THE DYNAMICS OF FERTILITY, FAMILY PLANNING AND FEMALE EDUCATION IN A DEVELOPING ECONOMY

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Abstract

Unlike most empirical works on fertility analysis, this study is the first attempt to analyse the dynamics of fertility and its determinants with a particular focus on the role played by female education and family planning program in the context of a traditional society. The analysis is based on the application of the following dynamic time-series techniques in a multivariate context: cointegration, vector error-correction modelling and variance decompositions. These 'dynamic' tools are recently developed and hitherto untried in fertility analysis in the context of a poor developing economy, such as India. The results based on the above most recently developed methodology, broadly indicate that in the complex dynamic interactions, the importance of conventional 'structural' hypothesis as a 'Granger-causal' factor in bringing fertility down in the longer term cannot be denied. However, overall, in the short to longer term, our findings appear to be more consistent with the recent 'ideational' hypothesis (emphasizing the critical role played by the two policy variables in our analysis - i.e. changes in the female secondary enrolment ratios, and family planning programs - to ensure 'initial' fertility decline) than with the conventional 'structural' hypothesis (emphasizing a significant socio-economic structural change as a pre-condition for 'initial' fertility decline).

Key Words: India, fertility, diffusion, dynamics, multivariate cointegration, vector error-correction model, error-correction causation, variance decomposition.

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Introduction

Between 1965 and 1990, India's total fertility rate fell from about 6.2 to 3.9, a 37 per cent decline. The conventional criterion that is usually adopted for the onset of demographic transition is a decline in fertility of 10 percent. India's case is remarkable since this fall in fertility was achieved despite relatively poor socio-economic structure. During that period, real per capita GNP rose from about US$90 to $350 which is no higher than the average of low-income countries. The growth rate of GNP was only 1.8 percent per year. Female labour force participation rate (as percentage of total labour force) rather fell from 26.5 to 20.4 (the low-income countries average in 1990 being 34.6 percent). The percentage of people in urban areas rose sluggishly from about 19.0 to 27.0, well below the average of low income countries in 1990 which is about 39.0. The female secondary student (as percentage of school-age group) rose from 16.3 in 1966 to 32.0 in 1990. This is also below the average of 33.0 for low-income countries in 1990. Although the infant mortality rate fell from 149.8 (per thousand live births) to 91.8, it is still well above the average of 66.9 for low-income countries in 1990.

The above figures tend to demonstrate that, in terms of socio-economic structure, India is still one of the least developed countries of the world. However, despite all these indicators, the total fertility rate in India appears to have gone down significantly. How could that happen? Coincidentally, use of contraceptives among married women (15-49) had jumped from less than 10 percent in the mid 1960s to about 45 percent in 1990. India's family planning program is credited to be the oldest and the second largest in the world beginning in 1952 (China's being the largest), although the program gained momentum in 1966 when a department of family planning was constituted in the ministry of health and family planning to give technical and administrative direction and coordination to the program. In the fourth five-year plan (1969-74), family planning was included among the programs of highest priority and by 1969, sterilization became the major plank in the government strategy and remained so throughout the period under review (World Bank 1993, 1992 and U.N. ESCAP 1982). Prior to 1966, national performance statistics are incomplete. The intensified
activity of the late 1960s resulted in a significant increase in the number of acceptors. The number of sterilizations increased from 0.5 million in 1965-66 to 1.8 million in 1967-68 (U.N. ESCAP 1982). As mentioned earlier, India's total fertility rate fell by about 37 percent, and the World Bank (1992) believes that between two-thirds and three-quarters of this decline is due to increased use of modern contraceptive methods.

**Theoretical Underpinnings**

Explanations of the causes and dynamics of fertility transitions fall into two major theoretical categories: the conventional 'structural' hypothesis and the recent 'ideational' (or diffusion) hypothesis. Although both hypotheses clearly recognize interdependence of the elements involved in both, they differ on the relative importance of different determinants in affecting fertility transitions over time.

The conventional socio-economic structural hypothesis broadly includes, among others, microeconomic theories, the threshold hypothesis, the classical demographic transition theory, and Caldwell's theory of intergenerational flow of wealth. Microeconomic theories incorporate Becker's (1960) Chicago model which was later adapted for developing countries; Easterlin's (1969a, b) hypothesis emphasizing that one's preference for the number of children is partly shaped during one's childhood; and Leibenstein's (1974) theory focusing on the 'social influence groups'. These microeconomic theories apply modern economic analysis to the explanation of fertility and family size. The threshold hypothesis (United Nations, 1963) states that there are threshold values or ranges of certain social, economic, and health variables which need to be crossed by a population before any decline in fertility can be expected. The theory of classical demographic transition (United Nations, 1973) describes the transition of a population from a state of high fertility-high mortality to a stage of low fertility-low mortality in the process of socio-economic development in which mortality levels decline first followed by fertility decline. Caldwell (1982) hypothesizes that fertility transition is caused by a reversal of the intergenerational flow of wealth.
The structural hypothesis recognizes the important role played by elements in the ideational hypothesis such as: changing the perceptions, ideas, and attitudes towards fertility control through institutions such as organized family planning, and mass elementary education. However, it emphasizes that the ideational forces need to be preceded or at least firmly supported by a certain level of socio-economic development in terms of the level of per head income, the level of poverty and landlessness, rate of urbanization, female participation in the work force, level of education (particularly of female education), rate of infant mortality, life expectancy at birth, and the average age of females at first marriage.

