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Fertility Behaviour under Income Uncertainty

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Abstract. This paper develops a two-period stochastic model of fertility behaviour to provide a possible explanation for the recent sharp decline in birth rates in the former Soviet Republics and Eastern European countries. Due to the existence of irreversibilities associated with the childbearing decision and the option of postponing childbearing for a later time, it may be optimal for individuals to postpone childbearing during times of increased income uncertainty.

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Résumé. Cet article développe un modèle stochastique de comportement fécond, à deux périodes, qui tente de fournir une explication possible du déclin récent et rapide des taux de natalité dans les ex-Républiques soviétiques et dans les pays d'Europe de l'Est. Du fait de l'existence d'effets irréversibles associés à la décision d'avoir un enfant et du fait de la possibilité de repousser une naissance à une date ultérieure, la meilleure solution, pour les individus, peut être d'ajourner leurs naissances pendant les périodes d'incertitude croissante sur les revenus.

1. Introduction

There has been, in recent years, a sharp decline in the birth rate in most of the former Soviet block countries undergoing transition from a controlled economy to a market based economy. Tables 1 and 2 present numbers showing a sharp decline in birth rates and total fertility rates in East Europe and the former Soviet republics. According to a New York Times article, in Brandenburg, a former East German state, the number of births declined from 38000 in 1989 to barely 12000 in 1993. This prompted Nicholas Eberstadt, a demographer with the American Enterprise Institute, to remark, "Eastern Germany's adults appear to have come as close to a temporary suspension of childbearing as any large population in human experience". The article further says, "the astonishing drop in the birth rate is comparable to those in war, plague or famine, and has been attributed in large part to economic uncertainty". This paper develops a theoretical model to show the link between economic uncertainty and fertility behaviour in order to provide a possible

Table I. Crude birth rates (per thousand of population)

Country	1970	1988	1990	1991	1992	1993
Poland	17	16	15	14	13	13
Bulgaria	16	13	13	11	10	10
Romania	20	16	16	14	11	11
Slovakia	19	15	14	14	15	14
Czech Rep.	16	13	14	13	13	13
Hungary	15	12	12	12	12	12
Latvia	14	16	14	14	12	11
Lithuania	17	16	15	15	14	13
Estonia	15	16	14	14	12	11
Azerbaijan	29	26	26	27	25	22
Uzbekistan	36	35	34	35	32	31
Kazakhastan	26	25	22	21	21	20
Turkmenistan	37	36	34	34	32	31
Armenia	23	22	23	23	22	20
Georgia	19	17	16	15	16	13
Russia	15	16	13	12	12	11
Ukraine	15	14	13	12	12	11
Belarus	16	16	14	13	13	12
Kyrgyz Rep.	31	32	29	29	28	
Tajikistan	35	40	39	39	36	

Sources: World Development Report (1989–96), The World Bank, Washington, D.C., Recent Demographic Developments in Europe, Council of Europe, Strasburg.

explanation for the observed decline in the birth rate in economies undergoing transition.

What can the existing theories of fertility say about the observed decline in the birth rate in these countries? Most of the countries under discussion fall under the category of societies where fertility is ‘demand driven’, and supply side factors like health, nutrition, infant mortality etc. do not play an important role in the determination of actual fertility; the desired fertility is same as the realized fertility. These societies are also known as ‘perfect contraceptive societies’. In these societies, according to the existing theories of fertility, there is a decline in fertility as income rises because the opportunity cost of time devoted to children rises; and also expenditure per child rises because people demand higher quality children (Becker, 1976). Becker (1981) explains episodes of sharp decline in birth rates in different countries by appealing to the quantity-quality substitution in the demand for children (Becker, 1981, chapter 5). An increase in the fixed cost of having a child leads to substitution of high quality children for the number of children. This means that a decline in the birth rate is accompanied by an increase in schooling,

Table II. Total fertility rates

Country	1970	1988	1989	1990	1991	1992	1993	1994
Poland	2.3	2.2	2.1	2.0	1.9	1.9	1.9	1.8
Bulgaria	2.2	2.0	1.9	1.9	1.8	1.5	1.5	1.5
Romania	2.8	2.1	2.1	2.2	1.9	1.5	1.5	1.4
Slovakia	2.5	2.2	2.1	2.1	1.9	2.0	1.9	1.7
Czech Rep.	2.1	1.9	1.9	1.9	1.9	1.9	1.8	1.4
Hungary	2.0	1.8	1.8	1.8	1.8	1.8	1.7	1.6
Latvia	1.9	2.2	2.1	2.0	1.9	1.8	1.6	1.4
Lithuania	2.3	2.1	2.0	1.9	2.0	1.9	1.8	1.5
Estonia	2.1	2.3	2.2	2.0	1.8	1.8	1.6	1.5
Russia	2.0	2.1	2.0	1.9	2.0	1.7	1.4	1.4
Ukraine	2.0	2.0	1.9	1.9	1.8	1.8	1.6	1.5
Georgia	2.6	2.1	2.1	2.2	2.2	2.2	2.2	
Azerbaijan	4.6	2.8	2.8	2.7	2.8	2.7	2.5	2.5
Uzbekistan	6.1			4.1	4.3	4.1	3.8	3.8
Kazakhastan	3.5			2.7	2.8	2.7	2.5	2.3
Turkmenistan	6.3			4.2	4.5	4.2	3.9	3.9
Armenia	3.2	2.5	2.6	2.8	2.7	2.8	2.6	2.0
Belarus	2.3	2.0	2.0	1.9	2.0	1.9	1.6	1.6
Kyrgyz Rep.	4.9			3.7	3.9	3.7		3.3
Tajikistan	5.9			5.1	5.3	5.2		4.4

Note: Total fertility rate: Total number of children a girl will bear if her childbearing follows the current fertility pattern.
Sources: World Development Report (1990–96), The World Bank, Washington, D.C., Recent Demographic Developments in Europe, Strasburg, Council of Europe (various years).

if schooling is a proxy for quality (Becker, 1981, tables 5.1 and 5.2). However, Table 3 in our paper makes it clear that, for the countries for which education data is available, a decline in birth rate has not been accompanied by a rise in the schooling of children. The primary enrollment ratio has declined between 1987 and 1992 for all 4 countries in Table 3. This evidence makes the quantity-quality substitution an inadequate explanation for the recent decline in birth rates.

