ISSN 1442-8563

SOCIAL ECONOMICS, POLICY AND DEVELOPMENT

Working Paper No. 36

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September 2003

SCIENTIA AC LABORE

THE UNIVERSITY OF QUEENSLAND

ISSN 1442-8563
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(Working Paper)

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WORKING PAPERS IN THE SERIES, *Social Economics, Policy and Development* are published by School of Economics, University of Queensland, 4072, Australia. They are designed to provide an initial outlet for papers resulting from research funded by the Australian Research Council in relation to the project 'Asset Poor Women in Development',

Chief Investigator: C.A. Tisdell and Partner Investigators: Associate Professor K.C. Roy and Associate Professor S. Harrison. However this series will also provide an outlet for papers on related topics. Views expressed in these working papers are those of their authors and not necessarily of any of the organisations associated with the Project. They should not be reproduced in whole or in part without the written permission of the Project Leader. It is planned to publish contributions to this series over the next few years.

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Fertility and Female Work Force Participation in Bangladesh: Causality and Cointegration

ABSTRACT

This paper examines the causal links between fertility and female labor force participation in Bangladesh over the period 1974-2000 by specifying a bivariate and several trivariate models in a vector error correction framework. The three trivariate models alternatively include average age at first marriage for females, per capita GDP and infant mortality rate, which control for the effects of other socio-economic factors on fertility and female labor force participation. All the specified models indicate an inverse long-run relationship between fertility and female labor force participation. While the bivariate model also indicates bidirectional causality, the multivariate models confirm only a unidirectional causality – from labor force participation to fertility. Further, per capita GDP and infant mortality rate appear to Granger-cause both fertility and female labor force participation.

JEL classifications: C32, J13, J22

Key words: Fertility, Female Labor Force Participation, Causality,

Fertility and Female Work Force Participation in Bangladesh: Causality and Cointegration

1. Introduction

The literature on female work force participation and fertility envisages an inverse relationship between the two (Ahn and Mira, 2002; Brewster and Rindfuss, 2000). With increasing female labor force participation, developed industrialised countries have experienced massive declines in fertility rates over time (Lim, 2002). The increased female labor force participation resulted in fertility transition for these countries. By 1980, fertility rates in most developed countries reached the replacement rate of 2.1 per woman and by 2000, the fertility rates dropped below the replacement rate. This shift in the fertility rates is largely attributed to the increasing workforce participation of the women in the prime age group of 25-54. In contrast, evidence from the developing countries shows a mixed picture and, in general, fertility declines in these countries have been rather slow, if not negligible.

The Bangladesh official data suggest a rising trend in the female work force participation, especially since the early 1980s owing largely to the expansion of the unskilled labor-intensive textiles sector as well as the spread of the micro-credit programs by various NGOs (Non-Government Organisations) including the celebrated *Grameen Bank*. Evidence on Bangladesh is also supportive of a declining fertility rate over time. The trends in fertility and female labor force participation rates in Bangladesh are evident from Figure 1.

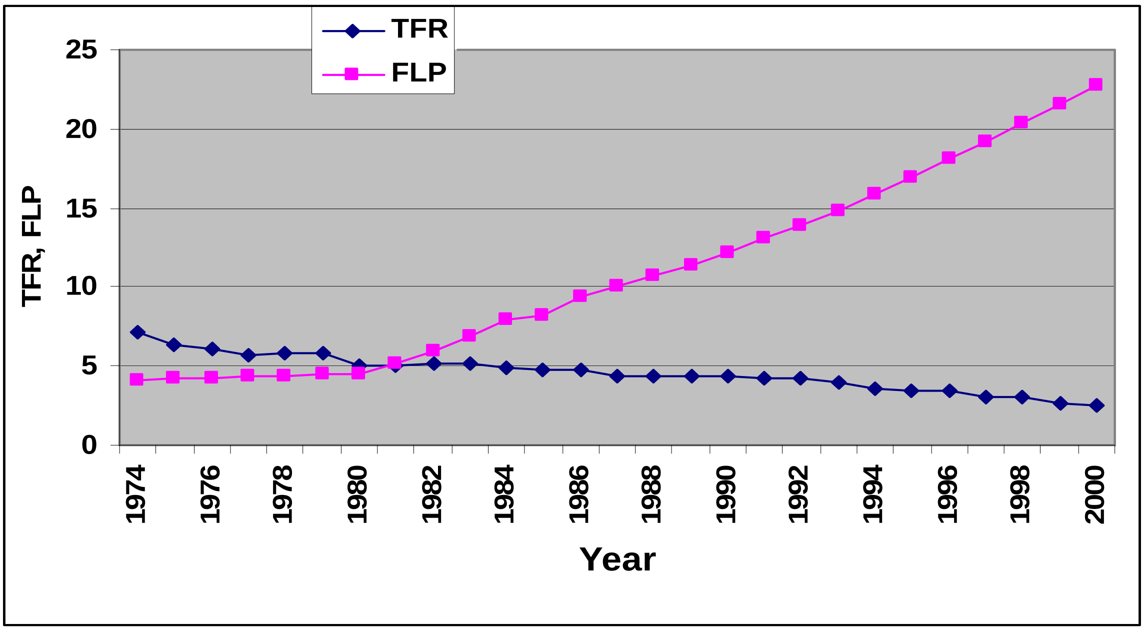

Figure 1: Total Fertility Rate (TFR) (per thousand women) and Female Labor Force Participation Rate (FLP) (per cent) in Bangladesh, 1974-2000.