In contrast, recent theoretical developments based mostly on the Asian experience [Caldwell (1992), Hirschman and Guest (1990), Cleland and Wilson (1987)] stress the importance of family planning and a few years of mass female schooling (which are components of ideational forces) rather than conventional structural socio-economic factors in order to bring about an 'initial' decline in fertility in developing countries. They divide the fertility transition into two temporal phases and suggest that although the second phase or the 'sufficient' condition may depend on a complex and poorly understood set of socio-economic structural changes, the first phase or the 'necessary' condition of fertility decline may not need that significant structural change as a prerequisite, but may require a family planning program integrated with the socio-cultural historical realities of the region. Implicit in the ideational hypothesis, however, is the need for a minimum economic (such as, transport and communications), and social (such as, a few years of mass schooling, particularly female) infrastructural support to make the hypothesis work. This way of stating things classifies not only the 'planned' family planning programs but also a few years of female schooling ('mass education' in Caldwell's words), as components of ideational hypothesis rather than of structural hypothesis. In other words, in order to bring about an 'initial' fertility decline, the ideational hypothesis stresses, in addition to planned family planning, the 'change' rather than the initial 'level' in female school enrolment ratios although structurally the existing enrolment ratios may be well below or no higher than even the average of the low-income countries.
A significant relationship between fertility and a few years of schooling should, according to the ideational hypothesis, be given cognitive rather than structural interpretations (Cleland and Wilson, 1987). The fact that a few years of schooling appear sufficient for a shift in reproductive behaviour is more likely to reflect changing perceptions, ideas, attitudes, and aspirations rather than changes in objective micro-economic realities. This interpretation of fertility-education relationship will be further strengthened by a finding that the link between female education and fertility does not operate through significant female employment, thereby raising the opportunity or indirect costs of children. There are a number of studies in support of the ideational and diffusion hypothesis such as Cleland et al (1993), Montgomery and Casterline (1993), Caldwell and Caldwell (1992), DeGraff (1991), Phillips et al (1988), Knodel and Van de Walle (1986), and Retherford (1985).

Based on these arguments we may postulate the following theoretical model:

\[ fr = \Psi[mr, st, ed, y, pr] \]  

(1)

where (with \( \Psi \) indicating some function and time subscripts dropped for convenience): fertility (\( fr \)) and infant mortality (\( mr \)) are the demographic variables; the contraceptives (\( st \)) and female secondary education (\( ed \)) are standing proxies for the ideational or diffusion hypothesis; and real per capita income (\( y \)) and female labour force participation (\( pr \)) are standing as proxies for structural hypothesis.

Despite the valuable contributions that the growing number of empirical studies on fertility have made towards enhancing our understanding of the role of family planning, female education (and other determinants) in affecting fertility in developing countries, their methodology based mostly on survey-based/qualitative approach is subject to the following limitations:

(i) Most of these works are confined to either visual inspection and/or cross-sectional analysis. The conclusions are drawn mostly on the basis of statistical correlation between the dependent and the explanatory variables. But correlation between variables does not necessarily mean causal relationship. There is need, therefore, to examine the causal relationship between variables and pinpoint the
direction of that causality as well.

(ii) Most of these works recognize theoretically the dynamics of demand and supply in the determination of fertility rate but they make no attempt to capture the dynamics of fertility on the one hand, and family planning, as well as other determinants, on the other. Since most of these works are confined to either visual inspection and/or static cross-sectional analysis, the dynamics of demand and supply cannot be properly captured. One cannot properly infer from observations across countries at a point in time what might happen in one country over time.

The decision to have a child results from a host of factors, the dynamic interactions of which create an attitude as well as an environment which result in the final act of the birth of a child. Unless the analytical tool used takes care of the dynamics of fertility within a multivariate causal framework, the complexity of interrelationships involved may not be fully captured. There is need, therefore, for employing advances in dynamic time series modelling within a multivariate causal framework, that allows the coexistence of both short and long term forces that drive the socio-economic - institutional influences so inherently interactive with fertility decisions.

The main purpose of this paper, therefore, is to make an initial attempt to employ such a methodology in order to examine the dynamics of fertility with a view to discerning the relative importance of its determinants within a multivariate temporal framework. A particular focus of the paper will be on the role played by female education and family planning programs in the context of the economy of India. The paper's aim is to extend existing works on the determinants of fertility in the following ways:

(a) Since a significant statistical correlation between variables does not necessarily mean a significant causal relationship between them, this paper [based on Johansen's multiple cointegration tests preceded by various unit root or non-stationary tests] will make the initial attempt to bind the different variables
related to fertility in a temporal Granger-causal framework through a multivariate cointegrated system in the context of a poor developing economy. Evidence of cointegration (i.e. long-term equilibrium relationship) between variables will rule out the possibility of Granger non-causality and will imply that there must be at least one way of Granger-causality either unidirectional or bidirectional (Granger, 1986, 1988).²

(b) Evidence of cointegration only rules out non-causality. Cointegration does not indicate the exact direction of causality. This paper will try to detect that direction of Granger-causality as well, and hence, identify the within-sample Granger exogeneity or endogeneity of each variable in the system through the vector error-correction model. In addition, the paper will try to distinguish between short-term and long-term Granger-causality.

(c) Finally, this paper intends to apply the variance decomposition technique to explain the total forecast error variance of each variable, at each time horizon beyond the sample period, in terms of the proportions attributable to innovations in other variables in the system including its own. A variable that is optimally forecast from its own lagged values will have all its forecast error variance accounted for by its own disturbances (Sims, 1982). In our case, this exercise gives an indication of the relative contribution of each determinant to explaining variation in a particular variable (say, fertility) beyond the sample period.

