out of the labor market should be attracted to participate in the labor market. An increase in the returns and job opportunities might also draw some women who were originally working in family enterprises to participate in the formal labor market. If the nature of female employment in the formal labor market is incompatible with child care, this change should have some adverse effect on the demand for children. This policy, along with a reduction in the traditional substitute for child care by a dissolution of the extended family (which tends to occur in the development process), a higher educational level of children and a decrease in the productive role of children should further reinforce a decline in the desired completed family size.

Even within the extended family, a reduction in the time of other members for child care should also have a similar effect. The other members who are present in the household are mainly elderly relatives of the head of the household. Traditionally few roles exist for elderly women to participate in social production besides the role of taking care of small children. If there are organizations which allow elderly people to pursue their own interests, such as schools for elderly people, and organizations which are related to charity or religious groups etc., this will further reduce the availability of time of these people for home production which will increase the cost of children to parents.

On the topic of elderly people, traditionally, parents depend on their children when they are old. Although this tradition may have much merit, the government should also consider providing alternatives for old people to live without having to depend entirely on their children. Children as the only source of old-age security has been mentioned by many authors (Hohm, 1975; Arnold and Pejaranonda, 1977) as an important motive of parents to have many children in developing countries and in Thailand. Therefore a better social security system and old-age support should further reduce the demand for children.

These policies are aimed at a long-run reduction in the demand for child-quantity. Their short-run effect on the fertility rate may be very small. An attempt to increase acceptability of contraception may produce a faster impact on fertility rates. However, promotion in contraceptive utilization can be done through fewer channels. Some barriers to con-

traceptive use are very hard to change, such as religion. The most promising channel seems to be through an increase in education which makes people more receptive to new ideas, and a reduction in the psychic cost of using contraception. For those who have already reached the targeted completed family size, sterilization or vasectomy should be encouraged and these services should be made readily available. An extension of family planning services should increase the utilization of modern contraception among people living in remote areas. However, in locations where family planning already exist, a reduction in the cost of contraception might not increase the use of contraception substantially, because family planning programs have been supported by the government and the cost of these services has already been reduced to a very low level.

DISCUSSION ON THE LIMITATION OF THIS STUDY

Limitations of the model

1) This study is based on Willis' model of the demand for children which assumes that a couple at the outset of marriage decides on the number of children they would like to have dependent on their perceived income and perceived cost of children. Although a static model can serve as a powerful analytical tool, such a model would be unable to deal with the sequential nature of family formation. First, one might argue that in reality, parents do not make a decision on a desired completed family size. Rather, they make a decision on whether or not to have another child, based on the expected utility of the next child, which obviously depends on the experiences they have had with their current children. There is no room in a static model for parents to revise their decisions over the long period of their life-cycles. Second, in general, parents are concerned not only with the number of children they have, but also with the timing of the births. This issue cannot be treated in a static model, yet it might be very important in trying to understand certain demographic phenomena. For example, one observes enormous swings in fertility in the United States as well as in other developed countries. It is unlikely that changes in the desired completed family size are the major cause of such fluctuations.

2) The model assumes the existence of a utility function which is supposed to reflect the utility of both the husband and the wife. Thus the problem of how disagreements within the household are solved is by passed. The influence of the relative bargaining powers of the husband and the wife, which might be important in household decision-making, cannot be incorporated into this model.

3) There is not yet a link between the findings of this research and fertility rates. In other words, we know, for example, that an increase in the educational level of a couple will have a negative effect on their desired completed family size and will also promote the utilization of contraception. However, we do not know quantitatively by how much the fertility rate will decline and how soon this decline will be realized.

Limitations of the data

1) *Limitations on the scope of the study.* Although the SOFT selected sample households from the whole country, about 30 percent of the households selected were excluded from this study for different reasons. Thus the research has been narrowed to couples in which both the husband and the wife have married only once, have established their own households and do not have adopted children.

2) *Income and labor-supply of the husband.* Because the required data are not available, this study assumes that the labor-income of the husband and his labor supply are exogeneously determined. Until now, mixed results of the effects of the number of children on the labor supply and labor-income of the husband have been reported. Dickenson (1974) finds that the number of children is irrelevant to male employment. Freeman and Coombs (1966) find that husbands who marry young, and whose wives have a short first birth interval, tend to have lower income. When additional data is available, the model used in this study can be expanded to treat the labor supply of the husband and his income as endogeneously determined.

3) *The value of the wife's time.* The wage rate has been used as a proxy for the value of the wife's time for the small group of women for whom the information is available. For the majority of the wives, no good proxy for the value of her time is available. Hence, a detailed investigation of the

effect of this variable on the demand for children has not been achieved.