Several micro-level studies provide useful insights on the declines in fertility rate in Bangladesh (for example, Razzaque, 1996; Khuda and Hossain, 1996). These studies identify particular factors such as the knowledge of family planning, economic cost of raising children, female education and employment as important determinants of fertility rate. However, these studies do not employ any statistical technique to substantiate their findings or observations. To the knowledge of these authors, no macro-level studies have yet been undertaken on Bangladesh to investigate the causal link between female labor force participation and fertility. This paper is intended to fill this vacuum. The study covers the period 1974 to 2000.

As elaborated in the next section, theory does not clearly indicate the direction of causality between female labor force participation and fertility. Thus empirical analysis is needed. Several macro-level studies have investigated this issue by applying the Granger-causality tests and/or the error correction modeling in a bid to ascertain the direction of causality as well as the existence of a long-run relationship between the two. Such empirical techniques are regarded as appropriate tools for dealing with time series that are not stationary in their levels, as in the present case. Most empirical studies to date have used a two-variable framework. Notwithstanding the fact that small sample sizes may force a researcher to adopt a two-variable framework, the omission of a third important variable may lead to misspecification bias. The present study uses the average age at first marriage (AFM), infant mortality rate (INF) and per capita gross domestic product (PGDP) as alternative possible third factors. These variables represent social and economic changes taking place in a country through time and, therefore, can be considered important factors determining both fertility behavior and female labor force participation. Some regard the socio-economic changes as constituting external factors responsible for a declining fertility rate (see, for example, van de Kaa, 1987).

Of the various causality and cointegration tests, the vector error correction modeling (VECM) suggested by Johansen and Juselius (1990), that is, the maximum likelihood in an error correction modeling (MLECM) satisfies well the desirable properties of a time-series modeling (Gonzalo, 1994) and, therefore, has gained wide acceptance in recent empirical applications. This paper, therefore, applies the Johansen-Juselius MLECM, in conjunction with the 'general to specific modelling', for examining the existence of long-run relationship as well as the causal link between female labor force participation and fertility. The rest of the paper is organised as follows. Section 2 reviews the theoretical issues underpinning the female workforce participation-fertility nexus as well as the past empirics. Section 3 explains the rationale for the inclusion of the variables and the suggested empirical technique. Section 4 examines the time series properties of the data. Section 5 provides the estimated results. Section 6 presents the concluding remarks.

2. A Brief Review of Theoretical Issues and Past Empirics

The observed downward trend in fertility rates, according to the theory of the 'second demographic transition', is mainly an outcome of the interaction between various social and economic changes (Lestaeghe, 1983; van de Kaa, 1987). The New Home Economics or the neoclassical theory of fertility as formulated and extended by Becker (1960, 1981), Becker and Lewis (1973), Willis (1973) and Cigno (1991) regards the market wage or the opportunity costs of mother's time as a fundamental economic variable influencing fertility behavior. Accordingly, the theory of fertility predicts a negative correlation between female labor force participation and fertility rates. Another explanation for the negative correlation between fertility and female labor force is pronounced in the commonly perceived theory of incompatibility which highlights the conflicts between child-bearing and female work force participation or, alternatively, the conflict between women's productive and reproductive roles. The theory of incompatibility is more relevant in the context of a developing country like Bangladesh where the childcare facilities outside home are almost non-existent.

Besides the above theoretical precepts, the experience of the developed countries suggests several stylised conditions relating to the negative association of the fertility rates and female work force participation. Lim (2002) lists an array of these stylised observations which clearly support the theoretical contention made above. Some of the other possibilities that, accordingly to Lim, can explain this negative correlation are as follows:

(a) Women's employment raises their status in terms of control over resources and participation in family decision-makings including decisions on fertility;
(b) The interruption effects, that is, the costs of withdrawal from the labor force for child-raising are very high;
(c) The returns and satisfaction derived from work force participation outweigh the returns and satisfaction to be derived from having additional children;
(d) Women achieve financial independence as well as security for old age or against any adverse economic conditions through employment and income-earning activities;
(e) An increase in women's labor force participation leads to an increased investment in female education and age at first marriage and age at first pregnancy goes up; and
(f) Women enter the job market before marriage and as a result of which, age at first marriage and age at first pregnancy go up.

These stylised facts in conjunction with the theory of the 'second demographic transition' indicate that increased female labor force participation is responsible for a declining fertility rate. In other words, these observations imply a cause and effect relationship between female labor force participation and fertility in that order. The suggested causal relationship is less explicit in the New Home Economics theory or the theory of incompatibility. These theories do not specify the direction of causality between the two. Instead, they consider female labor force participation and fertility rate as being endogenous components of the same microeconomic model, and are caused by common exogenous factors, such as the female real wage rate, unemployment rate as well as the social norms and social institutions. Some researchers, on the other hand, argue that female labor force participation and fertility behavior are more of an outcome of a sequential decision process rather than being an outcome of a simultaneous decision problem and that part of the association between the two may not be determined by external factors (Engelhardt *et al.*, 2001). This implies the existence of a causal relationship between female labor force participation and fertility. Weller (1977) suggests that the causality can run either way or both ways or there may not be any causal relationship between the two.