It is hoped that the above dynamic and cointegrated time series techniques will test not only the temporal nature of the recent theoretical framework of fertility analysis, but also put the robustness of the conclusions arrived at through other competing methods (such as, cross-sectional or pooled cross-sectional and time series survey-based approaches) under rigorous scrutiny.

Methodology
The following sequential procedures will be adopted:

**Step 1: Cointegration and Granger (Temporal) Causality:**

The cointegration technique pioneered by Engle and Granger (1987), Hendry (1986) and Granger (1986) made a significant contribution towards testing Granger-causality. Two or more variables are said to be cointegrated if they share common trend(s) [for an application of this technique in related disciplines, see Masih and Masih (1994, 1995b)]. According to this technique, if two variables are cointegrated, the finding of non-causality in either direction - one of the possibilities with the standard Granger (1969) and Sims (1972) tests - is ruled out. As long as the two variables have a common trend, causality (in the Granger sense, not in the structural sense), must exist in at least one direction [Granger (1986, 1988)]. Evidence of cointegration among variables also rules out the possibility of the estimated relationship being spurious. However, although cointegration indicates the presence or absence of Granger-causality, it does not indicate the direction of causality between variables. This direction of the Granger (or temporal) causality can be detected through the vector error correction model derived from the long run cointegrating vectors.

**Step 2: Vector Error-Correction Modelling (VECM) and Exogeneity:**

Engle and Granger (1987) demonstrated that once a number of variables (say, \(x\) and \(y\)) are found to be cointegrated, there always exists a corresponding error-correction representation which implies that changes in the dependent variable are a function of the level of disequilibrium in the cointegrating relationship (captured by the error-correction term) as well as changes in other explanatory variable(s). A consequence of ECM is that either \(\Delta x_t\) or \(\Delta y_t\) or both must be caused by \(\epsilon_{t-1}\) which is itself a function of \(x_{t-1}, y_{t-1}\). Intuitively, if \(y\) and \(x\) have a common trend, then the current change in \(x\) (say, the dependent variable) is partly the result of \(x\) moving into alignment with the trend value of \(y\) (say, the independent variable). Through the error-correction term, the ECM opens up an additional channel for Granger-causality
[ignored by the standard Granger (1969) and Sims (1972) tests] to emerge. The Granger-causality (or endogeneity of the dependent variable) can be evidenced either through the statistical significance of the $t$-test of the lagged error-correction term(s) and/or the $F$-test applied to the joint significance of the sum of the lags of each explanatory variable. The nonsignificance of both the $t$-tests(s) as well as the $F$-tests in the VECM indicates econometric exogeneity of the dependent variable.$^4$

In addition to indicating the direction of causality amongst variables, the VECM approach allows us to distinguish between short-term and long-term Granger-causality. When the variables are cointegrated, then in the short-term, deviations from this long-term equilibrium will feed back on the changes in the dependent variable in order to force the movement towards the long-term equilibrium. If the dependent variable (say, the change in the fertility rate) is driven directly by this long-term equilibrium error, then it is responding to this feedback. If not, it is responding only to short-term shocks to the stochastic environment. The $F$-tests of the differenced explanatory variables give us an indication of the short-term causal effects, whereas the long term causal relationship is implied through the significance or otherwise of the $t$-test of the lagged error-correction term which contains the long term information since it is derived from the long term cointegrating relationship. The coefficient of the lagged error-correction term, however, is a short-term adjustment coefficient and represents the proportion by which the long-term disequilibrium (or imbalance) in the dependent variable is being corrected in each short period. Non-significance or elimination of any of the lagged error-correction terms affects the implied long-term relationship and may be a violation of theory. The nonsignificance of any of the differenced variables which reflects only short-term relationship, however, does not involve such violations because, theory typically has nothing to say about short-term relationships (Thomas, 1993). By example, applied work employing this formulation has been used to test for the causal chains implied by the major paradigms among macroeconomic theory [see Masih and Masih (1995a, 1997, 1997 forthcoming)].

Step 3: Variance Decompositions (VDCs) and Relative Exogeneity
The VECM, $F$- and $t$-tests may be interpreted as within-sample causality tests. They can indicate only the Granger-exogeneity or endogeneity of the dependent variable within the sample period. They do not provide an indicator of the dynamic properties of the system, nor do they allow us to gauge the relative strength of the Granger-causal chain or degree of exogeneity amongst the variables beyond the sample period. VDCs which may be termed as out-of-sample causality tests, by partitioning the variance of the forecast error of a certain variable (say, fertility rate) into proportions attributable to innovations in each variable in the system including its own, can provide an indication of these relativities. A variable that is optimally forecast from its own lagged values will have all its forecast error variance accounted for by its own disturbances (Sims, 1982).

**Estimation Results**

The model consists of six variables: sterilization contraceptive consumption ($st$), total fertility rate ($fr$), infant mortality rate ($mr$), female secondary enrolment ratio ($ed$), female labour-force participation rate ($pr$), per capita real GDP ($y$). As stated earlier, the total fertility rate in any country is, of course, the result of many differing influences and it is not possible to capture all within a single quantitative model such as ours. Given the limited number of observations, the incorporation of the variables has been dictated mainly by theories discussed briefly earlier and the availability of data. The sample consists of logged annual time-series observations (1965 - 1991) for India.

