VIENNA INSTITUTE OF DEMOGRAPHY

Working Papers

04 / 2005

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Learning by Doing and Learning from Others in Contraceptive Technology

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Abstract

This paper provides a theoretical and empirical investigation of the impact of social learning on modern contraceptive prevalence. A theory is developed where own or neighbors' experience increases the benefit from using modern contraceptives by reducing the uncertainty regarding contraceptive efficacy. Empirical results from the Indonesian Family Life Survey suggest that the more own experience of modern contraceptives a woman has she is more likely to use those methods. However, neighbors' experience does not have a significant impact on one's current usage of contraceptives. One explanation of these findings is that the information on contraceptive efficacy, or failure rates is likely to contain much noise when women communicate with each other. These findings contrast those of recent literature, which show the adoption of contraceptives by one's social contacts has positive impact on one's own adoption.

Keywords

Knowledge Diffusion, Social Learning, Contraceptive Technology, and Indonesia.

JEL Classification Number: D83, J13.

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Acknowledgements

I would like to thank Andrew Foster for his valuable insights and excellent guidance. I also would like to thank Mark Pitt, Kaivan Munshi, and Hans-Peter Kohler for their valuable discussions. However, I am responsible for all the remaining errors.

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1 Introduction

Recent developments in the literature on social learning have provided some evidence on externalities generated by the experience of neighbors. In the example of an agricultural technology, Foster & Rosenzweig (1995) showed that farmers learn from their own and neighbors' experience in adopting new high yield crop varieties when uncertain about the optimal fertilizer use. Since social learning involves the adoption of new technology, the introduction of the modern contraceptives in developing countries provides a good situation where social learning may take place. In the demography literature, social learning implicated the studies detailing that one is more likely to adopt modern birth control methods the more people in one's social network have already done so (Montgomery et. al. 2001 and Behrman, Kohler & Watkins 2002). However, the inference from the impact of neighbors' experience on one's usage of contraceptives is not based on any consideration on the return to learning about modern contraceptives. When the return to learning in contraceptive technology is considered, social learning may generate different implications.

Two potential informational contents in contraceptive technology are the efficacy of a method and its side effects. Since the side effect is likely to be related to a method itself rather than usage in practice, the goal of the paper is to investigate both theoretically and empirically how the reduction in the uncertainty regarding efficacy is going to affect choice of contraception.

In general, a key aspect of the learning process in agricultural industry is that the productivity of crop is affected by own or neighbors' experience as pointed out by Foster & Rosenzweig (1995). In the case of contraceptive technology, however, the return to learning is not clear. Therefore, the paper develops a theory where the accumulation of own and neighbors' experience increases the benefit from using contraceptives by reducing uncertainty regarding contraceptive efficacy. While previous literature on social learning in contraceptive technology examined a process of choosing between modern and traditional contraceptive methods (Kohler 1997) or a process of social interaction (Munshi & Myaux 2002), this study focuses on a learning mechanism specific to contraceptive technology.

The theoretical part of the paper demonstrates that the choice of current contraception is affected by first and second moments of contraceptive efficacy. The first moment, the mean of efficacy, could have a positive or negative impact on contraception depending on the parameter values, whereas the second moment, the expected squared efficacy, always has a negative impact. Assuming that prior knowledge of contraceptive efficacy is correct on average, a Bayesian learning model generates an implication about the expected path of first and second moments of efficacy; on average, the posterior first moment is constant, whereas the posterior second moment is always decreasing as experience of contraceptive usage is accumulated. Therefore, the theory generates a testable implication distinctive from previous literature. That is, own cumulative experience as well as those of neighbors' will increase the benefit of using modern contraceptives.

The empirical part of the paper tests the hypothesis of *learning by doing and learning from others* using a panel sample from the Indonesian Family Life Survey. A well-known problem in the estimation of the determinants of contraceptive usage is that the choice of using contraceptives is likely to be positively correlated with unobserved fecundity at the individual and at the community levels. In addition, it is likely that the change in experience is correlated with realization of contraceptive failure. An individual fixed-effect instrumental variables estimation in a linear probability model is taken to remove such a correlation.

The results suggest that a woman is more likely to use modern contraceptives the more experience of her own she has. However, neighbors' experience does not seem to have a significant impact on one's current usage of contraceptives. One explanation of these findings is that the information on contraceptive efficacy, or failure rates is likely to contain much noise when women communicate with each other as discussed by Kohler (1997) and Montgomery & Casterline (1998) among others. These results contrast a body of literature that finds the positive impact of the adoption by one's social contacts on his or her adoption of modern birth control methods (Montgomery et. al. 2001 and Behrman, Kohler & Watkins 2002).

The rest of the paper is organized as follows. Section 2 discusses the uncertainty of contraceptive technology and contraceptive prevalence in Indonesia. Section 3 presents an economic model of social learning in the context of adoption of modern contraceptives. Section 4 provides a description of the data. Section 5 presents the empirical findings. Section 6 concludes.

2 Modern Methods of Birth Control

The benefit of using contraceptives is to prevent pregnancies, but no method other than sterilization is perfect. Moreover, the failure rate varies across different methods. Table 1 presents the contraceptive failure rate by method as estimated by Trussell & Vaughan (1999) using the 1995 National Survey of Family Growth in the U.S.[1] The contraceptive failure rate is defined as the proportion of women experiencing an unintended pregnancy during 12 months of typical contraceptive use. These estimates can be considered as the failure rates for typical use. As can be seen in Table 1, modern methods have significantly lower failure rates than do traditional methods like withdrawal and periodic abstinence. The failure rates for modern methods vary from 2.3 percent for implant to 18.4 percent for sponge.

[Table 1 about here.]

