Are Breastfeeding and Contraception Substitute Family Planning Strategies?

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ABSTRACT

Using data from the Cebu Longitudinal Health and Nutrition Survey, this paper attempts to disentangle the complex interrelationship among breastfeeding, postpartum amenorrhea, and contraceptive method choice. Three different hypotheses have been suggested as possible causes for an observed inverse relationship between breastfeeding and contraceptive use. First, because breastfeeding delays the resumption of menses, an inverse relationship would be observed if couples delay adoption of a contraception until menses resumes. Second, if women are forward thinking, they might actually breastfeed, in part, to delay the resumption of menses, thereby substituting breastfeeding for contraception. Lastly, the observed inverse relationship may be caused by endogeneity bias.

This study finds evidence that women do substitute breastfeeding for contraception but that endogeneity bias must be controlled to avoid overstating the relationship. Additionally, the results suggest that although increased education and income result in decreased breastfeeding, the resulting fertility impact will be offset by changes in contraceptive use.

This study explores how breastfeeding and contraception are used to jointly affect fertility. Although numerous studies have observed a distinct inverse relationship between breastfeeding and contraceptive use, the determinants of this relationship are not fully understood. Because policies designed to affect either breastfeeding or contraceptive use can have differing effects on fertility depending on the nature of this relationship, it is critical to understand how they are related. This involves disentangling the complex interrelationship among breastfeeding, postpartum amenorrhea, and contraceptive method choice.

While the effect of contraception on fertility is clear, the role of breastfeeding is not obvious. Breastfeeding is the primary determinant of the duration of postpartum amenorrhea[1] (Bongaarts and Potter, 1983; McNeilly, 1988). This postpartum amenorrhea effect makes breastfeeding a key proximate determinant of the total fertility rate in many developing countries. For example, Thapa, Short and Potts (1988) find that breastfeeding is the most important fertility determinant in all five countries they studied in Africa, eight of ten countries in Asia, and two of twelve countries in Central and South America.

Differences in contraceptive use and breastfeeding rates across countries generally reflect a strong inverse relationship between breastfeeding and contraceptive use; those countries with high breastfeeding rates tend to have low levels of contraceptive use and vice-versa. Numerous other studies have also observed this relationship at the individual level.[2] Three hypotheses have been advanced to explain this relationship. The first two hypotheses presented below, the Signal Hypothesis and the Substitution Hypothesis, are behavioral while the third, the Endogeneity Hypothesis, is based on the premise that the observed inverse relationship is the product of statistical mismeasurement.

Signal Hypothesis. Couples aware of their infecundity while the woman is amenorrheic may delay adoption of a contraceptive method until menses resumes. That is, resumption of menses might signal to women that ovulation has resumed and that they should begin using a contraceptive to avoid conception. Since breastfeeding delays the return to menses, an exogenous decrease (increase) in breastfeeding would lead to shortened (lengthened) duration of amenorrhea and an earlier (later) adoption of contraception. In support of this hypothesis, many studies have found an increase in contraceptive use following the resumption of menses (Knodel, Kamnuansilpa, and Chamratrithirong, 1985; Laukaran and Winikoff, 1985; Millman, 1985).

Substitution Hypothesis. Because of its amenorrheic effect, breastfeeding has long been used as a means to control fertility (Fides, 1987; Thapa and Williamson, 1990).[3] Women who not only use the resumption of menses as a signal to begin using contraception, but who also use breastfeeding to delay that resumption of menses, are in effect using breastfeeding as a substitute for contraception. Several researchers have attempted to determine the extent of such behavior. Millman (1985) finds the desire to stop having children increases breastfeeding, but this result is only significant when an endogenous "method use" variable is included in the equation. Jain and Bongaarts (1981) determine the partial correlation between breastfeeding and contraceptive use while controlling for several variables that affect both. They conclude that women in five of seven countries studied may substitute breastfeeding for contraception as a family planning strategy.[4] In trying to answer this same question, RamaRao (1991) finds that 26 percent of his Malaysian sample report having used breastfeeding as a contraceptive. This hypothesis differs from the Signal Hypothesis in that it assumes that women are forward thinking to the extent that they control their breastfeeding, in part, to affect their future need for contraception.

Endogeneity Hypothesis. The magnitude of the inverse relationship between breastfeeding and contraceptive use may be the product of unobserved factors having opposite effects on the two behaviors. For example, increasing economic development might lead to increased contraceptive use and a reduction of breastfeeding. Left uncontrolled, such factors would lead to an overstating of the inverse relationship. At the extreme, it is possible that unobserved factors are entirely responsible for the inverse relationship while breastfeeding and contraceptive use have no direct impact on each other. If so, the observed inverse relationship between breastfeeding and contraceptive use could be a product of endogeneity bias.[5] In fact, none of the research that has found an inverse relationship between breastfeeding and contraceptive use adequately controls for possible endogeneity.[6]

The goal of this study is to quantify the relationship between breastfeeding, post-partum amenorrhea, and contraceptive use and, in doing so, to begin to understand the nature of the inverse relationship between breastfeeding and contraceptive use. Next, a dynamic stochastic model explains how couples aware of the postpartum effect of breastfeeding control their fertility by combining breastfeeding and contraception. Although the model is based on the Substitution Hypothesis, its implications can be used to test the relative validity of the Substitution and Signal Hypotheses in the statistical analysis. As it is a statistical issue, the Endogeneity Hypothesis will be accounted for with a statistical approach that controls for endogeneity biases.

If the Substitution Hypothesis dominates behavior, policies that increase access to contraception may lead to a reduction in breastfeeding as an unintended consequence. Alternatively, a reduction in breastfeeding would not be expected if the Signal Hypothesis dominates behavior. To the degree that a woman's behavior conforms to either the Signal or Substitution Hypothesis, changes in fecundity caused by policies that lead to changes in breastfeeding could largely be offset by changes in contraceptive use. If, on the other hand, the inverse relationship is found to be solely a product of endogeneity bias, then policies which directly affect either breastfeeding or contraceptive use should not affect the other behavior.

ECONOMIC DEMAND MODEL OF THE SUBSTITUTION HYPOTHESIS

The model described here explains how couples make decisions about breastfeeding and contraception to optimally space their children and maximize the expected present discounted value of lifetime utility. The model generates the decision rules under which households make choices concerning breastfeeding and contraception. To demonstrate how breastfeeding might be substituted for contraception by a couple attempting to optimally space their children, the model includes the level of breastfeeding, its effect on duration of postpartum amenorrhea, and subsequent contraceptive choices.[7]

Utility from Completed Family Size

Couples derive utility not only from current breastfeeding and contraceptive use behavior, but also from proximity to their optimal desired completed family size when the mother reaches menopause -- the closer their completed family size comes to matching their optimal family size the higher is household utility. While couples cannot perfectly control their fertility, they can take steps to delay conception. Although these efforts to delay conception are costly, failure to limit the number of children in the household can lead to a substantial decrease in lifetime utility as a result of overshooting their optimal family size. Alternatively, draconian measures to delay fertility would be exceedingly costly and might even lead to decreased utility from undershooting the couple's optimal completed family size. To maximize the expected discounted present value of lifetime utility, couples will choose a level of fertility control to balance the disutility of that control in the current period with the disutility resulting from under- or over-shooting their optimal completed family size.

Because fertility control is costly and imperfect, there is a possibility that a couple's completed family size will not equal their optimal family size. For example, a couple using reasonable fertility control measures could possibly reach their optimal family size several years before the onset of menopause.[8] In this case, it may be optimal for the couple to overshoot their optimal family size because the cost of using the family planning measures required to reduce the probability of conception to zero would reduce lifetime utility more than overshooting.

Current and Future Utility

Using the Bellman formulation, the present discounted value of lifetime utility can be broken down into the sum of utility from the current period and the expected present discounted value of all future utility along the optimal path. Utility in the current period is a function of current period consumption, leisure, contraceptive use, and the health of the breastfeeding infant. Future utility along the optimal path is a function of the number of children in the household at the beginning of the next period. The mother's labor supply and the husband's labor supply and leisure all are assumed to be fixed. The cost of breastfeeding in the current period is therefore measured by the foregone value of the mother's leisure activities.[9] In keeping with economic theory, it is assumed that this cost increases at an increasing rate.[10] An additional benefit to breastfeeding is the increased health of the infant, which positively affects the mother's utility.

Contraceptive intensity has both indirect and direct negative effects on current period utility. First, consumption is equal to household income less contraceptive expenditure. It is reasonably assumed that the price of more effective methods is higher than the price of less effective methods so that use of more effective methods reduces consumption more than use of less effective methods.[11] Second, all methods can be made more effective with reduced coital frequency, and reduced coital frequency adds an additional psychic cost to contraception. Breastfeeding and contraceptive decisions will also depend on whether the woman is in the anovulatory or ovulatory state in the current period.