Data for total fertility rate, infant mortality rate, female secondary enrolment ratio, female labour force participation rate, per capita real GDP, were obtained from the 'Social Indicators of Development' (Diskette Version) published by the World Bank (1993). We believe that this annual data set is superior to any other data previously available for the study of fertility in developing economies. In terms of temporal and definitional comparability among independent variables, these data were the best available to us. The time-series technique employed in our study ideally requires a long time series of each variable.
Although India was born in August 1947, we could obtain consistent data from the World Bank for India only as far back as 1965. For the sake of effective use of our techniques, we require at least the same length for the contraceptive data. Although, India's family planning program began in 1952, the organised program gained momentum only in 1966 when a department of family planning was established in the ministry of health and family planning. Prior to 1966, national performance statistics are incomplete (U.N. (1982). Of the different types of contraceptives, sterilization became the major plank in the government strategy and remained so throughout the period. We have therefore, taken sterilization as the variable representing the use of contraceptives. Data for sterilization are sourced from the *Statistical Indicators for Asia and the Pacific* and the *Country Monograph Series* both published by ESCAP, U.N. Apart from the problem of availability of high frequency data for all six variables going back to 1965, in defence for our using annual data we would like to cite Shiller and Perron (1985) who argue strongly that, particularly when analyzing the long-run characteristics of economic time series, the length of the time series is far more important than the frequency of observations.

A wide range of unit root (i.e. non-stationary) tests (Table 1) were applied (some of which are not presented here due to space) to test the order of integration of the variables i.e. to test the number of times a variable is differenced in order to turn it stationary. Tests indicated that all variables were non-stationary at the level form but stationary after first differencing, i.e. they were $I(1)$. This is a necessary step in order to test the cointegration of the variables. The results based on Johansen's [Johansen (1988), and Johansen and Jesulius (1990)] multivariate cointegration tests (Table 2) tend to suggest that these six variables are cointegrated i.e. have common trends. In other words, all six variables are bound together by long run equilibrium relationships (the number being two as indicated by the test of null or alternative hypotheses through the Maximum Eigenvalue and Trace Statistics). This evidence of cointegration among all these six variables rules out spurious correlations and also implies at least one direction of Granger. The number of cointegrating relationships found in Table 2 will result in a corresponding number of residual series and hence error-correction terms (ECTs) in the vector error-correction model (VECM) in Table 4. Tests of
restrictions on coefficients of the cointegrating vectors are shown in Table 3. It shows that all of them are statistically significant i.e. all variables enter the vectors at a statistically significant level.\textsuperscript{11}

[Insert Tables 1, 2, 3 and 4]

Since the primary focus of this paper is on the fertility dynamics and the relative impact of its determinants, in particular that of family planning and female education in the context of a poor socio-economic environment as in India, we restrict ourselves to explaining that aspect in particular.

As stated earlier, cointegration cannot detect the direction of Granger causality which is indicated by the VECM (see Table 4). The VECM tends to indicate that of all the cointegrating variables, it is the female education variable that stands out econometrically exogenous as evidenced through the statistical significance or otherwise of both the t-tests of the error-correction terms, and the F-tests of the independent variables. In other words, the VECM evidence tends to suggest that in the Granger-causal sense, the female enrolment ratio is the leading variable being the most exogenous of all, and all other cointegrating variables had to bear the burden of short-run adjustment (to long term trend) endogenously in different proportions in order to bring the system back to long term equilibrium. For example, in the case of the change in fertility rate, the evidence based on VECM tends to indicate that in the short run, although individually the explanatory variables did not significantly Granger-cause fertility rate (as reflected in the non-significance of the F-tests of the lags of the explanatory variables), the proportion by which the fertility rate was responding to the short-term deviations from its long term equilibrium relationship is nevertheless significant (as evidenced in the significance of the t-test of the lagged error-correction term derived from the long term cointegrating relationship). In other words, the short-term deviations from the long term equilibrium relationship (captured by the lagged error-correction term) did Granger-cause the change in fertility rate. The econometric problems of serial correlation, heteroscedasticity and normality of the residuals as well as the functional form of the VECM model are examined through the standard diagnostic tests (see Table 5), and in each case, the null hypothesis could not be
rejected at the conventional 5% level of significance, implying thereby that our results are statistically free from any specification problems.

[Insert Table 5]

However, as stated earlier, although the VECM can help us discern the relative endogeneity or exogeneity of a variable and also can give us an indication of the direction of Granger-causality within the sample period, it cannot provide us with an indication of the dynamic properties of the system, nor does it allow us to gauge the relative strength of the determinants of a variable beyond the sample period. While the earlier exercise, VECM (Table 4) could be thought of as a within-sample causality test, the VDCs (Table 6) could be deemed to be an exercise of an out-of-sample causality test. Similarly, whereas the VECM F-tests tell us the within-sample effects of 'anticipated' (say, policy) variables on target variables, the VDCs tell us the relative strength of the variables (unlike VECM) and also the out-of-sample 'unanticipated' impact of a (say, policy) variables on a target variable.12

[Insert Table 6]

In the overall dynamic interplay between fertility and its determinants, our evidence based on VDCs (Table 6) seems to be strong in favour of a consistently significant role played by female education variable followed by the use of contraceptives in contrast to an equally consistent but insignificant role played by economic structural variables, such as female labour force participation and real income per capita. As we can see, a shock in female education coupled with that in the use of contraceptive explain about 27 percent of the variance in the fertility rate in the short-term (say, a two-year horizon), rising to about 60 percent at five-year horizon and finally accounting for about 94 percent in the long term (say, at 10-year horizon). This dynamic exercise between fertility and its determinants tends to indicate that about 90 percent of the forecast error-variance of most of the cointegrating variables (say, at ten-year horizon) has been explained by the combined impact of only two variables: female education and the use of contraceptives, unlike the economic structural variables such as female labour force participation and the real income per
capita which explain very little of the variance of most of the variables. This kind of evidence appears to be consistent more with the cognitive rather than structural interpretation of the education-fertility relationship. Our evidence of a significant impact of schooling on reproductive behaviour is more likely to reflect changing perceptions, ideas, attitudes, and aspirations than changes in objective micro-economic realities. This cognitive interpretation of education-fertility relationship is also supported by our finding that the link between female education and fertility does not operate through enhanced employment prospects for the better educated females (thereby raising the opportunities or indirect costs of children), or through the improved standard of living.13


