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Abstract

This paper presents an analysis of the effects of Canadian child benefit policies on fertility and female labor supply. A theoretical model incorporates alternative forms of child benefit policies, and presents testable predictions for the econometric analysis. Cointegration methods accommodate problems of nonstationarity and endogeneity that characterize models of fertility and female labor supply. Time series data on fertility, female labor force participation, female wages, male incomes, female education, and child benefits show evidence of mixed orders of integration. Two cointegrating relations are found, and these are identified as a fertility relation and a female labor supply function. All economic variables, including child benefits, have statistically significant and appropriately signed coefficients. The estimates are used to evaluate the effects of policy and other economic changes on fertility.

JEL CLASSIFICATION: H3, J0, C32

KEYWORDS: Fertility, child benefits, time series models, cointegration.

1 Introduction

Since the adoption in 1918 of a tax exemption for children, Canada has experimented with a variety of subsidies and tax credits for families with children. Although the original motivation of such policies may have been equity, more recent concerns over low fertility levels have also driven changes in child benefit policies during the post-baby boom era. Family allowances that began in 1945 were tripled in 1973, for example, in the face of the persistent decline in fertility rates that began in the early 1960s. Despite numerous changes in the system of child benefits, fertility in Canada has continued to decline over the post-baby boom period.

Zhang, Quan, and Van Meerbergen (1993) analyzed these policies, using time series regressions to estimate an economic model of fertility. Although their benefits measures show statistically significant effects on fertility, female wages and male incomes do not. Since the child benefits are argued to work through economic incentives, the failure to find significant effects from the standard economic determinants of fertility is troublesome. The source of this problem may be methodological, since regression analysis of time series data is fraught with potential problems of rampant endogeneity, under-identification, and nonstationary data.

The objective of this study is to apply contemporary time series methods to an economic model of fertility, incorporating child benefits as a variable of central interest. The analysis employs cointegration methods, which can accommodate the problems of nonstationarity and rampant endogeneity that characterize models of fertility and female labor supply. The analysis begins with development of an economic model of fertility, embodying alternative forms of child benefit policies, which provides testable predictions for the econometric analysis. Time series data on fertility, female labor force participation, women's wages, male incomes, female education, and child benefits are tested for nonstationarity as a prerequisite to the examination of the long run relations among the variables. Two cointegrating relations are found, and these are identified as a fertility relation and a female labor supply function. All economic variables have statistically significant and appropriately signed coefficients. The child benefits variable, in particular, shows significant positive effects on fertility and reverse effects on female labor force participation. The estimated model allows evaluation of the effects of prospective policy and other economic changes on fertility, with comparisons from other time series studies of Canadian fertility.

2 An Overview of the Child Benefit System in Canada

The child benefit system started in 1918 with the introduction of the child tax exemption, which has value to each family equal to the amount of the exemption times the marginal tax rate. Family allowances were introduced in 1945. Family allowances were delivered outside the income tax system, were paid to all mothers on behalf of their children, and were, during the first 28 years, a flat-rate non-taxable payment of equal value to all families.

Federal child benefits began to change direction in the 70s towards a more progressive (although still universal) system. In 1973, family allowances were tripled, fully indexed to the cost of living and made taxable. However, the most important change was the introduction of an income-tested refundable child tax credit in 1978. This credit reduced the taxpayer's tax liability directly rather than through a reduction in taxable income. The new program paid its maximum amount to poor families, with actual payments decreasing at a fixed rate as family income surpassed a certain threshold.

The 1980s brought a series of changes that made the system more progressive and less universal. The child tax exemption was lowered in 1987 and converted to a non-refundable child tax credit subject to a fixed benefit rate in 1988. In 1989, a cutoff on family allowances for upper-income families was introduced.

In 1993, the universality of the system ended when family allowances and the refundable and non-refundable child tax credit were replaced by the child tax benefit. The child tax benefit paid non-taxable monthly benefits that were calculated on a sliding scale based on net family income. It also included an earnings-based Working Income Supplement for working poor families with children.

Along with the federal government, provincial and territorial governments have also delivered child benefits for decades, but those are ignored in the present analysis. In 1997, the set of federal and provincial/territorial child benefit programs were integrated into a single national child benefit system, where the child tax benefit, renamed the Canada child tax benefit, was restructured.

Figure 1 shows the time profile for the period under analysis (i.e. 1947-1999) of total child benefits in real 1992 C$. The line shows the sum of the three benefits available up to

1992 and equal to the child tax benefit/Canada child tax benefit thereafter.[2] Child benefits do not show any clear trend up to 1973, then rise dramatically between 1973 and 1978, and decrease thereafter except for the last two years.

3 Theoretical Framework

The following model provides a simple framework within which to study the effects of different tax-benefit policies. The model is developed in the spirit of Cigno (1991). The static nature of the model precludes the consideration of the timing of fertility and intertemporal labor supply. However, a dynamic model, while certainly richer and more realistic, requires further simplifications and yields fewer unambiguous predictions.[3] Finally, although the quality of children is not modelled in the empirical section, a model of family choice with tax-benefit policies would lack completeness without the consideration of the relationship between quantity and quality of children.

For ease of exposition, the model considers a prototypical household consisting, at the outset, of a woman and her spouse, who are assumed to act in unison to make fertility and time and resource allocation decisions. The couple derives utility from their own consumption, x, and from child services they receive during their lifetime, c, according to the utility function,

$$U = U(x, c), \quad (1)$$

[2] See Section 4 for details on the construction of the child benefits variable.

[3] See Hotz et al. (1997) for a review of dynamic models of fertility.

where $U(.)$ is twice differentiable and quasi-concave. Child services are governed by the production process $c = nq$ where n represents the number of children and q denotes child quality.[4] Child quality represents parental perception of a child's lifetime utility. The latter is assumed to be a function of the mother's child care time and child related market goods in excess of the minimum amount of the mother's time, t_c^0, and child-related goods, e^0, necessary to raise a child of whatever quality (i.e. subsistence levels),[5]

$$q = V(t_c, I), \tag{2}$$

where $V(.)$ is an indirect utility function with properties similar to $U(.)$, and $t_c = t_c^{'} - t_c^0$ and $I = e - e^0$. Another simplification will be to assume that, above t_c^0, maternal time is perfectly substitutable with the father's time or nonparental time in childcare.[6] Assuming, further, that the wage rate of hired helpers is always lower than those of the parents, t_c^0 is all the maternal time that a child will get. Purchased child care is then treated as a child-related good. Thus we can rewrite (2) as $q = V(I)$.

