Discount Rates in Risk v. Money and Money v. Money Tradeoffs

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Summary

We use data from a survey of residents of five Italian cities conducted in late Spring 2004 to estimate the discount rates implicit in (a) money v. future risk reductions and (b) money v. money tradeoffs. We find that the mean personal discount rate is 2% in (a) and 8.7% in (b). The latter is lower than the discount rates estimated in comparable situations in many recent studies, greater than market interest rates in Italy at the time, and exhibits modest variation with age and gender. The discount rate implicit in money v. risk tradeoffs is in line with estimates from studies in the US and Europe, and does not depend on observable individual characteristics.

Keywords: Value of a statistical life, Latent risk reductions, Individual discount rates, Stated preference questions

JEL Classification: J17, I18, D91

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1. Introduction

In many environmental and safety contexts, it is important to find out how much the beneficiaries of a policy that save lives are willing to pay *now* to secure a reduction in risk that occurs *in the future*. With many carcinogens and pollutants, for example, it may take exposure over a long period of time before the onset of symptoms or diseases, and, conversely, several years before a reduction in exposure translates into a reduction in risk. Future risk reductions are also an important consideration when the policy (e.g., an air quality program) improves environmental quality permanently.

We generally expect people to be willing to pay less for a risk reduction that occurs in the future than for a comparable risk reduction that takes place immediately. This is for two reasons. First, the individual may not be alive at the time in the future when the risk reduction takes place. Second, the life-cycle model implies that future risk reductions should be discounted to the present at the consumption rate of interest. With perfect capital markets, this consumption rate of interest should be equal to the market interest rate. If individuals face borrowing constraints, the consumption rate of interest may be higher than the market interest rate (Cropper and Sussman, 1990; Cropper and Portney, 1990).

The discount rates implicit in people's choices between money and future risk reductions have been estimated using stated- and revealed-preference approaches. These discount rates are usually in the range of 0.3-14% (Horowitz and Carson, 1990; Moore and Viscusi, 1990; Johannesson and Johansson, 1996; Alberini et al., 2005), prompting researchers to conclude that they tend to be low in comparison to the discount rates people typically exhibit in money (now) versus money (later) tradeoffs.

For example, by observing people's purchases of appliances (which vary for degree of energy efficiency and up-front payment), Hausman (1979) estimated an average personal discount rate of 25% and Ruderman et al. (1986) rates of 17%-243%. Warner and Pleeter (2001) infer the discount rates implicit in the decision to accept early retirement separation packages by members of the armed forces. They conclude that the discount rates are 10-21% among officers, and 35%-57% among enlisted personnel, depending on model specification, the differences among the two groups being driven primarily by their different education, race, sex and number of dependents.

In field experiments, Harrison et al. (2002) estimate the average discount rate of a sample of Danes to be about 28 percent, with individual discount rates depending on individual characteristics of the study participant (e.g., income, retirement status, being a student, etc.), and with only modest variation in discount rates across the time horizon specified for the payments. Earlier studies (e.g., Benzion et al., 1989) obtained even higher estimates. Warner and Pleeter (2001) conclude that the estimates of personal discount rates in money v. money tradeoffs (i) tend to be higher in studies based on hypothetical questions and relatively small sums, (ii) may well depend on the time delay of the payment, to the point that there may be hyperbolic discounting (see Shane et al., 2002), and (iii) have sometimes been found to depend on individual characteristics, which may capture access to capital markets, borrowing constraints, etc.

These comparisons, however, rely on different studies and groups of individuals, raising the question whether people's implied discount rates would be closer if they were asked to engage in risk v. money and money v. money tradeoffs within the same survey or study. In this paper, we ask two questions: First, what is the individual discount rate implicit in people's willingness to pay for a future reduction in the risk of dying for causes that have been linked with environmental exposures, such as cardiovascular and respiratory causes, and how does this discount rate compare with the discount rates used in benefit-cost analyses of the relevant environmental programs? Second, how does this discount rate compare with the discount rate for money exhibited by the *same* individuals?

In what follows, we report the results of a study that employs stated-preference approaches—contingent valuation questions to elicit the willingness to pay to reduce the risk of dying for specified causes immediately and in the future, and a hypothetical choice between a lump sum and annual payments over 10 years—which we use to answer the above questions. The survey was self-administered using the computer by a sample of residents of five Italian cities in May 2004. Our WTP regressions—from which we estimate the discount rates exhibited by respondents in money v. risk tradeoffs—control carefully for the size and timing of the risk reduction, experimental treatments and hypothetical scenario features, and individual characteristics of the respondents. We find that the discount rate in money v. risk tradeoffs is about 2%, while that in money v. money tradeoffs is 8.7%.

The remainder of the paper is organized as follows. We present the life-cycle model under uncertain lifetime, from which one derives expression for WTP for a reduction in the risk of dying, and the corresponding econometric equations, in section II. Section III presents choice questions used to infer the discount rate in money v. money tradeoffs. The survey questionnaire, administration and data are presented in section IV. Section V presents the estimation results. We offer concluding comments in section VI.

II. Risk v. Money Tradeoffs

The willingness to pay for a reduction in one's risk of dying can be obtained within the life-cycle model, according to which an individual at age j receives expected utility V_j over the remainder of his lifetime:

$$V_j = \sum_{t=j}^{T} q_{jt}(1+\rho)^{j-t} U_t(C_t)\,, \tag{1}$$

where V_j is the present value of the utility of consumption in each period, $U_t(C_t)$, times the probability that the individual survives to that period, q_{jt}, discounted to the present at the subjective rate of time preference ρ. T is the maximum lifetime. The specific expression of the budget constraint of the individual depends on the assumptions about opportunities for borrowing and lending. If, for example, it is assumed that the individual can borrow and lend at the riskless rate *r*, but never be a net borrower, and that the individual's wealth constraint is binding only at T, the WTP for a small change in the risk of dying—i.e., the Value of a Statistical Life (VSL)—at age j is equal to:

$$VSL_j = (1-R_j)^{-1} \sum_{t=j+1}^{T} q_{jt}(1+\rho)^{j-t} \frac{U_t(C_t)}{U_t^{'}(C_t)}\ , \tag{2}$$

where R_j is the probability of dying at age j.[1]