There is an alternative theory of fertility due to Easterlin (Easterlin et al., 1980), which emphasizes the importance of taste factors. However, tastes do not change overnight, therefore, a sharp decline in births in the wake of economic transition can not be explained satisfactorily by taste factors either.

It is a fact that in most of the countries experiencing a decline in birth rates there has been a sharp increase in economic uncertainty as a consequence of transition from a controlled economy to a market based economy. Inflation and unemployment are running high. Public sector companies are being privatized and

Table III. Gross enrollment ratios

Country	1987			1992		
	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Poland	101	80	18	98	83	23
Romania	97	79	10	88	80	9[a]
Bulgaria	104[b]	75[b]	25[b]	90	79	16
Hungary	97	70	15	89	81	15

Note: Enrollment ratios are percentage of relevant age group enrolled in education.
Source: World Development Report (1989–95), The World Bank, Washington, D.C.
[a] For year 1991
[b] For year 1988

as a consequence job security is vanishing. This raises the natural question is there a possible link between economic uncertainty and the timing of childbearing which can explain the current drop in births in the transition economies. The existing demand side theories of fertility behavior are completely deterministic, and hence inadequate to answer this question.

This paper develops a simple two period model of fertility decision, where future income is stochastic, to show the link between fertility and economic uncertainty. The uncertainty about future income is expected to capture the impact of economic uncertainty on fertility decision. The link between income uncertainty and fertility behaviour arises because of two factors: 1) irreversibilities associated with the fertility decision; and 2) the option to postpone childbearing decision for a later time. In the presence of irreversibilities, the ability to postpone a decision till the resolution of uncertainty is valuable. It allows the agent to avoid making irreversible expenditure in bad states of the world. Dixit and Pindyck (1994) provide models of impact of uncertainty on irreversible investment. In the present paper irreversibility is captured by a commitment to spend a minimum amount on the child once a person decides to have a child. This is shown in a model where the only fertility decision that the agent makes is whether to have a child in the first period or wait till the second period for the uncertainty to be resolved. The agent knows her first period income but second period income is uncertain. If the agent did not have the option to wait then she would have a child in the first period only. However, if she can wait till the second period she would like to do so in many cases. Other things remaining same, the greater the uncertainty about the second period income the greater the attractiveness of the waiting option. Thus, people would like to postpone their fertility decision during times of increased economic uncertainty.

The result is robust in respect of several extensions and generalizations. The expenditure on a child is endogenized by making the benefit derived from a child a function of the expenditure on the child. The agent is allowed to choose this expenditure optimally. This is same as Becker's concept of choosing 'quality of children'. The larger the amount spent on a child the higher the quality (Becker, 1976). As long as there are irreversibilities associated with this expenditure in the sense that the agent can not spend less than a certain amount on her child once she decides to have a child, the same result is obtained.

In another extension, leisure is included in the utility function and the time spent on a child is included in the cost in the form of forgone wages, in addition to the direct monetary expenditure. As long as the direct monetary expenditure is more important than the foregone wages the agent would want to avoid having a child when she expects her wages to be low. The main result of the paper – uncertainty affects fertility behaviour negatively – holds irrespective of the relative magnitudes of direct expenditure and foregone wages.

The main contribution of this paper lies in bringing economic uncertainty into the determination of fertility behaviour and providing new insights about the economics of timing of childbearing decision and their impact on the aggregate fertility behaviour of societies.

The organization of rest of the paper is as follows. Section 2 discusses the benchmark model with exogenous expenditure. Section 3 endogenizes the expenditure on a child by making the benefits derived a function of this expenditure. Section 4 introduces leisure in the utility function, and the cost of raising a child includes time spent on them as well as the direct expenditure. Section 5 concludes.

2. The benchmark model

Assume there is a single agent who lives for two periods. At the beginning of period 1 the agent knows her current income y, but does not know her second period income with certainty. Her second period income increases by δ with probability 1/2 and decreases by δ with probability 1/2, so, δ captures the mean preserving spread in the distribution of income. The per-period expenditure on the child is γ, and the per-period benefit from the child is ϕ. The total welfare of the agent in each period is the sum of utilities derived from own consumption, $U(c)$, and from the child, ϕ. It is assumed that the utilities derived from consumption and from children are additively separable. The main reason for doing so is analytical tractability. As is discussed later in the section, this assumption is not crucial for the results obtained in this section. A similar formulation is used in Becker et al. (1990), where the utility of parents, V_t, is sum of the utility derived from own consumption, $u(c_t)$, and a constant times the utility of children, V_{t+1}. If the agent decides not to have a child then the expenditure on the child and the benefit from the child both are zero. β is the rate of time discount $(0 < \beta < 1)$.