Behavior in the Anovulatory State. Immediately following childbirth, the woman is assumed to be in an anovulatory state. The model assumes that couples use resumption of menses to indicate that ovulation has resumed and contraception is necessary to avoid pregnancy.[12] Therefore, after the birth of a child and until menses resumes, the couple's only family planning decision is how to allocate the mother's time between leisure and breastfeeding intensity. By taking time away from leisure, the breastfeeding decision not only affects utility in the current period, but it also affects the probability that the woman will remain in the anovulatory state for the next period or transition to the ovulatory state. While the cost of breastfeeding, measured by the value of the mother's time, would certainly affect this decision, so would the price of breastmilk subsitutes -- e.g. infant formula -- and contraception. The higher the cost of contraception, the more attractive breastfeeding, as a means to remain in the anovulatory state, becomes as a substitute for contraception. In addition, as David, Mroz and Wachter (1987) demonstrate for a similar model, the more children in the household, the closer the household must be to reaching, and exceeding, the ideal family size.[13] The closer they are to reaching the ideal family size, ceteris paribus, the more effort they will exert to delay resumption of menses through breastfeeding. As older women are less likely to overshoot their optimal family size, ceteris paribus, they are expected to breastfeed less. Once ovulation begins, however, the couple needs to make a contraceptive use decision.

Behavior in the Ovulatory State. Once in the ovulatory state, contraceptive use joins breastfeeding as a household decision. Breastfeeding may still continue as it provides health benefits to the infant.[14] However, as there is no longer any contraceptive benefit, breastfeeding would be expected to decrease. Contraceptive use in the current period not only directly and indirectly effects utility in the current period, but also affects the likelihood that a woman will remain in the Ovulatory State or become pregnant. The number of children in the household and the age of the mother would affect contraceptive use. Holding the number of children constant, households with older mothers will be less likely to overshoot their ideal family size and will use less, or less effective, contraception. Similarly, holding the mother's age constant, households with more children will be more likely to overshoot their ideal family size and will use more, or more effective, contraception (David, Mroz and Wachter (1987) and Newman (1988)).

In summary, anovulatory, sexually active women who desire to delay their next pregnancy will choose a level of breastfeeding that not only provides health benefits for their child but also provides contraceptive benefits by delaying the resumption of menses. By maintaining a high level of breastfeeding to delay the need for contraception, women are substituting breastfeeding for contraception and their behavior is consistent with the Substitution Hypothesis.[15]

Testing the Substitution and Signal Hypotheses

Assuming the Substitution Hypothesis holds, the theoretical model predicts several results. First, higher contraceptive prices will result in increased breastfeeding as women attempt to use breastfeeding to delay resumption of menses so that they can put off the purchase of contraceptives. Second, since older women face a reduced likelihood that they will overshoot their ideal family size, they get less benefit from the contraceptive effects of breastfeeding and will breastfeed less often. Similarly, women with more children are closer to overshooting their ideal family size and will breastfeed more often. Lastly, when menses resumes, the contraceptive effect of breastfeeding is greatly reduced. Therefore, we would expect women who have begun to menstruate again after giving birth to reduce their level of breastfeeding.

The basic premise of the Signal Hypothesis is that women do not use breastfeeding to control their fertility. It suggests that couples are not forward looking, ignore the contraceptive benefits of breastfeeding, and simply adopt contraception once menses resumes if they desire to delay conception. There are four testable implications of such an assumption that differ from the those outlined above. First, changes in the price of contraception would not affect breastfeeding as breastfeeding would not be viewed as a substitute to contraception. Second, breastfeeding would not be expected to decrease once menses resumes. Third, breastfeeding would not be expected to increase with age since it is not used as a substitute for contraception. Fourth, the number of children in the household would not be expected to affect breastfeeding behavior.

DATA AND METHODOLOGY

The Cebu Longitudinal Health and Nutrition Survey

This paper uses the Cebu Longitudinal Health and Nutrition Survey (CLHNS). Details of the survey, its design and methodology have been presented elsewhere (Adair and Popkin 1988; Cebu Study Team 1992; Schwartz and Flieger 1989). Briefly, the CLHNS was conducted on the Philippine island of Cebu, which includes Cebu City, the second largest city in the Philippines. The island is divided into 243 barangays (the smallest administrative unit in the Philippines) and has a population of just over 1 million inhabitants. The study includes households in 33 barangays in and around Cebu City -- 17 classified as urban and 16 as rural.

The data were collected through two types of surveys -- individual and facility. The baseline household survey was administered at the sixth month of pregnancy for 3327 women who gave birth between May 1, 1983, and April 30, 1984. This was followed by twelve longitudinal surveys in two month intervals beginning within three days after birth. Data gathered include detailed information on infant feeding, contraceptive use, and demographic and socioeconomic information. Of the 39,924 possible longitudinal interviews of the original 3327 baseline women, 32,444 longitudinal interviews were completed.

To enable the study of the supply side of the health and family planning sectors, a survey of health facilities was also conducted. A baseline survey of health facilities was followed by a series of longitudinal health facility surveys. The third survey, which covered 261 health care and family planning providers is used in this research. This survey included questions about the characteristics of the facility, including questions about price and availability of contraception. Sample statistics for the data used in the estimation are presented in Tables 1 and 2.

{--- Tables 1 and 2 about here ---}

The Equations

The empirical model is made up of five equations which estimate the number of children in the household in the initial period, breastfeeding frequency, resumption of menses, contraceptive method choice, and pregnancy. According to the theoretical model, both breastfeeding and contraceptive decisions are a function of the number of children in the household. Furthermore, the contraceptive choice decision is a function of whether menses has resumed and menses resumption is a function of a previous breastfeeding decision. The empirical model is specified to account for and measure these relationships. The number of children in the household, the breastfeeding and contraceptive choices, and menses resumption are all endogenously determined, as is becoming pregnant and temporarily dropping out of the empirical model. To control for such potentially bias causing endogeneity, the five equations are estimated jointly.

Parity. The first equation in the model estimates the number of children in the household (i.e., parity) at the beginning of the survey period. According to the theoretical model, the number of children in the household is a major determinant of breastfeeding and contraceptive use. As one of the state variables in the theoretical model, the variable is endogenously determined. The number of children in the family can only change through the birth or death of a child. So if data covering all time periods relevant to the couple's fertility history were available, the number of children in the household could be controlled through equations predicting pregnancy and child mortality. The endogeneity of births during the survey period is accounted for with the pregnancy equation while assuming that infant and child mortality during the survey period is exogenous.[16] When modeled this way, only the number of children in the household in the initial observed time period remains endogenous. This equation is estimated for each household. The number of children in the household at the start of the survey period is treated as a continuous outcome in the following equation:

(1)

Household parity in the initial period is modeled as a function of individual and household variables. Along with typical demographic variables such as mother's and father's age and education family wealth and urban/rural household location, other variables included are the mother's age at menarche, the number of years the couple has been married and whether they live in the same area where the mother grew up -- indicating access to relatives for child care help. The ∀ represents regression parameters to be estimated and ,$^{k}_{i\,t}$. represents the disturbance term.

Breastfeeding. The second equation in the system estimates the number of times the mother

$$(B_{i\,t}|B_{i\,t-1}>0,\ h_{i\,t-1}=0)\ =\ \alpha^{b}X_{\ i\,t}^{b}+\gamma^{b} v_{i\,t-1}^{b}+\delta^{b} k_{i\,t}^{b}\ +\ \epsilon_{i\,t}^{b}$$

breastfeeds her infant per day. The outcome is empirically modeled as:

(2)

where the dependent variable is the number of times the mother breastfed her baby per day. Individuals are included in the estimation of this equation up to and including the time period in which they report a cessation of breastfeeding – i.e., as long as $B_{i\,t-1} > 0$. This is done because once a mother has stopped breastfeeding, her body will no longer produce breastmilk and nursing is no longer an option. A continuous measure of breastfeeding is used since different levels of breastfeeding intensity may affect the duration of post-partum amenorrhea (Zohoori and Popkin, 1996).[17] In addition, women are only included if they are not currently pregnant, $h_{i\,t} = 0$.