In Indonesia, contraceptives are available at public providers like family planning clinics and private providers like hospitals and midwives. Women visit contraceptive providers for consultation, which includes discussion on proper usage of contraceptives, general failure rates and side effects. Although the contraceptive efficacy (failure rate) an individual perceives differs by region for various reasons including social norms of sexual activity or level of sex education in each community, it is plausible that the expectation on the distribution of efficacy will eventually converge to the true rate as more experience is accumulated. However, the expected path of convergence may differ depending on the amount of experience available in a community, which is explored as a source for social learning in the next section.

[1] Although it is hard to perfectly take into account the selection issue and the underreporting of abortion related to users of different methods, a body of empirical studies provides roughly consistent results.

[Table 2 about here.]

The more effective class of contraceptive methods is more widely used in Indonesia. Table 2 shows the share of contraceptives used by current users in the Indonesian Family Life Survey (IFLS) in 1993 and 1997. In both years, pills, injection, IUD, and implant account for more than 80 percent of women using contraceptives. Due to the availability of data on experience with contraceptives, the hypothesis of *learning by doing and learning from others* is tested by examining the current usage of these four most effective and most popular methods in the IFLS sample.

3 An Economic Model of Social Learning

This section establishes a hypothesis that accumulation of experience has a positive impact on current usage of modern contraceptives in two steps. First, it presents a simple two-period model in an expected utility framework where lower expected value of squared efficacy leads to higher chance of engaging in contraception in the first period. Second, it identifies a set of conditions under which accumulation of experience reduces the expected value of squared efficacy in a Bayesian learning model.

Consider a woman who is fertile for two periods. She is at the risk of pregnancy in each period. No time discounting is assumed. She cares only about the total number of children she has after her reproductive periods end. She prefers to have only one child in her lifetime. That is, $u0 < u1$ and $u2 < u1$, where $u0$, $u1$, and $u2$ denote the life-time utilities of having no child, one child and two children, respectively. Her natural fertility is represented by p, which is the probability of being pregnant without any contraception effort. The contraceptive efficacy is denoted by e $(0 < e < 1)$, in which case the probability of being pregnant with a contraceptive is pe. Note that a lower value of e implies more effective contraception. Therefore, contraceptive efficacy, e, can be considered as failure rate. Contraceptives are assumed to be costless.

Notice that the choice of engaging in contraception in the second period is determined by the birth outcome in the first period, because her goal is to have only one child. The expected utility associated with contraception choice in the first period is denoted by $EU(y)$, where y is an index for using contraceptives. Then, the expected utility when each choice is made is the following.

$$EU(0) = E\{(1-p)[(1-p)u_0 + pu_1] + p[(1-pe)u_1 + peu_2]\} \quad (1)$$
$$EU(1) = E\{(1-pe)[(1-p)u_0 + pu_1] + pe[(1-pe)u_1 + peu_2]\} \quad (2)$$

The decision to engage in contraception in the first period depends on the relative magnitude of these two utilities.

$$\begin{aligned} y = 1 \quad &\Leftrightarrow \quad EU(1) - EU(0) > 0 \\ &\Leftrightarrow \quad -p^2(u_1 - u_2)E(e^2) + [p(u_1 - u_0) + p^2(u_0 - u_2)]E(e) \\ &\qquad -p(1-p)(u_1 - u_0) > 0 \end{aligned} \quad (3)$$

Therefore, an increase in the first moment of efficacy could have a positive or negative impact on contraceptive usage in period 1 depending on the utility values associated with different numbers of children. On the other hand, an increase in the second moment always discourages contraception in period 1 by multiplying the utility loss from having one more child than optimal. In what follows, a Bayesian learning model is developed in order to examine how expected efficacy and expected squared efficacy converge to the true values with accumulation of experience. A special attention is paid to the case in which a prior is unbiased, that is, the parameters of prior are distributed such that the expectation of prior mean over parameter values in papulation equals the true value of efficacy.

Suppose there exists a true efficacy (failure rate), e, across villages. An individual has a prior of beta(α, β) distribution.[2]

$$\pi(e) = \frac{e^{\alpha-1}(1-e)^{\beta-1}}{\int_0^1 e^{\alpha-1}(1-e)^{\beta-1}}, 0 < e < 1, \alpha > 0, \beta > 0 \tag{4}$$

An individual observes N independent draws from a $Bernoulli(e)$ distribution at time t. In other words, she observes y failures out of N trials, where y has a $binomial(N, e)$ distribution.

$$\begin{aligned} & x_1, x_2, ..., x_N \sim^{i.i.d.} Bernoulli(e) \\ \Leftrightarrow \ & y \sim binomial(N, e) \end{aligned} \tag{5}$$

When $f(x_1, ..., x_N|e)$ is the likelihood of data given a prior and $\pi(e)$ is prior density, the posterior density is calculated by applying Bayes' Rule.

$$\begin{aligned} \pi(e|x_1, ..., x_N) &= \frac{f(x_1, ..., x_N|e)\pi(e)}{\int_0^1 f(x_1, ..., x_N|\theta)\pi(\theta)d\theta} \\ &= \frac{e^y(1-e)^{N-y}e^{\alpha-1}(1-e)^{\beta-1}}{\int_0^1 \theta^y(1-\theta)^{N-y}\theta^{\alpha-1}(1-\theta)^{\beta-1}d\theta} \\ &= \frac{e^{y+\alpha-1}(1-e)^{N-y+\beta-1}}{\int_0^1 \theta^{y+\alpha-1}(1-\theta)^{N-y+\beta-1}d\theta} \\ &= beta(y+\alpha, N-y+\beta) \end{aligned} \tag{6}$$