Now, the agent has to decide whether she wants a child in the first period, without knowing her second period income. To begin with, assume that she does not have the option to have a child in the second period. In that case the decision problem is simply to choose: $Max\{V_k(y), V_{nk}(y)\}$, where $V_k(y)$ and $V_{nk}(y)$ denote the lifetime utilities from having a child in the first period and from not having a child in the first period, respectively, given by

$$V_k(y) = U(y-\gamma) + \frac{1}{2}\beta[U(y+\delta-\gamma) + U(y-\delta-\gamma)] + (1+\beta)\phi, \quad (1)$$

$$V_{nk}(y) = U(y) + \frac{1}{2}\beta[U(y+\delta) + U(y-\delta)]. \quad (2)$$

Whether the agent will decide to have a child in the first period or not depends on the parameters, however, it can be easily shown that $d(V_k(y) - V_{nk}(y))/dy > 0$ for any diminishing marginal utility function, $U''(c) < 0$. This implies that the decision to have a child in the first period becomes more attractive as the level of income rises. The intuition for this is simple. The benefit from having a child in the first period is $(1 + \beta)\phi$, which is a constant, while the cost of having a child in utility terms is declining with income. The cost of having a child here is: $U(y) - U(y - \gamma) + (1 + \beta)(EU(y)$ - $EU(y - \gamma))$. Clearly this is declining in y for any diminishing marginal utility function, $U''(c) < 0$. The cost of having a child in this model is the own consumption foregone, which is low when income is high because the marginal utility is low. For a quadratic utility function of the form $U(c) = ac - bc^2$, where $a > 0$, $b > 0$ are the parameters of the utility function, $V_k(y) > V_{nk}(y)$ if and only if

$$y > y_1^* = \frac{a\gamma + b\gamma^2 - \phi}{2b\gamma}. \quad (3)$$

Therefore, in the absence of the option to postpone the agent has a child in the first period only if her income is greater than the threshold level of income denoted by y_1^*. It should be noted that this threshold does not depend on the uncertainty about future income captured by δ.

Now, suppose the agent has the option to have a child either in the first period or in the second. If the agent waits till the second period, she can see the realization of her second period income and then decide whether she wants a child in the second period. To make the option worthwhile we assume that the agent does not want to have a child if she gets a bad shock in the second period, while she does want to have a child if she gets a good shock in the second period. This implies the following restrictions on the parameters.

$$U(y-\delta) > U(y-\delta-\gamma) + \phi, \quad (4)$$

$$U(y+\delta) < U(y+\delta-\gamma) + \phi. \quad (5)$$

We assume (4) because if she does not mind having a child in the bad state then she will have a child in the first period only, and hence the option is worthless. Also, if she does not want to have a child even in the good state then she will never have a child, so, again the option is worthless. There is an asymmetry regarding the expenditure and benefit from children born in periods one and two. If a child is born in period one, parents have to spend γ in both periods. However, if a child is born in period two they have to incur this expenditure only once. This can be easily remedied by adding a third period, so that parents have to spend γ in the third period as well on the child born in the second period. If the uncertainty about the third period income is resolved in the second period, then none of the results changes.

(4) and (5) imply the following lifetime utility denoted by $F_k(y)$ for the agent who waits for the uncertainty to be resolved before taking her fertility decision.

$$F_k(y) = U(y) + \frac{1}{2}\beta[U(y + \delta - \gamma) + U(y - \delta)] + \frac{1}{2}\beta\phi. \tag{6}$$

Now, the decision problem at the beginning of period one is simply to choose $Max\{V_k(y), F_k(y)\}$. $V_{nk}(y)$ has been left out of the decision making because it is always dominated by $F_k(y)$ whenever (5) is true. If $V_k(y) > F_k(y)$, the agent decides to have a child in the first period only, and does not want to wait till the second period. However, if $V_k(y) < F_k(y)$, the agent waits for the uncertainty to be resolved before taking her fertility decision. Depending on parameter values $F_k(y)$ can be larger or smaller than $V_k(y)$. However, we are more interested in how their difference behaves as uncertainty increases. Let us look at the difference of $F_k(y)$ and $V_k(y)$.

$$\begin{aligned} F_k(y) - V_k(y) &= U(y) - U(y - \gamma) - \phi \\ &\quad + \frac{1}{2}\beta[U(y - \delta) - U(y - \delta - \gamma) - \phi]. \end{aligned} \tag{7}$$

In (7) $U(y) - U(y - \gamma) - \phi$ is the loss from not having a child in the first period, while the other term is the gain from not having a child in the first period. This second term captures the impact of irreversibility associated with childbearing. Due to the irreversibility associated with childbearing the option to postpone becomes valuable. It can be easily shown that

$$\frac{d(F_k(y) - V_k(y))}{d\delta} = \frac{1}{2}\beta[U'(y - \delta - \gamma) - U'(y - \delta)] > 0, \tag{8}$$

for any diminishing marginal utility function, $U''(c) < 0$. (8) implies that the attractiveness of postponement option increases with uncertainty. The intuition behind this result is simple. The greater the uncertainty the greater the likelihood that the agent will end up with a child in a bad state of the world in the second period. In (7) the loss from postponing childbearing is independent of uncertainty, while the gain from postponement is an increasing function of uncertainty. This happens because the agent does not want a child in the bad state. The option to postpone her fertility decision is valuable precisely because it allows her to avoid being burdened with an undesirable child in a bad state of the world.

