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Research Article

Does Infant Mortality Regulate Fertility Behaviour of Women in Uttar Pradesh? A Causality Test Analysis

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Abstract

The two major aspect of demography is fertility and mortality in India. Several studies are already been taken place in the past on fertility and mortality separately and about their cross sectional relationship but this study has been done specially keeping the question of the actual cause of the increase between the two. For which the longitudinal relation between fertility and mortality has been considered here. This work is an attempt to run some time series analysis for the mortality and fertility in the most populated state of India i.e. Uttar Pradesh and explains the cause of this increasing trend through granger causality among the proxy measures of mortality and fertility i.e. IMR and TFR respectively. The application of these models is illustrated through real data taken from Sample Registration System (SRS) data and National Family Health Survey-III (2005-06) for the major state of India

Introduction

Although many studies have examined the phenomenon of child loss as well as fertility behaviour and aspirations of men and women, less attention has been given to the possible relations between child loss and fertility behaviour of women. The interrelationship between mortality and fertility is considered one of the most significant areas of policy-oriented population research. In the past several decades, the adoption and implementation of many national family planning programmes, despite potential opposition, have been based, at least in part, on research documenting the adverse consequences of excessively high fertility on health and mortality (Wray et al., 1971, Nortman et al., 1974). Such information has also provided a key policy rationale for the participation of health scientists and ministries in population control programmes. Research findings regarding the reverse relationship, the influence of mortality on fertility, however, are much less conclusive. Some have argued that child mortality experience is an important determinant of fertility and thus a reduction of child mortality should be a pre- condition for successful population control. It would follow that resources directed towards achieving demographic goals would have a high cost-effectiveness if invested in mortality control programmes (WHO, Taylor et al., 1965). Sustentative support of such conclusions, it is argued, comes from research validating the 'child survival hypothesis'. This term has been used to denote various proposals regarding the effect of mortality on reproductive attitudes and behaviour. Poor child survivorship, it is argued, raises desired family size, causes couples to have more children than they really want, and acts as a barrier to contraceptive practice (Taylor et al., 1971). These effects may operate at either the community (macro) or individual (micro) level. At the community level, child mortality experience may shape the reproductive norms and behaviour of a community while among individual couples; previous child deaths may affect fertility differentials. These effects need not be mutually exclusive; if present, they would be expected to reinforce each other.

Previous investigations on the 'child survival hypothesis' have been at both the macro and micro levels. Using cross-sectional data, several investigators have reported that lower regional death rates are correlated with lower levels of fertility or that a decline in the death rate, when lagged

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several years, has substantial negative effects on the birth rate (P. T. Schultz, 1966; M. Nerlove and P. T. Schultz, 1970.). One difficulty with these macro studies, however, is an inability to isolate the effect of mortality on fertility. There has been a study on micro and macro effects of child mortality on fertility on India (P.N. Mari Bhat, 1996) with several other International studies on countries Europe, United States, Indonesia, Costa-Rica etc (Montgomery).

Correlations between these two variables measured by regions or communities could be due to the reverse effect: the well-documented adverse effects of high fertility on mortality or to other confounding variables. Most researchers, therefore, have focused on the micro level, studying the differential fertility of individual couples according to their experience of child mortality. By studying retrospective pregnancy histories, several researchers in Egypt, Turkey, Taiwan as well as India have found higher fertility among women who have lost children compared with their counterparts whose children survived (S. S. Hassan, 1966; A. L. Adlakha, 1970; J. B. Wyon and J. E. Gordon, 1971; J. A. Harrington, 1971). That concluded the observed differentials in fertility were due to a desire to replace children who had died.

The difficulty with this conclusion is that the reproductive consequences of child loss are far more complex than simply attitudinal and behavioural. Death of infants may shorten the period of post-partum lactational amenorrhoea, thereby exposing a woman to the risk of conception earlier than if the child had survived. Breast-feeding is nearly universal in rural areas of low-income countries and cessation of breast-feeding has been shown to have profound effects on fertility (D. B. Jelliffe, 1968; C. Tietze, 1961; R. C. Potter, J. B. Wyon, M. Parker and J. E. Gordon, 1965). This mechanism is more direct and biological in character than attitudinal or behaviour effects. Many previous researchers have neglected to control for this factor. Those who recognized this difficulty have rarely adequately isolated behavioural from biological factors.