The posterior density represents $beta(y + \alpha, N - y + \beta)$ distribution. Accordingly, $E_t(e|x_1, ..., x_N)$ and $E_t(e^2|x_1, ..., x_N)$ can be computed using the posterior density.

$$\begin{aligned} E_t(e|x_1, ..., x_N) &= \frac{\int_0^1 \theta f(x_1, ..., x_N|\theta)\pi(\theta)d\theta}{\int_0^1 f(x_1, ..., x_N|\theta)\pi(\theta)d\theta} \\ &= \frac{y+\alpha}{N+\alpha+\beta} \end{aligned} \tag{7}$$

$$\begin{aligned} E_t(e^2|x_1, ..., x_N) &= \frac{\int_0^1 \theta^2 f(x_1, ..., x_N|\theta)\pi(\theta)d\theta}{\int_0^1 f(x_1, ..., x_N|\theta)\pi(\theta)d\theta} \\ &= \frac{(y+\alpha)(y+\alpha+1)}{(N+\alpha+\beta)(N+\alpha+\beta+1)} \end{aligned} \tag{8}$$

Since the actual number of failures are not observed, the effect of an increase in experience on the expected squared efficacy is examined by taking the approximation $y \approx eN$ for large

[2]There are few probability densities defined on an interval (0,1), and the beta distribution is reasonably flexible for two reasons. First, it represents different unimodal, bimodal densities for the same mean. Second, there are three linear densities nested in beta distribution: $\pi(e) = 2e, 1, 2-2e$, $e \in (0, 1)$).

N.

$$\begin{aligned}
\frac{\partial E_t(e|x_1,...,x_N)}{\partial N} &\approx \frac{\partial}{\partial N}\left(\frac{eN+\alpha}{N+\alpha+\beta}\right) \\
&= \frac{(\alpha+\beta)e-\alpha}{(N+\alpha+\beta)^2} \qquad (9) \\
\frac{\partial E_t(e^2|x_1,...,x_N)}{\partial N} &\approx \frac{\partial}{\partial N}\left(\frac{(eN+\alpha)(eN+\alpha+1)}{(N+\alpha+\beta)(N+\alpha+\beta+1)}\right) \\
&= \frac{((2\alpha+2\beta+1)p^2-(1+2\alpha)p)N^2}{(N+\alpha+\beta)(N+\alpha+\beta+1)} \\
&\quad + \frac{((2\alpha^2+4\alpha\beta+2\beta^2+2\alpha+2\beta)p^2-2\alpha^2-2\alpha)N}{(N+\alpha+\beta)(N+\alpha+\beta+1)} \\
&\quad + \frac{(2\alpha^3+4\alpha^2\beta+2\alpha\beta^2+3\alpha^2+4\alpha\beta+\beta^2+\alpha+\beta)p}{(N+\alpha+\beta)(N+\alpha+\beta+1)} \\
&\quad + \frac{-2\alpha^3-2\alpha^2\beta-3\alpha^2-2\alpha\beta-\alpha+2\beta}{(N+\alpha+\beta)(N+\alpha+\beta+1)} \qquad (10)
\end{aligned}$$

If a prior is unbiased, or $E(e) = \frac{\alpha}{\alpha+\beta} = e$,

$$\frac{\partial E_t(e|x_1,...,x_N)}{\partial N} \approx 0 \qquad (11)$$

$$\frac{\partial E_t(e^2|x_1,...,x_N)}{\partial N} \approx -\frac{\alpha\beta}{(\alpha+\beta)^2(N+\alpha+\beta+1)^2} < 0. \qquad (12)$$

Proposition 1: If prior has beta(α, β) distribution, and is unbiased ($E(e) = \frac{\alpha}{\alpha+\beta} = e$), experience has no effect on the posterior first moment, $E_t(e|x_1,...,x_N)$, but the posterior second moment, $E_t(e^2|x_1,...,x_N)$, is decreasing as experience is accumulated for large N.

[Figure 1 about here.]

Proposition 1 states that the impact of experience on current usage of contraceptives is mainly through the expected squared efficacy when prior is unbiased. Figure 1 shows the expected path of the posterior first moment and second moment in a simulated data. As can be seen in panel (a), (c), and (e), experience has no impact on the expected path of first moment. However, panel (b), (d), and (f) illustrates that the second moment is always decreasing as experience is more accumulated for all values of efficacy. Therefore, the implication that accumulation of experience has a positive impact on current usage of contraception is tested in the empirical part of the paper.

4 Data Description

The 1993 and 1997 waves of Indonesian Family Life Survey (IFLS1 and IFLS2) are used for empirical analysis. The first wave consists of 7,224 households interviewed over the period August 1993 to February 1994. A detailed questionnaire regarding contraceptive knowledge and use was administered to 4,890 women age 15 to 49.[3] Subsequently, IFLS2 targeted all the respondents in IFLS1 and the members in the split-off households. There are 6,160

[3]These women are household heads, their wives, or the women randomly selected from the rest of household members. Refer to Frankenberg & Karoly (1993) for the complete selection rule.

women who provided information on contraceptive knowledge and use in IFLS2, and 4,352 women among them are in the panel sample. The sample of this study consists of all the women who were interviewed in the both waves and for whom there is no missing values for the relevant variables. The dependent variable in the analysis is the current contraceptive usage of four modern contraceptives; pills, injection, IUD, and implant. Those who are not exposed to the risk of pregnancy or want to have a child at the time of the survey are dropped. After the observations with missing values for the relevant variables are removed, the final sample contains 1,389 individuals. The summary statistics for the sample at individual level is presented in Table 3.

[Table 3 about here.]