Another result, which is important for empirical implementation of the model is that as income increases, other things including the level of uncertainty remaining

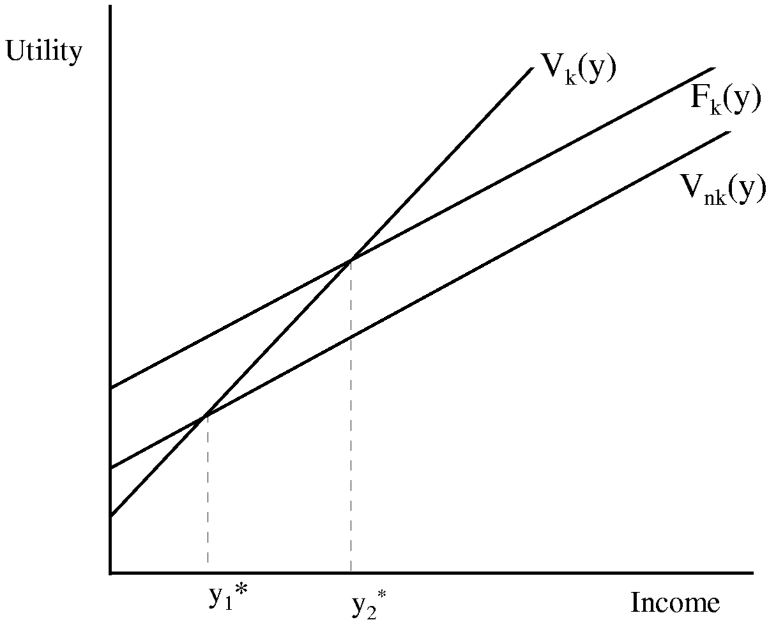

Figure 1. Determination of threshold level of income.

same, the attractiveness of postponement option decreases.

$$\frac{d(F_k(y) - V_k(y))}{dy} = U'(y) - U'(y-\gamma) + \frac{1}{2}\beta[U'(y-\delta) - U'(y-\delta-\gamma)] < 0 \tag{9}$$

for any diminishing marginal utility function, $U''(c) < 0$.

The intuition behind this result is that with an increase in income the utility cost in terms of own consumption foregone of having a child goes down, while the benefit derived from having a child remains constant. This implies that being stuck with a child in a bad state hurts less and less as income increases. Therefore, the option to postpone the decision to have a child becomes less valuable as income increases.

Since $F_k(y)$ and $V_k(y)$ both are monotonically increasing in y, and their difference is shrinking in y, there exists a y_2^* at which $F_k(y_2^*) = V_k(y_2^*)$. y_2^* is given by the following for a quadratic utility function:

$$y_2^* = \frac{a\gamma + b\gamma^2 - \phi}{2b\gamma} + \frac{\beta\delta}{2+\beta} = y_1^* + \frac{\beta\delta}{2+\beta}. \tag{10}$$

Individuals above this level of income want to have a child immediately, while those below wait for the uncertainty to be resolved. Figure 1 shows the determination of the threshold level of income, y_2^*.

Next we do some comparative statics on the threshold, y_2^*. It can be easily seen from (10) that, for a quadratic utility function, the threshold level of income is increasing in the uncertainty parameter δ since from (3) y_1^* is independent of δ. However, this result holds for any diminishing marginal utility function, $U''(c) < 0$. For a y_2^* satisfying $F_k(y_2^*) = V_k(y_2^*)$ it can be easily shown that

$$\frac{dy_2^*}{d\delta} = \frac{U'(y_2^* - \delta) - U'(y_2^* - \delta - \gamma)}{U'(y_2^*) - U'(y_2^* - \gamma) + \frac{1}{2}\beta[U'(y_2^* - \delta) - U'(y_2^* - \delta - \gamma)]} > 0. \qquad (11)$$

Since the numerator and the denominator both are negative in (11), $dy_2^*/d\delta$ is positive. (11) implies that the greater the uncertainty the greater the threshold level of income above which postponement option becomes irrelevant. From (10) we also see that the threshold is increasing in β and γ. Former implies that more patient people have a larger threshold; the value of waiting is more for them. The latter implies that the larger the cost of raising a child the greater the benefits from waiting. This is so because a larger expenditure on a child makes being burdened with a child in bad state more costly. Again, the comparative statics with respect to β and γ can be easily derived for any diminishing marginal utility function, $U''(c) < 0$. The results above can be summarized in the following proposition: An individual facing an uncertain future income follows a threshold behaviour in deciding when to have a child. If her income is above the threshold she wants to have a child immediately, while if it is below the threshold she waits for the uncertainty to be resolved. The threshold itself is increasing in the level of uncertainty and in the cost of raising children.

Connecting to the transition economies, what is happening there is probably a rise in the threshold level of income above which people want to have a child immediately. While the threshold is likely to have risen due to an increase in uncertainty, and possibly due to a collapse of socialist day care and other welfare schemes, people's actual incomes have fallen in the wake of transition. Tables 4 and 5 present evidence on declines in per capita income in the former Soviet block countries in the process of transition. Table 4 presents real per capita income data from the updated Penn World Table 5.6 on 4 East European countries. It shows a declining trend in per capita income along with annual fluctuations. Table 5 presents the same evidence on a larger number of countries including the independent republics of former Soviet Union. Thus, the evidence on decline in births presented in Tables 1 and 2 along with the evidence on decline in per capita incomes presented in Tables 4 and 5 support the model of postponement of childbearing in the face of increased uncertainty about future income.