The explanatory variables include a set of observed individual, household, and market characteristics that determine breastfeeding frequency, $X^{b}_{i\,t}$, an indicator of whether menses has previously returned, $v_{i\,t-1}$, and the number of children in the family, $k_{i\,t}$. The ∀, ß, and ∗ are regression parameters to be estimated and ,$^{b}_{i\,t}$ is the disturbance term. As discussed in the theoretical model, the effect of several of the explanatory variables will help distinguish the validity of the Signal and Substitution hypotheses. These variables include $v_{i\,t-1}$, $k_{i\,t}$, the age of

```
~=~{1}over
{1+exp(alpha^{v} X_{t}^{v}~+~beta ^{v} B_{t-1}^{v}))}
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the mother, and measures of price and accessability of contraception. In addition, an indicator of spousal absence from the home reflects the couple's need for a family planning strategy.

Menses Resumption. The third equation estimates the hazard of resuming menses.[18] The probability of resuming menses is specified as a discrete time hazard function with a logistic error structure. That is:

(3)

where the probability that individual i is currently amenorrheic $v_{it} = 1$ relative to $v_{it} = 1$ in period t is estimated. Individuals are included in the sample for this equation only if they are not pregnant, $h_{it} = 0$ and if they reported being postpartum amenorrheic in the previous period, $v_{t-1} = 0$. The $X^{v}_{i\,t}$ are a set of individual and household characteristics that determine the probability of menses such as the age of the mother, the log of the mother's body mass index, the number of days since giving birth, the number of children in the household and the mother's age at menarche. B_{t-1} is the mother's breastfeeding frequency during the previous period. The ∀, and ß are regression parameters to be estimated.

Contraceptive Method Choice. The fourth dependent variable in the system is contraceptive method choice, an unordered, categorical variable. Using the multinomial logit

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(Prob(M_{~i`t}=`j)| h_{i`t-1}=0,M_{i`t-1}!=6)`=`
{exp(alpha_{j`}^{m}X
_{~i`t}^{m}`+`gamma_{`j}^{m}`v_{~i`t-
1}`+`delta_{`j}^{m}`k_{i`t})}over{ SUM_{j=1}^{6}
exp(alpha_{j`}^{m}X
_{~i`t}^{m}`+`gamma_{`j}^{m}`v_{~i`t-
1}`+`delta_{`j}^{m}`k_{i`t})}
```

specification, contraceptive method choice is modeled as:

(4)

(Prob(h_{i t}=1)|h_{i t-1}=0, M_{i t-1} ≠
6)~=~{{1}over{1+exp(alpha^{h}X_{~i`t}^{h}+beta^{h}M_{~i
-1}^{h}+gamma^{h} v_{i`t-1}^{h})}}

where the probability that individual i will chose method type j (j=1,2,3...M) in period t is estimated -- where type 1 is using no method, 2 is traditional methods (withdrawal, rhythm), 3 is condoms, 4 is the pill, 5 is IUD, and 6 is female sterilization (tubal ligation). Individuals are included in the estimation of this equation only if they are not pregnant, $h_{it} = 0$ and have not previously chosen a permanent method, m_{it-1} 6. The $X^{m}_{i\,t}$ are a set of individual, household, community, and method choice characteristics which affect method choice. $v_{i\,t-1}$ indicates whether menses has resumed and $k_{i\,t}$ is the number of children in the household.[19] The ∀, ß, and (represent a set of regression parameters to be estimated.

The theoretical model predicts three results of interest in this equation. First, increased price of a contraceptive method should lead to a lower probability of its use. Second, older women should be less likely to use contraception or more effective methods of contraception as there are fewer years remaining in which they can overshoot the couple’s ideal family size. Third, women in households with more children will use more effective methods as they are more likely to be closer to overshooting the household’s ideal family size. In addition, resumption of menses should result in an increase in the likelihood that any method will be chosen over no method as the probability of becoming pregnant is much higher once menses resumes.

Conception. The fourth equation estimates the hazard of conception. The discrete time hazard of conceiving is specified with the following logit equation:

(5)

where the probability that the woman, i, is pregnant, $h_{i\,t} = 1$, relative to the probability that she is not, $h_{i\,t} = 0$, is estimated. Individuals are included in this equation only if they were not pregnant in the previous time period, $h_{i\,t-1} = 0$ and have not previously chosen sterilization, M_{t-1} 6. The probability that a woman becomes pregnant is assumed to be a function of the set of observed exogenous household characteristics, denoted by X^{h}_{t}, contraceptive method choice in the previous period, $M_{i\,t-1}$, and whether the woman has previously returned to menses, $v_{i\,t-1}$. The ∀, ∃, and (are regression parameters to be estimated.[20]

Unobserved Heterogeneity Issues

Both the Substitution Hypothesis and the Signal Hypothesis assume that contraceptive method choice is a function of resumption of menses, which itself is largely a function of breastfeeding intensity. However, according to the Endogeneity Hypothesis, attempting to estimate method choice as a function of resumption of menses without controlling for the endogeneity of breastfeeding could bias the results. Furthermore, breastfeeding, resumption of menses, and contraceptive method choice are only observed if the mother is not pregnant. Since it is likely that the same unobserved factors that determine pregnancy also determine breastfeeding, resumption of menses, and contraceptive choice, failing to control for self-selection into the pregnant state may also lead to biased results. Finally, the number of children in the household is hypothesized to be a determinant of contraceptive choice and breastfeeding. Since the number of children in the household is largely determined by past breastfeeding and contraceptive choice decisions as well as past duration of postpartum amenorrhea, inclusion of parity as a variable in these equations is another potential source of endogeneity bias. The source of both the endogeneity and self-selection biases are derived from one cause -- correlation between each of the outcomes and the same unobserved factors. These potential biases can therefore be referred to as "unobserved heterogeneity" biases. Once the endogeneity between the estimated equations is controlled, any remaining inverse relationship between breastfeeding and contraceptive use would be strong evidence that endogeneity bias is not the sole source of the previously observed inverse relationship.

The Discrete Factor Method

To remove the unobserved heterogeneity biases discussed above, a discrete factor method similar to that described in Heckman and Singer (1984), Akin and Rous (1997), and Mroz (1999) is employed to jointly estimate equations for pregnancy, number of children in the family, breastfeeding frequency, resumption of menses, and contraceptive method choice. The technique is full-information maximum likelihood, but instead of making a multivariate, parametric assumption about the error term (e.g., multivariate normal), a joint, discrete, semi-parametric

}^{n}~+~nu_{1 t}^{n}

multivariate distribution that approximates the true distribution of the unobserved variables responsible for the correlation between the error terms is estimated. The approximated distribution is made up of a set of factors and corresponding probability weights. The structure of the likelihood function used here is similar to the one detailed in Akin and Rous (1997).[21]

To account for community specific and individual specific unobserved factors correlated with the error terms, the estimation includes both community and individual level distributions. An example of a community level factor that might affect any number of the equations is a local priest's charisma and beliefs on use of contraception. Possible individual level unobserved factors that might help determine more than one of the outcomes modeled include, a woman's overall fecundability, the mother's health endowment that might affect breastmilk production and resumption of menses, the mother's knowledge of the incompatibility between breastfeeding and estrogen based contraception, or a couple's desire for a large family.

To facilitate this estimation technique, I expand the error terms and assume the following mixed error structure for the pregnancy equation.

(6)

where

γ^{h}_{it}	is the pregnancy equation disturbance term.
T^{h}_{c}	are the unobserved community level factors that help determine conception. They are random variables that follow a multivariate joint distribution.
T^{h}_{l}	are the unobserved individual level factors that help determine conception. They are random variables that follow a multivariate joint distribution.
$<^{h}_{it}$	is the portion of the disturbance term that is independent across time and outcomes.

The community level factors, T^{h}_{c}, are allowed to be correlated across equations. Similarly, the individual level factors, T^{h}_{l}, are allowed to be correlated across equations. Using discrete factor analysis, separate joint discrete multivariate distributions for the individual and community level factors are estimated. The discrete community and individual level distributions are made up of the T and corresponding probability weights, all of which are estimated with the rest of the parameters in the model. This error term correlation controls for any unobserved heterogeneity including sample selection, endogeneity, and clustering.[22] The error structure for each equation in the model follows the same general structure as the error term in the pregnancy equation.

The < for the discrete outcomes – pregnancy, contraceptive method choice and resumption of menses -- are are assumed to be distributed logistically, while the < for the continuous outcomes -- breastfeeding frequency and number of children in the family -- are assumed to be distributed normally, and all < are independent across time and outcomes.[23, 24]

EMPIRICAL RESULTS

The breastfeeding and method choice equations are of particular interest because they include the parameters most relevant for testing the validity of the Substitution Hypothesis versus the alternative Signal Hypothesis. Because the major interest of this research is in the relationship between breastfeeding and contraceptive choice, the discussion focuses on the results that are relevant to hypotheses concerning that relationship. The results of the children, pregnancy, and menses equations are not discussed. These three equations are included in the model mainly to control for the endogeneity of the outcomes. A full set of the results from these equations are presented in Appendix A. In general, the results are strong statistically and support the assumptions of the theoretical model. That is, in the menses equation, increased breastfeeding in the previous time period is found to have a statistically significant negative effect on resumption to menses, and in the pregnancy equation, previous contraceptive use has a statistically significant negative effect on the likelihood of becoming pregnant.