Suppose now that an individual were asked how much he is willing to pay at age j for an infinitesimal reduction in the risk of dying R_k when he is k years old. Assuming

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[1] Alternatively, it is possible to assume, as in Cropper and Sussman (1990), that individuals can save by purchasing actuarially fair annuities and borrow via life-insured loans. These assumptions slightly change the expression for the VSL, but not the conclusions about discounting.

that individuals smooth consumption, we can use the results in Cropper and Sussman (1990, p. 162) to show that

(3) $$VSL_{jk} = VSL_{kk} \cdot q_{jk} \cdot (1+r)^{k-j} .$$

In other words, the WTP now for a small reduction in the future risk is equal to the marginal WTP for an immediate risk reduction if the individual were of age k, discounted back to the present, and multiplied by q_{jk}, the probability of surviving to age k conditionally on being alive at age j. In what follows, we approximate discrete-time discounting with its constant exponential equivalent, and denote the individual discount rate as δ:

(4) $$VSL_{jk} = VSL_{kk} \cdot e^{-\delta(k-j)} \cdot q_{jk} .$$

In contingent valuation surveys, individuals are asked to report their WTP for a small, but finite, risk reduction (see, for recent examples, Johannesson et al. 1997, Persson et al. 2001; Alberini et al., 2004). For small risk reductions, $WTP \approx VSL \cdot \Delta R$, implying that

(5) $$WTP_{jk} = VSL_{jk} \cdot \Delta R = VSL_{kk} \cdot e^{-\delta(k-j)} \cdot q_{jk} \cdot \Delta R$$

where ΔR is the size of the risk reduction.[2]

Consistent with expression (2) and recent evidence that the VSL may well be "individuated" (see Smith et al., 2004, and Sunstein, 2004), the VSL should, in general, depend on baseline risk, the risk reduction, and individual characteristics **x** of the respondents. Formally,

(6) $$WTP_{jk} = VSL_{kk}(R_k, \Delta R, \mathbf{x}) \cdot e^{-\delta(k-j)} \cdot q_{jk} \cdot \Delta R ,$$

[2] However, several studies have found that the WTP is not strictly proportional to the size of the risk reduction (see, for example, Hammitt and Graham, 1999, Persson et al., 2001, and Krupnick et al., 2002), implying that the VSL is not a constant for all ΔR s.

which means that the WTP will depend on these factors, plus the discount factor and the likelihood of surviving until the age when the risk reduction begins.

In 2004, we administered a contingent valuation survey questionnaire to a sample of Italian citizens to elicit a person's WTP for a mortality risk reduction ΔR_j that begins immediately and WTP for a reduction of a specified size ΔR_k in the risk of dying at age k. Both the present and future risk reductions were varied across respondents, as was the age when the future risk reduction was to occur. In our empirical analysis of the data from this study, we specify the following functional form for equation (6):

(7) $$WTP_{jj} = \exp(\mathbf{x}_j \boldsymbol{\beta}_1) \cdot (R_j)^{\beta_2} (\Delta R_j)^{\beta_3}$$, and

(8) $$WTP_{jk} = WTP_{kk} \cdot e^{-\delta(k-j)} \cdot q_{jk} = \left[\exp(\mathbf{x}_k \boldsymbol{\beta}_1) \cdot (R_k)^{\beta_2} (\Delta R_k)^{\beta_3}\right] \cdot e^{-\delta(k-j)} \cdot q_{jk}$$

On taking logs, we obtain

(9) $$\log WTP_{jj} = \mathbf{x}_j \boldsymbol{\beta}_1 + \beta_2 \log R_j + \beta_3 \log \Delta R_j$$, and

(10) $$\log WTP_{jk} = \mathbf{x}_k \boldsymbol{\beta}_1 + \beta_2 \log R_k + \beta_3 \log \Delta R_k + \delta(j-k) + \log q_{jk}$$,

which become econometric equations once we append error terms. The discount rate δ is thus the coefficient on (j-k) in equation (10). The regression coefficients and δ can be estimated in one of two possible ways: (i) from a single-equation model that consists of equation (10), or (ii) by estimating a system of two equations—namely (9) and (10)—with cross-equation restrictions on the parameters. It should be noted that equation (10) also restricts the coefficient on log q_{jk}, the probability of surviving to age k given that the individual is alive at age j, to be equal to one.

III. Money v. Money Tradeoffs

Within the same survey, we asked people to imagine being given the opportunity to receive the sum of €10,000 now, or to receive annual payments of €X for 10 years, where X was varied to the respondent (and €X>€1000). Which, we asked, would they prefer—the lump sum, or the annual payments over 10 years?[3]

People should choose the lump sum if the present value of the annuity is less than the lump sum, the annuity if the converse is true, and will be indifferent between the two options if the present value of the stream of annual payments and the immediate payment are equal. In other words, if D* denotes the (constant exponential) discount rate that makes the present value of the annuity equal to the lump sum, then the respondent chooses the lump sum if his or her own discount rate, D, is greater than D*, the annuity if D is less than D*, and is indifferent between the two options if D=D*. Since X varies across respondents in our survey, so does D*.

Assuming that D is a normal variate with mean δ and variance σ^2, the probability of choosing the lump-sum payment is:

(11) $$\Pr(\text{choose lump sum}) = \Pr(D_i > D_i^*) = \Pr\left(\frac{\varepsilon_i}{\sigma} > \frac{D_i^*}{\sigma} - \frac{\delta}{\sigma}\right) = \Phi\left(\frac{\delta}{\sigma} - \frac{D_i^*}{\sigma}\right)$$

where $\Phi(\cdot)$ is the standard normal cdf.

IV. The Questionnaire, Survey Administration and Data

A. The Questionnaire

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[3] This is one of two possible approaches to inferring people's personal discount rates in money v. money tradeoffs. The alternative is to ask people whether they prefer a certain sum now, or a larger sum M periods from now.