Setting t_c^0 equal to unity, by measuring time in terms of the number of children, the mother's labor supply is given by $h = T - n$. An implicit assumption in this formulation is that leisure is exogenous (T is constant). Adding leisure as a choice variable does not alter

[4] This formulation rules out the possibility that, with n variable, q could be complementary for x or n. It also assumes that all siblings are treated equally. The model further assumes that parents can control n perfectly (or, equivalently, that n is an expectation and parents are risk neutral) and the cost of fertility control is either negligable or independent of n.

[5] Child-related goods include, for example, consumption, health, and education. If parents give their children just the subsistence levels of these goods, q is zero.

[6] In this simplified structure, the father's allocation of time is given, and thus his income is exogenous.

the main results of the model. Furthermore, the mother's labor supply is still endogenous through the endogeneity of n.

Assume the mother's human capital is given by the following linear homogeneous production function [7]

$$k = k^0 + \beta h \ , \ \beta > 0, \tag{3}$$

where k^0 is the initial endowment (i.e. a measure of her innate talent, education and work experience before marriage) and β is the rate at which human capital increases with work experience. Her wage rate is endogenously determined by $w = \omega k$, where ω is the market rate of return to k. Suppose maternal paid leave is available and takes the form $\chi = \eta w$, where η is the after-tax earnings replacement rate.[8] Under these assumptions, the budget constraint may be written as

$$x + [(1-s)p(e^0 + I) - \theta]n = \varepsilon + A + (1-\tau)wh \equiv Y, \tag{4}$$

where A denotes the husband's income, p is the price of child-related goods, s is a subsidy on p,[9] ε is a lump-sum subsidy, and θ is the value of non-taxable benefits per child.[10] Consistent with the objective of horizontal equity, this formulation asssumes that

[7] The assumption of constant returns to scale is only an approximation to what is probably a function with increasing returns initially, and subsequent dimishing returns.

[8] Note that withdrawal from the labor force for childbearing of an additional child is confined to time t_c^0, which is normalized to 1, and thus the relevant replacement rate per unit of maternal time is η. Whereas most industrialized countries offer paid maternity leave, the US law provides only 12 weeks of unpaid leave.

[9] This subsidy can be interpreted, for example, as an education subsidy or even as a child care tax credit.

[10] This formulation assumes, for simplicity, that the value of child benefits is independent of family income.

child benefits are designed to partly compensate parents for the 'survival' cost of raising a child (e.g. the cost of maintaining an adequate diet). In the contex of the Canadian child benefits system, θ is equivalent to non-taxable family allowances. If we make θ taxable, the value of the allowance to the family would be $(1-\tau)\theta$, but the basic results would not change. Furthermore, the basic results would also hold if θ takes the form of the statutory value of the tax exemption per dependent, where the value of the exemption to the family would be $\tau\theta$, or the child tax credit, where θn would be substracted from the tax liability τwh. Lump-sum subsidies, child benefits, and maternity leave payments are financed by a proportional tax on earnings at a rate τ.[11] Finally, note that Y stands for actual income and not full income, since it does not include the potential earnings foregone from childbearing.

The household decision problem is to choose $\{x, n, I\}$ to maximize (1) subject to (3) and (4). From the first order conditions for this problem, parents will equate the marginal utility of income spent on themselves to that of income spent on each child (5), as well as the marginal rate of substitution of quantity for quality to their relative price (6)

$$U_x = U_c V'(I) \tag{5}$$

$$\frac{V(I)}{V'(I)} = \frac{\pi}{(1-s)p}, \tag{6}$$

where π is the shadow price of a child

$$\pi = \pi_0 + (1-s)pI + (1-\tau)h\omega\beta, \tag{7}$$

[11] Linearity of the tax system can be taken as a local approximation to a non-linear tax schedule.

and $\pi_0 = (1-s)pe^0 + (1-\eta)(1-\tau)w - \theta$ is the subsistence cost of a child. The shadow price of a child has three components. The first, $(1-\eta)(1-\tau)w$, is the direct opportunity cost of foregone earnings from childbearing. The second, $(1-\tau)h\omega\beta$, represents the potential wage increases missed through foregone human capital accumulation.[12] The third term, $(1-s)p(e^0 - I) - \theta$, represents net lifetime expenditures incurred on a child.

3.1 Comparative Statics

The effect of an increase in θ on n and I are given by

$$\frac{\partial n}{\partial \theta} = -s_{nn} + nz_n > 0 \tag{8}$$

$$\frac{\partial I}{\partial \theta} = -s_{in} + nz_i \gtrless 0 \tag{9}$$

where s_{ij} is the substitution effect of the marginal cost of i on the demand for j, and z_i is the income effect. Suppose that n and I are normal goods, so that z_n and z_i are positive. Then since $s_{nn} < 0$ and $s_{in} > 0$, an increase in child benefits will induce parents to have more children (and the effect is increasing in τ), but has an ambiguous effect on child-quality investment. The ambiguity of $\partial I/\partial\theta$ arises because θ reduces the price of n, but not of I (and q), and thus makes the latter relatively more expensive. The effect on the mother's labor supply is of the same magnitude as that on n but of opposite sign. In contrast with θ, the effects of lump-sum subsidies, ε, are pure income effects.

Now consider the effects of a change in the subsidy to child-related goods

[12] We can think of this cost as the appreciation in the woman's stock of human capital that will not be realized if she stays at home for one unit of time.

$$\frac{\partial n}{\partial s} = p(enz_n - es_{nn} - s_{ni}) \gtrless 0 \quad (10)$$

$$\frac{\partial I}{\partial s} = p(enz_i - es_{in} - s_{ii}) \gtrless 0 \quad (11)$$

Thus s has ambiguous effects on both n and I. However, under the plausible assumption that the sum of income and own price effects dominates the cross price effect, an increase in the subsidy to child-related goods induces parents to have more children and invest more in child-related goods.[13] Next consider changes in the exogenous variables affecting the opportunity cost component of the shadow price of a child. The effects of those on child-quality investments are unambiguous: child-quality investments increase with $\{k^0, \beta, \omega\}$ and decrease with $\{\eta, \tau\}$.[14] However, their effects on the desired number of children (and then the mother's labor supply) are, except for the maternity leave benefit, ambiguous

$$\frac{\partial n}{\partial \eta} = -ws_{nn} > 0 \quad (12)$$

$$\frac{\partial n}{\partial \tau} = -\left[whz_n + (w + h\omega\beta)\, s_{nn}\right] \gtrless 0 \quad (13)$$

$$\frac{\partial n}{\partial k^0} = (1-\tau)\left[\omega s_{nn} + \omega h z_n\right] \gtrless 0 \quad (14)$$

$$\frac{\partial n}{\partial \beta} = (1-\tau)\left[2\omega h s_{nn} + \omega h^2 z_n\right] \gtrless 0 \quad (15)$$

$$\frac{\partial n}{\partial \omega} = (1-\tau)\left[(k + h\beta)s_{nn} + khz_n\right] \gtrless 0 \quad (16)$$

[13] If we interpret this subsidy as a child care tax credit, the model would then predict a negative effect of this credit on female labor supply through an increase in fertility. In this simplified model all child care time in excess of the minimum required for the survival of the child (t_c^0) is purchased in the market, precluding any effect of this subsidy on the mother's labor supply through changes in the mother's child care time. The latter could partly compensate the negative effect of the subsidy on labor supply through increased fertility.