Breastfeeding Equation

The dependent variable in the breastfeeding equation is the number of times the infant breastfed in the 24 hours previous to each bimonthly longitudinal survey. Briefly, the results provide evidence that women not only use resumption of menses as a signal that ovulation has resumed, but also that women use breastfeeding as a substitute family planning strategy. The results from the breastfeeding equation are presented in Table 3.

Knowledge of Breastfeeding's Effect on Conception. An important assumption of the theoretical model is that women are aware that increased breastfeeding reduces their likelihood of conceiving. Without such knowledge, it would be impossible to argue that women use breastfeeding as a substitute for contraception. A variable that indicates whether a woman believes that breastfeeding delays the onset of conception is included in the breastfeeding equation.[25] If women who are aware that breastfeeding can delay the onset of conception breastfeed more than women who are not, it would indicate that breastfeeding is used as a method of family planning. Women who believe that breastfeeding delays conception are found to breastfeed statistically significantly more than women who do not. The coefficient supports the Substitution Hypothesis and indicates that women who believe breastfeeding offers some protection from conception breastfeed an additional 0.237 times per day. As the average breastfeeding frequency is 7.22 times per day, women who are aware of breastfeeding's effect on conception are found to breastfeed 3.3 percent more than other women.

Menses Resumption. Strong evidence supporting the Substitution Hypothesis is the result that breastfeeding statistically significantly decreases once menses resumes. This indicates that women who realize that there is no longer a family planning benefit to breastfeeding will reduce the number of times per day that they breastfeed their infants. According to the estimation, once menses resumes, women reduce the number of times per day they breastfeed by 0.680 times per day -- an 9.42 percent decrease.

Spousal Absence. Also interesting is the result that spousal absence has a statistically significant negative effect on breastfeeding frequency. This suggests that women who have less opportunity for sexual relations, and therefore may not need the contraceptive benefit from prolonging amenorrhea, will breastfeed their children less often.[26] An absent spouse is responsible for a significantly significant reduction in breastfeeding frequency of 0.438 times per day -- a 6.1 percent decrease. This result further supports the Substitution Hypothesis.

Parity. The theoretical model predicts that, ceteris paribus, women using breastfeeding as part of their family planning strategy will breastfeed more frequently if there are more children in the household because the couple faces a greater risk of overshooting their ideal family size. Each additional child in the family is found to increase breastfeeding frequency by 0.043 times per day -- a 0.6 percent increase. While this coefficient is small, it is statistically significant. This result further supports the Substitution Hypothesis. It does, however, appear inconsistent with

Stewart, et al. (1991) who find that increased parity decreases the likelihood that, as of the sixth month of pregnancy, the mother intends to breastfeed.

Access to Contraception. The theory predicts that as price or distance to contraception rises, women using breastfeeding as a substitute for contraception will breastfeed more to delay their need for contraception. However, if women are simply using resumption of menses as a signal that ovulation has resumed, the theory predicts that an increase in price or distance to contraception should not affect breastfeeding. The mean prices of pills and of condoms at the closest private facility to each household are used to proxy for the price of contraception for each household. Distance is treated in a similar fashion, based on the nearest facility offering either pills or condoms. In the empirical results, price and distance to contraceptives are not found to have a statistically significant effect on breastfeeding. These findings support the Signal Hypothesis over the Substitution Hypothesis and suggest that policies that improve access to contraception are not likely to lead to reduced breastfeeding and, given current understanding about the health benefits of breastfeeding, diminished infant health.

{--- Table 3 about here ---}

Contraceptive Method Choice Equation

To measure contraceptive method choice, women were asked at each longitudinal survey which method they were currently using.[27] The method choice equation contains several variables that provide evidence about the relationship between breastfeeding and contraceptive choice. The results are presented in Table 4. Point estimates from the logit equations are in the usual log odds form and are difficult to interpret directly beyond the sign and significance of the parameters.[28]

Menses Resumption. The theoretical model predicts that resumption of menses will cause a jump in contraceptive use because it is assumed that a woman who has resumed menses is susceptible to conception. The empirical results support this prediction, which is consistent with both the Signal and Substitution hypotheses. Because the statistical method used controls for any endogeneity between breastfeeding, resumption of menses, and contraceptive use, this finding, paired with the result that breastfeeding frequency drops with resumption of menses, is strong statistical evidence that the observed inverse relationship between breastfeeding and contraceptive use are not simply a product of endogeneity bias. The importance of resumption of menses as a determinant of method choice indicates that omitting that variable from an equation used to predict method choice could seriously bias the results. The somewhat inconsistent finding that menses status does not seem to affect adoption of female sterilization may be explained by the fact that female sterilization, in this region of the Philippines, is most often performed immediately after childbirth, long before menses resumes. Furthermore, unlike other methods, there is little to gain by delaying adoption of sterilization until menses resumes.[29]

Parity. The number of children in the household is hypothesized to have an important effect on method choice. The more children the couple has at a given age, the greater is the extent to which they might exceed their ideal family size by the end of their fertile years. This means that for a given age of the mother, households with more children would be expected to choose more effective methods. While this generally holds true in the results, the one exception is the IUD. IUD users are younger and tend to have fewer children than users of other methods. It is possible that this behavior derives from a cohort effect caused by recent family planning programs that focus on use of the IUD as a reliable, cost-effective, long term contraceptive.

The result that increased parity statistically significantly increases the likelihood of using a contraceptive method or choosing a more effective method is not surprising. Most previous studies of contraceptive method choice have found similar results (Hamill et al., 1990; Kahn, et al., 1989; Phillips et al., 1989; Zablan, et al., 1989).

{--- Table 4 about here ---}

Unobserved Heterogeneity Correction

An important objective of this research is to test the Endogeneity Hypothesis that explains the observed inverse relationship between breastfeeding and contraceptive use as a result of common unobservables independently affecting contraceptive choice and breastfeeding. The results of the statistical model strongly indicate that there are unobserved factors at both the individual and community level that affect each outcome in the model. 15 of the 27 parameters that make up the community level distribution and 17 of the 27 that make up the individual level distribution are statistically significant at the 95% level.[30] While it is not possible to determine the nature of the unobservables that are being picked up by the estimation, it is interesting to note that the values of the individual level mass point parameters indicate opposite effects of the controlled unobserved factors on breastfeeding and contraceptive method choice. One such a factor might be desire for a large family. Women in these households would be expected to breastfeed less and use more, or more effective, contraception. These results are important evidence that endogeneity bias could have been partially responsible for the observed inverse relationship between breastfeeding and contraceptive in previous studies. To the extent that the affect of unobserved factors on breastfeeding and contraceptive use was similar to the effect found here, previous studies would have overstated the size of the inverse relationship. Appendix B contains a complete description of the discrete factor results.

SIMULATIONS

The complex dynamic relationships between the variables in the model and their effects on the outcomes under study are summarized through a set of simulation exercises. The simulations are performed by first generating 10,000 identical observations with mean values for each exogenous variable. For the discrete outcome equations (e.g., method choice, resumption of menses, and pregnancy), the parameter estimates from the statistical estimation are used to predict the probability of each possible outcome at each time period. For the continuous outcome equations (e.g., parity and breastfeeding frequency) the parameter estimates are used to calculate a predicted outcome at each time period for each of the 10,000 simulated observations. The predicted outcomes from each equation in each time period are then used in place of the actual variables where they appear as lagged explanatory variables in the following time period.

For the continuous outcome equations, the predicted outcome is calculated by combining the simulated observation with the actual parameters estimated by the model. Since the exogenous variables for each simulated observation are identical, the predicted outcome for each observation would not contain much variation. To generate variation, a stochastic element is incorporated by multiplying the predicted outcome by a number drawn from a normal distribution with a mean of zero and a standard deviation equal to the estimated standard error of the regression. For the discrete equations, predicted outcomes were randomly assigned to each individual based on the predicted probability of each outcome. For example, assume the predicted probability of resuming menses is 24%. If a selected random number between zero and one is less than 0.24, the simulated observation is assumed to have resumed menses. That information is then used where the "menses resumed as of previous time period?" variable appeared in each equation in the following time period.

The baseline predicted outcomes using the original 10,000 simulation observations can then be compared to predicted outcomes after a change in one of the variables has been made. For example, to simulate a change in education, three years of education can be added to each simulated observation. The dynamic simulation then not only measures any direct effect of the change in education on breastfeeding and contraceptive use, but also the effects these changes in breastfeeding and contraceptive use might have on resumption of menses, contraceptive use, and fertility. Finally, the simulation incorporates the effect that any resulting changes in fertility might affect subsequent breastfeeding and contraceptive use decisions.