Thus as the above replacement hypothesis is concerned, high fertility is a necessary biological and behavioural response to high mortality i.e. the parents try to replace those children who die, and their aim to produce enough children to ensure the survival of some intended number up to adulthood (Chawdhury et al., 1982). Therefore, child death has positive impact on fertility and later which has been explained by Bhuyan in his study, “Fertility differential according socio-economic status and family planning adoption in rural Bangladesh”, (Bhuyan et. al., 1996) and reduction in child death or enhance in the probability of survival of children is one of the known reasons of reduction in the fertility. That implies Reduction in infant and child morality which is likely the most important aims of the millennium development goals, as children are the most important assets of a nation.

Among above two hypotheses a widely accepted hypothesis holds that high childhood mortality contributes to parental desire to have many children. Conversely, declining childhood mortality increases the number of surviving children, leading to couples to compensate with fertility control. Though the theory of demographic transition provides ample empirical data on high association in the level of birth and death rates, its interdependence should be naturally clear. After all it is believed that, high fertility is a biological and behavioral response to high mortality and vice versa.

A couple would like to have children for social, religious and emotional satisfaction. If there is higher risk of death of children, the parents are likely to bear more children in order to achieve their desire. Thus, reduction in mortality brings about reduction in fertility and it is obvious, therefore, that both of these variables mortality and fertility have re-enforcement effect on each other. In other way we can say that the effect of child loss may affect the reproductive behavior of women in two ways. First, the death leads to sudden termination of breast-feeding and this, in turn, triggers resumption of menses and ovulation thus increasing the period of exposure to a new conception. The magnitude of this purely **physiological effect** is relatively large and remarkably consistent in different demographic contexts. This mechanism implies a birth changes in child loss with a lags not longer than one or two years and should be more powerful in societies where the practice of breastfeeding is pervasive and where contraception is not universally used. The second mechanism, better known as the **replacement effect**, refers to couple’s deliberate attempts to ‘replace’ any child who dies at an early age in order to attain a desired number of surviving children at the end of their reproductive life. This replacement strategy serves to raise subsequent fertility and should be most evident in a context of controlled fertility. This mechanism, however, is believed to be less powerful than the one working through the physiological effect of breast-feeding.

In this study we present an empirical analysis of the causal effects of child deaths on fertility or vice-versa in the most populated State of India i.e. Uttar Pradesh, using time series model. The analysis attempts to illustrate how inadequate methodological treatment of data may lead to conflicting results; to isolate possible behavioral effects from biological influences; to quantify the relative magnitude of these two factors; and to discuss the implication of these findings for future research. This study describes the relationship between two important demographic variables i.e. child loss and fertility, for this purpose two demographic indicators TFR and IMR have been taken. Also attempts have been made to give thoughtful reasoning to indicate the relationship and the mechanism of the relationship.

For the present study Uttar Pradesh has been selected as it is most populated state in the country. As per Sample Registration System (SRS) Uttar Pradesh has highest birth rate followed by Bihar, Rajasthan and Madhya Pradesh. SRS reveals that Infant mortality rate (IMR) in case of Uttar Pradesh is 63. Only Orissa (65) and Madhya Pradesh (67) in the country have recorded higher infant mortality rate higher than Uttar Pradesh.

In this study, 44 years of SRS data for TFR and IMR has been taken for the analysis and two statistical methods used are; the Ordinary Least Squares Method (OLS) and the Granger causality test. The coefficient of regression, β_i indicates how a unit change in the independent variable affects the dependent variable. The error, ε_i, is incorporated in the equation to provide estimate of other factors that may influence dependent variable. The estimators (α, β) are unbiased with an expected value of zero i.e., $E(\varepsilon_i)=0$, which implies that on average the errors cancel out each other. The validity or strength of the Ordinary Least Squares method depends on the accuracy of assumptions. This procedure involves specifying the dependent and independent variables; in this case, TFR is the dependent while IMR is the independent variable but it depends on the assumptions and that the results of the methods can be adversely affected by outliers, In addition, whereas the Ordinary Least squares regression analysis can establish the dependence of either TFR on IMR or vice versa; this does not necessarily imply direction of causation.