[14] Derivations are available from the authors upon request.

However, making the standard assumption that own substitution effects dominate income effects, a rise in the rate of income tax is likely to increase the number of children, whereas increases in k^0, ω and β are likely to induce parents to have fewer children. Female education could also be introduced as a preference shifter in the utility function, whereby more educated women would prefer smaller or larger families. This "preference" effect would then be added to the above income and substitution effects for female education. In any case, the number of children born to a woman is likely to move in the opposite direction to her wage rate and labor supply.

In short, in the context of this model, child benefits provide an incentive to procreation, but are not a reliable policy instrument for improving the well-being of children. By contrast, a subsidy to the price of child-related goods appears to be an effective policy for improving the quality of children, but this policy is also likely to induce parents to have more children. An increase in maternal benefits (through an increase in the replacement rate) reduces the foregone earnings component of the opportunity cost from raising a child, thus inducing parents to have more children but of lower quality. Finally, increases in the variables affecting the woman's gross wage rate, or a more lenient fiscal treatment of her earnings, are likely to reduce the number of children (and hence increase the mother's labor supply) and improve the quality of their lives. For instance, the model suggests that the latter could be achieved by an increase in the amount of education received by women (i.e. higher k^0), increases in labor productivity (through technical progress), and the mitigation or reduction of gender discrimination.[15]

4 Variable Definitions and Characteristics

In modeling fertility and female labor supply, the variables are defined, whenever possible, to correspond with the ages of the women giving birth. Data were collected spanning the years 1947 through 1999. As data on female labor force participation rates of women aged 25-44 could not be disaggregated any further for early years, fertility and female labor force participation rates are defined for women aged 20-44.

Fertility rates are expressed in births per thousand women in the 20-44 age group. The five-year age-specific fertility rates are collected from *Historical Statistics of Canada* (Statistics Canada) for the period 1947-1958, the *United Nations Demographic Yearbook* for 1959-1994, and the *International Data Base* (U.S. Bureau of the Census) for 1995-1999. These series are aggregated for the 20-44 age group using the population shares of each five year age group, which are collected from *Population 1921-1971: Revised Annual Estimates of the Population by Sex and Age Group, Canada and the Provinces* (Statistics Canada), and the CANSIM database (Statistics Canada).

Labor force participation rates for women aged 20-44 are constructed from *Historical Statistics of Canada* (Statistics Canada) for the period 1947-1963, OECD *Labor Force Statistics* for the period 1964-1999 and population data from the sources mentioned above.

Age-specific data on female wages and male income were not available, so aggregate

[15] These last two changes would raise the rate of return to human capital (corresponding to increases in β and ω).

series by gender are employed. Both series are expressed in 1992 C$. The female hourly wage series is obtained by dividing average annual earnings of all female workers by average weekly hours of work times 52, the usual number of weeks worked during the year, for the period 1967-1999. These data are collected from the CANSIM database (Statistics Canada). This series is projected back to 1947 using hourly earnings of female wage earners in all manufacturing industries from *Historical Statistics of Canada* (Statistics Canada).

The male income series is obtained from data on average annual earnings of all male workers for the period 1967-1999 (CANSIM, Statistics Canada). This series is projected back to 1947 using the series constructed by Hyatt and Milne (1991) which is based on *Taxation Statistics* (Revenue Canada) and weekly wages and employment of male employees by industry (*Historical Statistics of Canada* ,Statistics Canada).

Age-specific data on any stock measure of female education (e.g. average years of schooling of women aged 20-44) were not available. Thus, this paper makes use a flow measure of female education, namely, the number of females enrolled full-time in university programs as a percentage of the population of females aged 20-24 (i.e. the population at risk). The data on the number of females enrolled in university programs come from *Historical Statistics of Canada* (Statistics Canada) for the period 1947-1975, and the CANSIM database (Statistics Canada) for the period 1976-1999.

The key policy variable, child benefits, is defined as the average benefit per child. It is equal to the sum of the child tax exemption/non-refundable child tax credit, family allowances, and the refundable child tax credit for the period 1947-1992, and equal to the child tax benefit/Canada child tax benefit thereafter. This series is expressed in real 1992 C$. The value of the child tax exemption is calculated as the amount of the exemption times the aggregate average marginal tax rate up to 1987 (see ZQM for details) and times the appropriate flat rate for 1988-1992. Family allowances are equal to the flat yearly benefit for 1947-1973, and equal to this benefit time one minus the average marginal tax rate for 1974-1992. The data on the above two programs were generously provided by Zhang, and updated for 1989-1993 using the same data sources. The refundable child tax credit is calculated as the total amount of credits divided by the number of children eligible under the program. The child tax benefit/Canada child tax benefit is calculated as total benefits paid per year divided by the annual average number of children receiving benefits. The data on these last three programs are collected from *Social Security Statistics* (Human Resources Development Canada).

Maternity leave is defined as a dummy variable that reflects the introduction of the policy in 1971. Benefits equivalent to 60% of the mother's usual earnings (up to a maximum insurance earnings limit) are paid for 15 weeks to qualified employed women. Qualification requirements have become more flexible over the years, particularly since 1984. Availability of the birth control pill is represented by a dummy variable that reflects its introduction in 1963.

Figures 2 and 3 show the time profile of fertility and female labor force participation rates for women aged 20-44. Fertility rates generally increased during the baby boom period up to 1957, then decreased steadily after that except for the brief increases between 1988 and 1990. Female labor force participation rates remained fairly stable until the mid 1950s, then increased steadily until 1990, then decreased slightly until 1994 and increased slightly thereafter. The decline in labor force participation rates was partly due to a general deterioration in labor market conditions. However, the decline was more pronounced and prolonged for women aged 20-24 than for women aged 25-44. This sharp decline in participation rates for women 20-24 was accompanied by a concomitant increase in school enrolment rates for this women. Several researchers have tried to explain the above phenomena. For example, Beaudry et al. (2000) explain it in terms of the increased perceived net returns to education resulting from the smaller cohort size of women aged 20-24 during the 1990s.