It should be noted that even though the benchmark model did not allow for any borrowing or lending, the results do not depend on the presence of borrowing constraints. Even if we allow individuals to save in the first period the option to postpone is still valuable if they want to avoid having a child in a bad state of the world. It is straightforward to show for a quadratic utility function that the relative attractiveness of the waiting option increases with uncertainty. However, if the marginal utility is convex, then the saving increases with uncertainty because of the precautionary motive to save. If the marginal utility function is convex, an

Table IV. Real GDP per capita (in U.S.$ at 1985 international prices)

Country	1988	1989	1990	1991	1992
Poland	4529	4522	3821	3723	3839
Romania	2090	2045			1464
Bulgaria	6866	6739	6213	5265	5231
Hungary	5562	5584	5360	4948	4655

Note: Real GDP per capita is calculated using Laspeyer's price index. The base year is 1985. For details see A. Heston and R. Summers (1991), The Penn World Table (Mark 5): An International Comparison, 1950–88, Quarterly Journal of Economics, pp. 327–368.
Source: The Penn World Table 5.6 by A. Heston and R. Summers (1995).

Table V. Per capita GNP (in U.S.$)

Country	1991	1992	1993	1994
Poland	1790	1910	2260	2410
Bulgaria	1840	1330	1140	1250
Romania	1390	1130	1140	1270
Slovakia	2470	1930	1950	2250
Czech Rep.	2470	2450	2710	3200
Hungary	2720	2970	3350	3840
Latvia	3410	1930	2010	2320
Lithuania	2710	1310	1320	1350
Estonia	2830	2760	3080	2820
Russia	3220	2510	2340	2650
Ukraine	2340	1820	2210	1910
Georgia	1640	850	580	
Azerbaizan	1670	740	730	500
Uzbekistan	1350	850	970	960
Kazakhastan	2470	1680	1560	1160
Turkmenistan	1700	1230		
Armenia	2150	780	660	680
Belarus	3110	2980	2870	2160
Kyrgyz Rep.	1550	820	850	630
Tajikistan	1050	490	470	360

Note: The per capita GNP figures in U.S. dollars are calculated according to the World Bank Atlas method. The Atlas conversion factor is the average of a country's exchange rate for that year and its exchange rates for the two preceding years, after adjusting them for differences in relative inflation between that country and the United States.
Source: World Development Report, (1993–96), The World Bank, Washington, D.C.

increase in uncertainty about future income raises the expected marginal utility of future consumption (Jensen's inequality), which increases saving because future consumption becomes more attractive. This is known as precautionary saving. See Besley (1995) for a survey of literature on precautionary saving. An increase in saving cushions individuals in a bad state of the world. Now it may be difficult to satisfy conditions (4) and (5) simultaneously. However, under some restrictions on the parameter values we can still obtain the results in the proposition above.

Also, the results obtained above do not depend on the assumption that the utility derived from consumption and from children are additively separable. A sufficient condition for the results to go through is that the cost of having a child is decreasing in income and the benefit from having a child is non-decreasing in income. If this condition holds then a child may become undesirable in a bad state of the world because the benefit from having a child will decrease and the cost will increase. This is what makes the option to postpone valuable, and therefore, the results will go through even when the utilities derived from children and from direct consumption are non-additive.

Although, the main results were shown with a two-point distribution of income, Appendix A shows that the main results continue to hold for a continuous distribution of income and uncertainty in the sense of second order stochastic dominance (see Rothschild and Stiglitz, 1970).

3. Extension with endogenous expenditure on child

In this section the agent is allowed to choose the expenditure on her child, γ, optimally in each period and each state of the world. The expenditure is endogenized by making ϕ, the benefit derived from having a child, a function of γ and assuming that $\phi'(\gamma) > 0$ and $\phi''(\gamma) < 0$. In effect, the agent is allowed to choose what Gary Becker calls 'quality of children' (Becker, 1976). The more the outlay on children the higher is their quality. Also, it is assumed that if the agent decides to have a child she can not spend less than $\overline{\gamma}$ on her child in any period. This in some sense is the subsistence requirement for a child and captures the irreversibility associated with childbearing.

Now the optimization can be viewed to proceed in two steps. Firstly, the agent chooses γ optimally along both the branches, and then chooses: $Max\{V_k(y), F_k(y)\}$. At the beginning of the second period the agent has to decide how much to spend on her child. Her optimization problem becomes state dependent now. If she already had a child in the first period, she does the following optimization in a bad state of the world

$$\max_{\gamma} U(y - \delta - \gamma) + \phi(\gamma), \qquad (12)$$
$$\text{s.t. } \gamma \geq \overline{\gamma}.$$

Denote the optimal expenditure by γ_b. However, if she did not have a child in the first period, then her optimal action in the second period depends on $Max\{U(y -$

δ), $U(y - \delta - \gamma_b) + \phi(\gamma_b)\}$. Similarly, if she already had a child in the first period, then her second period optimization problem in a good state of the world is

$$\begin{aligned} &\operatorname*{Max}_{\gamma} U(y + \delta - \gamma) + \phi(\gamma), \\ &\text{s.t. } \gamma \geq \overline{\gamma}. \end{aligned} \tag{13}$$

Denote the optimal expenditure by γ_g. However, if she did not have a child in the first period, then her optimal second period action depends on $Max\{U(y + \delta), U(y + \delta - \gamma_g) + \phi(\gamma_g)\}$.

Again to make the problem interesting assume that parameters are such that the agent does not want a child in a bad state of the world and she does want a child in a good state of the world. This implies the following restriction on the parameters

$$U(y - \delta) > U(y - \delta - \gamma_b) + \phi(\gamma_b), \tag{14}$$
$$U(y + \delta) < U(y + \delta - \gamma_g) + \phi(\gamma_g). \tag{15}$$

Formulas (14) and (15) imply some restrictions on the shape of the utility from consumption and the benefit from having a child. They are easily satisfied for a large range of parameter values when both these functions are concave.