The proportion of individuals who live in urban area is 42 percent in 1993 and 43 percent in 1997. Mean age is 32.7 years, and mean age at marriage is 18.4 years in 1993. Mean duration of marriage is 15.2 years in 1993. Mean years of schooling are 5.0 years in 1993, and husbands have one more year of schooling on average. Age and duration of marriage increase by around four years in 1997, whereas schooling and husband schooling increase slightly (by around a quarter of a year) in 1997. The contraceptive prevalence in 1993 is 80.7 percent in terms of ever usage of modern contraceptives. Modern contraceptives consist of pill, IUD, injectables, diagram, condom, implant, and male and female sterilization. There is a slight increase in the prevalence in 1997 (by 0.8 percent), but it is not statistically significant. In terms of current usage of contraceptives, the prevalence increased from 73.0 percent in 1993 to 73.7 percent in 1997. When only pill, IUD, injectables and implant are counted, the proportion of women who are using contraceptives currently is 67.4 percent in 1993 and 67.0 percent in 1997. The duration of contraceptive usage is defined as the number of years since the first use.[4] Mean duration of own experience with any of four contraceptives is 6.2 years in 1993 and is 8.1 years in 1997.

Two kinds of variables were constructed at village level. One is the aggregate experience of using contraceptives and the other is the measure of family planning programs. In constructing a measure of aggregate experience of using contraceptives, all the women with non-missing values on duration of contraceptive usage (any of four methods) were aggregated at village level in each wave. In order to reduce the sampling error, the communities that have less than ten observations are dropped. The final sample includes women from 181 communities.[5] As can be seen in Table 4, the average number of observations in a village is 16.1 in 1993, and 19.8 in 1997. Average duration of contraceptives usage at village level is 5.7 years in 1993, and 6.3 years in 1997.

[Table 4 about here.]

The Indonesian Family Planning Program was implemented in Java and Bali in 1971, and it was extended to ten other provinces in 1974 and to the national level since 1978. It has been noted that the Indonesian family planning programs had a significant impact on the fertility decline in Indonesia in 1980s and early 1990s (Gertler & Molyneaux 1994 and 2000). By the time of 1993, the infrastructure of family planning programs was established covering most part of the country. According to the IFLS, only 21 out of 290 villages did not have any

[4] In IFLS1, the question was asked about the year of first usage of contraception, and, then, about the kind of method. If the first method used is among the four methods, then the duration is calculated. Otherwise, the duration is treated as missing for ever-users. In IFLS2, the question on the year of first use was asked for each of four methods. The earliest year of first use among four methods was used to calculate the duration of contraception usage.

[5] There are total 312 communities in the IFLS1.

family planning clinic according to the head of villages in 1993, and the number in 1997 is 8 out of 299 villages.[6] Therefore, the change in family planning program inputs between two waves appears to be small. Three institutions have been involved in family planning program; family planning clinic, Posyandu (integrated health post), and Puskesmas (community health center). These institutions cooperate closely in terms of organizing events and supplying birth control methods. Due to the data availability the number of family planning clinics and Posyandu and the duration of their existence are used as measure of family planning programs.[7] [8] Table 4 shows that there is one family planning clinic per 220 households and one Posayndu per 20,000 households in 1993. As expected, the change in number of family planning clinics and Posyandu per 100 household heads is close to zero. The mean duration of family planning clinics increased by 2.7 years and that of Posyandu increased by 4.5 years between 1993 and 1997.

5 Empirical Framework and Results

In estimating the effect of own and neighbors' experience on the probability of engaging in contraception, a linear probability model for equation (3) is employed.

$$y_{ijt} = X_{ijt}\beta + \beta_0 + \beta_1 S_{own,ijt} + \beta_2 S_{vil,jt} + \mu_j + \eta_{i,j} + \varepsilon_{ijt} \tag{13}$$

where y_{ijt} denotes an index for the decision to use contraceptives by a woman i in village j at time t, X_{ijt} is the set of observable characteristics of a woman i in village j at time t, $S_{own,ijt}$ is the amount of own experience up to time t, $S_{vil,ijt}$ is the average amount of neighbors' experience up to time t, μ_j and $\eta_{i,j}$ represent unobservable characteristics specific to a village and to an individual, respectively, and ε_{ijt} is a random error term that is independently and identically distributed across individuals and time. If a fertile woman is more likely to use contraceptives, ignoring unobservable fecundity ($\eta_{i,j}$) will produce a spurious correlation between own experience and current contraceptive choice. Likewise, average fecundity among women may be correlated with aggregate experience at village level. Additionally, given a certain budget, local family planning program inputs have been determined by the local needs and the target set by higher administration in Indonesia. Therefore, the measures of family planning inputs are correlated with average fecundity in a village, and this correlation will bias the estimates of all the coefficients through variance and covariance structure of observable characteristics. In order to remove bias due to individual and village specific unobservables, a differenced equation of equation (13) over two periods is taken.

$$\Delta y_{ijt} = \Delta X_{ijt}\beta + \beta_1 \Delta S_{own,ijt} + \beta_2 \Delta S_{vil,jt} + \Delta\varepsilon_{ijt} \tag{14}$$

One concern in equation (14) is that change in both own and neighbors' experience is endogenous with respect to realizations of contraceptive failure. In order to address the issue, instrumental variable (IV) estimation is taken using variables in period 1 that predict the change in contraceptive experience. At the individual level, age, duration of marriage and schooling in the first wave are likely to be related to access to information on contraceptives

[6]The villages that have missing values for this question are not included in the calculation.

[7]The number and the year of foundation of family planning clinics and Posyandu in a village were asked to a head of a village and a head of women's association. The answers are not necessarily the same. Therefore, the average of the two answers is used.

