10th National Convention on Statistics (NCS)
EDSA Shangri-La Hotel
October 1-2, 2007

Theoretical and Methodological Errors in the Use of Autoregression in the Prediction of Cumulative Fertility: Some Corrective Recommendations and Policy Implications

by

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ABSTRACT

The measurement of the impact of migration status on cumulative fertility popularly uses the autoregression model, where the response variable, some measure of cumulative fertility such as children ever born (CEB) is regressed on previous fertility (at *t-n, where n* is usually 5 or 10 years) for two groups: one, for those who moved spatially (migrated) at *t*; and two, for those who did not (also at *t)*. The use of this technique, with the addition of other variables, is considered to control for all other causes of differences in fertility, save that of the treatment variable of migration. The tool itself is considered the *de rigeur* procedure in eliminating confounding effects from other variables, the most crucial of which is the previous fertility level (fertility at *t-n*).

However, both theoretical and substantive errors can occur when the resulting coefficients of effect are interpreted when this technique controls for previous fertility (fertility at *t-n*). Specifically, the effect is to understate the negative impact of migration on cumulative fertility, and the underestimation is increased when migration is conceived to be a one time event. The paper will demonstrate this by presenting results from studies which used autoregression. In addition, it will also compare results derived from alternative techniques, such as ordinary least squares regression using age of woman as treatment variable on CEB, in order to show that substantive results are different, and render judgment why one or the other is preferable.

The paper ends with recommendations on the appropriate interpretation of autoregressive results when its theoretical limitations are taken into account. In addition, it will also recommend adjustments on significance tests to factor in the substantive (theoretical) errors of the autoregressive results when used in measuring the impact of migrant status on cumulative fertility.

I. Introduction: Revisiting an Old Controversy[1]

The impact of migration on a measure of cumulative fertility such as children ever born (CEB) has been empirically investigated for some time and is accepted as a substantive finding in historical demographic literature[2]. The findings, though, are contradictory. Given cross section data, a two column tabulation of CEB, one for non migrant women and the other for migrant women, will show that CEB for migrant women will be significantly[3] lower.

The theoretical interpretation of such a statistically significant difference has ever been controversial, and as I will show in this paper, intimately connected to methodological issues. Briefly, it has been claimed that this difference is due to other factors, such as higher education and urban employment of women rather than to spatial mobility *per se*. And that therefore the observed concomitant variation between migration and fertility loses statistical significance when these other variables are factored in. Construed in the language of econometrics, the problem is model specification: the inclusion of the appropriate variables will increase the accuracy of the model.

This paper, in its attempt to show that autoregression (at least in the various specifications that will be reviewed) will have attendant errors in predicting cumulative fertility, deals with both theoretical and methodological issues.

Theoretically, the fertility depression attributable to migration is tackled in one section where the substantive significance of disruption theory is advanced as the best approach to understanding and resolving the controversy. In addition, I also try to show that integrating multiple spatial moves (e.g., multiple migration) into the analysis increases the explanatory power of disruption theory and clears up the controversy.

Methodologically, I challenge the claim that the autoregression technique provides the best solution to isolating the effect of migration on fertility. Instead I try to show by logical analysis that it underestimates the disruption effect. By doing so, it inflates the CEB of spatially mobile women, leading to non-significant differences between the fertility of migrant and non-migrant women. In effect, it casts doubt on the depressing impact of migration on fertility.

Statistically, I propose that using even a simple multiple regression equation, specifying socioeconomic variables, such as female employment, and education, as control variables, will show the CEB of spatially mobile women as significantly lower than non mobile women. An appropriate data set which records the multiple moves in the migration history of Filipino women will be used.

II The Theoretical Debate: A Historical Account and a Critique

As culled from literature, three approaches have been advanced to describe the link between mobility and fertility. These are 1) the adaptation or assimilation approach; 2) the selectivity approach; and 3) the disruption approach (McKinney, 1993; Gorwaney, 1988; Goldstein and Goldstein, 1983). In this section, I critically view the arguments regarding their consequences on fertility.