Table 1 presents the results of the unit root tests applied to all stochastic variables. Following Dickey and Pantula (1987) tests for the highest expected number of unit roots (in this case two) are implemented first. The hypothesis of two unit roots cannot be rejected for labor force participation, female education and male income, although for the latter this conclusion holds at the 5% level but not at the 10% level. For the other variables, the hypothesis of two unit roots is rejected but the hypothesis of one unit root cannot be rejected, although for child benefits this conclusion holds at the 5% level but not at the 10%. Concluding that all variables are either I[2] or I[1], traditional regression methods that assume stationarity are precluded. There is, however, the possibility of cointegration among these variables that would allow further investigation of long run relations between fertility, female labor force participation and their covariates.

5 Empirical Methodology

Fertility, female labor supply, and their determinants have smooth, slowly changing time patterns characteristic of integrated processes. The unit root tests presented in section 4 indicate mixed orders of integration among the six variables modeled here. The joint modeling of series with differing orders of integration is based on Johansen's (1995, 1997) cointegration model.

A system of n time series, x_t, can be represented as a p-th order vector autoregressive system

$$\left(I - A_1 L - A_2 L^2 - ... - A_p L^p\right) x_t = \mu + \varepsilon_t, \tag{17}$$

where L is the lag operator, A_j are nxn coefficient matrices, μ is a vector of constants, and ε_t is a vector of white noise error processes. Equation (17) can be renormalized in error correction form

$$\Delta x_t = \mu + \sum_{j}^{p-1} \Gamma_j \Delta x_{t-j} + \delta \beta' x_{t-1} + \varepsilon_t \tag{18}$$

Johansen (1991) establishes that the vector x_t is integrated of order one if (i) $\Pi = \delta\beta'$ is of reduced rank r<n and (ii) $\delta_{\perp}^{'} \left(-I + \sum \Gamma_j\right) \beta_{\perp}$ is of full rank (n-r), where $\delta_{\perp}$ and $\beta_{\perp}$ are nx(n-r) orthogonal complements to δ and β, respectively. The rank of Π is the number of cointegrating vectors, which are stored as the columns of β. The parameters in δ show the responses of each variable to departures from the steady state defined by the cointegrating relations $\beta' x_{t-1}$.

If condition (ii) above is violated, then x_t is integrated of order two or more. For systems containing I[2] elements, Johansen (1995, 1997) presents an alternative renormalization of (2):

$$\Delta^2 x_t = \mu + \sum_{j}^{p-2} \Psi_j \Delta^2 x_{t-j} + \delta \left(\beta x_{t-1} + \psi \Delta x_{t-1} \right) + \Phi \Delta x_{t-1} + \varepsilon_t \tag{19}$$

The third term on the right hand side of this expression is a set of a r multicointegrating relations that form stationary linear combinations between levels and first differences of the elements of x_t. In the fourth term a set of s stationary linear combinations among the first differences of the elements of x_t is defined by the rows of Φ.

Johansen (1995) presents a likelihood ratio test for the number of stationary dimensions, r, the number of I[1] dimensions, s, and the number of I[2] dimensions, n-r-s. Critical values for the test, allowing linear but not quadratic trends, are provided in Table 1 of Rahbek et al. (1999). These tests are implemented with the CATS supplement to the RATS program documented in Hansen and Juselius (1995).

True critical values may differ from those of Rahbek et al. in models with deterministic or stochastic exogenous variables. Consequently, estimates of the roots of the original VAR provide useful confirmatory information. A system with n_1 I[1] and n_2 I[2] series has at most (n_1 + $2n_2$) unit roots. A comparison of this maximum value and the number of estimated roots that are close to one provides alternative evidence on the values of r and s.

Conditional on the values of r and s, Johansen (1997) presents maximum likelihood estimators of the parameters of (19). Given identifying restrictions (Johansen and Juselius, 1994), these estimators are consistent and have mixed Gaussian distributions. Johansen also presents an efficient two-step procedure that is asymptotically equivalent to maximum likelihood estimation. The first step involves the estimation of the nxr matrices, δ and β, in the I[1] model of equation (18). The equivalence of the two-step and maximum likelihood estimators establishes the mixed Gaussian distributions of the estimators in the I[1] model, despite the presence of higher orders of integration among the elements of x_t. This allows statistical inference on the parameters of the long run relations, the elements of β, employing conventional distributions. Conditional on a finding of cointegration, an innovation analysis of the original VAR provides information on the dynamic relations among the variables in the system.

6 Cointegration Model of Fertility and Female Labor Supply

Johansen's I[2] procedures are applied to the system with five endogenous variables (fertility, labor supply, women's wages, male incomes, and female education), one stochastic exogenous variable (child benefits), and two dummy variables representing the availability of the birth control pill since 1963 and the provision of publically funded maternity benefits after 1970. The model allows deterministic linear trends in the data. A vector autoregression of order two is found to be congruent with the data (Table 2), with no evidence of first order serial correlation, or autoregressive conditional heteroscedasticity (ARCH) in any equation. Non-normal errors are evident at the 5% level for the wage equation, but not for any of the other four sets of residuals. Overall, these diagnostics indicate the model is correctly specified.

Johansen's (1995) test statistics for the numbers of I[0], I[1], and I[2] dimensions in the system are presented in Table 2. The form of greatest complexity that cannot be rejected by the data contains two single stationary relations among the six series (r = 2), one I[1] dimension (s = 1), and a two I[2] components (n-r-s = 2), for a total of five unit roots. This model is consistent with the roots of the dynamic system, also shown in Table 2, with five roots close to one (0.85 and larger) and the remainder substantially smaller (less than 0.56).

With the finding of two cointegrating relations, one exclusion restriction from each equation is sufficient to exactly identify the model (Johansen and Juselius, 1994). Consistent with the theoretical model of section 3, female labor force participation is excluded from the equation normalized for fertility, and the fertility rate is omitted from the other cointegrating equation, which is normalized on female labor supply. With these identifying restrictions the estimated long run relations are presented in Table 3.

The estimated fertility equation is consistent with underlying economic theory, with coefficients on female wages and male incomes both statistically significant and correctly signed. Point estimates of these elasticities (-2.7 for female wages and 3.7 for male incomes) indicate substantial responses of the fertility rate to these economic variables, in contrast to the regression based estimates by Zhang, et al. (1993). These large values are consistent with their interpretation as long run elasticities. The smaller absolute elasticity for female wages compared with male incomes reflects the offsetting income and substitution effects of the former, while changes in male income induce only income effects in the traditional economic model.