To date, empirical studies based on macro-level data almost invariably provided evidence in favor of a causal relationship between fertility and female employment, the direction of causality, however, being mixed. Using the modified Granger causality test, Zimmermann (1985) (as cited in Engelhardt *et al*., 2001), shows that total fertility rate (TFR) Granger-caused female labor force participation rate (FLP) in Germany during 1960-1979.[1] By employing the standard Granger causality in levels of the variables, Michael (1985), finds that *FLP* caused *TFR* while age-specific fertility rate caused *FLP* in the United States during the period 1948-1980. In contrast, however, by applying the modified Granger causality test, Cheng (1996) finds *TFR* to have caused *FLP* in the United States during 1948-1999. Using the monthly survey data for the period 1977-1984, Klijzing *et. al.* (1988) find a two-way causation between the number of children born and *FLP*. Engelhardt *et al.*, (2001) find bi-directional causality between *TFR* and *FLP* for France, UK and USA (1948-1995) and also between various age-specific fertility rates and FLP for USA (1948-1995), unidirectional causality for Germany (from FLP to TFR), USA (from TFR to FLP for the period 1960-1994) and no causality for Sweden. Using the Engle-Granger cointegration procedure, Engelhardt *et al.*, (2001) also find the existence of a long-run relationship between *TFR* and *FLP* in all the cases mentioned above except for Sweden when normalised on *TFR*.

3. Rationale for the Choice of the Variables and Suggested Econometric Technique

Two important features of the empirical studies described in the previous section are: (a) all of them are based on a bivariate framework and (b) all these studies applied the Granger causality tests, in some form or the other, and the Engle-Granger cointegration test for ascertaining the direction of causality and/or the long-run relationship. The use of Granger causality tests with due consideration for the non-stationarity property of the time series represents an obvious improvement over the commonly used techniques of simple correlation and/or the ordinary least squares regressions.[2] But the absence of a third variable may render the causal models misspecified. Consequently, the parameter estimates may be biased and inconsistent thereby leading to misleading causal links between the variables in question (Maddala and Kim, 1998; Islam, 1998). Indeed, Granger (1969) himself cautions that the absence of other relevant factors in the model may result in spurious causality. Secondly, a pair of variables may not be cointegrated when tested in a bivariate framework but may turn out to be cointegrated in a multivariate setting (Maddala, 2001). Further, although considered as more powerful than the alternative causality tests (Geweke *et al*., 1983), the Granger-causality test draws criticisms on many grounds, especially in the context of a small sample (Conway *et al*., 1984). Similarly, the Engle-Granger cointegration and error correction methodology has a number of drawbacks.[3] *First*, the procedure produces different cointegrating vectors for a specified model depending on which variable is chosen for normalisation. It is thus not surprising that Engelhardt *et al.* (2001) found (for Sweden) TFR and FLP to be cointegrated when normalised on TFR but not when normalised on FLP. *Second*, the Engle-Granger technique cannot identify more than one potential cointegrating vector in a multivariate setting. *Finally*, being a two-step procedure, the Engle-Granger method is likely to carry forward any errors committed in the first step on to the second step.

To circumvent the misspecification bias, the present study checks the robustness of the two-variable results by adding a third variable in the model. Average age at first marriage (AFM), infant mortality rate (INF) and per capita GDP (PGDP) are alternatively used as the third variable.[4] The rationales for the choice of the variables are as follows. First, they bring in the effects that are due to external factors. The average age at first marriage is considered mainly to be an outcome of female education. Job opportunities for the more educated women are higher than for the less educated or women with no basic education. Thus, educated women intending to pursue a professional career are likely to delay their marriage and will tend to have fewer children. Per capita GDP is an outcome of the overall economic activities taking place in the country. Among other things, the growth of GDP makes possible the creation of new employment opportunities in the economy. Traditionally, the very high infant mortality rates in the underdeveloped countries have been perceived as a major cause for the high fertility rates. As a result, women's participation in career employment has been low. Better nutrition and the availability of affordable life-saving drugs in recent years have significantly reduced the infant mortality rates in many underdeveloped countries. For example, infant mortality rate in Bangladesh dropped from 13.8 per cent in 1974 to a remarkable 5.1 per cent in 2000 (BBS, 2000). A fall in infant mortality rate results in a decline in fertility rate. The time thus released by females from reproduction during their life cycle can then be spent in income-generating activities. This highlights the possibility that infant mortality and the consequent changes in fertility can both influence female labor force participation. Secondly, the inclusion of these variables captures effects of the social and economic changes thereby conforming to the suggestions of the various theories of fertility.