Brief Overview of the Methodology

The theory behind the further estimation is based on stationary time series. A series is said to be (weakly or covariance) stationary if the mean and auto-covariances of the series do not depend on time. Any series that is not stationary is said to be non-stationary. The finding that many macro time series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non stationary time series are said to be co-integrated. The stationary linear combination is called the co-integrating equation and may be interpreted as a long-run equilibrium relationship among the variables. The purpose of the co-integration test is to determine whether a group of non-stationary series is co-integrated or not.

Unit Root Test

The standard classical methods of estimation are based on the assumption that the mean and variances of the variables are independent of time. But applications of unit root test have that these assumptions are not satisfied in number of macroeconomic time series. Variables where mean and variances are changes over time are called non-stationary or unit root variables. Further, the unit root has also shown that classical estimation method like OLS, to estimate relationship with unit root variable gives misleading inferences. This is the problem of spurious regression. If the mean and variances of the unit root variables changes over time, all the computed statistics in regression model, are also time dependent and fair to converge to their true value as the sample size increases. Further, conventional test of hypothesis will be biased towards rejecting the null hypothesis of no relationship between dependent and independent variables.

Dickey-Fuller (DF) & Augmented Dickey-Fuller (ADF) Test

Two types of trends may be present in any time series is deterministic trend and stochastic trend. The series should be detrended works well former, rendering it ‘trend stationary’. If a series has stochastic trend, it must be ‘differenced’ before being regressed on another stationary series to avoid the problem of spurious regressions. Such series is called a ‘differenced stationary’ series. With the following Dickey and Fuller the formal testing of stationarity begins with the unit root tests. In the absence of full information about the variable, we must test if a time series is non-stationary. To do this, a test called the Augmented Dickey-Fuller (ADF) test is performed.

Co-Integration Test

To test for co-integration between two or more non-stationary time series developed by Engel- Granger (1987), it simply requires running an OLS regression, saving the residuals and then running the ADF test on the residual to determine if it is stationary. The time series are said to be co-integrated if the residual is itself stationary. In effect the non-stationary *I(1)* series have cancelled each other out to produce a stationary *I(0)* residual.

$$y_t = \beta_0 + \beta_1 x_t + u_t$$

Where, y and x are non-stationary series. To determine if they are co-integrated, a secondary regression is estimated. This produces a t-statistic and according to this we would reject the null hypothesis of non-stationary time series and conclude the error term was stationary and the two variables are co-integrated.

Application

In this paper we present an empirical analysis of the effects, both behavioral and biological, of child deaths on subsequent fertility or vice-versa in the most populated State of India i.e. Uttar Pradesh, with moderately high levels of child mortality and fertility. Data for the investigation come from secondary data sources of National level: retrospective death and birth histories of a national probability sample of currently married women interviewed in the Survey and longitudinal vital registration data of women followed from 1970 to 2013 by the Sample Registration System (SRS) in a rural urban setting of Uttar Pradesh population in India. The analysis attempts to illustrate how inadequate methodological treatment of data may lead to conflicting results; to isolate possible behavioral effects from biological influences; to quantify the relative magnitude of these two factors; and to discuss the implication of these findings for future research.

In the study, 44 years of SRS data for TFR and IMR has been taken for the analysis. This is a time series longitudinal data. A time series is a set of observation on the values that a variable takes at different times. Time series analyses have long recognized that regression analysis can be highly misleading when applied to series with variable trends. In some cases the results can be dramatic errors in forecasting. In other cases an improper treatment of variable trends can result in false conclusions about how the economic works. Such series require separate econometric analysis to know the different sources of variation affecting the nature of behavior of the observation. Moreover, the analysis is meaningful for deeper understanding of the inner behavior of the character under study as well as for forecasting the future time dependent observed value. In time series analysis there are broadly three types of series;

- Those series which have mean reverting fluctuations around level.
- Which have mean reverting fluctuations around a deterministic trend (increases by some fixed amount every period).
- Those series which having fluctuations, not mean reverting around a deterministic trend.

From the above the first category represents stationary series. The second category represents deviations from trend are stationary. In the third category, the deviation from trend too is not stationary. This type of series creates problems. In such situation the usual practice of running regression on time stands invalidated and one has to test for variable trend. Estimation of relationship among variables may results in spurious relationship if the nature of the data generating process series under consideration is not taken care of. Most of the empirical work based on time series data assumed that the under consideration time series are stationary. In regression analysis a strong relationship between two variables may obtained due to strong trends. So in this case high R^2 value will be obtained. This high R^2 value may not reflect the true association between the two. This high value is due to presence of strong trend, the relationship between two variables is spurious not true.