Our questionnaire was self-administered using computers at centralized facilities by a sample of residents of five Italian cities (Venice, Genoa, Milan, Rome and Bari) in May 2004.[4] We obtained a total of 801 completed questionnaires.

The questionnaire began with eliciting the respondent's gender and age, which are inputs into the calculation of age- and gender-specific mortality risks to be shown to the respondent in a later section of the questionnaire, plus extensive information about the respondent's current health, the presence of any risk factors for chronic cardiovascular and respiratory illnesses, any impairments to mobility, and physical and psychological well-being.

Respondents were then given a simple probability tutorial leading to the explanation of one's chance of dying, and subsequently tested for probability comprehension. Since many people find it difficult to grasp the concept of risk, we used visual aids that represented risks as blue squares (mortality for all causes other than cardiovascular) and orange squares (mortality for cardiovascular and respiratory causes) out of a grid of 1000 squares (see Corso et al., 2001, Krupnick et al., 2002). Baseline risks and risk changes were expressed as X in 1000 over 10 years.[5]

After showing examples of possible behaviors and actions—such as medical tests, etc.—that reduce one's risk of dying, attention was restricted to cardiovascular and respiratory illnesses. Respondents were given the opportunity to learn more about heart disease and other cardiovascular and chronic respiratory illnesses by double-clicking a

[4] These cities are representative of Northern, Central, and Southern Italy. We restricted attention to city residents because the original focus of the study was on risks due to extremely hot weather. Urban areas are generally judged to be at higher risk for the human health effects of extremely hot weather (Intergovernmental Protocol on Climate Change, 2001).

[5] Assuming that the risk reduction is spread evenly over the 10 years, this is equivalent to X in 10,000 a year. As in Alberini et al. (2004), our initial focus groups revealed that people find the risk reductions more credible when they are presented using a 10-year frame. In addition, the visual aids based on the X in 1000 risk reduction are much clearer than those depicting an X in 10,000 risk.

link on the screen, and were then asked whether they were tested regularly for early diagnosis of (or treated for) cardiovascular diseases.

The questions at the heart of the questionnaire queried respondents about (i) their WTP for each of 10 years for a reduction ΔR_j in their risk of dying for cardiovascular and respiratory causes spread over the next 10 years, starting immediately (i.e., at age j), and (ii) their WTP for a reduction ΔR_k in their risk of dying for the same causes starting at age k. Question (ii) was asked only of persons aged less than 60.

In both cases, we told people what the baseline risks at age j and k are for people like them,[6] making sure that the risk of dying for other causes was also presented to the respondent for comparison. ΔR_j and ΔR_k ranged from 1 in 1000 to 22 in 1000, depending on the respondent's current age, gender, and k. All baseline risks, risk reductions and possible values of k are displayed in tables A.1 and A.2 in Appendix A,[7] and an example of a screen presenting the risk reduction to the respondent is shown in Figure 1.

We focus on the risk of dying for cardiovascular and respiratory causes because excess mortality rates for these causes have been observed during peak air pollution episodes and during heat waves, especially among the elderly (ages 65 and older). Long term exposures of fine particulate matter and ambient ozone have also been linked with a

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[6] We based our estimate of the respondent's risk of dying for cardiovascular and respiratory causes on age- and gender-specific population mortality rates. However, people were told that the risk was calculated based on their age, gender, *plus* risk factors *and* risk-reducing behaviors. The purpose of doing this was to prevent respondents from thinking that the baseline risks stated in the questionnaire do not apply to them, which would create a problem of errors-in-variables in our econometric model (Greene, 2003).

[7] Table 1 shows that after a certain age, people were randomly assigned to one of two possible risk reductions. Practical considerations dictated that the absolute risk reduction be greater for older respondents because they have higher baseline risks, although this means that they are given smaller percentage risk reductions than younger people. There are a total of nine different risk reductions, which should allow us to identify the relationship between WTP and risk change.

wide range of cardio-respiratory health effects (and hence deaths). Elevated levels of heavy metals in blood have also been linked with cardiovascular outcomes.

This means that the WTP for a reduction in the risk of dying for these causes, and hence the VSL, can be used to estimate the benefits of environmental policies that reduce air pollution and of public policies that protect persons at risk during extremely hot weather episodes, which the Intergovernmental Protocol on Climate Change (2001) predicts to increase as a result of global climate change.[8]

Respondents were randomly assigned to one of two versions of the questionnaire. In version 1, they were asked to imagine that a new medical test is available that is safe and delivers the stated risk reduction, but must be done and be paid for every year to be effective. In this variant of the questionnaire, the payment mechanism is a co-pay modeled after the fee for medical tests charged by the Italian national health care system.

Version 2 of the questionnaire is similar in all respects, except that people are simply asked to imagine that it is possible to reduce their risk by a certain amount, without mentioning any other specifics. Our focus groups indicated that people accepted such an abstract risk reduction, and that with this approach they tended to focus more sharply on the size of the risk reduction, without being distracted by other details. We use this split-sample experiment to see whether the insights from focus group participants are confirmed in the field and an abstract risk reduction is an acceptable way of framing the willingness to pay questions.

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[8] Because the risk reductions we query our respondents about are private, these benefits may underestimate the true benefits from public and environmental policies. Private risk reductions, however, allow researchers to circumvent the problem of altruism, which may lead to double-counting of benefits.

We elicited information about the respondent's WTP for the two risk reductions using dichotomous-choice questions with a follow-up.[9] The bid amounts—to which respondents were randomly assigned—are reported in table A.3 in Appendix A. Although we do not observe directly the respondent's WTP for the specified risk reduction, we can use the responses to the payment questions to form intervals around the respondent's unobserved WTP amount and to estimate interval-data models of WTP (see section V).

The money v. money tradeoff questions were placed immediately thereafter. For consistency with the WTP scenario, we asked respondents whether they would prefer €10,000 now or a payment of €X a year for 10 years. X is varied at random to the respondents, and ranges from €1150 to 1650.[10] Three response options were offered: The respondent could (a) prefer the €10,000 now, (b) prefer the annuity, and (c) be indifferent between the immediate payment and the annuity. In contrast to Coller and Williams (1999) and Harrison et al. (2002), we did not offer actual payments to our respondents, nor did we provide any cues about current market interest rates or the discount rates implicit in the annuity.