4) *Preferences of parents for children.* We have attempted to account for the effect of the productive role of children on the parents' demand for child-services, but we do not yet have any variable which accounts for the effect of differences in tastes for children. Conceivably, this variable can be an index which measures the parents' perceived benefit of children. We have attempted to create such an index which is based on questions such as: Do you plan to stay with your children when you are old? Do you expect financial support from your children? Do children help around the house? etc. Yet, this method is not quite successful because the index measures both the actual and the perceived benefits of children. Therefore this index is highly correlated with the respondents' current number of children. When data become available and an index which actually reflects the preferences of parents for children can be obtained, we might be able to say more about the effects of tastes on the demand for children and the factors which influence tastes.

CONCLUSION

In empirical studies of family formation, there is always a gap between a conceptual variable and on observable variable. At the micro level, a conceptual variable is, for example, the desired completed family size, which is determined, theoretically, by many other variables which are mainly non-observable, such as tastes, perceived life-time income, perceived cost of children, etc. These variables, combined with biological factors and stochastic variation, produce some observable variables such as actual family size or intervals between births. Hence, problems arise in the attempt to estimate causal effect of a set of unobservable input variables on the set of observable output variable. This study has attempted to investigate the determinants of both the desired completed family size and contraceptive use which will affect actual completed family size. Improvement on the procedures used in this study can be made, depending on the availability of data and mathematical techniques. But we believe that the approach taken in this study provides another way to search for more understanding of the complex behavior of human fertility.

APPENDIX I
ESTIMATION OF HOUSEHOLD INCOME AND HOUSEHOLD ENTERPRISES*

Household income

Household income is calculated as the sum of the following components:

1) Wages and salaries of every member in the house who is related to the household head.
2) Net income from the enterprise. If net income cannot be obtained directly, it is estimated as the difference between gross income and business expenses.
3) Rental income from land and buildings.
4) Net income from farming. Net income per rai (approximately 0.4 acres) for each crop was computed from estimates of yield per rai, average farm price of crops, and the cost of farming. Rent for unowned land was estimated to be one half of net farm income.
5) Income from raising animals. Net income was calculated indirectly for each type of animal. It is calculated as the difference between the average sale price and the cost of raising that type of animal.
6) Income from selling fish, shrimp, or silkworms which is obtained directly.
7) Non-labor income. This includes income such as property rent, bonuses, pensions and remittances from relatives living elsewhere which were received by household members related to the household head.

Size of family enterprises

Size of family enterprises is an index calculated as the sum of the point values assigned to each of the following components:

Land for Farming

Amount of land for farming

(in Rai)	Points assigned
0	0
1 — 9	1
10 — 19	2
20 or more	3

Double Cropping

Whether double cropping is employed?

No	0
Yes	1

Farm Equipment

Farm equipment consists of water pumps, motors, rice milling machines, ploughing machines, tractors and so on:

No equipment used in farming	0
Has 1 or 2 items	1
Has 3 or 4 items	2
Has 5 or more items	3

Number of farm workers

Number of workers hired to help in farming:

None	0
1 — 2	1
3 or more	2

Number of animals raised.

Animals are classified as large, medium and small. Large animals consist of cattle and water buffalos. Medium animals are pigs and goats, etc. Small animals are chickens, ducks, birds, and so on: If a family owns one large, at most one medium and five small animals, then zero points will be assigned. If a family owns at most two large, 10 medium and 20 small animals, then one point will be assigned. Otherwise two points are assigned.

Fish or Silk Worm Business

Size of fish or silk worm business is measured by income earned per year:

Less than 500 Baht	0
500 — 2,000	1
2,000 or more	2

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* These estimation procedures were adopted from the methods used in "Economic Factors in Family Size Decision in Thailand" by Arnold and Pejaranonda (1977).

Size of other business

Size of other business undertakings will also be measured by income earned per year:

0 — 100 Baht	0
100 — 3,000	1
3,000 — 10,000	2
10,000 — or more	3

Business Vehicles

If a motorcycle, car or truck is used for business purposes, then one point is assigned, otherwise zero points are assigned.

Business Equipment

If the household has any tools or equipment utilizing fuel or electricity used in the business, then two points are assigned, and zero if otherwise.

Number of Business Workers

Number of workers hired in the business:

None	0
1 — 2	1
3 or more	2

Income from Rent:

0 — 6,000 Baht	0
6,000 or more	1

APPENDIX II
AN ESTIMATION OF NATURAL FECUNDABILITY

Natural fecundability, which is defined as the monthly probability of conception if no contraception is employed, is known to depend on the age of the wife, the age of the husband and the "natural" level of coital frequency of the couple. Due to lack of data, this study assumes that natural fecundability depends merely on the age of the wife.

Assume that the event of conception follows a Markov renewal process and the waiting time is distributed as a geometric distribution with the mean (1—p)/p where p is the monthly probability of conception (Michael, 1976). Following this assumption, natural fecundability for each age group can be calculated from the mean waiting time of those women who have never used any contraception.

