Families and the Economics of Risks to Life

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To value a project that will reduce risk of death for N persons, one would like to know what each person is willing to pay to reduce his own probability of death, and, in addition, what his friends and loved ones are willing to pay to reduce his risk of death. The second component of willingness to pay (WTP)—the WTP of loved ones—has been investigated by L. Needleman (1976). Own WTP has been examined in a life-cycle context by W. B. Arthur (1981) and by Donald Shepard and Richard Zeckhauser (1982, 1984) under the assumption that individuals have no loved dependents. This note extends their work by examining how the presence of a family alters WTP to reduce one's own risk of death.

In life-cycle models for a single person WTP is the value of the change in expected utility of consumption caused by a change in probability of death. To extend these models to a head of household, utility should be made a function of the head's own consumption and the consumption of his dependents. Utility that the head receives from dependents' consumption while he is alive should increase his WTP since this utility is lost if he dies. A head of household may, however, receive utility from dependents' consumption after he is dead. This portion of lifetime utility—the utility of a bequest—reduces WTP by reducing the disutility associated with dying.

The net effect of dependents on WTP in the life-cycle consumption model thus depends on the strength of the bequest motive. We attempt to infer the strength of the bequest motive by comparing actual survivors' benefits with the estate stream predicted by the life-cycle consumption model. The estimated bequest motive is sufficiently strong that dependents should, on balance, reduce WTP. This conclusion, however, contradicts empirical evidence that the WTP of married persons to reduce risks to their own lives exceeds the WTP of single people (Michael Jones-Lee, 1986). For the life-cycle model to yield this result it must be modified to incorporate the utility received from dependents that is independent of their consumption (Arthur, 1981). This "utility of family existence" term is analogous to a pure "utility of being alive" term in a single person's utility function (Theodore Bergstrom, 1982). Utility that is independent of consumption may justifiably be ignored when the life-cycle model is used to analyze saving and investment behavior, but cannot be ignored when the model is used to make inferences about WTP.

The remainder of this note formalizes the effect of dependents in a life-cycle model in which the head of household can buy actuarially fair life insurance and annuities. The model is solved using an isoelastic utility function and the resulting estate streams are compared with actual survivors' benefits to infer the marginal rate of substitution between consumption and bequest. Given this information, one can compute the WTP of married and single people based solely on utility of consumption. By comparing this difference with empirical estimates of WTP one can infer the value of dependents independent of their consumption. This "family existence value" comprises a large fraction of a head of household's WTP.

I. The Effect of Dependents on Willingness to Pay in the Life-Cycle Consumption Model

We first consider the effect of dependents on WTP in the conventional life-cycle model, ignoring utility that is independent of con-

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sumption. To value a change in probability of death at age j we examine the head of household's lifetime expected utility. This consists of two terms—the utility the head receives while alive from his own consumption and that of his family, and the utility he receives from leaving a bequest. Equation (1) gives the head's expected lifetime utility from age k onward,

$$(1)\qquad J_k=\sum_{t=k}^{T} q_{t,k}\alpha^{t-k}m_t u(c_t) + p_{t,k}\alpha^{t-k}V_t(S_t),$$

where $q_{t,k}$ represents the probability of surviving at least to the end of year t, given that one is alive at age k, $p_{t,k}$ is the probability of surviving exactly $t-k$ years, given that one is alive at age k, and α is the inverse of one plus the rate of time preference.

The head's utility of consumption if he is alive at age t is given by $m_t u(c_t)$, where m_t is the number of equivalent adults in the family and c_t is consumption per equivalent adult. $u(\ )$, the period utility function, is assumed increasing, strictly concave, and bounded from below.