Ideally, the validation of any empirical approach regarding the effects of mobility on fertility should depend on its net, or in statistical terms, *partial*[4] effect on fertility. The conceptual difficulties that arise where at least two of the approaches may simultaneously explain the phenomenon suggest that the distinction made between these two approaches may be more apparent than real. They also suggest that these approaches as they were presented need to be updated to explain the observed correlation.

For example, a female migrant of child bearing age is thought to be self selected, or distinguished from non migrants due to her individual characteristics; in principle, it is this selectivity (and not migration) which predisposes her to lower fertility. At the same time, in the process of moving, she conceivably disrupts her fertility-related activities, and thus ultimately lowers her fertility.

In terms of the debate, the locus of conceptual difficulty lies in the task of separating the fertility depressing effects pertaining to each of the two perspectives. I suggest that, following the lines drawn by Bongaarts and Potter (1983), and Davis and Blake (1956) before them, that we favor the perspective that explain along physical, physiological, or behavioral terms. He has termed this the proximate determinants approach.

II.A. The Selectivity Approach

As stated in the literature, a selectivity approach does not explain adequately why fertility should be lower for movers. At best it only describes the characteristics of the mobile segment of the population and differentiate it from the non-mobile. As an example, without further reference to specific physical causes, there is no logical necessity for higher educated women to bear less children than lesser educated ones. Unless it is conceded that the effect of getting an education is to physically interfere with the proximate processes by which children are generated, in which case the effect is better described as disruption.

Others have sought to address criticism of the selectivity approach by reference to the value structure of the couple or at least of the woman. In this variation, the woman who is predisposed to migrate prefers lesser number of children (see Macisco, Bouvier and Renzi, 1969). A devastating critique of this notion is the tenuous connection between intentions and its realization into actual behavior. It is a well established behaviorist principle that values and intentions do not always translate into behavior.

II.B The Assimilation Perspective

The assimilation perspective assumes that flow of movement is from the rural areas where fertility is higher to urban areas where fertility is lower. However, if the culture at the area of destination has higher fertility, as is conceivable in an urban to rural movement, then the effect of assimilation cannot always be assumed to depress fertility. If, on the other hand, a movement from one urban area to another, or from a rural origin to a destination that is also rural nonetheless produced reduced fertility among migrants, this effect can not be therefore attributed to assimilation.

II.C The Disruption Thesis

As an alternative view, disruption refers to the interruption of fertility processes that the action of moving *per se* entails (McKinney, *op. cit.*). Disruption may then be considered as the real[5] consequence of mobility on fertility. Disruption highlights the fact that mobility costs resources, that is to say, it has a price. The costs of moving are both physical and social.

In his classic work on migration, Lee (1966) included among the intervening obstacles which encumber the mover:

1. distance and other geographic barriers
2. impediments such as children and other dependents
3. the costs and efficiency of transportation
4. material accoutrements accumulated through time
5. emotional disruptions from breaking social relations

Relocation, whether performed alone or collectively, is often dramatized as an uprooting and an upheaval[6].

Disruptive mobility is construed to be a powerful depressant of fertility because it interposes physical barriers to any stage in a sequence of events that would lead to a successful birth. In physiological terms, these stages are sexual intercourse or insemination, conception or fertilization, and parturition or birth.

Among the barriers raised by mobility may be 1) spatial distance between potential marital and therefore sexual partners; 2) insufficiency of time and opportunity for frequent intercourse; 3) energy depletion resulting in lack of desire for intercourse.

Mobility may delay sexual unions by preventing progressive intimacy that results in marriage. It may also constrict time and opportunity for another birth and subsequent upbringing.