[8]IFLS1 provides a detailed information on each Puskesmas up to five in a village. Therefore, the average number of workers in a Puskesmas in a village or the minimum cost of birth control methods available in a village can be constructed. However, it is questionable whether they can be considered as a consistent measure of family planning inputs at village level over two waves of IFLS.

that could lead to change in own experience in subsequent periods. At the village level, if different government programs in Indonesia come as a package as noted by Pitt, Rosenzweig, & Gibbons (1993), the level of government programs other than family planning programs in the first wave may predict a change in neighbors' experience. Specifically, the existence of public transportation, the condition of the main road, and educational facilities at the village level are used as instrumental variables.

The model in Section 2.3 predicts that own experience will have a positive impact on the probability of using contraceptives by reducing the variance of the efficacy ($\beta_1 > 0$). Neighbors' experience is also predicted to have a positive impact ($\beta_2 > 0$). Table 5 presents the results from the estimation of linear probability model using the 1993 wave. In the basic specification of column (1) in Table 5, age has a significantly negative impact on contraceptive usage, which is consistent across other specifications. Duration of marriage has a nonlinear effect, which is positive before 17.1 years of duration, and negative afterwards. Neither own schooling nor husband's schooling have a significant impact. When own and neighbors' experiences are included as in column (2) of Table 5, both coefficients on duration of own experience with contraceptives and average duration in a village are positive and significant. These estimates continue to be positive and significant when family planning program inputs are included (column (3)), but they may reflect the spurious correlation between unobservable fecundity and experience of contraceptives at the individual and village levels.

[Table 5 about here.]

This possibility of bias is examined by estimating the differenced equation later in this section. All the coefficients on the measures of family planning programs are not significant either individually or jointly. Again these coefficients may be biased due to the nonrandom placement of family planning programs.

The result from the estimation of the differenced equation is presented in Table 6, where differences in age, duration of marriage and schooling variables are dropped due to collinearity. When individual fixed effect is removed in column (1), the coefficient on squared duration of marriage is negative and significant as in Table 6. It also shows that own experience has a positive and significant impact on current usage of contraceptives, but that neighbors' experience now has an insignificant impact. Note that in terms of magnitude, the coefficient on own experience is only 20 percent of that in Table 5, which implies a positive correlation between fecundity and individual experience of contraceptives. When compared to Table 5, the insignificance of the coefficient on neighbors' experience also suggests a positive correlation between fecundity and aggregate experience at village level. The measures of family planning programs are in general insignificant except the number of family planning clinics, which implies that the marginal impact of family planning program inputs is very small between 1993 and 1997.

[Table 6 about here.]

When own and neighbors' experiences are instrumented as in column (2) of Table 6, the coefficient on own experience is still significant, and its magnitude increases by 20 times compared to fixed-effect estimation. The magnitude of the impact of neighbors' experience increases three-fold, but still remains insignificant. The comparison between column (1) and column (2) in Table 6 shows that it is important to take into account the endogeneity of experience with respect to realizations of contraceptive failures. The main result suggests that there is learning by doing in contraceptive technology but that there is little evidence for learning from others. One year of own experience increases the probability of engaging in contraceptives by 10 percent based on the individual fixed-effect instrumental variables estimation. The lack of evidence for learning from others can be interpreted as an imperfect transfer of information in learning from others.

It is true that the assumption of unbiased prior is crucial in the theoretical implication of the model. As discussed earlier, given that the information on failure rate is available from contraceptive providers, it is hard to expect individuals to have a systematically wrong prior. We can also consider an alternative one-period model where people tend to underestimate the benefit of new technology. Since experience will increase the benefit of using contraceptives in every period given its cost through the realization of efficacy, social learning may take place. This alternative model and the model in the study generate for most of cases the same implication that experience will increase the benefit of using modern contraceptives. However, they have different predictions on the last of period of reproduction. Alternative model implies that there is learning from experience in the last period, whereas the model in the study implies no learning from experience in the last period. Although it is hard to tell which year a woman's last reproduction period is, it will be informative to see the effect of learning from experience is different across age groups. As can be seen in columns (3) and (4) of Table 6, the effect of learning by doing is still present for women who were 40 and less years old in 1993, whereas it does not exist for women who were older than 40 years in 1993. These results provide a limited evidence that prior mean on contraceptive efficacy is correct on average.

6 Conclusion

This paper develops a learning mechanism in the context of contraceptive technology, and generates two implications. First, the choice of engaging in contraception is affected by the expected path of convergence of expected contraceptive efficacy and expected squared efficacy. Second, when a prior is unbiased, as experience is accumulated, the expected squared efficacy is decreasing, whereas there is no general path for the expected efficacy. Therefore, own or neighbors' experience will have a positive impact on current contraceptive usage by reducing the uncertainty regarding the expected squared efficacy. The result suggests that there is learning by doing in adopting modern birth control methods, but it finds no evidence for learning from others. It can be interpreted that there exists an imperfect transfer of information on contraceptive usage. This result contrasts the finding in recent literature on social network that the adoption by one's social contacts has a positive impact on his or her own adoption. In addition, the effect of learning by doing appears to be different across age groups, which provides a limited support for the assumption that prior mean on contraceptive efficacy is unbiased.

This research can be extended in several ways. One is to investigate whether education and experience are substitutes or complements in the learning process. Further, it will be also interesting to check the implication of the possible correlation between education and the amount of noise in the information of one's experience. Another is to examine how to distinguish empirically between social learning and social interaction in the context of adoption of modern birth control methods.