Conclusions and Policy Implications

(i) This paper made the initial attempt at putting fertility analysis in a temporal Granger-causal framework (using data from as India) by binding the relationship between fertility and its determinants in a multivariate cointegrated system. Evidence of cointegration among these variables tends to suggest that institutional, socio-economic, and demographic variables are bound together by common trends or long term equilibrium relationships. This implies that although these variables will have
short term or transitory deviations from their long term common trends, eventually forces will be set in motion which will drive them together again. In other words, evidence of cointegration tends to suggest that although in the short term some determinants may not be related to fertility in a temporal causal relationship, in the long term it is the dynamic interplay of all these variables with which the fertility rate is ultimately 'causally' related. Moreover, evidence of cointegration rules out the possibility of the estimated relationship being spurious and implies that Granger-causality must exist among these variables in at least one direction either unidirectional or bidirectional. This finding of cointegration or long run equilibrium relationship among all these variables is very important for policy designers.

(ii) This paper goes further, and tries to detect the direction of Granger-causality and hence the within-sample Granger exogeneity or endogeneity of each variable, as well as distinguishing between short term and long term Granger-causality. Our analysis tends to indicate that of all the cointegrating variables, it is female education that stands out econometrically exogenous and all other variables including the fertility rate had to adjust endogenously to the long term trend. That implies that female education is the initial receptor of an exogenous shock to the long term equilibrium relationship. In other words, the movements of the female secondary enrolment ratio away from its old long term equilibrium level creates short term deviations which Granger-cause subsequent error-corrections through changes in other variables.

(iii) This paper decomposes the total impact of an unanticipated shock to each of the variables, beyond the sample period, into proportions attributable to shocks in the other variables, including its own. This exercise enables us to examine the relative contributions of the determinants of fertility in explaining the forecast error variance of fertility. The VDCs exercise gives us the additional useful information that a substantial part of the (forecast error) variance of fertility is explained by changes in the use of contraceptive and female education alone not only in the long term (94 per cent at ten-year horizon), but also in the short term (27 per cent at two-year horizon) unlike the conventional structural economic variables. This exercise also brings to light the significant and predominant role played by our two policy variables: female secondary
enrolment ratio and use of contraceptives, in explaining the variance of not only fertility rate but also most of the cointegrating variables. This is a major finding and has strong policy implications.

(iv) This study tried to analyse the dynamics of fertility and its determinants in a traditional society with a particular focus on the role played by female secondary education and organized family planning programs. It binds the relationship between fertility and its determinants within a multivariate cointegrated Granger-causal framework. Our findings appear to be consistent with recent theoretical statements that maintain that: although in the long term, the second phase or the sufficient condition of fertility decline may be the result of a complex dynamic interaction with planned family planning and significant socio-economic structural change, in the short term the first phase or the necessary condition of fertility decline may not need that significant structural change, but may require a client-oriented affordable but persuasive 'planned' family planning program, coupled with a few years of schooling, particularly female, firmly supported by the political and social elite at all levels of that society, and also adapted to the socio-cultural realities of the vast masses of the people of that region.

(v) Finally, whilst these findings are revealing, some warnings are in order. There is no room for complacency at the decline in the fertility rate in India. There remains the potential danger that it may rise again before finally falling. This is mainly because the first phase in fertility decline may be dominated by a decrease in marital fertility among older women which constituted mostly of the decision to stop child bearing. Theoretically, this first phase may happen with or without decline in the fertility rate of younger women. However, the decline in the fertility rate of younger women, which is likely to dominate the second phase of fertility decline, is closely linked with the structural socio-economic factors. Therefore, it is imperative that in order to sustain the fertility decline, long term socio-economic factors (such as female employment, further female education and urbanization, etc) be enhanced through policy measures so as to strengthen the effectiveness of family planning. It is worth remembering that in the early stage of modernization, there is a likelihood that the marital fertility level of younger women might even record an increase because of an
easing off of the traditional methods of fertility control in a poor society [such as, the long periods of breast-feeding and postpartum amenorrhea, as well as poverty-related malnutrition-induced sub-fecundity, etc. Amin et al. (1993) Mitra et al. (1993), Huq and Cleland (1990)]. While the fertility level of older women could decline rapidly over time, it is likely that the fertility level of young women might hover around medium value for quite sometime (because of lack of associated structural economic, social, and health developments) before they begin to decline to low level resulting in the second phase of fertility decline (Srinivasan and Pathak, 1981). Hence, from the policy point of view, it is of paramount importance that the current tempo of organized family planning services as well as female secondary education be not only maintained, but hastened in order to cope with the following: (a) unmet demand for both birth-spacing and birth-stopping; (b) offset the 'easing off' of the traditional methods of fertility control at the initial phase of modernization; (c) greater demand stemming from modernization measures; (d) rising proportion of women of reproductive age; and (e) growth in population.