In order to overcome the difficulties associated with the Granger causality test and the Engle-Granger cointegration methodology, this study applies the Johansen-Juselius maximum likelihood in an error correction modelling (MLECM). Besides avoiding the above-mentioned problems with the Engle-Granger methodology, the MLECM presents an analytical framework that can check the Granger causality and the existence of cointegration or long-run relationship simultaneously (Enders, 1995; Patterson, 2000).

To put into context the Johansen-Juselius MLECM procedure, let us assume a bivariate framework with y_t and x_t as the variables. Normalising on $y_{t,}$ the long-run relationship between the two variables, following Engle and Granger (1987), can be written as:

$$y_t = \alpha_0 + \alpha_1 x_t + \varepsilon_t \tag{1}$$

Assuming that the variables are I(1) or integrated in the first differences, the vector error correction representation of Equation (1) can be given by:

$$\Delta y_t = \delta_0 + \sum_{i=1}^{p} \delta_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \delta_{2i} \Delta x_{t-i} + \delta_3 EC_{t-1} + \varepsilon_t \tag{2}$$

where EC_t is the residuals from equation (1) and p is the chosen lag length. The Engle-Granger method derives the long-run relationship and, therefore, the EC_t by applying the OLS in a single-equation framework, while the Johansen-Juselius procedure uses the maximum likelihood estimation in a system of equations. In a cointegrated system, x_t does Granger-cause y_t if and only if the coefficients of the lagged x_t as well as the error correction term are simultaneously different from zero.

4. The data and their Time Series Properties

Using lower-case letters to denote natural logarithm of the variables, the models of our interest can be symbolically represented as follows:

Model 1: $U_1\ (tfr_t, flp_t)$

Model 2: $U_2\ (tfr_t, flp_t, afm_t)$

Model 3: $U_3\ (tfr_t, flp_t, pgdp_t)$

Model 3: $U_3\ (tfr_t, flp_t, inf_t)$

where

tfr_t = total fertility rate;

flp_t = female labor force participation rate;

afm_t = average age at first marriage;

$pgdp_t$ = real per capita gross domestic product; and

inf_t = infant mortality rate (per cent)

The data are all taken from various issues of the *Bangladesh Statistical Yearbook*, the official data source for Bangladesh. While the TFR, AFM, PGDP and INF data are available on a year-to-year basis, data on FLP are based on the Labor Force Surveys conducted at different time intervals. More specifically, data on FLP are available for the years 1974, 1981, 1984, 1986, 1989, 1991, 1996 and 2000. The missing observations within an interval are calculated by estimating the exponential growth rate for that interval. During the sample period of 1974-2000, the Labor Force Surveys employed two different definitions of the labor force participation rate. The new or the 'extended' definition, introduced in 1989, and the old definition show marked differences in FLP with respect to both the crude and refined activity rates. This is due to the inclusion of activities such as threshing, boiling, drying and husking of crops, and processing and preserving food at the household levels under the new definition. These activities are hardly separable from the routine day-to-day activities of a typical rural household in Bangladesh. From economic point of view, these activities probably do not have a serious implication other than contributing to an inflated perception about the female labor force participation. This study, therefore, applies the old definition. Further, the study uses the refined activity rates, that is, FLP for persons 15 years and above.

4.1 Time Series Properties of Data

The prerequisite for the existence of cointegration or long-run relationship is that the time series are integrated of the same order, that is, they are stationary in identical order of the level variables. The stationarity status of the time series are usually examined through some standard unit root tests such as the Phillips-Perron (PP) test and the Augmented Dickey–Fuller (ADF) test. However, the application of these conventional unit root tests is contingent upon the requirement that the time series in question does not contain a sudden jump or break at any time period(s) (Zivot and Andrews 1992; Ben-David *et al.* 1997).