If the agent wants to have a child in the first period she chooses the expenditure γ_1 optimally giving the following lifetime utility

$$\begin{aligned} V_k(y) = &\operatorname*{Max}_{\gamma_1}\{U(y - \gamma_1) + \frac{1}{2}\beta[U(y + \delta - \gamma_g) + U(y - \delta - \gamma_b)] \\ &+\phi(\gamma_1) + \frac{1}{2}\beta[\phi(\gamma_g) + \phi(\gamma_b)]\} \\ &\text{s.t. } \gamma_1 \geq \overline{\gamma}. \end{aligned} \tag{16}$$

Note that in (16) the agent is forced to spend γ_b in the second period on her child born in the first period even though she would have been better off without a child in bad state of the world as implied by (14). This is where the irreversibility about childbearing kicks in, which makes the option to postpone valuable in the presence of uncertainty. Since there is no saving in the model the first order condition for the optimal choice of γ in the first period is independent of what happens in the second period.

The lifetime utility when the agent decides to postpone her childbearing decision is simply

$$F_k(y) = U(y) + \frac{1}{2}\beta[U(y + \delta - \gamma_g) + U(y - \delta)] + \frac{1}{2}\beta\phi(\gamma_g). \tag{17}$$

Again whether (16) is greater than (17) or not will depend on the parameters as in section 2. What is more interesting is to look at how their difference behaves as current income and the uncertainty about future income increases. It can be easily seen that for any diminishing marginal utility function, $U''(c) < 0$,

$$\frac{d(F_k(y) - V_k(y))}{d\delta} = \frac{1}{2}\beta[U'(y - \delta - \gamma_b) - U'(y - \delta)] > 0, \tag{18}$$

$$\begin{aligned}\frac{d(F_k(y) - V_k(y))}{dy} &= U'(y) - U'(y - \gamma_1) \\ &\quad + \frac{1}{2}\beta[U'(y - \delta) - U'(y - \delta - \gamma_b)] < 0.\end{aligned} \tag{19}$$

Clearly, the greater the uncertainty the greater the attractiveness of the waiting option compared to immediate action. As well, the attractiveness of the postponement option relative to the immediate action decreases as income increases. The intuition behind these results is same as before. Therefore, a threshold behavior is obtained again: If income is above the threshold individuals want to have a child immediately, and for incomes below the threshold individuals want to wait. The threshold level of income is determined as in Figure 1 discussed earlier, and is again increasing in the level of uncertainty about future income.

Comparing the results obtained here with those for the benchmark model in section 2, it can be easily seen that the lifetime utility of individuals is going to be higher, irrespective of the timing of childbearing, if they can choose the expenditure on their children optimally. This can be seen by comparing the expressions in (16) and (17) with those in (1) and (6), respectively. The benchmark model can be thought of as the constrained version of the model in the present section, where in the former individuals are forced to spend a fixed sum γ on their children in each period, while in the latter they can choose this amount optimally.

As well, the threshold level of income is likely to be lower when individuals can choose γ optimally compared to the benchmark model. This can be seen as follows. Even though (16) and (17) are higher than (1) and (6), respectively, the increase in lifetime utility from immediate childbearing (excess of (16) over (1)) is likely to be greater than the increase in lifetime utility from waiting (excess of (17) over (6)). This happens because the benefit from optimally choosing the expenditure is realized in both periods in the immediate action case, while it occurs only in the second period in the waiting case. Thus, the upward shift in the $V_k(y)$ in Figure 1 is going to be greater than the upward shift in $F_k(y)$ when the agent can choose the expenditure optimally, yielding a lower threshold level of income.

4. Inclusion of foregone wages in the cost of having a child

It is widely believed that an important cost of having a child arises because they are intensive in mother's time. This gives rise to foregone wages as a cost of having a child in addition to the direct expenditure on them. This section shows that the main results are robust to the inclusion of this cost of raising a child.

Assume that the cost of having a child arises both from the time spent and the direct monetary expenditure on them. For simplicity assume that the time spent on a child is fixed and is a deduction from the total time endowment for work and leisure. By putting leisure in the utility function income is made endogenous which is now determined by the optimal choice of leisure.

For analytical tractability assume a Cobb-Douglas utility function for the agent in consumption, c, and leisure, l, given by

$$U(c, l) = c^{\theta} l^{1-\theta};\ 0 < \theta < 1. \tag{20}$$

Her total time endowment is T. The per-period benefit from having a child is ϕ as before. The time spent on a child is α in both periods, and the expenditure is γ as before. In the first period, the agent faces a wage rate of w, while the second period wage is $w + \delta$ with probability 1/2, and $w - \delta$ with probability 1/2.

Again the decision problem is solved backwards by finding out the optimal choice in the second period first. Suppose she gets a positive wage shock in the second period. If she decides not to have a child, she chooses $(1-\theta)T$ amount of leisure. The amount of leisure consumed is simply $(1-\theta)T$ which is independent of the level of wage. This is a consequence of the Cobb-Douglas utility function where income and substitution effects of a change in wage cancel out. Her utility is

$$(w+\delta)^{\theta} \theta^{\theta} (1-\theta)^{1-\theta} T. \tag{21}$$

If she decides to have a child, then her optimal choice of leisure is

$$(1-\theta)(T-\alpha) - \frac{\gamma(1-\theta)}{w+\delta}. \tag{22}$$

The monetary expenditure on the child, γ, induces the agent to increase her income by consuming less leisure. Since the expenditure on the child increases the marginal utility of her own consumption, she wants to have higher consumption. This can be achieved by increasing work and reducing leisure. The amount by which work increases depends on the wage rate. The higher the wage rate the lower the marginal utility of consumption so the lower is the amount of increase in work. Her utility in the second period when she decides to have a child is given by

$$\theta^{\theta}(1-\theta)^{1-\theta}[(w+\delta)(T-\alpha) - \gamma](w+\delta)^{\theta-1} + \phi. \tag{23}$$