While analyzing time series the relationship among them are likely to be spurious (Gujarati, 1995). This happens when one or more of the series in regression equation are non-stationary or contains unit root in their auto regressive representative. In such cases an appropriate strategy is to test, all the series under considerations for stationary before analyzing further, some of them are found to be non-stationary. The relation among them as estimated generally using ordinary least square (OLS) are likely to be spurious. This paper attempts to investigate the nature of series under consideration for stationary and find their order of integration, which is the first step in further analysis of time series. Further in the paper we tend to find the causal relationships between the child deaths and fertility explaining the two replacements theories stated earlier.

Granger Causality Test

Testing causality among variables is one of the most important and, yet, one of the most difficult issues in economics and social science studies. Two most difficult challenges are:

- Correlation does not imply causality. Distinguishing between these two is by no means an easy task.
- There always exists the possibility of ignored common factors. The causal relationship among variables might disappear when the previously ignored common causes are considered.

While there are no satisfactory answers to these two questions and there might never be one, philosophers and social scientists have attempted to use graphical models to address the second issue. As for the first issue, time series analysts look for rescue from the unique unidirectional property of time arrow: cause precedes effect. Based upon this concept, Clive W.J. Granger has proposed a working definition of causality, using the foreseeability as a yardstick which is called Granger causality.

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another, first proposed in (Granger,1969). Ordinary, regression reflect “mere” correlation, but Clive Granger argued that causality in time series data could be tested by measuring the ability to predict the future of that series using prior values of another time series. Since the question of “true causality” is deeply philosophical and because of the post hoc ergo propter hoc fallacy of assuming that one thing preceding another can be used as a proof of causation, econometricians assert that the Granger test finds only “predictive causality”. Granger causality remains a popular method for causality analysis in time series due to its computational simplicity.

Results & Discussion

For the present relationship among the pattern of mortality and fertility which may vary between cultural regions results in experiencing differing levels of mortality and fertility. There might be several other background characteristics seems worth reviewing briefly in the population under study due to which we can get the idea of present causation of the pattern i.e. weather mortality is governing the excessive fertility or vice-versa. This can be analyzed by the average number of children ever born for women besides the fact that weather they have experienced child loss or not. The results has been presented in Table 2 which shows average number of children ever born for women according to several background characteristics for the state of Uttar Pradesh. As the data indicate, Uttar Pradesh had moderately high levels of fertility in case of infant loss in each and every background characteristics in comparison to ones those have not experienced the same. Further, for getting the present causation of the pattern i.e. weather mortality is governing the excessive fertility or vice-versa average most recent closed birth interval has been obtained by the survivorship of the last but one birth in the state.

The results has been presented in Table 3 which shows average most recent closed birth interval for women by the survivorship of the last but one birth. According to the table, as the results indicate, we can say in Uttar Pradesh the women are tending to lower their closed birth interval in case their last born survived less than an year in comparison with those whose last born survived up to an year. It can also be said that this pattern is all the same whatever the order of birth is. The same results can be interpret by the Parity Progression Ratios presented in the Table 4, as women tend to have larger PPR in case their last born died before 12 months in comparison to others whose last born survived up to an year and the pattern is similar for all the parities.

The data graphically presented here in figure 1 and 2 as the 3-year moving average TFR and IMR of the Uttar Pradesh data for the years 1970-2013 given in SRS data. The figure portrays the declining trend in both throughout the years which is the objective of different policy programmes as well but from this we cannot state that what the main cause of this decrement is. This leads us for the further analysis.

Table 5 represents the linear regression estimates for IMR and TFR in rural and urban settings. The correlation coefficient between TFR and IMR for rural area is 0.87 and for urban area it is 0.83 in Uttar Pradesh. This obviously not provides the causal relationship between the two variables. So in order to get that causal relation between the variables we are applying some time series techniques and the results of those are given below. But before using the Granger causality test to know the direction of causality, we performed some of the other test like unit root test and co-integration test as mentioned earlier.