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Appendix

A First Stage Estimation in Table 6

As discussed in Section 5, one concern in equation (14) is that change in both own and neighbors' experience is endogenous with respect to realizations of contraceptive failure. One solution is to take instrumental variable estimation using variables in period 1 that predict the change in contraceptive experience. At the individual level, age, duration of marriage and schooling in the first wave are likely to be related to access to information on contraceptives that could lead to change in own experience in subsequent periods. At the village level, if different government programs in Indonesia come as a package as noted by Pitt, Rosenzweig, & Gibbons (1993), the level of government programs other than family planning programs in the first wave may predict a change in neighbors' experience. Specifically, the existence of public transportation, the condition of the main road, and educational facilities at the village level are used as instrumental variables. Table 7 presents results of the first stage estimation in the individual fixed-effect IV estimation in Table 6. In each column, the null hypothesis that the set of instrumental variables does not predict the variation of the dependent variable is rejected at conventional significance level.

[Table 7 about here.]

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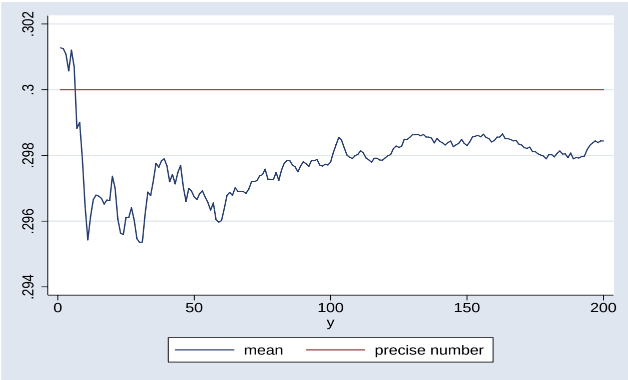

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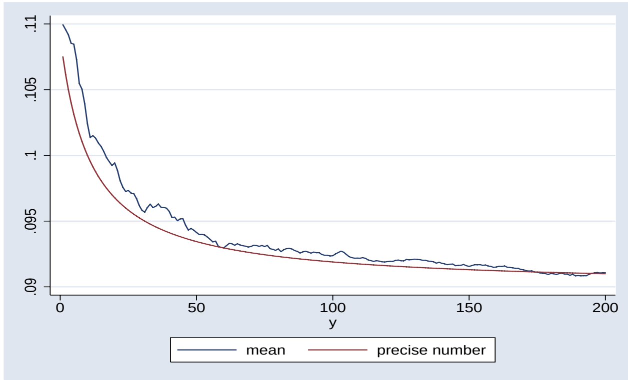

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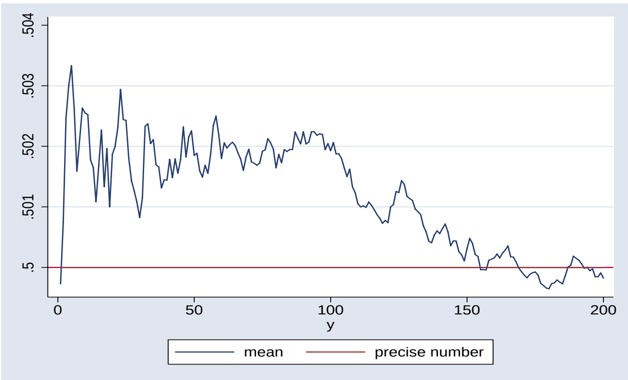

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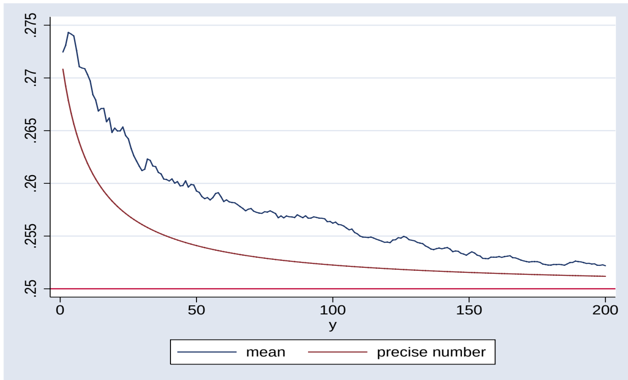

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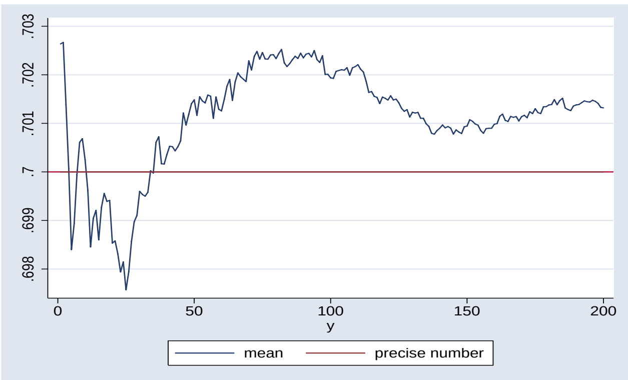
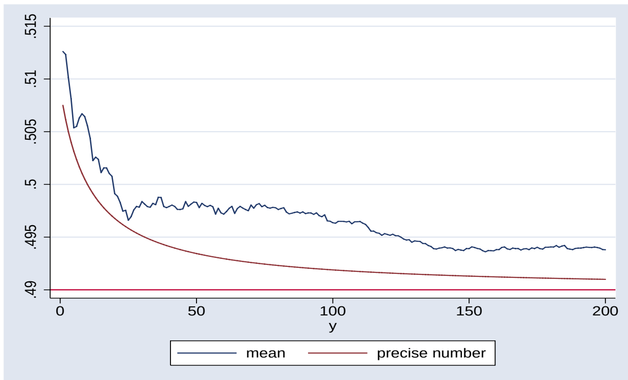


(e) $E(e), \alpha = 7, \beta = 3, e = 0.7$



(f) $E(e^2), \alpha = 7, \beta = 3, e = 0.7$

Figure 1: Expected Path of Posterior Distribution

Notes: Posterior Distribution from Random Sample and from Precise Number When Prior is Beta(α, β) (average of 1,000 realizations)