These elasticity estimates may also be compared with those of Hyatt and Milne (1991), who employ 1948-1984 Canadian data to test an economic model of total fertility. They find statistically significant male income and female wage effects on total fertility, with implied elasticities of 1.38 and -1.55, respectively. Not only are these estimates considerably lower than the cointegration based elasticities reported here, but the relative magnitudes of these two elasticities are reversed, with female wages showing the larger absolute effect.

Of particular interest is the significance of the coefficient on the total child benefits variable, with an estimated elasticity of 0.7. This is substantially larger than the 0.05 elasticity at the mean computed by Zhang, et al. (1994) from their regressions for the total fertility rate. This estimate also exceeds the range of elasticity estimates (0.127 to 0.248) in the Whittington, et al. (1990) analysis of the U.S. personal tax exemption on the birth rate of 15-44 year old women.

The 0.7 point estimate implies that a twelve percent increase in total child benefits, such as occurred over the decade of the 1950s, would induce an eight percent rise in the fertility rate, which is quite close to the change that was observed over this decade. However, the 1970s surge in child benefits was offset by the effects of a 26 percent rise in female wages (with a more moderate increase in male incomes), so that fertility declined over this decade. Changes in child benefits of the magnitudes observed over this historical period can be overwhelmed by changing economic conditions.

The dummy variable representing the introduction of the birth control pill has a small, negative effect on fertility. Public funding of maternity benefits did not affect the fertility rate according to the coefficient on this variable. Zhang et al. (1993) point out that eligibility for these benefits was low when this program was first adopted, and subsequent reforms expanded coverage. Their experimentation with other dates defining this dummy variable did not produce statistical significance for this factor.

In the female labor supply equation the key economic variables also have theoretically correct signs and are statistically significant at the one percent level. These elasticities are quite large, at 2.0 for female wages and -2.7 for male incomes. According to these estimates women are highly responsive in their long run labor supply decisions to wage incentives and to the economic conditions facing their husbands. The female education variable has a small positive elasticity that is significant at the ten percent level. Increases in total child benefits discourages female labor force participation, mirroring its positive effect on fertility.

In general, the cointegration analysis establishes quantitatively strong long run effects of the economic variables on fertility and female labor force participation. Complementary to this long run analysis, impulse response functions and variance decompositions depict the dynamic responses of each variable to exogenous shocks in each of the others. This innovation analysis employs orthogonalized errors using an ordering that treats total child benefits as exogenous: total child benefits, male incomes, female education, women's wages, female labor supply, and fertility. Alternative orderings did not change the major substantive conclusions described below. The impulse response functions are displayed in figure 4.

This discussion focuses on the effects that show statistically significant impulse responses that also account for substantial proportions of variation. Male income contributes positively to female education, which could reflect the use of husbands' financial resources to pay for college expenses by their wives. Women's wages show positive responses to shocks in male incomes, which in this analysis may proxy business cycle effects. Female wages are also inversely related to fertility shocks, consistent with the loss of job continuity that accompanies childbearing.

Female labor force participation shows considerable endogeneity in this model, with significant effects from shocks to fertility, total child benefits, and female education. The inverse effect from fertility confirms the well-established negative correlation between these two variables in the literature (Lehrer and Nerlove, 1986). According to the evidence here, this inverse relation is due to fertility effects on female labor supply, but the reverse effect is not statistically significant. Child benefits and women's education are also seen to increase female labor supply in the short run.

The most surprising result is the lack of statistically significant responses of fertility to innovations in any of the other variables in the model. According to the variance decompositions, the education variable has the strongest impact, but these effects are not significant in the impulse response functions. Although fertility is part of a long run relation involving the economic factors, it does not respond significantly to unanticipated shocks in these same variables in the innovation analysis. According to the cointegration analysis, household decisions concerning fertility are consistent with economic incentives, so that all variables in the system share common long run trends. In the innovation analysis, however, only the responses to unanticipated components of the variable are recorded, and fertility is seen to be unresponsive to these purely exogenous, temporary shocks. Because the fertility decision has long lasting implications for the household, it is not surprising that it is not responsive to purely transitory changes in the other variables.

7 Discussion and Conclusion

This study has combined economic theory and time series analysis in an investigation of the determinants of fertility and female labor force participation while focusing on the effects of child benefit policies. The theoretical model accommodates alternative forms of child benefit policies, reflecting the different policies adopted by Canada over the past five decades. All forms of these policies are expected to have positive effects on fertility, with reverse effects on female labor supply. The theory also indicates that male incomes should have greater absolute effects on fertility than do female wages, since the latter reflects offsetting income and substitution effects. In addition, the theoretical model predicts a positive effect of maternity benefits on the number of children.

Each of these propositions is examined empirically through cointegration analysis of aggregate Canadian data from 1947 through 1999. Cointegration testing establishes the existence of two long run relations among the fertility, female labor supply, women's wages, female education, male incomes, and the value of child benefits. These relations are identified as a fertility equation and a female labor supply function, with appropriately signed and statistically significant elasticities on the economic variables in these relations. Since child benefit policies are expected to affect fertility through changing economic incentives, establishing the significance of women's wages and male incomes in the fertility equation is a sine qua non for the existence of these policy effects. Unlike the regression analyses of Whittington, et al. (1992) for the United States and Zhang, et al. (1993) for Canada, the cointegration based estimates presented here do produce statistically significant female wage and male income elasticities. Moreover, these elasticity estimates are quite large in absolute values, indicating substantial long run responsiveness of fertility (and of labor supply) to economic factors.

Focusing on the policy variable, the elasticity of the fertility rate to child benefits is estimated to be 0.7. Because this is considerably smaller than the absolute values of the female wage and male income elasticities, it is likely that feasible changes in tax and expenditure policies for child benefits would be swamped by other economic changes. For example, the maximum level of child benefits of C$1154 was attained in 1978, an amount that exceeds its 1999 value by 22 percent. If a sustained increase to this level were enacted, controlling for changes in other factors, the fertility rate would be expected to rise by 15 percent. Meanwhile, if female wages and male incomes were to continue to rise by the same percentages as occurred over the 1990s (16 percent and 3 percent, respectively), these changes would lower fertility by 32 percent. The combined effect of all three changes over a ten year period would be to reduce fertility among 20-44 year old women from 56 to 46 births per 1000 women. This hypothetical projection illustrates the strength of the fertility reducing economic forces against which pronatalist policies must compete.

Although these estimates cast doubt on the effectiveness of child benefit policies for raising fertility, it is possible that future economic forces could do so instead. In the economic model presented here, changes in male incomes have no substitution effects on fertility, while female wage effects involve both income and substitution effects. Consequently, with the elasticity on male incomes larger in absolute value than that for female wages (3.7 versus 2.7), equal rates of growth in these two variables would cause fertility to rise at the same common rate as the two wage/income variables. This scenario presents a more reasonable possibility for the restoration of replacement levels of fertility than is likely to be achieved through increases in child benefit policies.