The objective of the test is to empirically examine whether a series contains a unit root or not. If the series contains a unit root, this means that the series is non-stationary. For this Augmented Dickey-Fuller test has been done. In Table 6 we show the Augmented Dickey- Fuller statistics in level and in first difference for IMR and TFR in rural and urban settings. Unit Root Test indicates that data are non-stationary in level but stationary in first difference so these data are integrated in order (1). The next test was Johansen Co-Integration test for identifying the long run relation between variables. The results of the test are shown in Table 7. The trace statistics J_T rejects the null of none against the alternative but the null of at most one is not rejected against the alternative in both the Rural and urban case settings. The statistics λ_{max} rejects the null of none against the alternative, whereas the null of at most one is not rejected against the alternative. Thus λ_{max} also supports the existence of a single co-integrating vector.

Since now we get that TFR and IMR are, in fact, interlinked and co-related through various channel. There is no theoretical or empirical evidence that could conclusively indicate sequencing from either direction. So for that causation we applied Granger causality test. The results based on this test are shown in Table 8. The table reveals that in both rural and urban areas that IMR does not Granger Cause of TFR at all, where as TFR Granger Cause of IMR as the *p*-value suggests. Thus we can predict TFR by IMR but IMR cannot be predicted by TFR.

Conclusion

In this paper we have investigated the causal relationship between the mortality and fertility of most populated state of India, Uttar Pradesh. The Ordinary least Square Method indicates that there is positive relationship between TFR and IMR but without telling the actual cause of it. The advantages of the method employed in this study, however, appear effectively to counterbalance these limitations. This analysis is the first to utilize unusually reliable longitudinal data and the first to apply birth interval dynamics to a study of this relationship. Moreover, it has demonstrated that how the ordinary least square gives same results for both dependent and independent variable without the actual prediction.

The Ordinary least Square Method indicates that there is positive relationship between TFR and IMR and Unit Root Test indicates that data are non-stationary in level but stationary in first difference so these data are integrated in order (1). Similarly Johansen Co-Integration test indicates that the null hypothesis that there is no co-integration is rejected for rank of zero at 5% level of significance. This means that there exists a long-run relationship between the variable. Finally, for the causation the Granger causality test reveals that IMR does not Granger Cause of TFR at all, where as TFR Granger Cause of IMR in both rural and urban settings of Uttar Pradesh. Thus we can predict TFR by IMR but IMR cannot be predicted by TFR. The investigation of the influence of infant mortality on fertility among the studied population has brought out a positive impact that the increasing mortality trend is a cause of increasing fertility in the studied population.

Overall, the Uttar Pradesh data presented in this study make a convincing case against the importance of the child-replacement hypothesis, particularly when the magnitudes of the behavioral effects are compared with biological effects. There is, however, evidence that mortality control programs could reduce fertility through a biological mechanism. Better survivorship of infants would facilitate lactation and prolong the period of post-partum sterility, and thus the entire birth interval. Perhaps the most important contribution of this paper has been its illustration of how different approaches may lead to conflicting results and fallacious conclusions.

Figure 1: Trend in Total Fertility Rate, 3- year moving average, Uttar Pradesh, 1970-2013

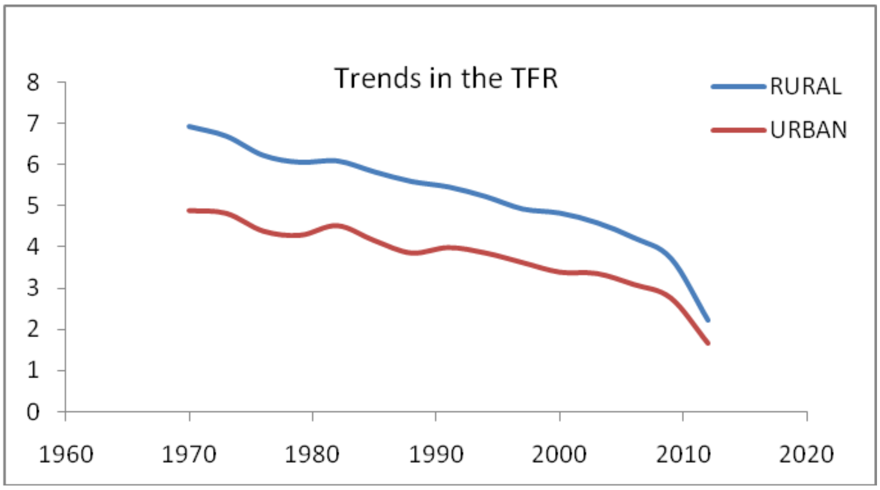

Figure 2: Trend in Infant Mortality Rate, 3- year moving average, Uttar Pradesh, 1970-2013