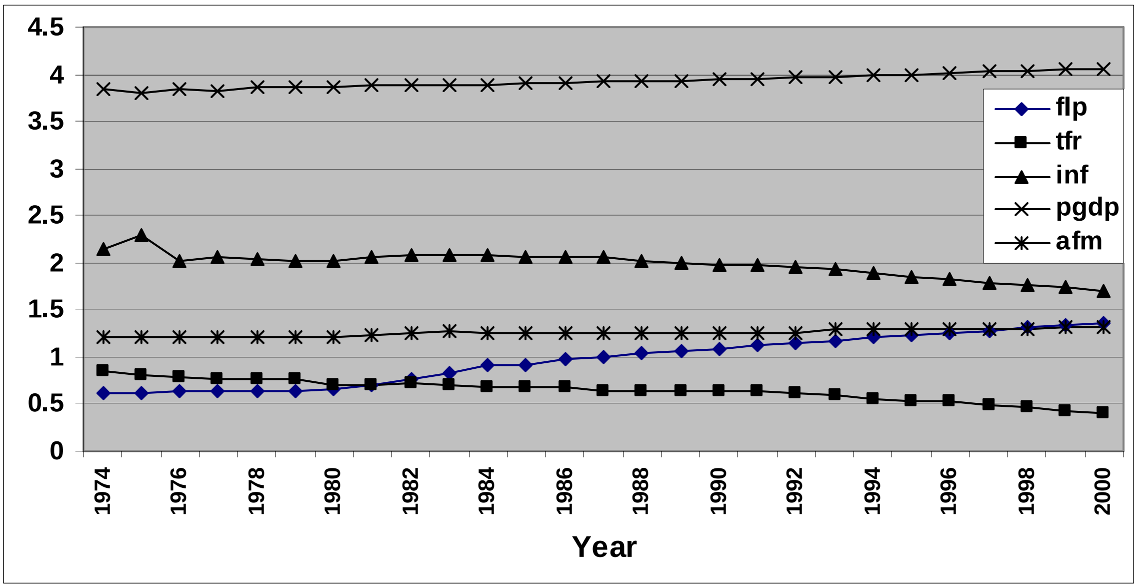

Figure 2: The plots of TFR, FLP, AFM, PGDP and INF (in logarithmic scale) for Bangladesh

From the plots (of the log) of the variables in Figure 2, it can be observed that only the *FLP* series is susceptible to any such break or jump, seemingly after 1980. But relevant statistical test based on a *pulse* dummy approach rejects the null hypothesis that there exists a sudden break in the *FLP* series.[5] This implies that the conventional unit root tests can be applied to all four variables specified in the models. Both the ADF and the PP tests suggest that tfr_t, flp_t, $pgdp_t$ and inf_t are stationary in their first differences, or I(1), while afm_t is stationary in the level, or I(0). By virtue of being I(1), tfr_t, flp_t, $pgdp_t$ and inf_t can be interpreted as being cointegrated or that they have a long-run relationship between themselves provided they pass the appropriate cointegration tests. On the other hand, the I(0) variable afm_t is not cointegrated and, hence, does not have any long-run relationship with the other three variables. Nonetheless, afm_t can be expected to have a contemporaneous impact on these variables. The tests for the existence of cointegration and the number of cointegrating relationships as well as the existence of Granger-causality for the stipulated models are presented in the next section.

5. Empirical Results on Cointegration and Causality

We begin with the bivariate framework as specified in Model 1. The cointegration tests are presented in Table A.1 in the Appendix. The λ_{max} and λ_{trace} statistics reject the null hypothesis of no cointegration (r = 0) against the alternatives of one or more cointegrating vectors (r = 1 or r ≥ 1). But the test statistics do not reject the null hypothesis of one or less cointegrating vectors (r ≤ 1) against the alternatives of two or more cointegrating vectors (r = 2 or r ≥ 2). Hence, we conclude that there exists exactly one cointegrating relationship between tfr_t and flp_t. The conclusion also holds when afm_t, $pgdp_t$ and inf_t are alternatively added to the model as in Models 2 through 4. The cointegration tests for Models 2, 3 and 4 are presented respectively in Tables A.2, A.3 and A.4 in the Appendix.[6]

5.1 Estimated Long-Run Relationships

The cointegrating vector for each model is derived by applying the Johansen-Juselius method. As noted before, the Johansen-Juselius procedure produces identical cointegrating vector(s) irrespective of the variable (in the model) chosen for normalisation. Normalising on tfr_t, the long-run relationships involving the four models are estimated as follows:

Model 1 [$U_1(tfr_t, flp_t)$]: $$tfr_t = \underset{(0.05)}{0.12} \; \underset{(0.29)}{-0.85}\, flp_t$$

Model 2 [$U_2(tfr_t, flp_t, afm_t)$] $$tfr_t = \underset{(6.83)}{-9.02} \; \underset{(0.25)}{-0.67}\, flp_t$$

Model 3 [$U_2(tfr_t, flp_t, pgdp_t)$] $$tfr_t = \underset{(1.36)}{-5.26} \; \underset{(0.17)}{-0.39}\, flp_t \; \underset{(0.58)}{-3.55}\, pgdp_t$$

Model 4 [$U_2(tfr_t, flp_t, inf_t)$] $$tfr_t = \underset{(0.99)}{-2.18} \; \underset{(0.17)}{-2.53}\, flp_t \; \underset{(0.32)}{+1.73}\, inf_t$$

The long-run coefficients all have the expected signs, and are statistically significant as suggested by the standard errors (in brackets). All four models verify that total fertility rate and female labor force participation rate are inversely related. As expected, per capita GDP has a negative while infant mortality rate has a positive influence on total fertility rate. Alternatively, among other factors, increasing labor force participation and per capita GDP as well as decreasing infant mortality rate can be interpreted as being responsible for the declining trend in total fertility rate in Bangladesh over the period 1974-2000.