The utility of bequest, $V_t(S_t)$, represents the satisfaction that the head receives from his heirs' consumption in the event of his death. This is given formally by

$$(2)\qquad V_t(S_t)=\max_{\{\tilde{c}_{i,t}\}}\sum_{i=t+1}^{T'}\alpha^{i-t}n_{i,t}f_{i,t}u(\tilde{c}_{i,t})$$

$$\text{s.t.}\ \sum_{i=t+1}^{T'} r^{i-t}\tilde{c}_{i,t}n_{i,t}=S_t,\quad r=1/(1+\rho),$$

where S_t is the estate in year t, ρ is the rate of return on bonds, and T' is the maximum age to which heirs can live. $n_{i,t}$ denotes the number of equivalent adult heirs in year i, assuming the head dies in year t, and $\tilde{c}_{i,t}$ their per capita consumption. $f_{i,t}$ is the weight that the head attaches to his dependents' consumption after he is dead versus when he is alive.[1]

Following Arthur (1981) and Shepard and Zeckhauser (1982) we assume that the head can purchase both actuarially fair annuities and bonds.[2] By selling \$1 of annuities and investing the dollar in bonds, the head can purchase actuarially fair life insurance. To prevent unlimited sale of annuities, consumption expenditure and investment in bonds, s_t, must satisfy (3), where A_k is the stock of annuities held at the end of year k and y_t is earnings at age t,

$$(3)\qquad \sum_{t=k+1}^{T} r^{t-k}q_{t,k}(m_t c_t+s_t) = A_k+\sum_{t=k+1}^{T} r^{t-k}q_{t,k}y_t.$$

We now consider a head of household's willingness to pay at age k for a small change in his conditional probability of death at age j, $\mathrm{WTP}_{j,k}$, and see how this is affected by the strength of the bequest motive. Formally, $\mathrm{WTP}_{j,k}$ is the wealth that can be taken away from the head in year k in response to a change in his conditional probability of dying in year j, $D_j=1-(q_{j+1,k}/q_{j,k})$, holding utility constant.

In evaluating WTP we label the case in which the head values the consumption of his dependents equally whether he is dead or alive ($f_{i,t}=1$ for all i and t) the strong bequest case. In this case the head purchases life insurance to the point at which each dependent's consumption is the same whether the head lives or dies. Since the utility received from dependents' consumption is independent of D_j, all that the head loses

[1]If dependents receive utility from the head's consumption and the head incorporates this into his utility function, one could argue that $m_t u(c_t)$ should be multiplied by a factor γ; however, this is equivalent to adjusting the weights on the bequest term (the $f_{i,t}$'s), since multiplying J_k by $1/\gamma$ does not alter WTP.

[2]We have also investigated an alternative assumption, namely, that the individual can borrow and lend at the riskless rate of interest but can never be a net borrower. This does not alter our main conclusion, that the WTP of a head of household falls short of a single person's WTP if a family existence term is excluded from the utility function.

when D_j is increased is the utility of his own consumption, net of the increased cost of consumption, and the present value of lifetime earnings,[3]

$$(4)\quad \mathrm{WTP}_{j,k} = (1-D_j)^{-1} \left[\sum_{t=j+1}^{T} q_{t,k} r^{t-k} \{ [u(c_t)/u'(c_t)] - c_t \} + \sum_{t=j+1}^{T} r^{t-k} q_{t,k} y_t \right].$$

Equation (4) implies that a head with a strong bequest motive has a WTP that is unambiguously lower than that of a single person with the same utility function $u(\ )$, earnings stream, and rate of time preference. The single person's WTP is identical in form to (4), but his consumption at each age is higher than the head's, since the head must provide for his family. As long as WTP is increasing in consumption,[4] the head's WTP is lower than that of an otherwise identical single person: dependents unambiguously lower WTP.

For the life-cycle consumption model to predict otherwise, one must either assume a weaker bequest motive, or one must assume that married and single people differ systematically in their preferences. Specifically, married people must, on average, be more risk averse than single people. In the absence of evidence to support the latter, we believe that it is more appealing to view marriage as adding bequest and utility-of-dependents terms to a person's utility function.[5] We therefore maintain the assumption that single and married people do not differ in α or $u(\ )$.

For the life-cycle consumption model to yield the result that dependents raise WTP, one must therefore assume a weaker bequest motive. To simplify matters, suppose that $f_{i,t} = \bar{f}$ for all i and t. If $\bar{f} < 1$, the head receives more utility from dependents' consumption when he is alive than after he is dead. This means that the bequest term no longer fully offsets the utility received from dependents' consumption while the head is alive. This adds an extra term to the head's WTP that is not present in the single person's WTP and makes it possible for the head's WTP to exceed the single person's.