Comparing (21) and (23) it is seen that the cost of having a child (in terms of utility from own consumption and leisure foregone) in a good state is given by

$$[\alpha(w+\delta)^{\theta} + \gamma(w+\delta)^{\theta-1}]\theta^{\theta}(1-\theta)^{1-\theta}. \tag{24a}$$

The benefit from having a child remains constant at ϕ. Similarly, the cost of having a child in the second period when the agent receives a bad shock is given by

$$[\alpha(w-\delta)^{\theta} + \gamma(w-\delta)^{\theta-1}]\theta^{\theta}(1-\theta)^{1-\theta}. \tag{24b}$$

From (24a) and (24b) it can be seen that there are two elements of the cost of having a child. The first one arises due to the time spent on them, while the second one arise due to the direct expenditure. When the wage rises these two elements of cost move in opposite directions. A rise in the wage increases the opportunity cost of mother's time, so the time spent with a child becomes more expensive. However, high wage causes low marginal utility of consumption, so the utility cost of direct expenditure is low. The net effect depends on the relative strengths of these two opposing forces. Assume that the second effect is more important. For this to be true γ has to be large relative to α. This implies that with a rise in the wage the cost of childbearing decreases.

Again, to make the option valuable, assume that the agent wants to avoid having a child when she receives a negative shock in her wage. A sufficient condition for this to be true is

$$\phi < [\alpha(w-\delta)^{\theta} + \gamma(w-\delta)^{\theta-1}]\theta^{\theta}(1-\theta)^{1-\theta}. \tag{25}$$

To make the problem interesting assume that the agent wants to have a child in the second period if she gets a good shock to her wage. A sufficient condition for this to be true is

$$\phi > [\alpha(w+\delta)^{\theta} + \gamma(w+\delta)^{\theta-1}]\theta^{\theta}(1-\theta)^{1-\theta}. \tag{26}$$

For (25) and (26) to be satisfied simultaneously γ has to be large relative to α. (25) and (26) define the optimal action for the agent in the second period. If she decides to wait in the first period, then she has a child in the second period if she gets a positive wage shock, and does not have a child if she gets a negative shock. If she decides to have a child in the first period only, then she continues to spend time and money on her child in the second period irrespective of her wage. In the latter case her lifetime utility is given by

$$\begin{aligned} V_k(w) = & \max_{lv_1, lv_g, lv_b} \{((w(T-\alpha-lv_1)) - \gamma)^{\theta}(lv_1)^{1-\theta} \\ & + \frac{1}{2}\beta\{[((w+\delta)(T-\alpha-lv_g)-\gamma)]^{\theta}(lv_g)^{1-\theta} \\ & + [((w-\delta)(T-\alpha-lv_b)-\gamma)]^{\theta}(lv_b)^{1-\theta}\} + (1+\beta)\phi\}. \end{aligned} \tag{27}$$

In (27) above the optimal choices of leisure are given by

$$lv_1 = (1-\theta)(T-\alpha) - \frac{\gamma(1-\theta)}{w}, \tag{28a}$$

$$lv_g = (1-\theta)(T-\alpha) - \frac{\gamma(1-\theta)}{w+\delta}, \tag{28b}$$

$$lv_b = (1-\theta)(T-\alpha) - \frac{\gamma(1-\theta)}{w-\delta}. \tag{28c}$$

If the agent decides to wait then her lifetime utility is given by

$$
\begin{aligned}
F_k(w) = & \operatorname*{Max}_{lf_1, lf_g, lf_b} \{(w(T - lf_1))^{\theta}(lf_1)^{1-\theta} \\
& + \frac{1}{2}\beta\{[(w+\delta)(T-\alpha-lf_g)-\gamma]^{\theta}(lf_g)^{1-\theta} \\
& + [(w-\delta)(T-lf_b)]^{\theta}(lf_b)^{1-\theta}\} + \frac{1}{2}\beta\phi\}. \qquad (29)
\end{aligned}
$$

Similarly in (29) above the optimal choices of leisure are given by

$$lf_1 = T(1-\theta) = lf_b, \qquad (30a)$$

$$lf_g = (1-\theta)(T-\alpha) - \frac{\gamma(1-\theta)}{w+\delta}. \qquad (30b)$$

Subscript b denotes the leisure when the second period shock is bad and g denotes the leisure when the second period shock is good. It should be noted that when the second period shock is bad, the amount of leisure chosen along the waiting branch is independent of the wage rate because the agent does not want to have a child in bad state. Also, the amount of leisure chosen when the second period shock is good is same along both the waiting and the immediate action paths.

It can be shown that if $\gamma(1-\theta) > \alpha\theta(\mathrm{w}-\delta)$, then

$$
\begin{aligned}
& \frac{d(F_k(w) - V_k(w))}{d\delta} \\
& = \theta^{\theta}(1-\theta)^{1-\theta}\left[-\frac{\theta\alpha}{(w-\delta)^{1-\theta}} + (1-\theta)\frac{\gamma}{(w-\delta)^{2-\theta}}\right] > 0. \qquad (31)
\end{aligned}
$$