5.2 *Estimated Error Correction Equations, and Granger-Causality*

The existence of cointegration, following the Granger Representation Theorem (Engle and Granger, 1987), implies the existence of a short-run adjustment process leading to the long-run equilibrium. The simultaneous estimation of the short-run dynamics and the long-run relationship is carried out by estimating a VECM similar to Equation (2). Following are the error correction terms for the models as derived from the estimated long-run equations:

Model 1: $EC_t^1 = tfr_t - 0.12 + 0.85\, flp_t$

Model 2: $EC_t^2 = tfr_t + 9.02 + 0.67\, flp_t$

Model 3: $EC_t^3 = tfr_t + 5.26 + 0.39\, flp_t + 3.55\, pgdp_t$

Model 4: $EC_t^4 = tfr_t + 2.18 + 2.53\, flp_t - 1.73\, inf_t$

The VECMs are estimated by choosing an arbitrary lag length of 4 for each variable in the model(s).[7] Such a generous lag structure allows us to carry out a 'testing down' procedure, known as the 'general to specific modeling' in order to arrive at a parsimonious or economically interpretable model pertaining to each error correction equation. The method involves the gradual elimination of the statistically insignificant lags from the estimated equation which, however, needs to be consistent with relevant diagnostic tests for serial correlation, normality, functional form and heteroscedasticity. The parsimonious equations are estimated for both $dtfr_t$ and $dflp_t$. The estimation of the error correction equations for $dflp_t$ permits the verification of reverse and/or bi-directional causality between total fertility and female labor force participation. The estimated equations are presented in Tables 1 to 4.

The bivariate model, as reported in Table 1, shows that the lagged error correction term, EC_{t-1}^1, in the equation for $dtfr_t$ is negative and statistically significant. This implies that there exists a short-term mechanism that leads to the long-run equilibrium concerning the TFR and the FLP variables. However, an absolute value of 0.03 of EC_{t-1}^1 indicates that the speed of adjustment is extremely low. Alternatively, once disturbed, it takes about 33 years for the long-run relationship involving TFR and FLP to get back to equilibrium. Nonetheless, the significance of EC^1_{t-1} has important implications for Granger-causality in that the statistical significance of the lagged $dflp_t$ in the presence of a significant error correction term suggests causality from female labor force participation rate (*FLP*) to fertility (*TFR*). The equation for $dflp_t$ also indicates the existence of a short-run adjustment mechanism. Further, it shows the presence of reverse Granger-causality, that is, Granger-causality from *TFR* to *FLP*. Thus, the bivariate model is indicative of the existence of bi-directional Granger-causality between total fertility rate and female labor force participation rate.

Table 1

Parsimonious Error Correction Equations for $dtfr_t$ and $dflp_t$ for the Bivariate Model (Model 1)

Dependent Variable: $dtfr_t$			**Dependent Variable: $dflp_t$**		
Regressor	**Cofficient**	**t-Value**	**Regressor**	**Cofficient**	**t-Value**
$dtfr_{t-2}$	-0.41	-1.95**	*constant*	0.49	4.56*
$dflp_{t-2}$	0.41	2.38*	$dtfr_{t-1}$	0.42	2.47*
EC^1_{t-1}	-0.03	-4.56*	$dflp_{t-4}$	0.41	2.49*
			EC^1_{t-1}	-0.19	-3.98*
$R^2 = 0.30$	$LMS = 2.68$ [.10]		$R^2 = 0.62$	$LMS = 0.41$[.52]	
Adjusted $R^2 = 0.23$	$RESET=0.04$ [.85]		Adjusted $R^2 = 0.53$	$RESET = 0.22$ [.64]	
$F(2, 19) = 4.09$*	$NORM = 3.59$ [.17]		$F(3, 18) = 7.03$*	$NORM = 0.29$ [.86]	
$DW = 2.70$	$HET = 0.75$ [.39]		$DW = 2.17$	$HET = 0.00$ [.96]	

Legend: *significant at 5% level less; **significant at 10% level or less.

Note: figures in parentheses denote the rejection level of significance.

Diagnostic Tests:

LMS: Lagrange multiplier test for residual serial correlation.

RESET: Ramsey RESET tests for functional form misspecification.

NORM: Jarques-Bera test for normality of residuals.

HET: Test for heteroscedasticity based on squared residuals.

The inclusion of the I(0) variable *AFM* (average age at first marriage) in the model also verifies the existence of the short-run adjustment process as can be seen from the statistical significance of the coefficients of the error correction term EC^2_{t-1} for both $dtfr_t$ and $dflp_t$ equations (Table 2). However, Model 2 only confirms unidirectional causality, the direction of causality being from *FLP* to *TFR*, as implied by the estimated equation for $dtfr_t$. FLP, on the other hand, is mainly affected by its own past records. As expected, *AFM* has respectively negative and positive contemporaneous effects on *TFR* and *FLP*.

Table 2

Parsimonious Error Correction Equations for $dtfr_t$ and $dflp_t$ with afm_t as the third variable (Model 2)

Dependent Variable: $dtfr_t$			Dependent Variable: $dflp_t$		
Regressor	**Cofficient**	**t-Value**	**Regressor**	**Cofficient**	**t-Value**
$dtfr_{t-1}$	-0.33	-3.61*	*constant*	1.46	2.51*
$dtfr_{t-2}$	-0.43	-2.10*	$dflp_{t-2}$	0.38	2.11*
$dflp_{t-2}$	0.54	2.59*	afm_t	0.22	1.95**
afm_t	-0.16	-2.81*	EC^2_{t-1}	-0.17	-2.50*
EC^2_{t-1}	-0.03	-2.37*			
$R^2 = 0.40$	$LMS = 0.07$ [.80]		$R^2 = 0.33$	$LMS = 0.12$ [.73]	
Adjusted $R^2 = 0.27$	$RESET = 1.38$ [.24]		Adjusted $R^2 = 0.22$	$RESET = 1.62$ [.20]	
$F(4, 18) = 6.97$*	$NORM = 0.65$ [.72]		$F(3, 19) = 3.00$**	$NORM = 1.91$ [.39]	
$DW = 2.05$	$HET = 0.74$ [.39]		$DW = 1.70$	$HET = 3.53$ [.06]	

Legend, Note and Diagnostic tests: As in Table 1.