List of Tables

Table 1: Estimates of Contraceptive Failure Rates in the United States

Method	N	Failure Rate in 12 months	95% Confidence Interval
Implant	146	2.3	0.6-8.6
Injectable	209	3.2	0.6-14.4
IUD	59	3.7	0.5-22.6
Pill	2,130	6.9	5.5-8.6
Diaphragm	166	8.1	3.4-17.9
Male condom	2,925	8.7	7.1-10.7
Spermicide	164	15.3	7.9-27.7
Sponge	111	18.4	8.3-36.0
Withdrawal	440	18.8	13.4-25.7
Periodic abstinence	250	19.8	13.4-28.4
Other	267	32.0	12.2-61.4
Total	6,867	9.4	8.3-10.5

Notes: The numbers indicate the percentages of women experiencing contraceptive failure according to duration of use. The data used are the 1995 National Survey of Family Growth in the United States. This table is quoted from Table 1 in Trussell and Vaughan (1999).

Table 2: Contraceptive Prevalence by Type of Methods in Indonesia

	1993		1997	
Methods	Frequency	Percent	Frequency	Percent
Implant/Norplant	141	5.45	211	6.80
Indjectable (1 month)	5	0.19	45	1.45
Indjectable (2 month)	24	0.93	9	0.29
Indjectable (3 month)	663	25.61	1,137	36.64
IUD	550	21.24	490	15.79
Pill	742	28.66	834	26.88
Diaphragm	2	0.08	5	0.16
Condom	51	1.97	29	0.93
Tubal Ligation	231	8.92	243	7.83
Vasectomy	15	0.58	12	0.39
Withdrawal	34	1.31	5	0.16
Rhythm/ Calendar Method	84	3.24	68	2.19
Traditional Herbs	25	0.97	12	0.39
Traditional Massage	12	0.46		
Others	8	0.31	2	0.06
N/A	1	0.04		
Missing	1	0.04	1	0.03
Total	2,589	100.00	3,103	100.00

Notes: The numbers are based on the women who are currently using contraceptives. The data used are IFLS1 (1993) and IFLS2 (1997).

Table 3: Summary Statistics at Individual Level ($N = 1,389$)

Variable	Mean	S.D.	Min.	Max.
In 1993				
Urban residence	0.420	0.494	0	1
Age	32.685	7.115	15	49
Age at marriage	18.449	4.332	12	44
Duration of marriage	15.237	7.493	1	35
Schooling	4.961	3.594	0	16
Husband's schooling	5.900	4.049	0	17
Ever used modern contraceptives[2)]	0.807	0.395	0	1
Currently using modern contraceptives[2)]	0.730	0.444	0	1
Currently using any of four contraceptives[3)]	0.674	0.469	0	1
Duration of own experience of any four contraceptives[3)]	6.236	5.842	0	39
In 1997				
Urban residence	0.430	0.495	0	1
Age	36.627	7.059	17	56
Age at marriage	18.549	4.508	12	48
Duration of marriage	19.078	7.588	1	42
Schooling	5.227	3.641	0	17
Husband's schooling	6.136	4.036	0	18
Ever used modern contraceptives[2)]	0.815	0.388	0	1
Currently using modern contraceptives[2)]	0.737	0.440	0	1
Currently using any of four contraceptives[3)]	0.670	0.471	0	1
Duration of own experience of any four contraceptives[3)]	8.063	6.583	0	29
Changes between 1993 and 1997				
Change in age	3.942	1.758	-9	31
Change in duration of marriage	3.841	2.576	-26	27
Change in schooling	0.266	1.616	-9	10
Change in husband's schooling	0.236	1.734	-9	9
Change in current usage of any of four contraceptives[3)]	-0.004	0.407	-1	1
Change in duration of own experience of any of four contraceptives[3)]	1.826	5.418	-28	25

Notes: The data used are IFLS1 and IFLS2. Modern contraceptives include pill, IUD, injectables, diagram, condom, implant, and male and female sterilization. Four contraceptives consist of pill, IUD, injectables, and implant. The correction for the inconsistent answers over two waves on age, duration of marriage, schooling, husbands' schooling and duration of contraceptive usage has not been made.

Table 4: Summary Statistics at Village Level ($N = 181$)

Variable	Mean	S.D.	Min.	Max.
In 1993				
No. of observations used for producing village average	16.133	4.464	10	28
Average duration of contraceptive usage in a village	5.748	2.543	0	16
No. of FP clinics	4.517	4.956	1	31
No. of Posyandu	7.094	7.064	1	43
No. of household heads	1,695.2	2,088.4	107	14,178
No. of FP clinics per 100 household heads	0.452	0.936	0	12
No. of Posyandu per 100 household heads	0.005	0.003	0	0
Duration of FP clinic	9.834	5.055	0	28
Duration of Posyandu	9.039	3.405	0	22
In 1997				
No. of observations used for producing village average	19.823	6.336	10	37
Average duration of contraceptive usage in a village	6.295	2.498	1	13
No. of FP clinics	3.878	5.746	1	48
No. of Posyandu	6.845	5.643	1	44
No. of household heads	1,733.5	2,098.6	100	13,470
No. of FP clinics per 100 household heads	0.356	0.421	0	2
No. of Posyandu per 100 household heads	0.005	0.003	0	0
Duration of FP clinic	12.525	6.935	0	48
Duration of Posyandu	13.547	5.079	2	34
Changes between 1993 and 1997				
Change in average duration of contraceptive usage	0.547	1.639	-5	5
Change in no. of FP clinics per 100 household heads	-0.095	0.928	-10	2
Change in no. of Posyandu per 100 household heads	0.000	0.003	0	0
Change in duration of FP clinic	2.691	7.715	-20	38
Change in duration of Posyandu	4.508	5.467	-9	26

Notes: The data used are IFLS1 and IFLS2. The correction for the inconsistent answers over two waves on duration of contraceptive usage, duration of FP clinic and duration of Posyandu has not been made.