The disruptive consequences described above may be produced temporarily, and therefore relatively weakly by a one move migration, or more or less continually, and therefore strongly, by multiple migrations. A similar sort of continuous disruption may also be put into effect by some form of ongoing reciprocal mobility, such as metropolitan circulation and mega urban commuting.

In a much similar sense, temporal and sp atial incompatibilities can be induced by labor force participation, and educational activities, especially when they take place away from home, and therefore requires some form of mobility. Following this argument, it can be concluded that the negative effect of background characteristics, such as education and labor force participation highlighted by the selectivity approach actually work against fertility by constricting resources and interposing opportunity costs that otherwise may be used for reproduction.

III Methodological Issues

This paper is a critique of the autoregressive technique as a predictor of cumulative fertility. Therefore, this section begins with a simple discussion of the autoregressive technique.

III.A. Autoregression in General

Autoregression refers to a special branch of regression analysis aimed at analysis of time series. It rests fundamentally on autoregressive models - that is, models where the dependent variable is the current value and the independent variables are N pre vious values of the time series. The N is called "the order of the autoregression".

In the case of an autoregression analysis the regression of Y_t is done against values of itself in earlier periods (that is, Y_{t-1} or Y_{t-2} or… Y_n). The variables obtained from earlier periods are called "lagged variables". To give an example based on the annual change of the consumer price index (CPI): a one period lag would use last year's changes in the CPI to predict this year's changes in the CPI; a two period lag would use the data from the change two years ago to predict today's change.

III.B. Autoregression as Applied to Fertility

The work of Lee and Farber (1981) for the United States Agency for International Aid (USAID) represents the water shed for the application of autoregression to sociological topics. Previous to this ground breaking research, autoregression had been applied to economic research by Ashenfelter (1978).

In their work (*op. cit*), Lee and Farber claimed that autoregression, where the dependent variable is regressed on its previous values is the *best* statistical technique for isolating the effect of spatial mobility on fertility. I attempt to challenge that claim here. This attempt is based on both purely methodological (i.e., statistical) notion and also on conceptual grounds.

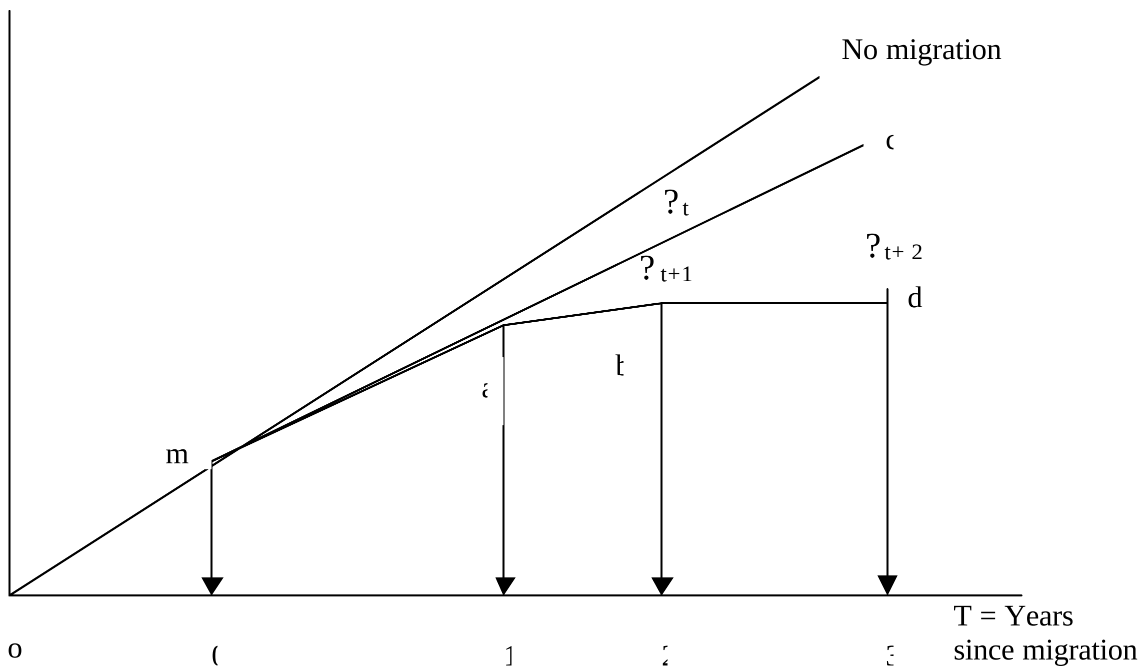
Methodologically, I attempt to show that autoregression will efface the differential (lower) fertility of migrants by neglecting their lower cumulative fertility to begin with, by setting equal previous fertility of the respondents, both migrants and non migrants. In its simplest form, without the inclusion of socio -economic variables, the autoregressive equation applied to migration and fertility can be set as follows:

$$y_t = ß_0 + ß_1 y_{t-s} + ?_t M_{t-s} \qquad (1)$$

The above equation includes a term which factors into the prediction of current cumulative fertility (that is, during the time of the observation, y_t) the level of previous fertility (that is fertility some time before the survey, y_{t-s}). This is the autoregressive term. In cases where the survey includes women who have borne one child or more children, the partial effect of the autoregressive term is to equalize previous fertility among the respondents. The intention of including this autoregressive term is to isolate the effect of the third term, $?_t M_{t-s}$, which specifies a dummy variable for migration s years before the year of the survey. Migration is a dummy variable having the subsequent values: M = 0 if the woman migrated, M = 1 if she did migrate. $?_t$ measures the effect of migration (the migration coefficient) on fertility.

Computer algorithms use numerical methods to estimate coefficients of this equation. Unfortunately, the working out of this equation in numerical methods is to find respondents, both migrants and non-migrants who have the same level of previous fertility, thereby effacing any previous negative effect of migration on cumulative fertility. In effect, what $?_t$ measures is not the effect of migration on cumulative fertility, but its effect on the probability of additional fertility in the period *t-s* to *t*. This is seen in the following graph.

Y=CEB



Graph 1. Illustration of paths of fertility without migration, with one move and with multiple moves

Assuming ß$_1$ = 1 and M = 0, the line ON (No migration) has slope ß$_0$. Letting the horizontal axis represent years since migration so that t = s = 1, $?_t < 0$ is the effect of migration on fertility in the (0,1) interval. In other words, the number of children (CEB) increased by $?_t$ less for migrants in this interval than for non-migrants. Pattern *mac* represents temporary impact of migration on fertility.

The model has an error that is immediately apparent. The addition of the autoregressive term "forces" equalization of fertility functions between the migrant and the non-migrant. In the diagram, this equality is signified by the line segment *mo*, which represents similar previous fertility function for both migrants and non-migrants (single line segment). If the respondents are all just entering the reproductive period, then this equalization would be correct; but indeed, it would not be needed. However, as real events happen, migration can occur at different ages, and therefore, at varying levels of previous fertility.

The model as specified here has another error over and above this forced equalization of previous fertility levels. Conceptually, the autoregressive model as used by Lee and Farber (op cit) and followed by Cabegin (1986) for Philippine data examines the effect of only one move, in effect neglecting the cumulative negative effect of multiple moves (summation of $?_{t,}$ $?_{t+1}$ and $?_{t+2}$). In the diagram above this cumulative effect is illustrated by the line segment *mabd*. Notice that it is not necessary to assume equal effect (equal slopes) for all moves[7]. I realize that an investigation of this assertion would be needed. Regardless of this, the cumulative effect of multiple moves is likely to be greater than a single move.

In the next section, I shall examine the empirical results of this model when applied to Korean and Philippine data.