What this condition implies is that the utility cost of direct expenditure is more important than that of foregone wages. This is also the condition required for (25) and (26) to be satisfied together. This condition is more likely to be satisfied at low levels of income. A positive derivative in (31) implies that the greater the degree of uncertainty the greater the attractiveness of the postponement option. Further, it can also be shown that if $\gamma(1-\theta) > \alpha\theta w$, then

$$
\begin{aligned}
\frac{d(F_k(w) - V_k(w))}{dw} = & \ \theta^{\theta}(1-\theta)^{1-\theta}\left[\frac{\theta\alpha}{w^{1-\theta}} - (1-\theta)\frac{\gamma}{w^{2-\theta}} + \right. \\
& \left. \frac{1}{2}\beta\left\{\frac{\theta\alpha}{(w-\delta)^{1-\theta}} - (1-\theta)\frac{\gamma}{(w-\delta)^{2-\theta}}\right\}\right] < 0. \qquad (32)
\end{aligned}
$$

Formula (32) implies that the lower the wage the greater the attractiveness of postponement action. It should be noted that if the time component is relatively more important than the direct expenditure then the agent would want to avoid having a child when her wages are high. However, uncertainty about wages still increases the attractiveness of postponement option.

Define the threshold level of wage, w^*, as the wage that satisfies $F_k(w^*) = V_k(w^*)$. People with wage above w^* decide to have a child immediately, while those with wage below w^* wait. It can be easily shown that a sufficient condition for $\frac{dw^*}{d\delta} > 0$ is the same as for (32). Therefore, the main result of the paper that increase in uncertainty increases the attractiveness of the postponement option is robust to the extension of endogenous income and inclusion of the time spent on the child as a cost.

5. Conclusion

We conclude that the increase in uncertainty about future income can lead people to postpone their childbearing decision. This happens because of the irreversibilities associated with the childbearing decision and the ability to postpone this decision for a later time. It gives rise to a threshold behaviour such that individuals above the threshold level of income want to have a child immediately, while those below the threshold wait for the uncertainty to be resolved. The threshold itself is increasing in the degree of uncertainty about future income. This might be a possible explanation for the recent decline in birth rates concomitant with a declining per capita income in most of the former Soviet Republics and the East European countries undergoing transition. While an increase in uncertainty in the wake of transition would tend to raise the threshold level of income, a decrease in income itself would tend to push more and more people below the threshold . These two effects reinforce each other and lead to a sharp decline in births.

Appendix A: Further generalization of the model for a continuous distribution of income

Suppose the next period's income is $y + \tilde{\delta}$, where $\tilde{\delta} \in (\underline{\delta}, \overline{\delta})$ has two distribution functions: $F(\delta, r_1)$ and $F(\delta, r_2)$; where $F(\delta, r_1)$ dominates $F(\delta, r_2)$ in the second order stochastic sense, i.e.

$$\int_{\underline{\delta}}^{\delta} F(\delta, r_2) d\delta \geq \int_{\underline{\delta}}^{\delta} F(\delta, r_1) d\delta, \text{ where } \delta \in (\underline{\delta}, \overline{\delta}).$$

We will show that

$$(F_k(y, r_2) - V_k(y, r_2)) \geq (F_k(y, r_1) - V_k(y, r_1)).$$

We define δ^* to be the level of income shock such that

$$U(y + \delta^*) = U(y + \delta^* - \gamma) + \phi. \tag{A1}$$

Where δ^* is itself going to be a function of y. For all shocks above δ^* the agent wants to have a child in the second period, and for all shocks below δ^* the agent does not want to have a child in the second period.

Now the value functions are given as follows:

$$\begin{aligned}
V_k(y, r_1) &= U(y-\gamma) + \beta \int_{\underline{\delta}}^{\overline{\delta}} U(y+\delta-\gamma) dF(\delta, r_1) + (1+\beta)\phi \\
F_k(y, r_1) &= U(y) + \beta \int_{\underline{\delta}}^{\delta^*} U(y+\delta) dF(\delta, r_1) + \beta \int_{\delta^*}^{\overline{\delta}} U(y+\delta-\gamma) \\
&\quad dF(\delta, r_1) + \beta\phi \int_{\delta^*}^{\overline{\delta}} dF(\delta, r_1) \\
\textit{Let } \varphi(r_1) &= F_k(y, r_1) - V_k(y, r_1). \text{ Similarly } \varphi(r_2) = F_k(y, r_2) - V_k(y, r_2). \\
\varphi(r_2) - \varphi(r_1) &= \beta \int_{\underline{\delta}}^{\delta^*} (U(y+\delta) - U(y+\delta-\gamma) - \phi)(dF(\delta, r_2) - \\
&\quad dF(\delta, r_1)) \qquad \text{(A2)}
\end{aligned}$$

The first term in the right hand side of (2) is positive because from (1) for all $\delta < \delta^*$, left side of (1) is greater than the right side. Since the distribution characterized by r_2 is riskier than r_1, r_2 assigns greater probability to larger numbers in the first term compared to r_1. So, (2) is positive, giving us the desired result.

Now we will show it a bit more rigorously. Let us call $(U(y+\delta) - U(y+\delta-\gamma) - \phi) \approx \pi(\delta)$. We know that $\pi(\delta) > 0\ \forall\delta < \delta^*$. Also, $\pi'(\delta) < 0\ \forall\delta < \delta^*$. So, we have

$$\varphi(r_2) - \varphi(r_1) = \int_{\underline{\delta}}^{\delta^*} \pi(\delta)(dF(\delta, r_2) - dF(\delta, r_1)) \qquad \text{(A2')}$$

Let us integrate (2′) by parts. After canceling terms we get $\varphi(r_2) - \varphi(r_1) = \int_{\underline{\delta}}^{\delta^*} (-\pi'(\delta))(F(\delta, r_2) - F(\delta, r_1))d\delta$. Since both terms under the integral are positive over the relevant range, their product is also positive.

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