In sum, our study has four "treatments" (the risk reductions, the mode of delivery of the risk reduction, the bid amounts, the annuity payments) for a total of 384 alternative versions of the questionnaire.

B. The Sample and the Data

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[9] The payment questions thus asked the respondent whether he would be willing to pay €B to obtain the stated risk reduction. The possible response options are "yes" or "no." Respondents who answered "yes" to this first payment question were queried about a higher amount, while respondents who answered "no" to the first payment question were asked whether or not they would purchase the proposed risk reduction for a lower price.

[10] The annual payments are thus comparable to the upper end of the bid amounts proposed to the respondents in the risk reduction valuation questions.

Respondents were recruited from the general population of the residents of the five cities aged 30-75. The sample was stratified by age, with an equal number of respondents in each of three broad age groups (30-44, 45-59, and 60-75) and a roughly equal number of men and women. Comparison with the population of Italy (see Alberini and Chiabai, 2005) suggests that this sample has a slightly lower income than the country as a whole,[11] but its educational attainment is in line with the national statistics.[12]

In this paper, attention is restricted to the respondents of ages 30-59 and to the WTP for the immediate and the future risk reductions. We further exclude 22 respondents who appear to have trouble grasping risks (i.e., who fail both of our probability test questions at the first attempt), for a total of 508 usable observations. Descriptive statistics for this final sample are reported in table 1.

The frequency of the responses to the WTP question is displayed in table 2. in both the immediate and future risk reduction, about 40 percent of the respondents declined to pay the initial bid as well as the follow-up bid (No-No [NN]), and almost 30% agreed to both. Smaller shares of the samples alternated responses.[13]

Regarding the choice between the hypothetical lump sum and annuity, the percentages of respondents who selected the various response options are reported in table 3. Perusal of table 3 shows that the fraction of the sample selecting the lump sum

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[11] In 2002, the average income of Italian households was €27,868 and the average income per household member was €10,000 (Banca d'Italia, 2002). For the full sample of 801 respondents, the average household income was €21,368 a year, and the average income per household member €8,513 a year.
[12] Eleven percent of the full sample of 801 respondents has a college degree, whereas 10.2% of Italians have a college degree.
[13] We wish to note that although the sample proportions for each sequence of responses to the payment question appear similar across the immediate and future risk reductions, many respondents switched to a different response category when going from the immediate to the future risk reduction. For example, of the 207 NN respondents for the immediate risk reduction, 177 answered NN in the future risk reduction as well. The remainder values the future risk reduction more highly than the immediate risk reduction, which is reasonable since the future baseline risk and the risk reduction are higher than the current baseline risk and immediate risk reduction.

decreases as the annual payment increases, as expected, and suggests that the median personal discount rate is in the neighborhood of about 8.7 percent.

V. Econometric models.

A. Econometric Models of WTP.

We wish to estimate the system of equations:

(12) $$\log WTP_{jj} = \mathbf{x}_j \boldsymbol{\beta}_1 + \beta_2 \log R_j + \beta_3 \log r_j + \varepsilon \text{, and}$$

(13) $$\log WTP_{jk} = \mathbf{x}_k \boldsymbol{\beta}_1 + \beta_2 \log R_k + \beta_3 \log r_k + \delta(j-k) + \log q_{jk} + \eta \,.$$

where WTP_{jj} and WTP_{jk} are the respondent's true WTP amounts, R is the baseline risk, r is the risk reduction (i.e., ΔR), and ε and η are jointly normally distributed error terms.

The vector **x** includes household income (divided by the number of household members), a companion dummy variable denoting whether the respondent declined to provide information about income,[14] a dummy for the presence of chronic conditions or risk factors (ATRISK), and city dummies. In addition, we wish to examine whether the mode—abstract or the medical test—of provision of the risk reduction influences WTP, and whether individuals who are particularly averse to financial risk report higher or lower WTP amounts (see Eeckhoudt and Hammitt, 2004). The latter regressor is a dummy that takes on a value of one if the respondent stated twice that he would choose

[14] When a respondent did not report household income, we recoded household income to 0, and coded the missing income dummy as 1. The recoded income variable and the missing income dummy are both included among the regressors. The coefficient on the missing income indicator thus captures any systematic differences in WTP among those respondents who did and did not report income, whereas the coefficient on recoded income measures the effect of income on WTP, conditional on knowing the respondent's income in the first place.

his current job and a constant income profile over another job with higher possible gains but also downside risk.[15]

While we expect income to be positively related to WTP, we do not have any priors about the sign of the coefficient on health, provision mode, and risk aversion. Regarding the latter, Eeckhoudt and Hammitt distinguish for the cases where the individual is and is not indifferent to his wealth in the event of death (utility of bequest). Even in the former case, the effect of risk aversion on the WTP to reduce mortality risks—without eliminating them completely—is ambiguous.

Although in principle $\mathbf{x}_k$ could reflect expectations about income and health at age k, and thus could be different from $\mathbf{x}_j$, data limitations force us to use the same vector of individual characteristics of the respondent in both WTP equations. We impute q_{jk} from the population life tables for Italy. For example, population statistics suggest that a woman in her early 30s has a chance of 0.978 of surviving to age 50 and 0.819 of surviving to age 70. In our sample, values range from 0.57 to 0.982, for an average of 0.805.