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Table 1. Dickey-Fuller Tests for Unit Roots

Variables	Null Hypothesis I[2]	Null Hypothesis I[1]
Real female wage	-6.65 (0)	-0.52(0,t)/-1.55 (0)
Real male income	-2.86 (1)	-0.49(0,t)/-2.96 (0)
Female education	-2.47 (0)	-2.45(1,t)/-1.26 (1)
Real child benefits	-8.79 (0)	-3.40(0,t)/-1.35 (0)
Labor force participation of women aged 20-44	-1.97 (1,2)	-1.22(2,3,t)/-2.16 (2,3)
Fertility rate of women aged 20-44	-3.48 (1)	-2.70(1,t)/-0.38 (1)

Notes: Number of lagged first and second differences for the I[1] and I[2] model, respectively, are shown in parentheses, with t if deterministic trend is included in the test equation. Five and ten percent critical values are –2.93 and –2.60 with no trend, and –3.50 and –3.18 when the trend term is included.

Table 2. Tests of cointegration among fertility and labor market variables

Test of cointegration rank in I[2] model					
			I[2]		
I[0]	5	4	3	2	1
0	289.55	230.20	188.53	157.11	145.77
	(198.2)	(167.9)	(142.2)	(119.8)	(101.5)
1		182.07	135.88	101.68	90.98
		(137.0)	(113.0)	(92.2)	(75.3)
2			106.93	63.28	48.46
			(86.7)	(68.2)	(53.2)
3				61.29	27.34
				(47.6)	(34.4)
4					30.01
					(19.9)

Residual diagnostics

Autocorrelation: $\chi^2_{[25]}$ (p-value)	24.50 (0.49)				
Error correction equation for:	Fertility	Labor supply	Female wage	Male income	Female edu.
Normality: $\chi^2_{[2]}$ (p-value)	1.15 (0.56)	0.90 (0.64)	7.49 (0.02)	0.54 (0.76)	3.60 (0.16)
ARCH: $\chi^2_{[3]}$ (p-value)	3.74 (0.29)	0.13 (0.98)	0.06 (0.99)	1.46 (0.69)	2.92 (0.40)

Roots of the autoregressive system

0.9933	0.8882	0.8882	0.8534	0.8534	0.5547	0.5547	0.5002	0.5002	0.0325

Notes: The I[2] model is based on a two-lag structure. Entries in the test of cointegration rank in I(2) model are Johansen's (1995) $S_{r,s}$ test statistics with null hypothesis indicated on the margins and 5% critical values (from Table 1 of Rahbek et al., 1999) shown below each entry in parentheses. ARCH tests for conditional autoregressive heteroscedasticity.

Table 3. Maximum likelihood estimates of the long-run and short-run coefficients of the Error Correction Model

	Fertility	Labor supply	Female wage	Male income	Female education	Child benefits
Fertility equation	-1.000		-2.707	3.733	-0.223	0.724
			(0.572)	(0.450)	(0.152)	(0.166)
Adjustment to disequilibria	-0.061	-0.178	-0.065	-0.094	0.201	
in the fertility equation	(0.058)	(0.033)	(0.046)	(0.047)	(0.080)	
Labor supply equation		-1.000	1.972	-2.680	0.219	-0.355
			(0.429)	(0.337)	(0.114)	(0.124)
Adjustment to disequilibria	-0.056	-0.202	-0.098	-0.254	0.290	
in the labor supply equation	(0.080)	(0.046)	(0.064)	(0.065)	(0.110)	
Coefficients on birth	-0.029	0.003	0.005	0.056	-0.018	
control pill	(0.014)	(0.007)	(0.011)	(0.012)	(0.020)	
Coefficients on maternity	0.004	-0.004	0.008	0.032	-0.040	
leave benefits	(0.014)	(0.008)	(0.012)	(0.012)	(0.021)	

Notes: In the first two panels, the top two lines present the long-run parameter estimates and their standard errors (in parentheses) respectively, and the second lines present the estimated adjustment coefficients and their standard errors. Short-run coefficients on the two dummy variables and their standard errors are reported in the third panel.