Three simulations were performed. The first two involve simulating a change in the exogenous mother's education level and household asset level. These two changes were chosen for two main reasons. First, both of these variables are statistically significant determinants of both breastfeeding and contraceptive choice. Second, increasing woman's education and household wealth have been important policy goals in developing countries. The third involves simulating the effects of zero breastfeeding. This extreme exogenous change in a variable that has, thus far, been treated as endogenous is used to help answer some of the initial questions which motivated this research -- including the degree to which changes in contraceptive use will compensate for the potential fertility effect of reduced breastfeeding. The results of these simulated changes on predicted breastfeeding, menses resumption and contraceptive choice can be found in figures 1, 2, and 3, respectively. Table 5 presents the number of predicted pregnancies for the 10,000 simulated observations over the 12 time periods of the simulation.

{--- Table 5 about here ---}

Mother's Education and Household Assets. For the first and second simulation, the mother's level of education is increased by 3 years and the value of the household's assets per person are increased by roughly one standard deviation (5000 pesos or $60 in 1980 US dollars). The predicted effects of both changes are similar. Both increases lead to a reduction in breastfeeding frequency (see Figure 1). As of the forth month after giving birth, the increase in education results in a 4.90 percent decrease in breastfeeding and the increase in household assets is results in a 2.68 percent decrease in breastfeeding frequency. By the 18th month, the education and asset level changes are responsible for a 12.17 percent and 7.13 percent decrease in predicted frequency respectively. The effect of these changes on resumption of menses, however, is small.

The simulated change in mother's education, through its effect on breastfeeding, leads to a 3.28 percent increase in the number of women who have resumed menses by the 4th month after giving birth and a 2.51 percent increase after 6 months (see Figure 2). The change caused by simulating an increase in the household's asset level is smaller: 1.97 percent increase in the number of women resuming menses by the 4th month and 1.60 percent increase by the 6th month. This percentage increase diminishes over time.

If contraceptive behavior were unaffected by this change, the effect of reduced breastfeeding would be increased fertility. It is apparent from the information presented in Table 5 that changes in either mother's education or household assets ultimately lead to reduced fertility. The positive fertility effect of reduced breastfeeding is nullified by an increase in contraceptive use -- both because the changes in education and household assets directly affect contraceptive use and because the earlier resumption of menses leads to earlier adoption of contraception. The predicted change in the use of the three most effective methods are presented in Figure 3. By 4, 8, and 12 months after birth, the simulated predicted percentage of women using one of the three most effective methods of contraception (the pill, IUDs, and female sterilization) after the simulated change in mother's education, is 11.4 percent, 10.4 percent, and 8.1 percent, respectively. For the same months, the predicted change caused by the change in household assets is 16.5 percent, 12.7 percent, and 11.9 percent. Because the change in resumption of menses caused by the reduction in breastfeeding is small compared to the increase in contraceptive use, it is clear that the majority of the fertility effect of changes in education and assets lies in their direct effect on contraceptive method choice and not on the earlier resumption of menses caused by reduced breastfeeding.

No Breastfeeding. The final simulation predicts the effect of zero breastfeeding.[31] The effect of such a drastic reduction in breastfeeding on resumption of menses is profound. The change leads to a 39.7 percent increase in the predicted number of women who have resumed menses after 4 months, 32.2 percent increase after 6 months, and 16.8 percent increase after 12 months (see Figure 3). However, the earlier resumption of menses leads to a moderate increase in contraceptive use. After 4, 6, and 12 months, use of the pill, IUDs and female sterilization are predicted to increase 1.0 percent, 3.8 percent, and 2.8 percent, respectively. Ultimately, this increased contraceptive use is not predicted to completely offset the fertility effect of earlier resumption of menses as the predicted number of pregnancies over two years increases by 7.09 percent (see Table 5). The increased contraceptive use does have some effect, however. Had contraceptive use patterns not been affected by the earlier resumption of menses, zero breastfeeding would be predicted to result in a 10.48 percent increase in fertility over the two years of the simulation. So increased contraceptive use is predicted to offset 32.4 percent of the potential fertility effect of zero breastfeeding. It must be noted that it is highly unlikely that any policy could have such a extreme effect on breastfeeding and the fertility effect of more reasonable exogenous changes in breastfeeding would be correspondingly lower.

All simulations are preformed with the estimation results that included the unobserved heterogeneity controls. According to the Endogeneity Hypotheses, part or all of the observed inverse relationship is caused by unobserved factors. To quantify the importance of endogeneity, this simulation is also performed with estimation results that did not control for endogeneity.[32] In this case, zero breastfeeding is found to lead to a 6.41 percent increase in the predicted number of pregnancies -- as opposed to the 7.09 percent found when endogeneity was controlled. Therefore, it appears that failing to control for endogeneity in the empirical model reveals a stronger inverse relationship between breastfeeding and contraceptive use than when endogeneity is controlled -- resulting in a 0.65 percent lower fertility rate. This result provides evidence of the magnitude of the bias caused by ignoring the endogeneity of breastfeeding, menses, and contraceptive use.

CONCLUSION

The relationship between breastfeeding, postpartum amenorrhea, and contraceptive choice is important and complicated. Three different hypotheses have been suggested as possible causes for the inverse relationship between breastfeeding and contraceptive use. This study finds that not only do women wait to adopt a contraceptive until menses resumes, but there is also evidence that breastfeeding is used to delay the resumption of menses. The statistical technique used in this study reveals that failing to account for endogeneity bias would affect the results in such a way as to overstate the inverse relationship between breastfeeding and contraceptive use. The simulation results provide some indication of the magnitude of the relationship between breastfeeding, contraceptive use, and fertility.

Thapa, Short and Potts (1988), express concern that the fertility effect of reduced breastfeeding will not be completely offset by an increase in contraceptive use. On this point, the results are mixed. On one hand, the results suggest that even though indicators of development such as education and household wealth may result in decreased breastfeeding, the fertility impact of reduced breastfeeding will be more than offset by changes in contraceptive use. It appears, however, that most of this counteracting effect is due to the direct effects of education and income on contraceptive use and that little of the effect stems from earlier adoption of contraception due to earlier resumption of menses caused by the decrease in breastfeeding. On the other hand, the results suggest that the fertility effects of policies that affect only breastfeeding, but not contraceptive use, will not be fully offset by earlier adoption of contraceptives. That is, policies that reduce breastfeeding without directly having a positive effect on contraceptive use are predicted to lead to increased fertility.

Finally, most research into the determinants of contraceptive use ignore the fact that a substantial portion of married women are post-partum amenorrheic at any given time and that breastfeeding and amenorrhea status play an important role in the contraceptive choice decision. This research has demonstrated that resumption of menses is an important determinant of contraceptive choice and that ignoring this factor when studying method choice may lead to serious biases in the estimation results. Furthermore, since the time these data used in this study were collected, researchers have identified guidelines for using breastfeeding as a contraceptive strategy -- known as the Lactational Amenorrhea Method (LAM) and have suggested that policymakers take an active role in promoting LAM (Townsend, 1992; Bender, 1998). To the extent that breastfeeding is promoted as a contraceptive strategy in the future, modeling contraceptive method choice while ignoring breastfeeding behavior and menses status will become increasingly problematic.

TABLES

Table 1: Sample Statistics -- Household Variables		
Variable Description	Mean	Standard Deviation
Log of assets per person in the household in hundreds of pesos	1.73	1.18
Days since the previous birth/100	3.30	2.07
Dummy indicating whether the mother has returned to menses	0.54	0.50
Dummy indicating whether the mother thinks that breastfeeding will delay conception or offers protection from conception	0.34	0.48
Dummy indicating whether the mother did not respond to questions about the effect of breastfeeding on conception	0.50	0.50
Dummy indicating whether the partner is presently absent	0.10	0.31
Dummy indicating whether the household is urban	0.74	0.44
Dummy indicating whether the mother is pregnant	0.04	0.20
Dummy indicating whether the mother has returned to menses, conditional on not being pregnant	0.20	0.40
Father's age	30.50	6.70
Father's years of completed education	7.11	3.41
Mother's age	27.93	6.12
Mother's years of completed education	6.89	3.26
Log of mother's body mass index (weight)/(height squared)	0.71	0.13
Number of times the mother breastfed the previous day	5.18	5.01
Number of children in the household	3.16	1.97
Mother’s age at menarche	14.00	1.59
Number of years the couple has been married	8.16	5.15