Regarding the other regression coefficient, economic theory suggests that β_3 should be positive, as WTP should be sensitive to scope, while it is not clear what the sign of β_2 should be. All else the same, one would expect WTP to increase with the baseline risk (Pratt and Zeckhauser, 1996), but in our study the baseline risk is higher

[15] The question was phrased as follows: "Suppose that you are the only wage earner in your family, and that you are assured for the rest of your life a safe job with a guarantee annual pay equal to your current annual pay. Suppose that, under these circumstances, you were offered a new job that is equally safe. With this new job, you have a chance of 50% of doubling your pay, and a chance of 50% that your pay is reduced by one-third. Would you accept this new job?" Respondents who said that they would turn down the new job were then asked if they would take one that has a 50% chance of doubling one's pay, and 50% chance of reducing it by a quarter. This question was adapted from a question included in wave I of the Health and Retirement Survey, which was administered to a large cross section of US households in 1992 (Barsky et al., 1997).

among older respondents, and older respondents may be willing to pay less for a given risk reduction (see Johannesson et al., 1997, and Alberini et al., 2004).[16]

We estimate system (12)-(13) using the "yes" or "no" responses to the initial and follow-up payment question, and the method of maximum likelihood. We form intervals around the respondent's true WTP figures, which remain unobserved, and obtain each person's contribution to the likelihood function from the cdf of a bivariate normal distribution (see Appendix B).

B. WTP Results

Table 4 reports the results of three specifications. In all three specifications, we impose the restriction that the variance of ε and η are identical, since in preliminary runs we found clear evidence that this was the case. In specification I, the error terms in (12) and (13) are independent, which means that the contribution to the likelihood is simply the product of the probability that the first WTP amount falls within the observed bounds, times the probability that the WTP for the future risk reductions falls within its own observed bounds.

When the two WTP amounts are assumed independent, WTP is consistently found to depend positively and significantly on the size of the risk reduction, but not on baseline risk, so we omit the latter regressor from specification I of table 4.[17] This omission has no discernible effects on the other coefficients, which are remarkably stable with respect to adding or deleting regressors. WTP increases with the size of the risk

[16] Earlier studies have included age and gender among the regressors in the WTP equations, but with our study design baseline risk, risk reduction, age and gender are too correlated to be all entered at the same time in the WTP equation.
[17] Although insignificant, the coefficient on log baserisk is always positive.

reduction, but in a less than proportional fashion, since the relevant coefficient is 0.56, which is significantly less than one. This finding is consistent with earlier studies, and with our own earlier analysis of the WTP for the immediate risk reduction from this study (Alberini and Chiabai, 2005). The discount rate is pegged at about 2%, which is reasonable and well within the range of estimates from earlier studies.[18]

When we relaxed the assumption of independent errors to allow for common unobserved factors to enter in both ε and η, we generally found that the estimates of the discount rate and the coefficients on most variables were similar to those in the models with independent errors. One exception—and a troubling finding—is represented by the coefficients on log baseline risk and log risk reduction, which bounced around quite a bit as regressors were added to or excluded from the model. This could be due to the (unavoidable) collinearity between them.[19]

For example, in specification II of table 4, WTP appears to increase only very weakly with the size of the risk reduction.[20] We experimented with restricting β_2 to be zero, but our estimation routine was not able to produce standard errors. We were able to achieve regular convergence only when we imposed additional restrictions on the parameters. In specification III of table 4 we restrict the discount rate to be equal to

[18] It is, of course, also possible to estimate equation (13) separately. Doing so produces a slightly larger elasticity of WTP with respect to the risk reduction (0.69) and a comparable discount rate (0.0202). The coefficients on all of the other variables are extremely close to, and within 5% of, their counterparts in Specification I of table 4, with the only exception of the coefficient on the Venice dummy, which doubles in size. The estimate of the scale of the error term from this run is about 1.84.

[19] To avoid off-hand rejection of the valuation scenario, respondents with higher baseline risks were asked to value larger risk reduction. Despite the collinearity between these regressors, in the system with independent error terms the estimates were very stable to changes in the right-hand side variables.

[20] The correlation between the error terms of the two WTP equations is also very high (0.92), suggesting that there many unobservable factors common to both WTP amounts that are absorbed into the error terms.

0.0218 (the value from specification II) and obtain an estimate of β_3 that is comparable to that of specification I.

The coefficients on all of the other regressors are remarkably similar across the three specifications. While income is positively, but not significantly, related to WTP,[21] and there is little evidence of systematic differences in WTP across cities, we find that individuals with chronic conditions are, all else the same, willing to pay 46 to 52% more for any given risk reduction.

It is striking that those respondents who were given the abstract risk reduction are prepared to pay 58 to 63% more than those who were to consider a medical test. We do not have an explanation for this finding. The risk reduction scenario could affect respondent focus on the key features of the valuation exercise, and hence the sharpness with which respondents form their WTP values. We tested this possible explanation by allowing different error variances for people assigned to the abstract and medical risk reduction, but found no evidence of such an effect. We also conjectured that medical tests may appeal differently to individuals in certain age categories or in compromised health, but when we included interactions between such respondent characteristics and the abstract/medical risk reduction, the coefficients on the interactions were insignificant.

Finally, those respondents that we identified as the most averse to financial risk hold WTP values that are consistently about one-quarter lower than those of all others. This result is in contrast with the findings in Smith et al. (2004), who estimate compensating wage differentials and find that persons with greater risk aversion have

[21] This finding is in contrast with our earlier analyses of the responses to the WTP for the immediate risk reduction, where income was positively and significantly related to WTP. We believe this may be an artifact of the different set of regressors we use in this paper, and of imposing the cross-equation restrictions.

larger VSLs. It should be borne in mind, however, that the Smith et al. study is for US individuals, uses revealed-preference data, and focuses on different age groups than ours.

C. Discount Rate in Money v. Money Tradeoffs

To estimate the discount rate implicit in the money (now) v. annuity choices, we remind the reader that respondents were offered three response categories: (a) choose the money now, (b) choose the annuity, and (c) indifferent between the two. Since respondents opt for (a) if D>D*, for (b) if D<D*, and for (c) when D is equal to D*, our sample is a mix of discrete and continuous observations. Given the assumptions reported in section III, a respondent's contribution to the likelihood is thus $\Phi(z)$ if the respondent prefers the money, $1-\Phi(z)$ if he prefers the annuity, and $\varphi(z)$ if he is indifferent between the lump sum and the annuity, where $z=\delta/\sigma-D_i^*/\sigma$, $\Phi(\cdot)$ is the standard normal cdf, and $\varphi(\cdot)$ is the standard normal pdf.[22]

Perusal of the responses to the lump-sum v. annuity question (see table 3) suggests that in this context the median discount rate is about 0.087, and indeed our econometric model confirms this figure. This discount rate is higher than that implicit in the risk v. money tradeoff questions, but much lower than many of the other money v. money rates reported in the literature. For comparison, at the time of the survey the interest rate on 12-month Treasury bills was 2 percent and the official discount rate was also 2 percent. Saving accounts with the Post Office and major financial institutions bear interest rates of 0.75% to a little over 2%.