To say whether the life-cycle consumption model in reality explains why the WTP of a head of household would exceed the WTP of a single person, we must know the strength of the bequest motive. In Section III we infer $\bar{f}$ by computing estate streams for the model of (1)–(3), under the assumption $u(c) = c^{\beta}$, and comparing them to actual survivors' benefits. Empirical evidence suggests that $\bar{f}$ is high enough to cause the WTP of a head of household to fall short of the WTP of a single person in the conventional model. This suggests that the model must be amended to include utility that is independent of consumption.

II. The Strength of the Bequest Motive and the Importance of Family Existence

In attempting to infer the strength of the bequest motive we have deliberately made assumptions that tend to bias $\bar{f}$ downward, thus strengthening the case for a model in which utility depends solely on consumption. Since the value of $\bar{f}$ consistent with a given estate stream is lower the lower is β, we have chosen a value of β, 0.2, which is at

[3] $\mathrm{WTP}_{j,k}$ is obtained by appending (3) to (1) with a Lagrange multiplier and evaluating $-(\partial J_k/\partial D_j)/(\partial J_k/\partial A_k)$. Use of first-order conditions for utility maximization and the fact that $c_t(m_t - 1) = \tilde{c}_{i,t} n_{i,t}$ when $f_{i,t} = 1$ yields (4).

[4] Since $u(\ )$ is assumed increasing and strictly concave, $(u/u') - c$ is increasing in c, provided utility is positive at the current level of consumption.

[5] The finance literature does not provide conclusive evidence on this point. Richard A. Cohn et al. (1975) using a mail survey of customers of a retail brokerage firm found that the ratio of risky to total assets is higher for single than for married investors. Marshall Blume and Irwin Friend (1975), using the 1962 Survey of Financial Characteristics of Consumers, find that the number of dependents has no effect on the ratio of stocks to net worth.

TABLE 1—COMPARISON OF WILLINGNESSES TO PAY FOR A HEAD OF HOUSEHOLD AND SINGLE PERSON

Age	(1) Estate—OASDI Benefits	(2) Single Person's WTP	(3) Head's WTP, No Existence Term	(4) Family Existence Term
25	21,694	1,823,848	1,496,653	886,075
30	18,312	1,793,385	1,359,648	895,288
35	31,354	1,725,722	1,312,319	867,585
40	50,475	1,619,302	1,223,459	832,437
45	58,269	1,476,938	1,059,643	788,099
50	56,997	1,306,922	877,050	732,606
55	36,863	1,117,229	727,536	665,370
60	11,379	914,550	567,268	577,813
65	−16,945	727,518	420,985	472,866
70	−22,711	614,887	348,349	344,099
75	−16,369	505,553	271,910	187,614

the low end of empirical estimates of this parameter (Sherwin Rosen, 1985). The rate of time preference is assumed equal to the real interest rate, which is 5 percent.

The head of household's earnings at each age are assumed equal to average 1979 earnings (measured in 1981 dollars) of males with 1–3 years of college education (U.S. Bureau of the Census, 1983) multiplied by the probability of employment at each age. The annualized value of these earnings, $21,627, is approximately equal to median income of full-time male workers in 1979, which is appropriate if one wants to capture an average value of $\bar{f}$. Using mortality rates for white males (U.S. National Center for Health Statistics, 1980), the individual's expected lifetime earnings, discounted to age 18, are approximately $375,000. Inherited wealth is assumed to be zero.

The head of household is assumed to marry at age 23 and to have children at ages 25 and 28. In computing m_t, each adult 18 and older is assigned a weight of 1.0. Each child receives a weight of 0.3 through age 13 and of 0.62 between 14 and 17 (Walter Dolde, 1978). Children are assumed to leave the household at age 22, and the spouse to die when the head is 80.

To infer $\bar{f}$ the estate streams generated by the model are compared to the present value of actual survivors' benefits, and $\bar{f}$ is varied until the two coincide. For most people, the bulk of survivors' benefits come from Social Security payments (mother's and children's benefits; widow's benefits), real estate, life insurance proceeds, and stocks and bonds. Since data on the last three, by age, are difficult to obtain, we have computed the present value of Social Security survivors' benefits that heirs would receive if the 1979 level of survivors' benefits were to remain constant in real terms.[6] The difference between these and the optimal estate stream when $\beta = 0.2$ and $\bar{f} = 0.75$ appears in column one of Table 1.