Table 5: Effect of Own and Neighbors' Experience on Current Contraceptive Usage (Cross-section in 1993)

	(1) OLS	(2) OLS	(3) OLS
age	−0.0151	−0.0163	−0.0162
	(4.85)	(5.54)	(5.46)
duration of marriage	0.0137	−0.0048	−0.0046
	(1.94)	(0.70)	(0.66)
duration of marriage^2	−0.0004	−0.0001	−0.0001
	(2.12)	(0.60)	(0.65)
schooling	0.0043	−0.0050	−0.0046
	(0.92)	(1.10)	(1.02)
husband's schooling	0.0032	−0.0004	−0.0005
	(0.79)	(0.10)	(0.12)
own experience of contraceptives		0.0245	0.0243
		(10.37)	(10.27)
neighbors' experience of contraceptives		0.0224	0.0212
		(4.55)	(4.20)
no. of FP clinics per household			0.0023
			(0.20)
no. of Posyandu per household			3.0158
			(0.66)
duration of FP clinic			0.0033
			(1.24)
duration of Posyandu			−0.0024
			(0.59)
constant	1.0368	1.0551	1.0276
	(12.84)	(13.28)	(11.96)
no. of observations	1,382	1,382	1,382
R^2	0.06	0.16	0.16

Notes: Dependent variable is the index of current usage of contraceptives. The data used are the 1993 Indonesian Family Life Survey. Absolute values of t-statistics are in parentheses.

Table 6: Effect of Own and Neighbors' Experience on Current Contraceptive Usage (Differenced Equation)

	(1) FE	(2) FE IV	(3) FE IV age in 93 < 41	(4) FE IV age in 93 > 40
Δ age				
Δ duration of marriage				
Δ duration of marriage^2	−0.0002	0.0001	0.0000	−0.0001
	(2.39)	(0.31)	(0.09)	(0.44)
Δ schooling				
Δ husband's schooling				
Δ own experience of contraceptives	0.0051	0.1075	0.0768	−0.0294
	(2.53)	(2.56)	(2.61)	(0.34)
Δ neighbors' experience of contraceptives	0.0029	0.0106	0.0378	−0.2050
	(0.43)	(0.16)	(0.75)	(0.97)
Δ no. of FP clinics per household	−0.0226	−0.0292	−0.0251	0.1240
	(2.10)	(1.58)	(1.68)	(0.63)
Δ no. of Posyandu per household	−7.3113	−15.0327	−10.9352	24.3719
	(1.76)	(1.98)	(1.86)	(0.33)
Δ duration of FP clinic	−0.0011	−0.0038	−0.0022	0.0085
	(0.75)	(1.40)	(1.02)	(0.55)
Δ duration of Posyandu	−0.0036	−0.0044	−0.0045	0.0064
	(1.73)	(1.20)	(1.44)	(0.58)
constant	0.0341	−0.1823	−0.1268	−0.0166
	(1.76)	(2.11)	(1.90)	(0.13)
no. of observations	1,382	1,382	1,180	202
R^2	0.02	0.01	0.01	0.01

Notes: Dependent variable is the difference in indices of current usage of contraceptives in 1993 and 1997. The data used are the 1993 and 1997 Indonesian Family Life Survey. Absolute values of t-statistics are in parentheses. In IV estimation, differences in own and neighbors' experience are instrumented using age, duration of marriage, schooling, the existence of public transportation, the main road being paved, and number of elementary schools per 100 households in 1993. The first stage estimation for column (2) is reported in Table 7 in Appendix A.

Table 7: First Stage Estimation in Fixed-Effect IV Estimation in Table 6

Dependent variable	(1) OLS Δ own experience	(2) OLS Δ neighbors' experience
Δ duration of marriage sq.	−0.0011	0.0002
	(0.79)	(0.52)
Δ no. of FP clinics per household	0.0669	0.1276
	(0.43)	(2.78)
Δ no. of Posyandu per household	68.7233	23.3320
	(1.24)	(1.41)
Δ Duration of FP clinic	0.0260	0.0132
	(1.31)	(2.24)
Δ Duration of Posyandu	0.0032	0.0156
	(0.11)	(1.87)
age in 1993 ($\widehat{\gamma_1}$)	−0.0468	−0.0273
	(1.25)	(2.45)
duration of Marriage in 1993 ($\widehat{\gamma_2}$)	−0.0190	0.0067
	(0.52)	(0.62)
schooling in 1993 ($\widehat{\gamma_3}$)	0.0521	0.0089
	(1.20)	(0.69)
public Transportation ($\widehat{\gamma_4}$)	0.0773	0.0567
	(0.22)	(0.53)
main road paved ($\widehat{\gamma_5}$)	0.1125	0.1311
	(0.29)	(1.13)
no. of elementary schools per 100 households ($\widehat{\gamma_6}$)	0.0023	0.6194
	(0.01)	(6.26)
constant	3.2855	0.5852
	(3.65)	(2.19)
no. of observations	1,382	1,382
R^2	0.01	0.05
$H_0 : \gamma_1 = \gamma_2 = \gamma_3 = 0$ (p-value)	0.0121	
$H_0 : \gamma_4 = \gamma_5 = \gamma_6 = 0$ (p-value)		0.0000

Notes: The data used are IFLS1 and IFLS2. Absolute values of t-statistics are in parentheses.

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