[22] We did not show respondents the break-even discount rates implicit in the annuity, nor were our respondents informed about market interest rates. Accordingly, we do not attempt to censor the observations at the market rates, as in Harrison et al. (2002).

As shown in table 5, discount rates are slightly higher among respondents of ages 40-59 than for respondents of ages 30-39, but this effect is not statistically significant. Males, however, hold significantly lower discount rates.[23] In runs not reported, we also entered income, city of residence, marital status, and family size, but did not find them to be significant determinants of the discount rate. Similar systematic associations were checked for, and dismissed, in the risk v. money tradeoffs.

VI. Discussion and Conclusions.

We used stated preference approaches to infer the discount rate implicit in money v. future risk tradeoffs, and money v. money tradeoffs. For a sample of residents of 5 Italian cities, these rates were 2% and 8.7%, respectively.

The 2% discount rate is within the range of values (1.3-8.6%) estimated from contingent valuation studies in Canada and the US, where risks and risk reductions were for all causes and not restricted to cardiovascular and respiratory causes (Alberini et al., 2005). Our respondents would, therefore, appear to discount future risk reductions at a rate lower than the social discount rate used by the European Commission (4%) and, in the US, by the Office of Management and Budget (7%). Using our 2% in lieu of the social discount rate of 4% used in the recent benefit-cost analysis of the Clean Air for Europe program (Hurley et al., 2005) would thus raise meaningfully the future mortality benefits of this program, even when attention is restricted to its first 20 years.[24] To

[23] Specification II of table 5 posits that $\delta_i = \mathbf{z}_i \gamma$, where $\mathbf{z}_i$ is a vector of individual characteristics and γ a vector of coefficients.
[24] Specifically, Hurley et al. employ the rate of 4% adopted by the European Commission to discount the value of the statistical life-years (VOLY) over the person's remaining lifetime to obtain the VSL:

illustrate, our WTP equations predict that the "average" Italian male (i.e., an individual that is 40 years old, has household income per household member equal to roughly €10,000, and that we assume to live in Rome) has a median WTP of €394 or €407 (depending on the specification) for an annual risk reduction of 2 in 10,000.[25] If the risk reduction is experienced at age 65 (25 years from now), the discount factor is 58% if the discount rate is 2%, and 37% if the discount rate is 4%.[26]

When estimating the discount rate for the money v. risk tradeoffs, we controlled for the fact that WTP should depend on the size of the risk reduction, its timing, experimental treatments and features of the hypothetical scenarios, and individual characteristics. For example, we found that telling people that the risk reduction is delivered by a medical test results in systematically lower WTP, all else the same, than if we ask people to consider a completely abstract risk reduction. This effect was not specific to certain groups of respondents, and, contrary to our expectations based on insights provided by focus group participants, the risk reduction delivery mode did not affect the variance of WTP.

As in earlier analyses, we found that people with chronic cardiovascular or respiratory conditions are willing to pay more for the same risk reduction, and that people whom we interpret as being more averse to financial risks are willing to pay less for a mortality risk reduction. This result goes against the findings by Smith et al. (2004) for

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$VSL = VOLY \sum_t q_{jt}(1+d)^{j-t}$. This formula can be obtained as a special case of equation (2) if the utility terms are constant over time.

25 The corresponding VSLs are €1.967 million and €2.036, respectively, and are well within the range adopted by the European Commission's Directorate-General for the Environment (http://europa.eu.int/comm/environment/enveco/others/recommended_interim_values.pdf).

26 This individual's probability of surviving to age 65 is 0.81, so to get his WTP for the 2 in 10,000 annual risk reduction at age 65, the figure of €394 (€407) annual must be multiplied by 0.58 (or 0.37) and then again by 0.81.

the near-elderly. Comparison between our two studies is difficult, due to the different population, age groups, and their use of a revealed-preference approach, suggesting that further research is needed on this matter.

In this study, we also asked questions aimed at estimating people's discount rate for money, and found that latter (8.7%) is larger than the former, but lower than the rates from other recent studies. As in other studies, we find that the personal discount rate for money v. money tradeoffs is larger than the market interest rate. Our questionnaire did not provide any reminders about the latter to the respondents. Age and gender were significantly associated with the discount rate for money. Our findings confirm Warner and Pleeter's point that discount rates may depend on individual characteristics, but refute their view that they tend to be high in stated-preference studies involving moderate sums.

It is also possible that people "anchored" on the discount rates previously exhibited in the WTP questions, which raises the question whether discount rates for money elicited under hypothetical conditions are influenced by the context of the questionnaire. In future research, it would be interesting to test this conjecture formally using independent samples that are given (i) the WTP questions only, (ii) the money choice questions only, and (iii) both types of questions, but in the reverse order.