Table 3

Parsimonious Error Correction Equations for $dtfr_t$ and $dflp_t$ with $pgdp_t$ as the third variable (Model 3)

Dependent Variable: *dtfr$_t$*			Dependent Variable: *dflp$_t$*		
Regressor	**Cofficient**	**t-Value$^{\xi}$**	**Regressor**	**Cofficient**	**t-Value**
constant	22.55	4.44*	*constant*	-7.67	-8.11*
time	0.05	4.06*	$dflp_{t-2}$	0.29	2.67*
$dtfr_{t-2}$	-0.34	-2.30*	$dpgdp_{t-1}$	-0.31	-2.36*
$dflp_{t-3}$	-0.36	-3.49*	EC^3_{t-1}	-0.39	-8.19*
$dpgdp_{t-1}$	1.37	2.66*			
EC^3_{t-1}	-0.72	-4.43*			
$R^2 = 0.72$	*LMS = 0.41 [.52]*		$R^2 = 0.39$	*LMS = 0.05[.82]*	
Adjusted $R^2 = 0.62$	*RESET = 4.95 [.03]*		*Adjusted* $R^2 = 0.32$	*RESET = 0.49 [.49]*	
$F(6, 16) = 6.93$*	*NORM = 1.85 [.40]*		$F(3, 19) = 5.98$*	*NORM = 0.37 [.83]*	
DW = 1.69	*HET = 6.49 [.01]*		*DW = 1.84*	*HET = 2.31 [.13]*	

Legend, Note and Diagnostic tests: As in Table 1. $^{\xi}$adjusted for heteroscedasticity

The implications of Models 3 and 4 for the short-term adjustment mechanism and Granger-causality are similar to those of Model 2. Alternatively, the long-run equilibrium relationship between *TFR* and *FLP* holds even when the effects of *PGDP* or *INF* are controlled, which can be evidenced from Tables 3 and 4. On the other hand, the presence of *PGDP* or *INF* confirms only unidirectional causality (from *FLP* to *TFR*). At best *TFR* may have a contemporaneous effect on *FLP*, which is suggested by the presence of $dtfr_t$ in the equation for $dflp_t$ in Model 4 (Table 4). One notable difference between Models 3 and 4 on the one hand and Models 1 and 2 on the other is that the speeds of adjustment are much higher in the former. This suggests that external factors, such as *PGDP* and *INF*, have an important role in the long-run relationship between *TFR* and *FLP*. It is also interesting to note that *PGDP* and *INF* Granger-cause both *TFR* and *FLP*.

Table 4

Parsimonious Error Correction Equations for $dtfr_t$ and $dflp_t$ with inf_t as the third variable (Model 4)

Dependent Variable: $dtfr_t$			Dependent Variable: $dflp_t$		
Regressor	**Cofficient**	**t-Value**	**Regressor**	**Cofficient**	**t-Value**
constant	-7.50	-5.49*	*constant*	-8.28	-7.33*
time	0.09	5.17*	*time*	0.10	7.33*
$dlfp_{t-1}$	0.77	2.71*	$dtfr_t$	0.30	2.51*
$dlfp_{t-2}$	0.71	3.98*	$dlfp_{t-1}$	0.31	2.12*
$dinf_{t-1}$	-0.88	-3.25*	$dinf_{t-1}$	-0.63	-3.79**
$dinf_{t-2}$	-0.80	-5.73*	EC^4_{t-1}	-0.45	-7.40*
$dinf_{t-3}$	-0.45	-6.12*			
EC^4_{t-1}	-0.47	-5.46*			
$R^2 = 0.80$	$LMS = 0.76\ [.39]$		$R^2 = 0.77$	$LMS = 0.49\ [.49]$	
$Adjusted\ R^2 = 0.68$	$RESET = 3.37\ [.07]$		$Adjusted\ R^2 = 0.68$	$RESET = 1.36\ [.27]$	
$F(7, 15) = 6.97*$	$NORM = 0.42\ [.81]$		$F(7, 15) = 8.74*$	$NORM = 1.48\ [.48]$	
$DW = 2.32$	$HET = 0.08\ [.78]$		$DW = 2.54$	$HET = 0.00\ [.99]$	

Legend, Note and Diagnostic tests: As in Table 1.