Figure 1. Total child benefits

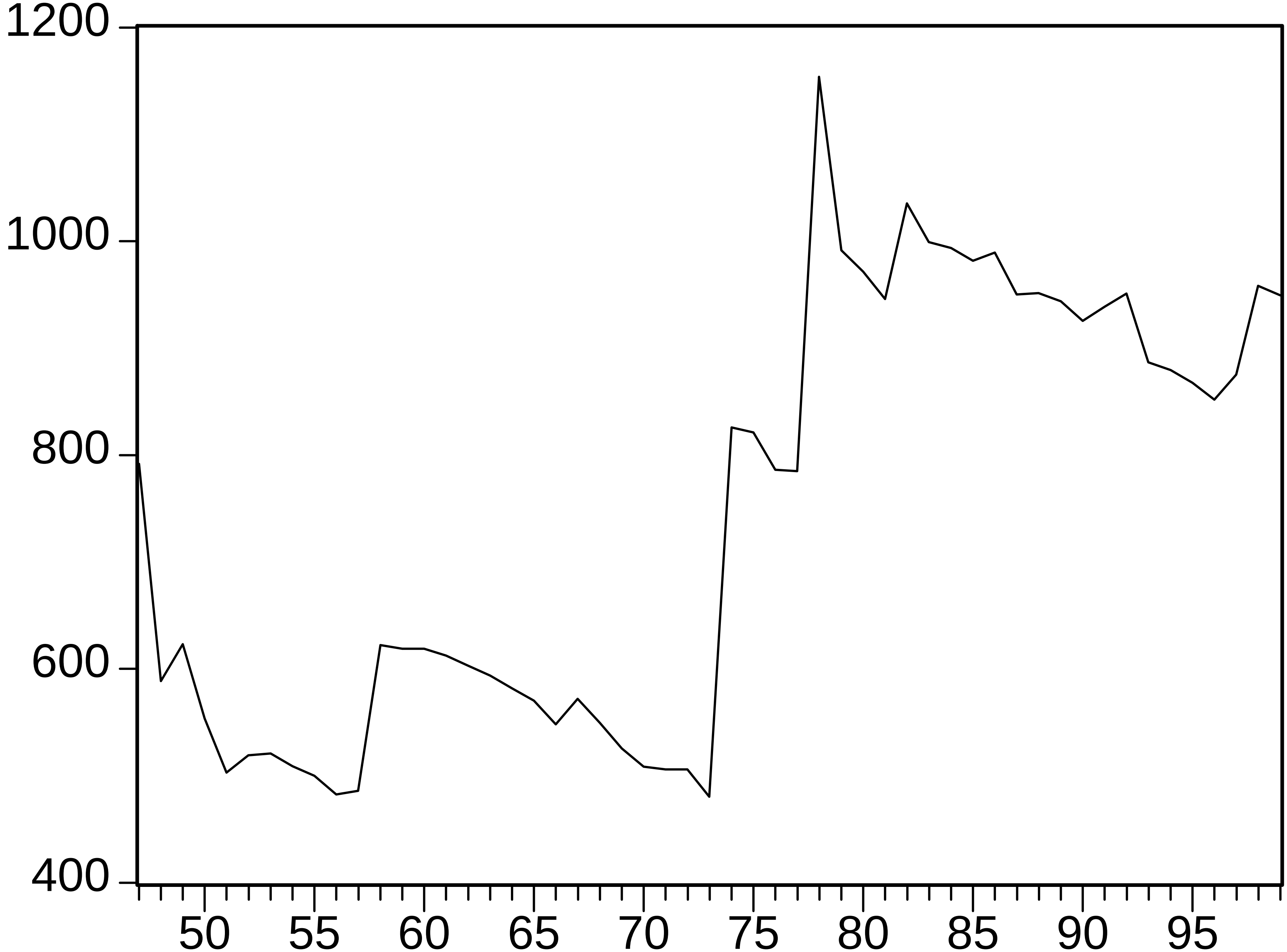


Figure 2. Fertility rates for women aged 20-44

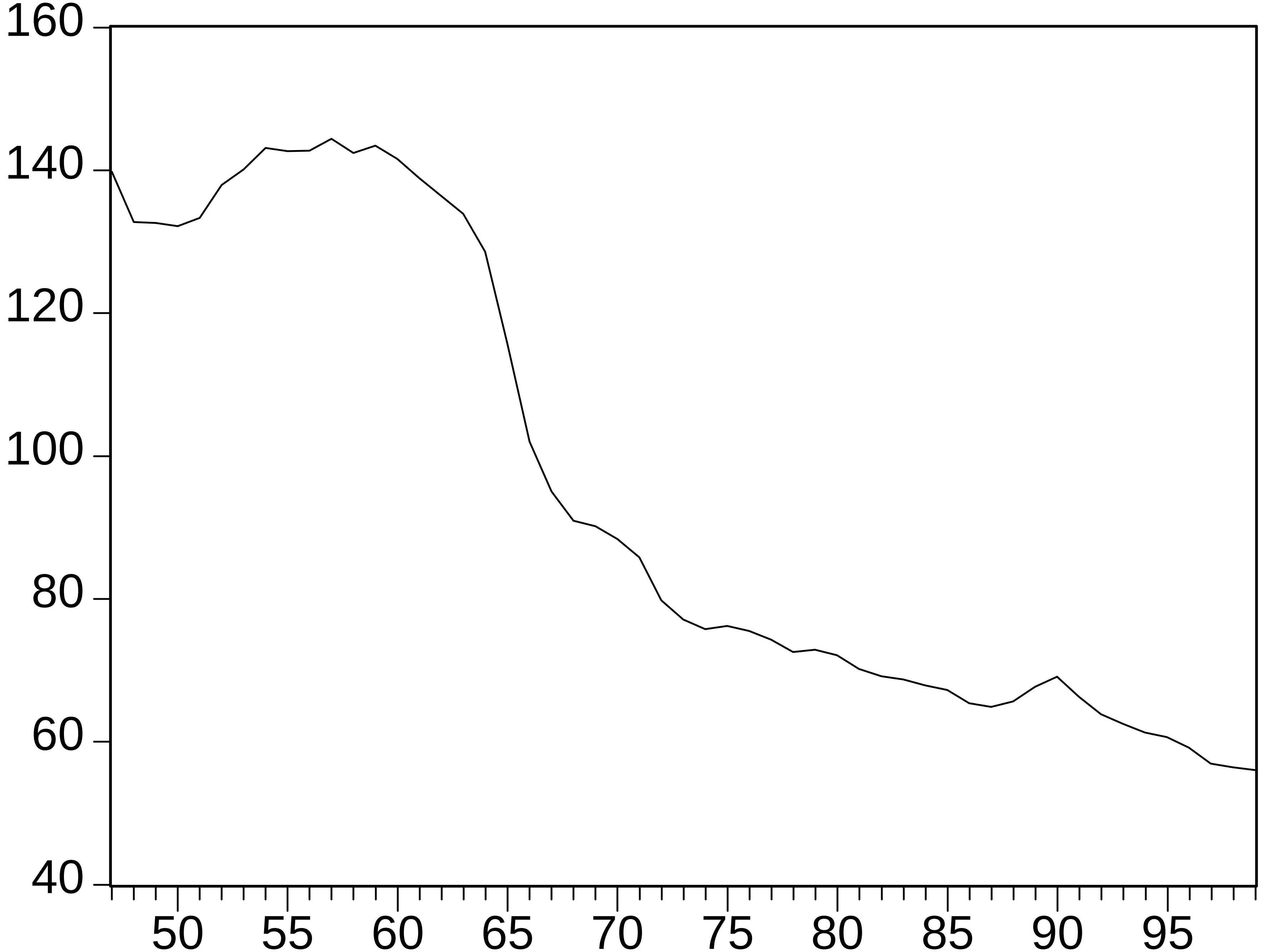


Figure 3. Labor force participation rate of women aged 20-44

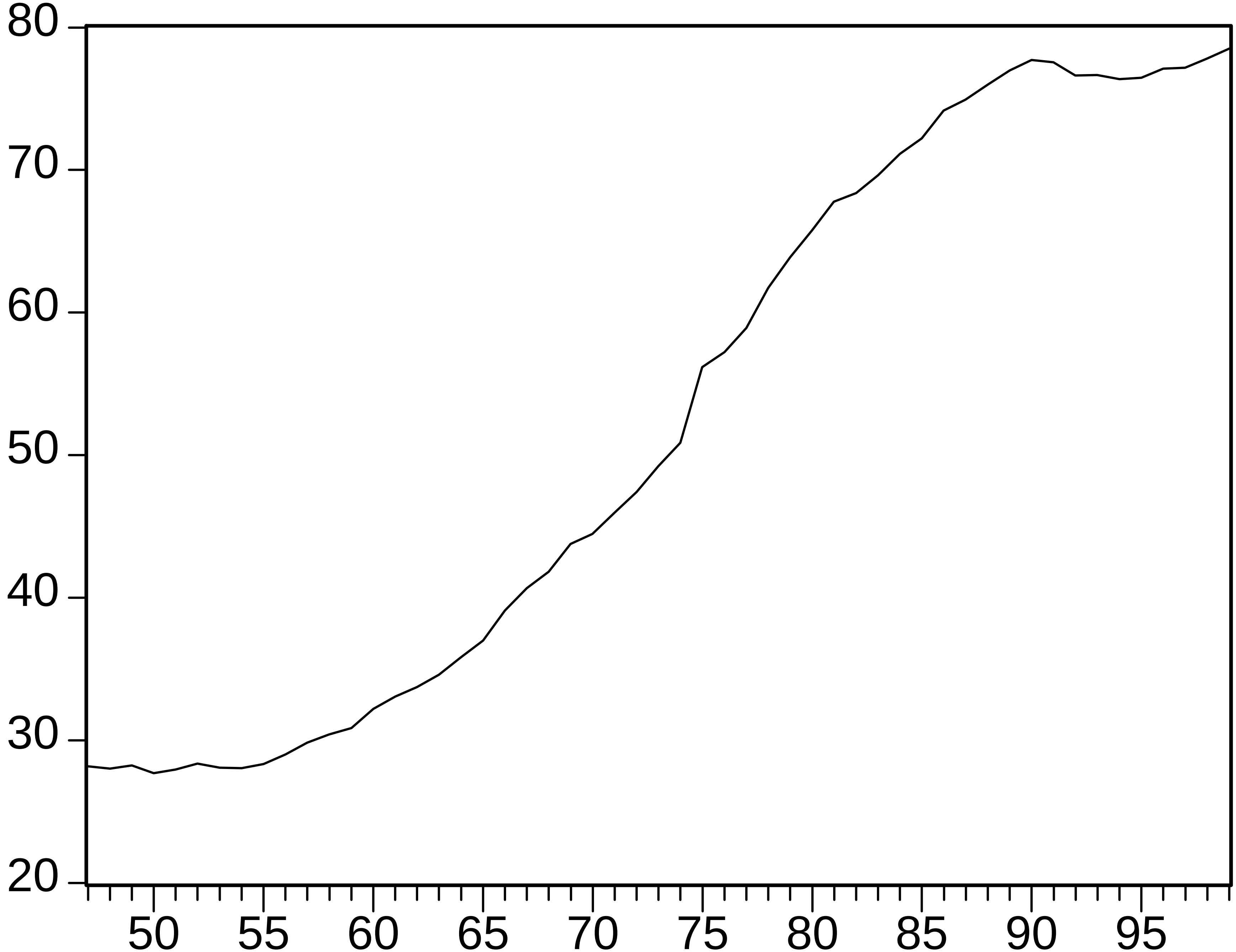