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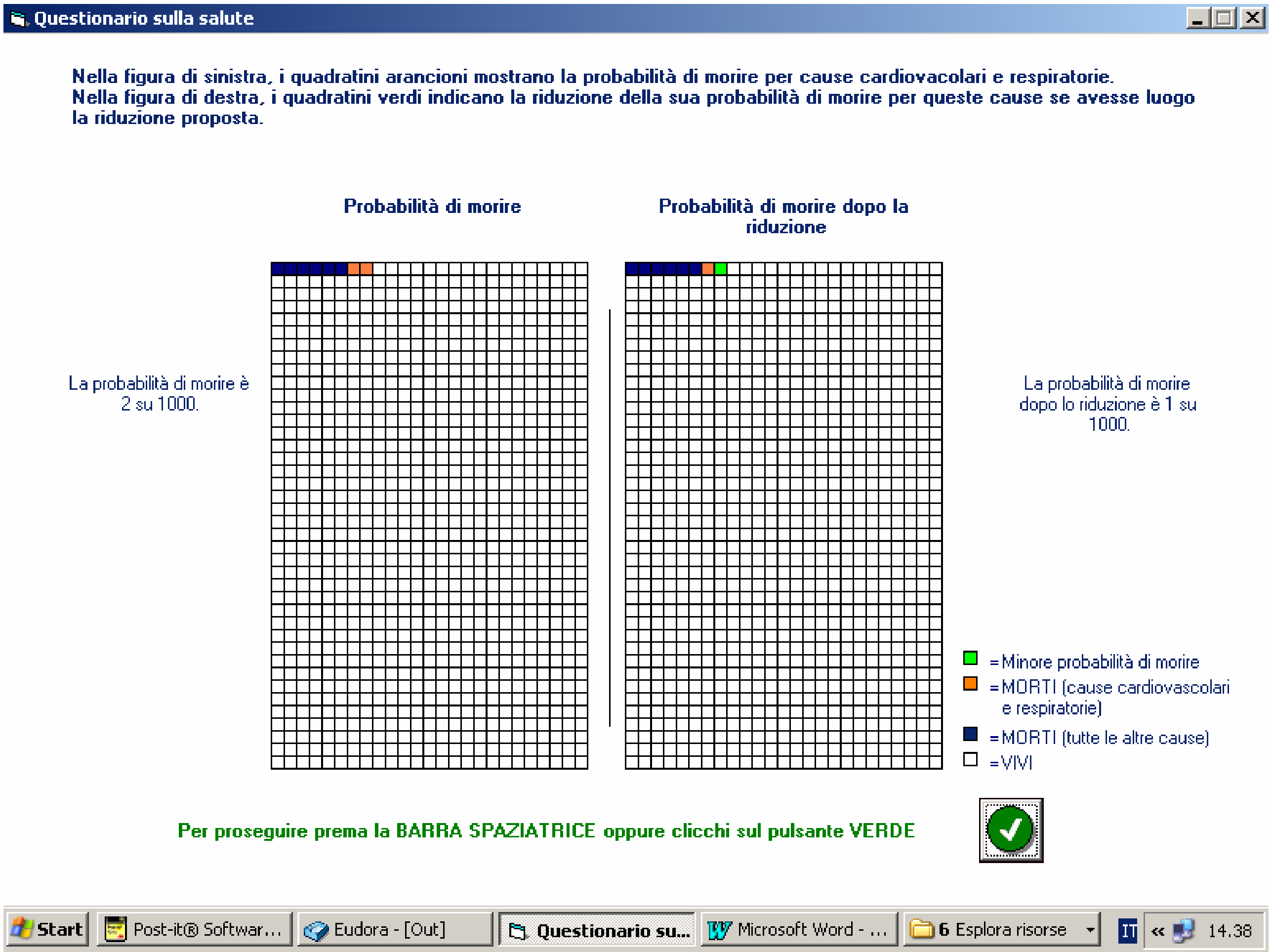

Figure 1. Presentation of baseline risk and risk reduction in the questionnaire.

Table 1. Descriptive statistics of the sample of 508.

Variable	Mean	Std Dev	Minimum	Maximum
Household income per family member (pcappinc)*………………………………………	8.8086	5.7490	2	48
Missing income dummy (missinc)………………	0.1240	0.3299	0	1
Respondent has chronic cardiovascular or respiratory illness, high blood pressure, or diabetes (atrisk)………………………………….	0.3996	0.4903	0	1
Abstract mode of delivery of the risk reduction (abstract)…………………………………………	0.5098	0.5004	0	1
Respondent is risk averse (riskaverse)**………..	0.5256	0.4998	0	1
Rome resident (roma)..	0.2008	0.4009	0	1
Bari resident (bari)...	0.3425	0.4750	0	1
Venice resident (venezia)....................................	0.2008	0.4009	0	1
Genoa resident (genova).....................................	0.0945	0.2928	0	1
Milan resident (milano)…………………………	0.1595	0.3664	0	1
Baseline risk (baserisk)………………………….	7.9587	8.2634	2	34
Risk reduction (deltarisk)………………………..	2.7539	1.83012	1	8

* Statistics for those respondents that report their household income.
** RISKAVER=1 if the respondent twice declined a job with higher potential gains, but also downside risk.

Table 2. Responses to the initial and follow-up WTP questions.

Response category	Percent (immediate risk reduction)	Percent (future risk reduction)
Yes-Yes (YY)	29.92	29.53
Yes-No (YN)	17.91	17.32
No-Yes (NY)	11.42	12.2
No-No (NN)	40.75	40.94

Table 3. Responses to the hypothetical lump sum v. annuity choice questions.

Annual payment	**D***	**Choose lump sum (percent of row total)**	**Choose annuity (percent of row total)**	**Indifferent between lump sum and annuity (percent of row total)**	**Total**
1150	0.0286	80 (55.55)	51 (35.42)	13 (9.03)	144
1500	0.0874	85 (50.59)	70 (41.67)	13 (7.74)	168
1650	0.1102	88 (44.90)	91 (46.43)	17 (8.67)	196

Table 4. WTP regressions. Interval-data models, N=508. Log normal WTP.