Despite structural socio-economic backwardness, the combined impact of an organised family planning program, coupled with a few years of female schooling appears to have been effective in bringing initial fertility down in India. However, it is worth pointing out that supply-oriented strategies such as family planning campaign incorporating information, education and communications programs may be effective in reducing the total fertility rate from six to about four, but without help from a significant socio-economic structural change, mere family planning program along with a few years of female schooling may not be sufficient to reduce the total fertility rate from four to replacement level (about two). This is evidenced from the fact that in some regions even within India or Indonesia, the total fertility rate approached replacement, such as Kerala (2.2), and Tamil Nadu (2.6) in India, and Yogyakarta (2.1), Bali (2.5) and East Java (2.6) in Indonesia. And in all these regions, social and economic development and/or administrative capacity is above the national average (World Bank 1993, 1992). Hence, government policies in India geared towards sustaining fertility decline can only be effective if family planning programs are strongly supported by policies designed to bring about significant socio-economic structural change.
Notes

1. See, for example, Zhang (1990) for further details.

2. Recently, the application of cointegration tests in fertility analysis in the context of advanced economies such as the USA has begun (Mocan, 1990). But the vector autoregressive model used was not designed to test either the direction of causality or to distinguish between the short and the long run causality, but to investigate dynamic relations between business cycles and fertility based on Engle-Granger procedure with its restrictive assumption of unit cointegrating vector, and also without any attempt at applying the dynamic variance decomposition technique. Our approach uses the recently developed superior Johansen procedure with no restrictive assumption on the number of cointegrating vectors and hence the corresponding vector error-correction model with multiple error-correction terms, along with the follow-up dynamic variance decompositions.

3. Causality is a subject of great controversy among economists. See, for example, Zellner (1988). Interested readers could refer to a supplementary issue of the Journal of Econometrics, September-October, 1988, that includes studies discussing this issue. Without going into a debate, we would like to state that the concept used here is in the stochastic or "probabilistic" sense, rather than in the philosophical or "deterministic" sense. Also the concept used here is in the Granger "temporal" sense, rather than in the "structural" sense.

4. The VAR being a system of unrestricted reduced form equations, have been criticised by Cooley and Le Roy (1985). Runkle (1987) is a good example of the controversy surrounding this methodology. Backus (1986) and Ambler (1987) are examples defending the use of VAR. It is debatable whether the method of identification employed by the simultaneous equation structural model which often relies on many simplifying assumptions and arbitrary exclusion restrictions together with the related exogenous-endogenous variables classification (which are often untested) is superior to the identification procedure used in the VAR model. The critics of VAR, however, all agree that there are important uses of the VAR models. For example, McMillin (1988) points out that VAR models are particularly useful in the case of "forecasting, analyzing the cyclical behaviour of the economy, the generation of stylized facts about the behaviour of the elements of the system which can be compared with existing theories or can be used in formulating new theories, and testing of theories that generate Granger-causality implications".

5. The results based on VARs, and VDCs are generally found to be sensitive to the lag length used and the ordering of the variables. A considerable time has been spent in selecting the lag structure through FPE criterion. FPE method is based on an explicit optimality criterion of minimizing the mean squared prediction error. The criterion tries to balance the risk due to bias when a low order is selected, and the risk due to increase in the variance when a higher order is selected. By construction, the errors in any equation in a VAR are usually
serially uncorrelated. However, there could be contemporaneous correlations across errors of different equations. These errors were orthogonalised through Choleski decomposition. In order to orthogonalise the innovations, a predetermined triangular ordering of the six variables had to be made. The innovations were orthogonalised in the following order: \([st, fr, mr, ed, pr, y]\).

The residual variance-covariance matrix being near diagonal, the results were not sensitive to alternative ordering of the variables.

6. We also tried urbanization (i.e. percentage of people in urban areas) as a separate economic structural variable. But it was found to be highly correlated with the per capita real income variable, and the impact of urbanization was evidenced to be not significantly different to that of income per capita. Hence, given the limited number of observations available in the context of time series data in India, we dropped urbanization as a separate variable in the interest of saving degrees of freedom.

7. That sterilization was the most popular of all contraceptives in the context of India, is supported by, among others, World Bank (1993), Caldwell (1992), Vlassoff (1991) and U.N. (1982).

8. See also Hakkio and Rush (1991) for similar observations. Moreover, real GDP data are only available annually for most of the Asian developing economies, such as India.

9. While applications of the JJ procedure have been quite popular in a multivariate context, results arrived from JJ statistics in bivariate studies have also been shown to be more robust than those arrived adopting the Engle-Granger approach [see, by example, Masih and Masih (1994, 1995b)].

10. With respect to both the Engle-Granger and JJ approach, it is important to acknowledge that should non-cointegration not be rejected at conventional significance levels, it is possible that the residual term may display fractional behaviour and still be mean-reverting implying fractional cointegration. For such an approach see Masih and Masih (1995).

11. In addition, cointegration also rules out the use of modelling any dynamic relationships through ordinary first-differenced VARs as these will be misspecified, and also structural VARs [see Rogers and Wang (1993) for applications], as these models do not impose cointegration constraints. Wang et al (1994) is another example of an application of a structural VAR model with imposed long-run restrictions based on theoretical predictions of endogenous consumption, labour-leisure and fertility. However, in order to arrive at the structural VAR, various univariate and multivariate stationarity tests were performed on the data since, "In addition to stationarity, the structural VAR requires that there exists no cointegrating relationships between the endogenous variables." [Wang et al (1994, p. 261)] (italics added). However, as noted by Karras (1994, p. 1768), "If cointegration relationships are found to exist, the model must be estimated by the Vector Error Corrections Model (VECM) examined by Engle and Granger (1987) and more recently used by King et al
12. See, for example, Chisti et al (1992) and Bessler and Kling (1985).