IV. Empirical Results

The results reported by Lee and Farber (op cit.) may be used to build the case for the possibility of further reduction of fertility concomitant with another move. However, I stress that this is an alternative interpretation in lieu of the adaptation thesis, which views the reduced fertility of migrants as a form of adaptation to the urban destination. The adaptation (or assimilation) thesis is used by the authors to interpret the computed coefficients of the equation which is described below.

In this section, I focus on the results they obtained when cumulative fertility is the dependent variable[8]. The equation they used for this run is specified as follows:

$$y_{it} = ß_0 + ß_1 y_{i,t-5} + ?_1 A_{it} + ?_2 A^2_{it} + Sa_j M_{ij} + e_{j} \qquad (2)$$

which pool all migrant cohorts[9]. In this equation, y_t and y_{t-5} (CEB05) are children ever born to women by year t and t-5, respectively; A_t (AGEC) is the woman's current age at year t; e_t is an error term; and are M_j are dummy variables for women who migrated during a given 5 year migration interval, j, with j = 1, 2, 3, 4, 5, 6 and 7 for the migration periods 1970-74, 1965-69, 1960-64, 1955-59, 1950-54, 1945-49, and before 1945, respectively.

Equation 2 states that when the fertility levels 5 years prior to time t of both migrants and stayers are equal, the current fertility levels are a function of age, the square of age and the migration status. The coefficients, a_j, of the migration dummy variables represent the fertility differential between non-migrants and migrants who migrated in the j^{th} period occurring during the past 5 years controlling for women's fertility level at the beginning of the period and age.

However, the results are much more amenable to the disruption theory, as the table below shows.

Table 3a

Period of Migration	**t-4**	**t-3**	**t-2**	**t-1**
1970-1974	-0.21	-0.151	-0.209	-0.206
1965-1969		-0.101	-0.001	-0.105
1960-1964			-0.096	-0.026
1955-1959				-0.233
1950-1954				
1945-1949				
before 1945				

Source: Lee and Farber (op cit.)

Table 3b

Period of Migration	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**	**t+6**	**t+7**
1970-1974	-0.202						
1965-1969	-0.267	-0.094					
1960-1964	-0.243	-0.274	-0.212				
1955-1959	-0.084	-0.173	-0.276	-0.359			
1950-1954	-0.068	0.112	-0.361	-0.424	-0.359		
1945-1949		0.084	0.094	-0.595	-0.26	-0.299	
before 1945			-0.025	0.05	-0.454	-0.449	-0.192

Source: Lee and Farber (op cit.)

In the tables above the darkened column represents the period of migration. Table 3a shows that the period immediately before migration shows the greatest magnitude of depression (except for the period 1960-1964), suggesting that the disruption effect of migration intensifies as the actual move becomes imminent.

Table 3b shows that for each migration cohort the rural-urban migrants have fewer births during almost every five-year interval after migration than rural stayers. However, the declines do not show uniform slopes nor suggest definite continuity: some of the coefficients are positive after migration (for the 1950-1954 cohort), even for extended periods (for the 1945-1949 cohort); thereafter they turn negative. These discontinuities have been explained by the authors variously by delay in assimilation, by destination city size or its level of urbanization differences, etc.

The discontinuities suggest that the autoregression may be erroneously estimating the effect of migration on fertility. In this context, there are two possibilities of errors. One error is attributable to the equation used by the authors because of its specification of only one move, thereby effectively effacing the effects of further moves. Second, the autoregressive term forces the effect of any previous migration to be disregarded, since both the experimental group - the migrants - and the control group - the stayers - are forced to have the same level of fertility (parity) at t-5.

With reference to the second error, this becomes critical when the forced equalization happens when parities are no longer equal, which may be the case when CEB may already be 2 or more. It is entirely conceivable that previous migration had already occurred and that this caused migrant fertility to be lower. It is this previous effect that is effectively effaced by the forced equalization. Thus, both spatial mobility and its effect on fertility are both underestimated in this case.