6. Conclusion

This study has investigated the existence of long-run relationship as well as the causal links between total fertility rate and female labor force participation rate in Bangladesh using macro-level data over the period 1974-2000. The empirical results are based on the application of the dynamic time-series modelling of the vector error correction. The specified models are all indicative of the existence of an inverse long-run relationship between fertility and female labor force participation. While the bivariate model also indicate a bidirectional causality between them, the multivariate models validate only a unidirectional causal link, the direction of causality being from labor force participation rate to fertility rate. The empirical results also indicate that per capita GDP and infant mortality rate Granger-cause both fertility and female labor force participation while average age at first marriage has only contemporaneous effects on them. On the whole, the findings of this study are consistent with similar macro-level studies for other countries.

The implications of the trivariate models *vis-à-vis* the bivariate framework should be considered more reliable in terms of bias and consistency of the parameter estimates as the former overcome the misspecification bias. However, the results should be interpreted in the light of the limitations of a small sample. Furthermore, while increased female participation in the labor force in the long run shows to be a significant precursor of a reduced fertility rate in Bangladesh and that the causality is unidirectional in the models involving three variables, it also needs to be remembered that the causal link in the sense of Granger-causality may not prove causality, or the lack of it, from the philosophical point of view.

Endnotes

1 Following Granger (1969), a variable *X* can be interpreted as Granger-causing *Y* if the lagged information on *X* can improve the forecast of *Y* in the presence of the lagged values of *Y*.

2 Non-stationarity means that mean, variance and covariance of the time series are not time-invariant. The conventional regression techniques, therefore, may lead to spurious parameter estimates when applied to non-stationary time series.

3 Banerjee *et al,* (1986), Banerjee *et al.* (1993) and Enders (1995) detailed discussion of these drawbacks.

4 A four-variable model is avoided considering the small size of the sample.

5 The following equation is estimated for flp_t:

$flp_t = flp_{t-1} + \in_t + DP_{1981}$ where DP_{1981} is the *pulse* dummy with a value of 1 for 1981 and 0 otherwise. The estimated coefficient (0.39) of DP_{1981} is not found to be statistically different from zero at the 10 per cent level of significance or less on the basis of the estimated t-statistic (of 1.51).

6 The cointegration tests are carried out by specifying an undifferenced VAR (vector autoregressin) for each of the models. The lag lengths for the models are based on the AIC (Akaike's Information Criterion) and/or the SBC (Schwartz Bayesian Criterion) and checked for the serial correlation and normality of the individual equations in

each model as specified by the undifferenced VAR. A lag order of 4 for Models 1, 2 and 4 and a lag order of 2 for Model 3 are found consistent with the diagnostic checks.

[7] The optimal lag order in a VECM is often decided on the basis of some standard criteria such as AIC, SBC and Akaike's minimum FPE (Final Prediction Error). In some empirical applications, the lag length has been chosen arbitrarily. The choice of the optimal lag length stills remains a contentious issue. There is no definitive reason as to why a criterion-based lag order should perform better than an arbitrarily chosen lag structure. On the contrary, as Jones (1989) shows, an arbitrary lag structure may perform better than a criterion-based lag length.

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Appendix

Table A.1:

Johansen-Juselius Tests for Cointegration for Model 1: (z_t: tfr_t, flp_t)

λ_{max} statistic				λ_{trace} statistic			
Null	Alternative	Statistic	95% Critical 't'	Null	Alternative	Statistic	95% Critical 't'
r = 0	r = 1	**16.86**	**11.03**	r = 0	r ≥ 1	**19.59**	**12.36**
r ≤ 1	r = 2	2.72	4.16	r ≤ 1	r ≥ 2	2.72	4.16

Note: r is the number of cointegrating vectors.

Table A.2:

Johansen-Juselius Tests for Cointegration for Model 2: (z_t: tfr_t, flp_t, afm_t)

λ_{max} statistic				λ_{trace} statistic			
Null	Alternative	Statistic	95% Critical 't'	Null	Alternative	Statistic	95% Critical 't'
r = 0	r = 1	**16.64**	**15.87**	r = 0	r ≥ 1	**20.98**	**20.18**
r ≤ 1	r = 2	4.34	9.16	r ≤ 1	r ≥ 2	4.34	9.16

Note: r is the number of cointegrating vectors.

Table A.3:

Johansen-Juselius Tests for Cointegrationfor Model 3: (z_t: tfr_t, flp_t, $pgdp_t$)

λ_{max} statistic				λ_{trace} statistic			
Null	Alternative	Statistic	95% Critical 't'	Null	Alternative	Statistic	95% Critical 't'
r = 0	r = 1	**29.12**	**21.21**	r = 0	r ≥ 1	**38.40**	**28.76**
r ≤ 1	r = 2	9.28	14.53	r ≤ 1	r ≥ 2	9.28	14.53

Note: r is the number of cointegrating vectors.

Table A.4:

Johansen-Juselius Tests for Cointegrationfor Model 4: (z_t: tfr_t, flp_t, inf_t)

λ_{max} statistic				λ_{trace} statistic			
Null	Alternative	Statistic	95% Critical 't'	Null	Alternative	Statistic	95% Critical 't'
r = 0	r = 1	**37.51**	**21.21**	r = 0	r ≥ 1	**51.01**	**28.76**
r ≤ 1	r = 2	13.50	14.53	r ≤ 1	r ≥ 2	13.50	14.53

Note: r is the number of cointegrating vectors.

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