If, indeed, $\bar{f} = 0.75$, then the first column of Table 1 should approximately equal the net worth plus life insurance coverage that the average male household head actually possesses. Data on life insurance coverage (American Council of Life Insurance, 1986) suggest that mean coverage per adult male is approximately equal to two years' disposable income. The actual amount of coverage, however, varies signficantly with age, with peak coverage occurring between the ages of 35 and 55 and the amount held declining sharply thereafter. These data are roughly consistent with the first column of Table 1, suggesting the $\bar{f} = 0.75$ if life insurance coverage is the only source of survivors' be-

[6]All computations are based on the 1978 *Social Security Handbook* (U.S. Social Security Administration). They assume that the head's children receive benefits through their 21st year, and that his spouse receives widow's benefits beginning at age 60.

nefits other than Social Security. To the extent that other sources of benefits exist, $\bar{f}$ exceeds 0.75 and the head's WTP is even lower than that computed below.

When $\beta = 0.2$ and $\bar{f} = 0.75$ the head's WTP for a change in his current probability of death is below the WTP of an otherwise identical single person at all ages. As indicated in Table 1 (compare columns 2 and 3), this difference is substantial: between the ages of 30 and 70 the head's WTP is less than 75 percent of the single person's WTP. If, as is commonly believed, the WTP of people with dependents exceeds the WTP of people without, this cannot be explained by the conventional life-cycle consumption model.

This model, however, ignores the utility that the head of household receives from his existence and that of his family independently of consumption. Adding such a term to (1) in no way affects the head's consumption and investment decisions, but adds a term to WTP—a term that reflects the existence value of the family—that does not enter the single person's WTP.

To get some idea of the magnitude of the family existence effect, one must know the difference between the willingness to pay of single people and those with dependents for a change in own risk of death. There is, to our knowledge, no published information on this topic. Jones-Lee (1986) reported to us that in a survey of willingness to pay to reduce risk of dying in a traffic accident, he and his colleagues found the willingness to pay of married people to be 7 to 28 percent higher than the WTP of single people for the same risk reduction.[7] Adding a term $g(M_t) = 2.25M_t$ to the period utility function, where M_t denotes the number of dependents in year t, produces the family existence value terms in column 4 of the table, which are consistent with the Jones-Lee et al. findings.[8] When these terms are added to the other components of the head's willingness to pay, the head's willingness to pay exceeds the single person's by approximately 25 percent between the ages of 25 and 65. The family existence term is substantial: it constitutes about 40 percent of total WTP between ages 25 and 40 and 53 percent of WTP at age 60.

[7] These percentages represent differences in mean responses to questions 18 and 20 of the survey, which is described in Jones-Lee, M. Hammerton, and P. Philips (1985).

[8] We assume that the head of household and single person receive the same utility from their own existence, hence only the utility received from dependents affects the difference between the two willingnesses to pay.

III. Summary and Conclusion

As Bergstrom (1982) has pointed out, an individual who has preferences over lotteries involving lifetime consumption streams and length of life will, under certain simplifying assumptions, have a utility function equal to the discounted sum of expected utility of consumption each period, plus a term that is a function of survival probabilities alone. The latter term, however, has been ignored in life-cycle WTP models, presumably because it is difficult to parameterize. This note suggests that this term should not be ignored, especially when the life-cycle model is modified to incorporate the effect of dependents on a person's WTP to reduce his own risk of death.

If one does ignore the term and computes WTP using a standard life-cycle model with bequest, the WTP of a married person falls short of the WTP of an otherwise identical single person. Since empirical results suggest that the WTP of married people exceeds the WTP of single people, one must either assume that a married person receives utility from the existence of his family which a single person does not, or one must assume that his degree of risk aversion is sufficiently higher than that of the single person. In the absence of conclusive evidence regarding the latter, our results suggest that a "utility of existence" term should be added to the life-cycle consumption model if the latter is to be used to analyze WTP.

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