Table 2: Sample Statistics -- Market Variables		
Variable Description	Mean	Standard Deviation
Price* for 100 grams of infant formula	2.58	2.33
Dummy indicating whether there is no infant formula available in the barangay	0.44	.50
Price per liter of evaporated milk	0.83	.59
Dummy indicating whether there is no evaporated milk available in the barangay	0.32	.47
Mean price of pills and condoms at the closest private provider	1.53	1.09

Mean distance to the closest public and private provider of pills and condoms**	1.90	2.91
Price of condoms at the closest public provider	0.04	.07
Price of condoms at the closest private provider	0.49	.35
Price of pills at the closest public provider	0.37	.51
Price of pills at the closest private provider	5.56	3.93
Price of IUDs at the closest public provider	1.00	1.41
Price of IUDs at the closest private provider	2.71	3.54
Price of female sterilization at the closest public provider	21.61	54.51
Price of female sterilization at the closest private provider	291.42	277.25
Mean distance to the closest public and private provider of condoms and pills**	2.01	0.96
Mean distance to the closest public and private provider of IUDs**	2.83	4.45
Mean distance to the closest public and private provider of female sterilization**	3.98	5.44
Price of kerosine in the barangay	538.68	115.90
Price of corn in the barangay	263.85	30.32

* Price in pesos
** Distance in kilometers

Table 3: Breastfeeding Frequency Equation Results
Including Controls for Error Term Correlation
n = 16,655

Variable	Coefficient	Standard Error
Constant	9.2168 [c]	0.9722
Log of household assets per person	-0.1478 [c]	0.0326
Number of children in the household	0.0430 [a]	0.0259
Age of the youngest child in days	-0.0004	0.0007
Age of the youngest child in days squared	-0.0054 [c]	0.0009
Father's age	0.00004	0.0082
Father's years of completed education	-0.0384 [c]	0.0129
Mother's age	-0.0574	0.0450
Mother's age squared	0.0617	0.0747
Mother's years of completed education	-0.1040 [c]	0.0142
Indicator that mother believes breastfeeding delays conception	0.2380[b]	0.1071

Indicator that data for variable "Indicator that breastfeeding delays conception" was missing	0.2438[b]	0.1019
Indicator of previous return to menses	-0.6798 [c]	0.0820
Indicator of absent spouse	-0.4377 [c]	0.1190
Indicator of urban residence	0.1544 [a]	0.0925
Distance to closest source of either pills or condoms in kilometers	-0.0112	0.0133
Average price of pills and condoms at closest private and public source	-0.0140	0.0329
Price of 10 grams of infant formula	0.0442	0.0744
Price of 1 liter of evaporated milk	0.1005	0.2429
Indicator of no infant formula available in barangay	-0.3739	0.3463
Indicator of no evaporated milk available in barangay	0.2312	0.3119
Price of kerosine in barangay	0.0006 [a]	0.00034
Price of corn in barangay	0.0012	0.0015

a denotes significant with 90% confidence (t-score > 1.645)
b denotes significant with 95% confidence (t-score > 1.960)

c denotes significant with 99% confidence (t-score > 2.576)

Table 4: Multinomial Logit Method Choice Equation Results
Including Controls for Error Term Correlation
n = 24,101

	Traditional vs. No method	Condom vs. No method	Pill vs. No method	IUD vs. No method	Sterilization vs. No method
Explanatory Variables	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Constant	-9.2592 [a] (0.7593)	-4.3655 [c] (1.0345)	-15.3606 [c] (1.1462)	-9.8462 [c] (1.0138)	-17.7168 [c] (1.6716)
Log of household assets per person	-0.0051 (0.0323)	0.1163 [b] (0.0558)	0.2134 [c] (0.0463)	0.2036 [c] (0.0645)	0.05031 (0.0659)
Number of Children in the household	0.0339 (0.0246)	-0.0528 (0.0421)	0.2209 [c] (0.0512)	0.0539 (0.0626)	0.1925 [c] (0.0463)
Days since birth	0.0031 [a] (0.0002)	0.0010 [c] (0.0003)	-0.0039 [c] (0.0003)	-0.0024 [c] (0.0005)	-0.0065 [c] (0.0007)
Father's age	0.0026 (0.0083)	-0.0286 [b] (0.0130)	-0.0520 [c] (0.0133)	-0.0369 (0.0191)	-0.0314 [a] (.0166)
Father's years of completed education	0.0302 [b] (0.0120)	-0.0115 (0.0220)	0.0426 [a] (0.0244)	-0.0839 [c] (0.0288)	0.0053 (0.0267)
Mother's age	0.2244 [a] (0.0479)	0.0774 (0.0670)	0.4736 [c] (0.0805)	0.4596 [c] (0.0868)	0.9318 [c] (0.1108)

Mother's age squared	-0.3473 [a] (0.0778)	-0.1514 (0.1129)	-0.8808 [c] (0.1386)	-0.9077 [c] (0.1607)	-1.4003 [c] (0.1820)
Mother's years of completed education	0.0527 [a] (0.0126)	0.1135 [c] (0.0250)	0.0279 (0.0222)	0.0685 [b] (0.0299)	0.0644 [b] (0.0273)
Dummy signifying menstruating last period	0.7791 [a] (0.0659)	0.3025 [b] (0.1091)	1.9724 [c] (0.1268)	0.3496 [b] (0.1605)	0.3212 [a] (0.1892)
Dummy signifying absence of spouse	-2.0843 [a] (0.1214)	-1.6099 [c] (0.2176)	-2.3423 [c] (0.2366)	-1.3919 [c] (0.3341)	-0.9821 [c] (0.3144)
Price of corn in the barangay	-0.0008 (0.0009)	-0.0068 [c] (0.0016)	0.0036 [b] (0.0016)	-0.0011 (0.0023)	-0.0013 (0.0023)
Dummy signifying urban status of household	-0.5180 [a] (0.1222)	-0.7562 [c] (0.2025)	-0.2050 (0.2084)	0.1678 (0.2731)	0.2871 (0.3335)
Distance to closest provider of condoms and pills	-0.0491 [b] (0.0163)	-0.0997 [b] (0.0458)	-0.1087 [c] (0.0301)	0.0106 (0.0426)	-0.0752 (0.0498)
Distance to closest provider of IUDs	0.0189 (0.0294)	0.0273 (0.0432)	0.0119 (0.0536)	0.0481 (0.0410)	-0.0298 (0.0555)
Distance to closest provider of sterilization	-0.0516 [b] (0.0263)	0.0238 (0.0369)	-0.0065 (0.0477)	-0.0557 (0.0370)	-0.1443 [c] (0.0291)
Price of condoms at closest public provider	0.6807 [c] (0.4460)	0.7455 (0.7519)	-1.6970 [b] (0.8124)	-3.4150 [c] (1.0806)	0.5148 (0.9743)
Price of condoms at closest private provider	-0.7195 [a] (0.1309)	-0.9150 [c] (0.2204)	-0.0625 (0.2269)	-0.4903 (0.3285)	0.1246 (0.3420)
Price of pills at closest public provider	0.1109 (0.0685)	0.0563 (0.1111)	0.2470 [b] (0.1073)	0.1102 (0.1321)	0.2588 [a] (0.1546)
Price of pills at closest private provider	0.0331 [b] (0.0112)	0.0331 [b] (0.0168)	0.0434 [b] (0.0184)	0.0550 [b] (0.0242)	-0.0121 (0.0263)
Price of IUDs at closest public provider	0.0645 [c] (0.0234)	0.0311 (0.0385)	-0.0424 (0.0365)	-0.0706 (0.0605)	-0.0734 (0.0510)
Price of IUDs at closest private provider	-0.0211 [a] (0.0117)	-0.0173 (0.0171)	-0.0044 (0.0168)	-0.7603 [c] (0.0203)	0.0167 (0.0212)
Price of sterilization at closest public provider	-0.0288 [c] (0.0092)	-0.0380 [b] (0.0161)	0.0201 (0.0157)	-0.0424 [a] (0.0237)	0.0347 [a] (0.0193)
Price of sterilization at closest private provider	0.0014 (0.0014)	-0.0021 (0.0024)	0.0085 [c] (0.0023)	0.0075 [b] (0.0030)	0.0110 [c] (0.0030)

a denotes significant with 90% confidence (t-score > 1.645)
b denotes significant with 95% confidence (t-score > 1.960)
c denotes significant with 99% confidence (t-score > 2.576)

Table 5: Simulated Number of Pregnancies Under Various Simulations		
Simulation	Predicted Number of Pregnancies	Percentage Change in the Predicted Number of Pregnancies
Base	4456	
Mother's eduaction increases by 3 years	4277	-4.02%
Assets per household member increases by one standard deviation	4375	-1.82%
No Breastfeeding	4772	7.09%
No breastfeeding (without controlling for endogeneity)	4741	6.41%