Theoretically, the waiting time should be counted from the time when a woman first enters the fecundable non-pregnant state, until the time when she enters the pregnant state. However the duration of time when a women is infecund following a live birth, stillbirth or fetal loss is not usually known or recorded. Moreover, women usually cannot remember the date of conception which did not lead to a live birth. Therefore it is not possible to obtain the waiting time directly from the survey data. Instead, waiting time is calculated from the interval between livebirths and the length of breastfeeding which should affect the returning time to the fecundable non-pregnant state. The waiting time (w) is calculated as follows:

$$w = MB - 9 \qquad \text{(A.1)}$$

for women who have only one child

and $$w = T - 9 - \min(BF, 12) \qquad \text{(A.1)}$$

for women who have more than one child,

where MB = time interval between marriage and first livebirth,

T = time interval between the last and next to the last child

and BF = length of breastfeeding of the next to the last child.

The length of pregnancy which leads to a livebirth is assumed to be 9 months. Since a woman is infecund during pregnancy, pregnant periods cannot be included as waiting time. Breastfeeding is known to prolong the resumption of ovulation, however the maximum length of time that such an effect persist is unknown. This study chooses a one year period as the maximum length of time that the effect of breastfeeding on resumption of ovulation persists.

The waiting time as calculated by equation A.1 is the waiting time of conception which leads to a livebirth. This waiting time (w) will be longer than the transitory time from the fecundable non-pregnant state to the pregnant state in the theory. The discrepancy will increase with the frequency of conceptions which do not lead to livebirths.

Table A.1 gives the mean waiting time (w) and monthly probability of conception, which are calculated from 1,265 women who have never used any contraceptive technique. The monthly probability of conception is calculated as $p_i = 1/(1 + w_i)$, which is the inverse of the equation $w_i = (1 - P_i)/p_i$.

Since natural fecundability is expected to increase as a women matures from a teenager to an adult, and to decrease gradually as she approaches the end of her reproductive period, p_i^*'s in table A.1 are used to fit a second degree polynomial against the age of wife. The result is

$$P_i^* = -0.02459 + 0.00501\ i - 0.00008\ i^2 \quad \text{for } 15 \leq i \leq 50 \qquad \text{(A.2)}$$

where i is the age of wife. The coefficients of i and i^2 are significant at a 10 percent confidence level. Equation A.2 is used to estimate the natural fecundability of women by their ages. This relationship is at a maximum at age 31 and at a minimum at age 50.

It should be noted that the natural fecundability which is indicated by equation A.2 applies only to women who remain fecund at that age. Therefore the natural fecundability computed by equation A.2 cannot be considered as the average monthly probability of conception in that age group. Since a large percentage of women in higher age group are infecund, the estimated natural fecundability will be an over-estimate of the average monthly probability of conception for women in these age groups.

Table A.1
Mean Waiting Time and Natural Probability of Conception by Age Group

Age Group (i) (1)	No. of Cases (2)	Mean Waiting Time (w_i) (3)	Probability of Conception per Month (4) = $p_i = 1/(1 + w_i)$
Total	1,265	17.9	0.0529
under 15	14	51.6	0.0190
15 - 19	195	18.1	0.0524
20 - 24	342	16.3	0.0578
25 - 29	282	18.2	0.0521
30 - 34	206	17.5	0.0541
35 - 39	180	18.1	0.0524
40 - 49	46	18.3	0.0518

Table A.2(*)
Length of Breastfeeding by Age

Current Age of Mother	Percentage of Mothers Who Breastfeed for at Least One Year
Total	72.4
Under 25	64.8
25 - 34	72.0
35 - 44	74.0
44 +	76.2

(*) This table is calculated from Table 4.1.2 of **The Survey of Fertility in Thailand: Country Report Volume II**, Institute of Population Studies and National Statistical Office, 1977.

From table A.1 and equation A.2, it can be seen that the fecundability of Thai women persists to be high even in an older childbearing age. Similar findings in terms of marital fertility have been shown previously by other authors (Knodel and Prachuabmoh, 1974). Knodel and Prachuabmoh report that the marital fertility of women is unusual in the persistence of high fertility through the older childbearing ages. About half of the Thai babies born in rural areas in 1968 were born to women above age 30. It is also possible that the persistently high fecundability of the older childbearing ages as shown here is due to a bias in the calculation of the waiting time. The bias might occur because the mean length of breastfeeding is not the same for mothers of different age groups. Table A.2 shows that the percentage of mothers who breastfeed longer than a year increases with the age of the mother. If the effect of breastfeeding on the resumption of ovulation is in fact less than one year, the mean waiting time of women in an older age group will be biased downward and thus the estimated probability of conception per month will be biased upward.

Admitting that this is just a very rough estimate of natural fecundability, one should not take the magnitude of these numbers too seriously. However, for the purposes of this study, where the natural fecundability enters the equation as a variable to affect the incentive to use contraception in different individuals, a rough estimate of natural fecundability may serve the purpose as well as a more elaborate one.

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