13. For further evidence in favour of our contentions, see Cleland and Wilson (1987) and Rodriguez and Cleland (1981). See also, World Bank (1993, 1992) and Caldwell (1980) for further evidence regarding the importance of education, particularly female, in imparting new ideas, attitudes, and knowledge including awareness about contraceptive methods.
Table 1. Tests of the Unit Root Hypothesis
(Tests for Stationarity of Variables)

<table>
<thead>
<tr>
<th>Aug Dickey-Fuller</th>
<th>Phillips-Perron</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \tau_{\mu} )</td>
<td>( \tau_{\tau} )</td>
</tr>
<tr>
<td><strong>Levels</strong></td>
<td></td>
</tr>
<tr>
<td><code>fr</code></td>
<td>-0.34</td>
</tr>
<tr>
<td><code>mr</code></td>
<td>-2.35</td>
</tr>
<tr>
<td><code>ed</code></td>
<td>-2.63</td>
</tr>
<tr>
<td><code>pr</code></td>
<td>-0.46</td>
</tr>
<tr>
<td><code>y</code></td>
<td>-1.09</td>
</tr>
<tr>
<td><strong>First Differences (( \Delta ))</strong></td>
<td></td>
</tr>
<tr>
<td><code>st</code></td>
<td>-4.16</td>
</tr>
<tr>
<td><code>fr</code></td>
<td>-4.34</td>
</tr>
<tr>
<td><code>mr</code></td>
<td>-4.35</td>
</tr>
<tr>
<td><code>pr</code></td>
<td>-4.80</td>
</tr>
<tr>
<td><code>y</code></td>
<td>-3.76</td>
</tr>
</tbody>
</table>

Notes: The sample consists of logged-annual time-series observations (1965-1990) for India. Definitions: sterilisation numbers (\( st \)); total fertility rate (\( fr \)); total mortality rate (\( mr \)); female secondary school gross enrollment ratio (\( ed \)); female labour-force participation rate (\( pr \)); real per capita gross national product (\( y \)). All data used are available upon request from authors.

The optimal lag used for conducting the Augmented Dickey-Fuller test statistic was selected based on an optimal criteria [Akaike's Final Prediction Error (FPE)], using a range of lags. The truncation lag parameter \( l \) used for the Phillips-Perron tests was selected using a window choice of \( w(s, l) = 1 - [s/(l + 1)] \) where the order is the highest significant lag from either the autocorrelation or partial autocorrelation function of the first differenced series. Relevant test equations and related technical descriptions for all unit root testing procedures appear in Appendix: A1. Approximate critical values, for \( n = 25 \) obs, at conventional significance levels appear below. Presented for levels tests only: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Critical Values

<table>
<thead>
<tr>
<th>Sig Level</th>
<th>( \tau_{\mu} )</th>
<th>( \tau_{\tau} )</th>
<th>( Z(\alpha) )</th>
<th>( Z(t_\alpha) )</th>
<th>( Z(\Phi_1) )</th>
<th>( Z(\alpha^*) )</th>
<th>( Z(t_{\alpha^*}) )</th>
<th>( Z(\Phi_2) )</th>
<th>( Z(\Phi_3) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>-4.38</td>
<td>-3.75</td>
<td>-22.50</td>
<td>-4.38</td>
<td>7.88</td>
<td>-17.20</td>
<td>-3.75</td>
<td>8.21</td>
<td>10.61</td>
</tr>
<tr>
<td>5%</td>
<td>-3.60</td>
<td>-3.00</td>
<td>-17.90</td>
<td>-3.60</td>
<td>5.18</td>
<td>-12.50</td>
<td>-3.00</td>
<td>5.68</td>
<td>7.24</td>
</tr>
<tr>
<td>10%</td>
<td>-3.24</td>
<td>-2.63</td>
<td>-15.60</td>
<td>-3.24</td>
<td>4.12</td>
<td>-10.20</td>
<td>-2.63</td>
<td>4.67</td>
<td>5.91</td>
</tr>
</tbody>
</table>

Table 2. Johansen's Test for Multiple Cointegrating Vectors

<table>
<thead>
<tr>
<th>H_{0}:</th>
<th>H_{1}:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotheses</td>
<td>Test Statistics</td>
</tr>
<tr>
<td>([ st, fr, mr, ed, pr, y ])</td>
<td>( r = 0 )</td>
</tr>
<tr>
<td>( r \leq 1 )</td>
<td>( r &gt; 1 )</td>
</tr>
<tr>
<td>( r \leq 2 )</td>
<td>( r &gt; 2 )</td>
</tr>
<tr>
<td>( r \leq 3 )</td>
<td>( r &gt; 3 )</td>
</tr>
<tr>
<td>( r \leq 4 )</td>
<td>( r &gt; 4 )</td>
</tr>
<tr>
<td>( r \leq 5 )</td>
<td>( r = 6 )</td>
</tr>
</tbody>
</table>

Notes: \( r \) indicates the number of cointegrating relationships. The optimal lag structure of 2 for the VAR was selected by minimising the Akaike's FPE criteria. All estimated coefficients of the cointegrating vectors, though not presented due to space/exposition constraints, are available on
Critical values are sourced from Johansen and Juselius (1990). ** indicates rejection at the 95% critical values.