APPENDIX A: PREGNANCY, CHILDREN AND MENSES EQUATION RESULTS

Table A1: Pregnancy Equation Results
Including Controls for Error Term Correlation
n = 26,401

Variable	Coefficient	Standard Error
Constant	-6.8155 [c]	0.9895
Days since birth	0.0110 [c]	0.0009
Days since birth squared	-0.0095 [c]	0.0010
Father's age	-0.0135 [a]	0.0080
Father's years of completed education	-0.0244 [b]	0.0121
Mother's age	0.1013	0.0660
Mother's age squared	-0.2680 [b]	0.1136
Mother's age of completed education	-0.0078	0.0127
Used traditional method in previous period	-0.5307 [c]	0.1178
Used condom in previous period	-0.3093	0.2072
Used pill in previous period	-2.7844 [c]	0.2800
Used IUD in previous period	-3.0406 [c]	0.3649
Resumed menses as of previous period	1.6946 [c]	0.1075
Spouse absent during previous period	-1.0227 [c]	0.1332
Household urban	0.2057 [b]	0.0924

b denotes significant with 95% confidence (t-score > 1.960)
c denotes significant with 99% confidence (t-score > 2.576)

Each woman who became pregnant, once the survey began, is censored from the estimation after the first survey in which she reported being pregnant until the pregnancy resulted in a live birth or was otherwise terminated. Bongaarts' proximate determinants of fertility are used as a guide in specifying the model. The basic determinants for fertile women include the following: fecundity, amenorrhea state, marital/cohabitation state (and disruption), coital frequency, and use and effectiveness of contraception. Woman's age and age squared proxy for fecundity. Amenorrhea state is jointly modeled and enters the pregnancy equation via a lagged term. Almost all of the women in the sample have been married or cohabitating – as evidenced by the fact that the women entered the survey through a pregnancy. Whether the spouse is absent at the time of the previous interview is used as a proxy for marital disruption and coital frequency. Method choice reported in the previous survey represents use and effectiveness of contraception that would effect conception.

Table A2: Children Equation Results Including Controls for Error Term Correlation n = 2,732		
Variable	Coefficient	Standard Error
Constant	-2.7439	(0.4408)
Mother's age at menarche	-0.0594 [c]	(0.0139)
Log of household assets per person	-0.1100 [c]	(0.0200)
Indicator that mother was born in her current Barangay of residence	0.1427 [c]	(0.0464)
Father's age	0.0365 [c]	(0.0051)
Father's years of completed education	-0.0193 [b]	(0.0083)
Mother's age	0.2659 [c]	(0.0291)
Mother's age squared	-0.3216 [c]	(0.0504)
Mother's years of completed education	-0.0512 [c]	(0.0088)
Indicator of urban residence	-0.0632	(0.0617)
Number of years the couple has been married	0.2001 [c]	(0.0069)

b denotes significant with 95% confidence (t-score > 1.960)
c denotes significant with 99% confidence (t-score > 2.576)

The number of children in the household, equal to the number of live births minus the total number of children who had died, is used as the dependent variable. Only information from the first longitudinal survey is used. I include the mother's age at first menstruation, whether she was born in the barangay, and the number of years that she has been married. Her age at menarche and the number of years that she has been married are included because they directly impact on her possible fertility. Whether the mother was born in her current barangay of residence is used as a proxy for access to child care. Women who live in the area where they were born are more likely to have relatives and close friends nearby that can offer child care.

Table A3: Menses Equation Results Including Controls for Error Term Correlation n = 12,783		
Variables	Coefficient	Standard Error
Constant	0.4591	0.4888
Mother’s age at menarche	-0.0461 [c]	0.0151
Number of children in the household	-0.1384 [c]	0.0178
Age of youngest child in days	0.0018 [c]	0.0005
Age of youngest child in days, squared	0.0006	0.0007
Mother's age	-0.1145 [c]	0.0313
Mother's age squared	0.2173 [c]	0.0526
Mother's body mass index: ln(weight/height^2) in the previous period	0.5342 [c]	0.1963
Breastfeeding intensity in the previous period	-0.0626 [c]	0.0051

c denotes significant with 99% confidence (t-score > 2.576)

The menses equation approximates a largely biological relationship. I therefore lean heavily on research from other disciplines to specify the model. Research indicates that breastfeeding, nutrition, health, time since birth, age, age at menarche and number of births all effect the mother's hormonal profile and are the most important determinants of return to menses (Zohoori and Popkin, 1996). To proxy for the nutritional and health status of the mother, The log of the woman's body mass index (BMI), which is simply the ratio of the woman's weight to the square of her height is used because the relationship between the BMI and a woman's health and nutrition status is not linear. Also included in the model are age, age squared, age at menarche, the number of children in the household, days since birth, and days squared. The squared terms are also included to account for possible non-linearities.

The results of the menses equation are consistent with the literature (Srinivasan, Pathak, and Pandey, 1989). Most importantly, the theoretical model's assumption that increased breastfeeding reduces the hazard of resumption of menses is supported by the results of the statistical model.

APPENDIX B: DISCRETE FACTOR RESULTS

The unconditional likelihood function was estimated with four factors to approximate the community level unobservable distribution (T_c) and four factors to approximate the individual level unobservable distribution (T_i). Table B1 and B2 show the probability weights (PW) associated with each mass point in the community and individual level distributions respectively and the values of all the factors that make up the distributions. The T_c and T_i for the first point of support in each distribution are normalized at 0.0 to identify the remainder of the individual level unobserved heterogeneity parameters.

Table B1: Community Level Heterogeneity Results -- Predicted Probability Weights and T_c

	Parameter Estimates of T_c at Each Mass Point (Standard Error)			
	1	2	3	4
Probability Weight	0.4834	0.2800	0.1457	0.0909
Equation				
Pregnancy	0.0*	-0.1068 (0.0685)	0.0420 (0.1859)	-0.1103 (0.1659)
Menses	0.0	0.0046 (0.0490)	-0.3620 [c] (0.1269)	-0.4051 [c] (0.1132)
Method choice:				
Traditional vs. No method	0.0	0.0017 [b] (0.0838)	0.0770 (0.2120)	-0.6010 [c] (0.2136)
Condom vs. No method	0.0	0.5922 [c] (0.1790)	-0.7706 [a] (0.4131)	-3.7642 [c] (0.7431)
Pill vs. No method	0.0	-0.2823 [b] (0.1300)	-0.1784 (0.3582)	-3.7177 [c] (0.5514)
IUD vs. No method	0.0	0.4832 [c] (0.1774)	-0.2713 (0.6630)	-2.3705 [b] (1.0046)
Female sterilization vs. No method	0.0	-0.5147 [b] (0.2040)	1.2104 [c] (0.3809)	-1.7572 [b] (0.8372)
Breastfeeding frequency	0.0	0.8429 [c] (0.0734)	1.8307 [c] (0.1741)	2.1743 [c] (0.1587)
Number of children	0.0	0.0531 (0.0468)	0.0498 (0.1205)	0.0510 (0.1161)

* Value of first mass point normalized to 0.0 in each equation.
a Denotes significant with 90% confidence (t-score > 1.645).
b Denotes significant with 95% confidence (t-score > 1.960).
c Denotes significant with 99% confidence (t-score > 2.576).

Table B2: Individual Level Heterogeneity Results -- Predicted Probability Weights and T_i				
	Parameter Estimates of T_i at Each Point of Support (Standard Error)			
	1	2	3	4
Probability Weights	0.5240	0.1427	0.0710	0.2624
Equation				
Pregnancy	0.0*	0.5489[c] (0.1476)	0.0946 (0.1851)	0.1629 (0.1171)
Menses	0.0	0.8152[c] (0.0917)	0.5202[c] (0.0984)	0.5963[c] (0.0599)
Method choice:				
Traditional vs. No method	0.0	2.3892 [c] (0.1329)	2.5393 [c] (0.1422)	4.5751 (0.0875)
Condom vs. No method	0.0	2.4549 [c] (0.2190)	5.7409 [c] (0.1659)	1.8273 [c] (0.2186)
Pill vs. No method	0.0	5.4427 [c] (0.1365)	1.0122 [c] (0.3010)	1.2345 [c] (0.2301)
IUD vs. No method	0.0	1.4285 [c] (0.2828)	1.3127 [c] (0.4021)	1.2618 [c] (0.2590)
Female sterilization vs. No method	0.0	1.0368 [c] (0.3902)	0.0272 (0.5048)	0.0105 (0.3613)
Breastfeeding frequency	0.0	-2.1157[c] (0.1567)	-0.1919 (0.1626)	-0.1405 (0.0960)
Number of children	0.0	0.1512[a] (0.0907)	0.1289 (0.0974)	0.1080[a] (0.1080)

* Value of first mass point normalized to 0.0 in each equation.
a Denotes significant with 90% confidence (t-score > 1.645).
b Denotes significant with 95% confidence (t-score > 1.960).
c Denotes significant with 99% confidence (t-score > 2.576).