	Specification I		Specification II		Specification III	
	Coefficient	T statistic	Coefficient	T statistic	Coefficient	T statistic
Intercept	4.4832	15.4967	4.5954	12.4850	4.5970	15.2780
BASERISK	--	--	0.1894	5.8690	--	--
DELTARIS	0.5603	4.8012	0.1358	1.3260	0.5172	14.2810
Household income per family member (thou. Euro) (PCAPINC)	0.0124	0.9612	0.0116	0.6830	0.0119	0.6740
Missing income (MISSINC) (dummy)	0.1182	0.5008	0.0986	0.3110	0.1074	0.3290
Respondent has chronic cardiovascular or respiratory illness, high blood pressure, or diabetes (ATRISK) (dummy)	0.3800	2.7104	0.4058	2.2400	0.4234	2.3150
Abstract mode of delivery of the risk reduction (ABSTRACT) (dummy)	0.4951	3.7226	0.4633	2.6860	0.4648	2.6330
Respondent is risk averse (RISKAVER) (dummy)	-0.2975	-2.0531	-0.2978	-1.6080	-0.3068	-1.5850
Resident of Rome (ROMA) (dummy)	0.4841	1.8295	0.4014	1.1700	0.4232	1.4690
Resident of Milan (MILANO) (dummy)	0.5774	2.2005	0.3707	1.0530	0.3809	1.2670
Resident of Bari (BARI) (dummy)	0.4642	1.6973	0.2598	0.8260	0.2739	1.0050
Resident of Venice (VENEZIA) (dummy)	0.3166	1.2730	0.5329	1.5730	0.5415	3.1820
Discount rate δ	0.0220	2.8570	0.0218	3.3250	0.0218	--
σ_ε and σ_η (scale of the error terms)	1.8295	21.2486	1.7765	19.1030	1.8178	19.2360
Correlation coefficient (RHO)	--	--	0.9221	82.2850	0.9168	78.2230
Log likelihood function	-1054.8366		-1061.79		-1306.23	

Table 5. Estimates of the discount rate in money v. money tradeoffs. N =508

	Specification I		Specification II	
Variable	**Coefficient**	**T statistic**	**Coefficient**	**T statistic**
Intercept	0.0878	19.5111	0.0918	10.9286
age4049	--	--	0.0146	1.4600
age5059	--	--	0.0111	0.9823
Male	--	--	-0.0250	-2.8080
Scale σ	0.0801	9.8889	0.0784	9.9240
Log likelihood	-266.25		-260.8997	

Appendix A.

Table A.1. Baseline risks and risk reductions assigned to respondents in the survey (immediate risk reduction)

Males				Females			
Age	Baseline risk (all causes of death)	Baseline risk (cardiovasc. and respiratory)	Risk reduction (cardiovasc. and respiratory)	Age	Baseline risk (all causes of death)	Baseline risk (cardiovasc. and respiratory)	Risk reduction (cardiovasc. and respiratory)
30-34	12	2	1	30-34	5	2	1
35-39	15	4	2	35-39	8	2	1
40-44	23	6	3	40-44	13	4	2
45-49	37	11	5	45-49	20	5	2
50-54	62	18	3 or 6	50-54	38	7	3
55-59	105	34	5 or 8	55-59	49	13	4
60-64	177	64	5 or 10	60-64	80	25	4 or 5
65-69	297	122	5 or 12	65-69	138	54	5 or 8
70-74	478	225	12 or 22	70-74	247	118	8 or 12

Table A.2. Baseline risks and risk reductions assigned to respondents in the survey (future risk reduction)

		MALES		FEMALES	
current age	age k when the risk reduction would start	baseline risk (cardiovascular and resp.causes) at age k*	risk reduction*	baseline risk (cardiovascular and resp.causes) at age k*	risk reduction*
30-34	50 or 70	18 or 225	6 if k=50, 12 if k=70	7 or 118	3 if k=50, 8 if k= 70
35-39	50 or 70	18 or 225	6 If k=50, 12 if k=70	7 or 118	3 if k=50, 8 if k=70
40-44	60 or 75	64 or 432	10 if k=60, 12 if k=75	25 or 276	5 if k=60, 12 if k=75
45-49	60 or 75	64 or 432	10 if k=60, 12 if k=75	25 or 276	5 if k=60, 12 if k=75
50-54	65 or 75	122 or 432	12 if k=65, 12 if k=75	54 or 276	8 if k=65, 12 if k=75
55-59	75	432	12	276	12

*: in 1000 over the subsequent 10 years

Table A.3. Bid amounts (annual payments).

initial bid (euro per year)	If yes	if no
110	250	70
250	500	110
500	950	250
950	1200	500

Appendix B.

The likelihood function of the data is:

(B.1) $$\sum_{i=1}^{n} \log \pi_i$$

where π_i is the probability of observing the respondent's responses to the payment questions for the immediate and future risk reduction, which is equal to:

(B.2)

$$\pi_i = \Phi(\ln WTP_{jj}^{H} / \sigma_{\varepsilon} - \mathbf{w}_j \boldsymbol{\theta}_1 / \sigma_{\varepsilon}, \ln WTP_{jk}^{H} / \sigma_{\eta} - \mathbf{w}_k \boldsymbol{\theta}_2 / \sigma_{\eta}, \rho) +$$
$$- \Phi(\ln WTP_{jj}^{L} / \sigma_{\varepsilon} - \mathbf{w}_j \boldsymbol{\theta}_1 / \sigma_{\varepsilon}, \ln WTP_{jk}^{H} / \sigma_{\eta} - \mathbf{w}_k \boldsymbol{\theta}_2 / \sigma_{\eta}, \rho) +$$
$$- \Phi(\ln WTP_{jj}^{H} / \sigma_{\varepsilon} - \mathbf{w}_j \boldsymbol{\theta}_1 / \sigma_{\varepsilon}, \ln WTP_{jk}^{L} / \sigma_{\eta} - \mathbf{w}_k \boldsymbol{\theta}_2 / \sigma_{\eta}, \rho) +$$
$$+ \Phi(\ln WTP_{jj}^{L} / \sigma_{\varepsilon} - \mathbf{w}_j \boldsymbol{\theta}_1 / \sigma_{\varepsilon}, \ln WTP_{jk}^{L} / \sigma_{\eta} - \mathbf{w}_k \boldsymbol{\theta}_2 / \sigma_{\eta}, \rho) \cdot$$

In (B.2), WTP^L and WTP^H signify the lower and upper bound of the interval around the respondent's unobserved true WTP, $\mathbf{w}_j$ and $\mathbf{w}_k$ are the vector of regressors in the right-hand side of equations (13) and (14), θ_j and θ_k are their respective coefficients, σ_{ε} and σ_{η} are the scale parameters of ε and η, respectively, and ρ is the coefficient of correlation between the error terms ε and η.

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