### Table 3. Tests of Restrictions on Coefficients of Cointegrating Vectors

<table>
<thead>
<tr>
<th>Vector</th>
<th>Hypotheses under Null</th>
<th>$\chi^2$ Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>[st, fr, mr, ed, pr, y]</td>
<td>st = 0</td>
<td>4.657*</td>
</tr>
<tr>
<td></td>
<td>fr = 0</td>
<td>4.325*</td>
</tr>
<tr>
<td></td>
<td>mr = 0</td>
<td>6.832**</td>
</tr>
<tr>
<td></td>
<td>ed = 0</td>
<td>8.768**</td>
</tr>
<tr>
<td></td>
<td>pr = 0</td>
<td>5.776**</td>
</tr>
<tr>
<td></td>
<td>y = 0</td>
<td>10.496*</td>
</tr>
</tbody>
</table>

**Notes:** The statistic is distributed as chi-square with 2 degrees of freedom. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

### Table 4. Temporal Causality Results Based on Vector Error-Correction Model (VECM)

<table>
<thead>
<tr>
<th>Dep Variable</th>
<th>$\Delta st$</th>
<th>$\Delta fr$</th>
<th>$\Delta mr$</th>
<th>$\Delta ed$</th>
<th>$\Delta pr$</th>
<th>$\Delta y$</th>
<th>ECT($\varepsilon_{1,t-1}$)</th>
<th>ECT($\varepsilon_{2,t-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta st$</td>
<td>-</td>
<td>2.59</td>
<td>2.10</td>
<td>0.97</td>
<td>3.07*</td>
<td>5.33**</td>
<td>-0.24</td>
<td>3.82***</td>
</tr>
<tr>
<td>$\Delta fr$</td>
<td>0.41</td>
<td>-</td>
<td>0.05</td>
<td>0.13</td>
<td>0.16</td>
<td>0.89</td>
<td>-0.17</td>
<td>-1.83*</td>
</tr>
<tr>
<td>$\Delta mr$</td>
<td>0.21</td>
<td>0.38</td>
<td>-</td>
<td>0.69</td>
<td>0.04</td>
<td>0.03</td>
<td>2.21**</td>
<td>-0.66</td>
</tr>
<tr>
<td>$\Delta ed$</td>
<td>0.38</td>
<td>0.60</td>
<td>1.30</td>
<td>-</td>
<td>0.03</td>
<td>0.03</td>
<td>-1.09</td>
<td>-0.41</td>
</tr>
<tr>
<td>$\Delta pr$</td>
<td>8.12***</td>
<td>6.03**</td>
<td>0.21</td>
<td>5.75**</td>
<td>-</td>
<td>5.73**</td>
<td>1.70*</td>
<td>3.25***</td>
</tr>
<tr>
<td>$\Delta y$</td>
<td>0.69</td>
<td>0.30</td>
<td>0.68</td>
<td>0.79</td>
<td>0.70</td>
<td>-</td>
<td>0.23</td>
<td>1.83*</td>
</tr>
</tbody>
</table>

**Notes:** The ECT ($\varepsilon_{i,t-1}$ for $i = 1, 2$) were derived by normalising the cointegrating vector on st resulting in $r$ number of residuals for each VECM. Figures beneath ECTs are estimated t-statistics testing the null that they are each statistically insignificant. All other estimates are asymptotic Granger F-statistics. The ECTs were also checked for stationarity by way of unit-root testing procedures applied earlier and inspection of their autocorrelation functions respectively. The VECM was based on an optimally determined criteria (Akaike's FPE) lag structure and a constant. ***, ** and * indicates significance at the 1%, 5% and 10% levels.

### Table 5. Summary of Diagnostics for VECM

<table>
<thead>
<tr>
<th>Equation</th>
<th>Serial Correlation</th>
<th>Heteroskedasticity</th>
<th>Funct Form</th>
<th>Normality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LM(1)</td>
<td>LM(2)</td>
<td>Het</td>
<td>ARCH</td>
</tr>
<tr>
<td>$\Delta st$</td>
<td>0.376</td>
<td>2.081</td>
<td>0.029</td>
<td>0.001</td>
</tr>
<tr>
<td>$\Delta fr$</td>
<td>1.819</td>
<td>0.912</td>
<td>1.438</td>
<td>0.753</td>
</tr>
<tr>
<td>$\Delta mr$</td>
<td>1.381</td>
<td>1.791</td>
<td>0.444</td>
<td>1.321</td>
</tr>
<tr>
<td>$\Delta ed$</td>
<td>1.657</td>
<td>0.081</td>
<td>0.144</td>
<td>0.381</td>
</tr>
<tr>
<td>$\Delta pr$</td>
<td>1.727</td>
<td>1.971</td>
<td>0.081</td>
<td>0.078</td>
</tr>
<tr>
<td>$\Delta y$</td>
<td>0.401</td>
<td>0.081</td>
<td>2.305</td>
<td>0.086</td>
</tr>
</tbody>
</table>

**Notes:** Distributional properties of diagnostics are respectively: LM(1) and LM(2) as $\chi^2(1)$ and $\chi^2(2)$ testing for the null of no first and no second order serial correlation amongst the residuals; Het: a $\chi^2(1)$ test based on regression of squared residuals on a constant and squares of the fitted values; a $\chi^2(1)$ test for first-order ARCH effects; Ramsey's REgression Specification Error (F) Test with (1, 7) df; and the Jarque-Bera $\chi^2(2)$ LM test for normality of residuals.
Figure 1. Impulse Responses of Fertility Rate to One-Standard Deviation Shocks in:
Contraceptive Consumption, Mortality rate and Female Education Variables

![Diagram 1](image1)

Years after shock

Figure 2. Impulse Responses of Fertility Rate to One-Standard Deviation Shocks in:
Contraceptive Consumption, Female Labour-Force Participation and Income Variables

![Diagram 2](image2)

Years after shock
References


______, *Country Monograph Series (Occassional),* ESCAP, Bangkok.


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<td>Characteristics of Reported and Unreported Road Crashes.</td>
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