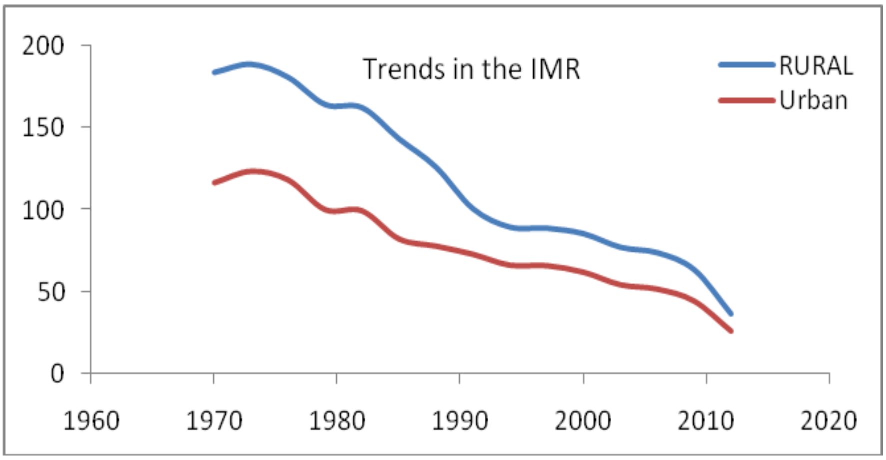

Table 1: Selected fertility and mortality rates in Uttar Pradesh from NFHS-III

Rates	Total	Rural	Urban
Fertility			
Crude Birth Rate*	29.1	30.9	23.5
Total fertility Rate#	3.8	4.1	3.0
Mortality			
Infant Mortality Rate†	72.7	74.8	64.2
years death rate*	25.6	27.2	19.4

*Per 1,000 population. # Birth per woman. † Per 1,000 live births.

Table 2: Average number of children ever born for women aged (40-49) having Infant/child loss or not, Uttar Pradesh

Background Characteristics	Having child loss	Not having child loss	Having Infant loss	Not having Infant loss
Place of Residence				
Urban	6.19	3.61	6.22	3.83
Rural	6.79	4.44	6.89	4.83
Education				
Illiterate	7.01	4.77	7.12	5.14
Literate	5.20	3.15	5.24	3.25
Religion				
Hindu	6.40	3.80	6.48	4.12
Muslim	7.61	5.05	7.73	5.40
Standard of Living Index				
Low	7.26	4.55	7.39	5.26
Medium	6.98	4.61	7.07	5.01
High	5.84	3.67	5.89	3.81
Caste				
SC/ST	6.86	4.64	6.94	5.07
OBC	6.79	4.42	6.89	4.75
Others	5.88	3.34	5.92	3.52
Total	**6.59**	**3.98**	**6.67**	**4.30**

Table 3: Average most recent closed birth interval by Survivorship of the last but one birth in Uttar Pradesh

Order of birth	Child survived up to 12 months	Child died before 12 months
1-2	37.60	30.71
2-3	38.81	28.81
3-4	36.01	28.85
4-5	35.75	31.18
5-6	34.96	29.56
6+	33.07	29.37
Total	36.46	29.56

Table 4: Estimates of Parity Progression Ratios in Uttar Pradesh

Parity	PPR in case last but one child survived up to 12 months	PPR in case last but one child died before 12 months
1	0.970	0.997
2	0.916	0.980
3	0.835	0.932
4	0.752	0.894
5	0.689	0.831
6	0.665	0.736

* Calculated by using birth order statistics

Table 5: Linear Regression Estimates

Regression equation of/on	Regression Equation	R^2
Rural		
of TFR on IMR	IMR=43.724*TFR-114.530	0.873
of IMR on TFR	TFR=0.020*IMR+2.967	0.873
Urban		
of TFR on IMR	IMR=35.078*TFR-56.943	0.829
of IMR on TFR	TFR=0.024*IMR+2.009	0.829