Similar contradictory results were obtained by Cabegin (1986), using data from the Philippine National Demographic Survey (NDS) of 1983, the only one in the series of NDSs which contain migration history of the respondents. Nevertheless, despite these conflicting results one finding emerges clearly: the period of migration is consistently attended by lower fertility among the migrants five years before and after the move itself, again highlighting the disruptive effect on fertility of the move.

Using the following equation (3),

$$CEB_t = ß_0 + ß_1 CEBG_{t-5} + ß_2 AGE_{1983} + ß_3 AGEM + ß_4 EDUC_{1983}$$

$+ \Sigma a_j MIG_{j+} e$ (3)

she reported the results below:

Table 4a. Partial Regression Coefficients for Migration on CEB for every 5 year period before the Move

migrant cohort	**t-1**
1979-83	0.09
1974-78	-0.35
1969-73	-0.04
1964-68	-0.06

Table 4b. Partial Regression Coefficients for Migration on CEB for every 5 year period after the Move

migrant cohort	**t-1**	**t-2**	**t-3**	**t-4**	**t-5**
1979-83	-0.05				
1974-78	-0.27	0.05			
1969-73	-0.25	0.31	0.17		
1964-68	-0.05	0.09	0.32	-0.09	
1959-63	0.14	0.23	0.01	-0.22	0.36

Given this sole consistent finding, I conclude that the case for an alternative explanation, that of disruption, has been established. The "clumping" of significant coefficients 5 years before and after migration for most of the cohorts certainly supports this argument.

The disruption thesis lends itself to straightforward interpretation why fertility goes down around the period of migration. Still, policy makers might question the significance of this temporary depression. In response, I point out that the temporary effect (which does not supposedly last long) can be offset by a sequence of migrations that maintains this temporal effect *in seriatim*, so that the cumulative effect on fertility lasts longer, or even become 'semi-permanent". In fact, this regime of semi-permanent depression only has to last until menopause, when childbearing is no longer possible. By then, the completed fertility of multiple migrants will be seen to be clearly lower than those who did not move. By extension, it can be asserted that multiple movers will have lower completed fertility than single movers.

This last hypothesis will now be tested here using ordinary least squares regression without the autoregressive term. I specify the equation as follows:

$$CEB = \beta_0+\beta_1X1+\beta_2X2+\beta_3X3+\beta_4X4 +\beta_5X5 +\beta_6X6 \qquad (4)$$

The meaning of the independent variables are:

1. AGESCMWS – age of currently married woman
2. NOMOVES – number of migrations
3. PREF – preference for a son
4. SESHH – income of household
5. CECONACT – current economic activity
6. EDUCATTA – Highest grade of ever married woman

IV.A. Multiple Partial Linear Regression without Autoregressive Term

The dependent variable is children ever born (CEB), measuring cumulative fertility.

The results of Equation 4 are given below:

Table 5. Partial Regression Coefficients for Equation 4

Variable	**B**	**Signif**
AGECMWS	0.17	0.00
NOMOVES	-0.05	0.05
PREF	-0.08	0.19
SESHH	-0.06	0.54
CECONACT	-0.25	0.00
EDUCATTA	-0.12	0.00
(INTERCEPT)	-0.48	0.00

Source: calculated for this study

When multiple migrations as measurement of mobility are examined for their effects on fertility, a significant lowering of fertility is found even after other socioeconomic variables have produced their separate effect. The ß coefficient calibrates this effect to be just over half of a tenth of a child for every move. This is not large compared to the reductions that were produced by working, or going to school. However, this effect, judging from its significance level, is real, and may be inferred to obtain in the national population.

This result is similar (see Table 6) to that reported by Goldstein and Goldstein (op cit.) on Malaysian data. It is bolstered by a subsequent run in which the magnitude of the partial mobility coefficient NOMOVES rises to .06 after a backward selection subroutine eliminated the nonsignificant SESHH and PREF variables.

As seen below, this magnitude is similar to those obtained by other studies (Table 6).