The significance of the results in Tables B1 and B2 strongly suggest that estimating the equations without allowing for error term correlation could produce biased results.

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[1]The period of time after the birth of a child and before the resumption of menses.

[2]See DeLeon and Potter, 1989; Akin, Bilsborrow, Guilkey, and Popkin, 1986; Jain and Bongaarts, 1981; Knodel and Debavalya, 1980; Millman, 1985; Pebley, Goldberg, and Menken, 1985; Zurayk, H., 1981

[3] See Bender, et al. (1998) for a review of the Lactational Amenorrhea Method of contraception.

[4] For the purposes of this study, "family planning" is defined as any means of fertility control.

[5]One possibly important unobserved factor is the degree to which women are affected by the incompatibility of breastfeeding with estrogen-based contraceptives -- most oral contraceptives (i.e. pills) and some IUDs. Breastfeeding and estrogen-based contraceptives are incompatible for two reasons, one physiological and the other behavioral. First, estrogen reduces the production of breast milk, which can lead to reduced breastfeeding. Second, estrogen may have an adverse effect on the nursing child if it passes into the breast milk (Saarikoski, 1993; Network, 1992; Hull, 1981). Knowledge of this adverse effect would almost certainly lead some women either to cease breastfeeding when adopting estrogen-based contraceptives or to delay their use of estrogen-based contraceptives

while breastfeeding.

[6]DeLeon and Potter (1989) and Millman (1985) both discuss the possibility of such bias but then claim that it could not affect their results since they include many of the factors that would determine each outcome. Since many possible bias-causing factors are unobservable, it seems unlikely that they could have completely controlled for endogeneity bias in this way.

[7]The basic structure of the model follows David, Mroz, and Wachter (1987) and Newman (1988), who explicitly model contraceptive choice as an integral part of birth spacing behavior. These models differ from the one presented here in that they did not include breastfeeding or post-partum amenorrhea. Where the results of this paper can be compared to these previous studies, they are similar.

[8]"Reasonable" meaning fertility control that balances effectiveness and cost.

[9]Here, leisure is defined as time spent at activities other than work outside the home or breastfeeding. This includes all types of home production.

[10]Allowing the mother's time allocation choices to include a labor supply decision would increase the complexity of the model (e.g. working women face an opportunity cost of their time equal to their wage rate for the hours that they work) without substantively affecting the results of interest.

[11]This assumption could be relaxed without affecting the model's results if it is further assumed that more effective methods negatively affect utility because of adverse side effects or other non-pecuniary costs.

[12]This is a rather strong assumption. It is possible for a woman to ovulate, and therefore conceive, before menses resumes. Incorporating this probability into the model would increase the complexity without substantially altering the results. Most notably, it would provide a reason for couples to adopt contraception before menses resumes. Such an extension would be useful in motivating research aimed at predicting contraceptive switching (e.g. from less effective to more effective methods) in the first year or so after the birth of a child.

[13]It should be noted that this model does not make allowances for the fact that women with more children may face a higher opportunity cost of time. Since the opportunity cost of time is the major cost of breastfeeding, women in households with more children may breastfeed less.

[14]It is assumed that the health benefit to breastfeeding diminishes as the infant gets older.

[15]A more mathematically detailed rendering of the theoretical model is available from the author as part of the Technical Appendix.

[16]Over the two years of the survey, 150 of the 3327 infants in the study died. If mothers believe that breastfeeding is a determinant of infant health and mortality, treating infant mortality over the survey period as exogenous may be problematic. For example, mothers with an unhealthy infant might breastfeed more if they believe that breast milk is more healthy than alternatives. Alternatively, if unhealthy children are too weak to nurse, then less breastfeeding might be observed in households with an infant death. To the extent that infant mortality over the survey period indicates an unobserved factor that is correlated with breastfeeding, the coefficient in the breastfeeding equation associated with the number of children in the household may be biased.

[17]An interesting extension to this paper might be to compare results using a discrete measure of breastfeeding to those using a continuous measure similar to the one used here.

[18]Although highly correlated, resumption of menses and ovulation are not perfectly correlated. It is possible that a woman will ovulate before resuming menses. For this reason, some women begin to use contraception before menses resumes. See also, footnote 12.

[19]According to a simplifying assumption of the theoretical model, women would not adopt a contraceptive until menses resumes. However, women are generally aware that they can ovulate, and therefore conceive, before menses resumes. As a result, couples sometimes begin to use contraception before menses resumes. For the same reason, resumption of menses is include as an explanatory variable in the hazard of conception equation.

[20]The full list of variables included in each equation can be found in Tables 3 and 4 in the Empirical Results section of this paper and in Appendix A.

[21]A full description of the likelihood function is available from the author as part of the Technical Appendix.

[22] The longitudinal nature of the data set and the community-based sampling used for the survey create an additional estimation problem. The same households are observed over several time periods and the survey involves households from only 33 barangays -- out of 243 in the survey area. It is likely that the observed behavior of the same individual over time or even individuals from the same community will be more homogeneous than observations chosen from the population at random. The resultant autocorrelation would result in incorrectly low standard errors if it were not controlled. Technically, this problem is caused by common unobservables correlated with each error term that contribute to similar behavior by either each individual over time or individuals from the same communities. The discrete factor estimation technique controls for unobserved factors that are correlated with each equation's error term, so, in these estimations, the standard errors are correct.

[23] The parameters in the model are technically identified by the nonlinear functional form of the equations. The model gains further identification because each equation contains contemporaneous exc lusion restrictions. The exclusion restrictions in each equation are listed in the Technical Appendix available from the author. Additional identification comes from the time varying nature of some of the explanatory variables and from the fact that individuals are observed making multiple decisions over twelve time periods (Chamberlain, 1984; Heckman and Honore, 1990; Cameron and Taber, 1994; Mroz and Surette, 1998).

[24]A detailed explanation of the discrete factor method can be found in the Technical Appendix.

[25]Although over 95% of women who responded answered that they thought that breastfeeding would delay conception, 50% of the women surveyed did not respond one way or the other and the variable was coded as missing. To control for this problem, the variable was assigned a value of 0 if the variable was coded as missing and a second variable was included which takes on a value of 1 if the woman did not respond and 0 if she did.

[26]In using the same (CLHNS) data, Stewart et al. (1991) find that spousal absence decreases the likelihood that during the sixth month of pregnancy the mother intends to breastfeed. They suggest that mothers in households with no father will have a higher opportunity cost of time, and will, therefore, be less likely to breastfeed. As some evidence that the Stewart hypothesis may be incorrect, alternate specifications of the model including variables indicating the amount of household help (e.g. number of relatives in the household) do not alter our result.

[27]The 63 observations where the father was reported to have obtained a vasectomy are dropped from the sample because the relatively low number of men who underwent the procedure create statistical difficulties. Merging male and female sterilization into one category is not feasible because of the large differences in the price of and the distance to each method.

[28]Although a mixed multinomial logit specification would be more parsimonious, that specification assumes that the effect of variables such as price and distance are the same for all choices. A likelihood ratio test strongly rejected that assumption.

[29]Postpartum amenorrhea is all but ignored in previous studies of contraceptive method choice. Exceptions include Schwartz, Akin, Guilkey and Paqueo (1989), Schwartz and Flieger (1989) and DeGraff (1991). Schwartz et al. include whether the woman is amenorrheic in their contraceptive use equation and find use of all methods studied statistically significantly increases once menses resumes. Using data from the first six longitudinal surveys of the CLHNS, but limiting their analysis to bivariate comparisons, Schwartz and Flieger find that resumption of menses leads couples to switch to a more effective method. DeGraff proxies for resumption of menses by including a variable indicating whether the mother is still breastfeeding. DeGraff finds that breastfeeding women are less likely to use contraception. Neither Schwartz et al. nor DeGraff control for the possible endogeneity of breastfeeding or amenorrhea.

[30]A likelihood ratio test was performed to test the null hypothesis that the 54 unobserved heterogeneity parameters (27 T_c and 27 T_i) are equal to zero. This test had a chi-square test statistic of 12,602.94. Since the chi-square critical value for a 95% test with 54 degrees of freedom is 71.87, the null hypothesis that the 54 heterogeneity parameters are jointly zero is strongly rejected.

[31]While this simulation involves exogenously changing an endogenous variable, it is the best way to measure the magnitude of a change in breastfeeding on contraceptive use and fertility, ceteris paribus.

[32]The results of the empirical model without controls for unobserved heterogeneity biases are available from the author as part of the Technical Appendix.