Table 6: Unit root test result

Characteristics	Augmented Dickey-Fuller test statistic	p-value
Variable in level		
TFR Rural	-0.128061	0.9388
IMR Rural	-0.578261	0.8640
TFR Urban	-1.295038	0.6223
IMR Urban	-0.569680	0.8656
Variable in first difference		
TFR Rural	-10.87472	0.0000
IMR Rural	-7.775511	0.0000
TFR Urban	-6.900705	0.0000
IMR Urban	-11.24514	0.0000

H_0: unit root, H_1: trend stationary

Table 7: Co-integration test result

Null hypothesis	Max. eigen value(λ_{max})	5% critical value	Trace statistics	5% critical value
TFR Vs IMR in Rural				
None	16.98648	15.89210	22.10664	20.26184
At most one	5.120165	9.164546	5.120165	9.164546
TFR Vs IMR in Urban				
None	16.32817	15.89210	21.20730	20.26184
At most one	8.879122	9.164546	8.879122	9.164546

H_0: has no co-integration, H_1: has co-integration

Table 8: Results based on Granger causality test

Pair wise Granger Causality Tests in Rural area		
Null Hypothesis	F-Statistic	Probability
IMR does not Granger Cause of TFR	3.91726	0.03814
TFR does not Granger Cause of IMR	2.02997	0.19501
Pair wise Granger Causality Tests in Urban area		
Null Hypothesis	F-Statistic	Probability
IMR does not Granger Cause of TFR	4.86839	0.01404
TFR does not Granger Cause of IMR	1.37414	0.26716

References

Adlakha, A.L. (1970) ‘A Study of Infant Mortality in Turkey’, Unpublished Ph.D. thesis, University of Michigan.

Bhat, M. (1996) ‘Contours of fertility decline in India: A district-level study based on the 1991 census’. in K. Srinivasan, ed., Population Policy and Reproductive Health. New Delhi: Hindustan pp. 96-177.

Bhuyan, K.C. (1996) ‘Fertility differential according socio-economic status and family planning adoption in rural Bangladesh’. *Sankhya: Indian Journal of Statistics*, Series B, 58(2), pp 302-322.

Chawdhury, R.H. (1982) ‘Social Aspects of fertility: with special reference to developing countries’ Vikas Publishing House Pvt. Ltd., New Delhi, 125-155.

Damodar, N. & Gujarati (1995) ‘Basic Econometrics’, Third Edition, McGraw-Hill Inc, New York.

Fuller, W.A. (1976) ‘Introduction to Statistical Time Series’, Wiley & Sons, New York.

Granger, C. W. J. (1969), ‘Investigating Causal Relations by Econometric Models and Cross-spectral Methods’, *Econometrica*, 37 (3), pp 424–438.

Harrington, J. A. (1971) ‘The Effect of High Infant and Childhood Mortality on Fertility: The West African Case’, *Concerned Demography*, 3, pp. 22-35.

Hassan, S. S. (1966) ‘Influence of Child Mortality on Population Growth’, Unpublished Ph.D. thesis, Cornell University.

Jelliffe, D. B. (1968) ‘Infant Nutrition in the Sub-tropics and Tropics’, WHO Monograph No. 29, Geneva.

Nerlove, M. & Schultz, P. T. (1970) ‘Love and Life between the Censuses: A Model of Family Planning Decision-making in Puerto Rico’, Rand Corporation.

Nortman, D. (1974) ‘Parental Age as a Factor in Pregnancy Outcome and Child Development’, Reports on Population/Family Planning, Population Council No. 16.

Potter, R. C., Wyon, J. B., Parker, M. & Gordon, J. E. (1965) 'A Case Study of Birth Interval Dynamics', *Population Studies*, 19, pp. 81-96.

Schultz, P. T. (1966) 'An Economic Analysis of Family Planning and Fertility', *Journal of Political Economy*, 77, pp. 153-180.

Taylor, C.E. (1965), ‘Health and Population’, Foreign Affairs, April, pp. 475-485.

Tietze, C. (1961), ‘The Effect of Breast-feeding on the Rate of Conception’, Proceedings of the International Population Conference, New York.

Wray, J. D. (1971) ‘Population Pressure on Families: Family Size and Child Spacin’, Rapid Population Growth, Vol. 2, Chap. 11, Baltimore, Johns Hopkins Press.

Wyon, J. B. & Gordon, J. E. (1971) The Khanna Study, Cambridge, Harvard University Press.