Table 6. Partial Regression Coefficients of Migration Across Studies

Variable	**B**
Cabegin[10]	-0.05
Goldstein	-0.05
Padilla[11]	-0.05

It is remarkable that although these studies are not parallel that is, they have different designs, there is similarity of the magnitudes of the coefficients. Fortuitous concordance of coefficients as seen here strengthen our confidence on the negative relationship between migration and fertility[12]. In addition, they give confidence on this study's finding, and suggest definite directions for policy.

At the outset, I have suggestions as to the use of autoregression when cumulative fertility is the dependent variable[13]. Ironically, a consideration of these suggestions highlights the limitation of the method when applied to cumulative fertility.

First, it should be used at the beginning of the fecund period for all respondents. In this case, however, it is virtually useless, since previous fertility is likely to be nil. Second, it can be used as a measure of incremental fertility after migration as long as other moves are controlled for. Even here, however, the application of the method will be severely limited. For highly mobile populations, the only feasible period consist of the first few years after the move, and analysis will have to contend with reduction of sample size as probability of moving increases. An alternative is using previous migrations as the autoregressive term, in which case, an equation would be required for every move. This would be methodologically equivalent to an analysis of covariance where each move represents a level of a categorical variable, or to a linear regression where migrations are treated as an interval scale independent variable. Finally, since the autoregressive model is seen to underestimate the effect of migration, levels of significance should be set lower.

V. Policy Implication

If we accept that each move reduces fertility by .05, then we can assume for a start that 3 or more moves by a married woman in the reproductive ages (15-49) will have approximately one child less than those who did not move at all. Since the OLS regression used here assumes that the decline is linear, a derivative conclusion is that a continuum exists for both spatial mobility and fertility. In the case for spatial mobility, the continuum starts at the non-mobile pole, goes through a one migration to multiple migration to daily mobility (such as commuting). This continuum of spatial mobility is inversely related to fertility as measured by CEB. Thus, a non-mobile woman will have the highest fertility, and the continually mobile woman the lowest.

While the State does not promote artificial contraception, it can encourage spatial mobility among its citizens[14] to lower the rate of population growth. This would require improved infrastructure for transportation, such as superhighways, and rapid rail transit systems. As Table 5 has shown, spatial mobility along with education and employment can reduce fertility. By themselves, an increase in the transportation infrastructure, in the employment and in the education of Filipino women are accepted as contributing to national development. In addition, the increased spatial mobility that infrastructure development is likely to generate and as this study has shown, the resultant depression of cumulative fertility will aid greatly our national economic growth.

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END NOTES

[1]The controversy is currently deemed to have been resolved due to the dominant view that migration per se does not lower fertility. This work revives *de facto* this controversy by presenting a renewed appreciation of disruption theory as a causal explanation of why migration does in fact lower fertility

[2] These will be summarized in the section Review of Literature

[3]I use the word "significant" to mean statistically significant. Otherwise, I shall explicitly state substantively significant when I mean so.

[4] Partial effects are so called because in a multiple prediction equation, the effects of other variables are controlled, or "partialed" out.

[5] This conclusion derives from the definition of disruption as the effect of the act itself, as distinguished from other factors

[6] "Upheaval" is an exact translation of the first word of the Tagalog phrase for relocation: "alsa balutan"

[7] However, to start simply, we can assume that $= ?_t = ?_{t+1...} = ?_{t+n}$

[8]They estimate separately several period (incremental) fertilities after migration, and cumulative fertility after migration. I focus on the latter here.

[9] Partial effect of migration for migrant cohort 1979-83 (see Table 4b)

[10] Partial effect of each move on CEB (see Table 5)

[12] It is worth noting that these results were obtained in two countries considered to have roughly similar developmental milieus: Thailand and the Philippines

[13]These would of course need to be tested and verified.

[14] It would be useful to study the effects of mobility on men and on their family formation behaviors