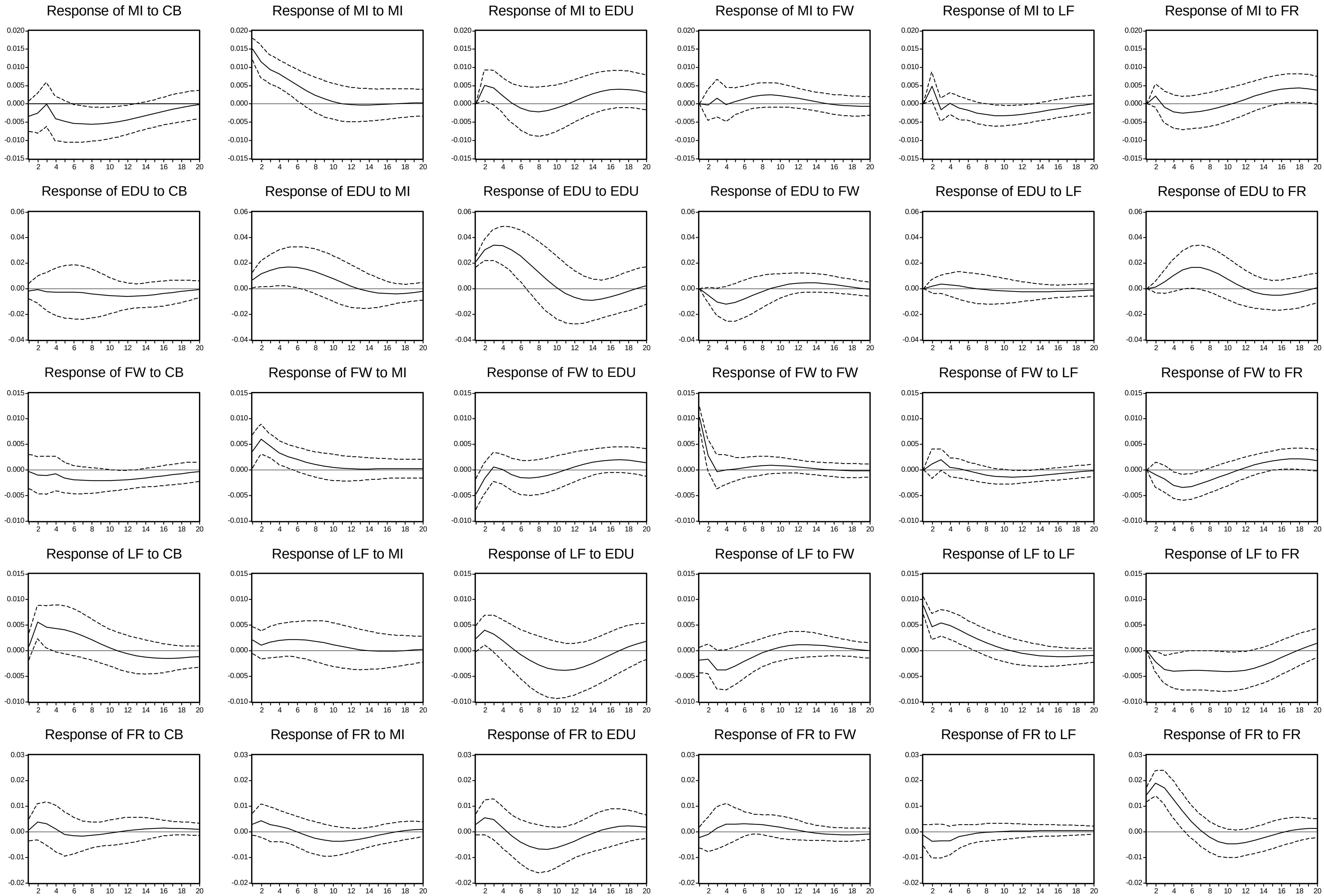


Figure 4. Impulse response functions: Response to one S.D. innovations ± 2 S.E.



MI = male income; CB = child benefits; EDU = female education; FW = female wage; LF = female labor force participation; FR = fertility