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Heterogeneous Rates of Time Preference and the Decision to Smok

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HETEROGENEOUS RATES OF TIME PREFERENCE AND THE DECISION TO SMOKE

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Individuals with higher personal rates of time preference will be more likely to smoke. Although previous studies have found no evidence of a relationship between smoking and rates of time preference, analysis of implicit rates of time preference associated with workers' wage fatality risk trade-offs indicates that smokers have higher rates of time preference with respect to years of life. Current smokers have an implied rate of time preference of 13.8% as compared to 8.1% for nonsmokers. Current smokers who are blue-collar workers have rates of time preference with respect to years of life of 16.3% compared to 7.8% for nonsmoking blue-collar workers. (*JEL* I12, D81, D91)

I. INTRODUCTION

Smoking imposes substantial health risks, many of which are not immediate and will also have long-term effects on smokers' well-being. Recent estimates of the lost life expectancy due to smoking are 2.4 years for women and 4.4 years for men, with some studies indicating even more substantial losses.[1] Given the latency period before many of the most severe smoking risks are manifested, people with greater individual rates of time preference will be less influenced by the discounted value of the health losses and will be more likely to be smokers. This paper examines whether this relationship between rates of time preference and smoking behavior is in fact borne out by developing empirical estimates of how smokers and nonsmokers discount years of life lost due to the fatality risks that they incur on the job.

A variety of researchers have theorized that individuals with higher rates of time preference will be more likely to engage in risky behaviors such as smoking. In some instances, these theories have utilized rational models of individual choice.[2] Fuchs (1986) views underlying differences in individual rates of time preference as governing choices of education and smoking, whereas Becker and Mulligan (1997) consider education and discount rates to be endogenous. Other models have hypothesized that smokers are guilty of intertemporal irrationality, possibly in the form of hyperbolic

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1. These estimates, which control for the demographic and risk-taking profiles of smokers and nonsmokers, appear in Sloan et al. (2004). Estimates of a life expectancy loss of 7 years for smokers appear in Rogers and Powell-Griner (1991). Viscusi (2002) provides a review of several other estimates as well.

2. See Fuchs (1986) and Becker and Mulligan (1997) for analyses along these lines. Becker et al. (1994) and Chaloupka (1991) use smokers' responses to cigarette price changes to show that adult smokers are not generally myopic in their cigarette consumption decisions, even though they may be addicted. Their results are consistent with the theoretical model of rational addiction formulated by Becker and Murphy (1988). Although these studies do show that smokers are generally not myopic, they do not show that individual decisions to smoke are internally consistent with their individual risk attitudes.

ABBREVIATIONS

CPS: Current Population Survey: Tobacco Use Supplement
NCHS: National Center for Health Statistics
NIOSH: National Institute for Occupational Safety and Health
NTOF: National Traumatic and Occupational Fatality
PCI: Per Capita Income

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discounting.[3] Indeed, the theoretical linkage between smoking and rates of time preference is sufficiently convincing that some have argued for the use of smoking status as a proxy for a high discount rate.[4]

Studies to date have found mixed evidence of such a relationship. The experimental evidence in Chesson and Viscusi (2000) yielded an unexpected negative relationship between smoking and rates of time preference, but the stated preference study by Baker et al. (2003) found that smokers had higher rates of time preference than did never smokers. Khwaja et al. (2007) hypothesize based on their analysis of survey data that it is not the differences in rates of time preference per se that influence smoking decisions but rather temporal myopia. If rates of time preference exert a common influence on risky behaviors, then smokers should be more likely to incur other health risks. Consistent with this view, Hersch and Viscusi (1998) found that smokers choose riskier jobs, are less likely to floss their teeth, are less likely to check their blood pressure, and have home accident rates double the level for nonsmokers. Cutler and Glaeser (2005) focused on a different mix of health-related behaviors—smoking, heavy drinking, obesity, and mammograms for women—and found correlations in the expected direction, but they concluded that the simple pairwise correlations were surprisingly weak, explaining under 20% of the variation.

Our approach here is quite different. By examining fatality risk–wage decisions in the labor market, it is possible to estimate the implicit rates of time preference that smokers and nonsmokers have with respect to years of life.[5] If people make consistent intertemporal risk choices for occupational fatality risks and smoking risks, then one would expect smokers to exhibit higher rates of time preference with respect to years of life in their labor market decisions as well. Consistent with the theoretical frameworks, we find that smokers have significantly higher rates of time preference than do their nonsmoking counterparts.

The labor market data permit estimation of average rates of time preference rather than the structure of discount rates over time. Thus, it is not feasible to examine whether individual rates of time preference decline over time, which is a central concern of models of hyperbolic discounting and time inconsistency. The most common hyperbolic discounting model hypothesizes that discount rates are high in the first period but decline to a constant, lower discount rate thereafter. Given the long time period for adverse smoking risks to be manifested, a greater influence on smoking than a high initial rate if time preference is likely to be a consistently high average rate of discount over many periods. Our estimates of smokers' rates of discount with respect to years of life capture the average influence of both initial hyperbolic discounting as well as high rates of time preferences thereafter. These average estimated rates of time preference in turn will prove to be very useful in assessing the discounted private mortality cost of smoking as perceived by smokers.[6]

Our estimates also contribute to the broader empirical literature on individuals' implicit rates of time preference. Early studies by Maital and Maital (1978) tested for individual differences in discount rates using hypothetical surveys. Hausman (1979) explored rates of discount implicit in the energy efficiency savings of appliance purchases and found discount rates in excess of 30%. Fuchs (1986) used a survey technique to estimate discount rates for health outcomes. These studies generally estimated discount rates far above those found in financial markets.

Our paper extends the approach of Viscusi and Moore (1989), who utilized an alternative time preference measurement approach based on actual labor market choices involving occupational fatality risks. This revealed preference approach has the advantage of not relying on

3. Schelling (1984) and Gruber and Köszegi (2001) hypothesize that intertemporal irrationality may be influential. Similarly, Gruber and Köszegi (2001) theorize that the potential presence of time-inconsistent preferences (i.e., hyperbolic discounting) is an important factor that should not be dismissed due to the policy implications stemming from such preferences. In concordance with this view, Hersch (2005) found that smokers who would like to quit may support smoking restrictions as a commitment mechanism used to overcome their time-inconsistent preferences. Nevertheless, in this paper, we abstract from the possibility of time-inconsistent preferences. Regardless of whether preferences are consistent over time, our finding of a variation of effective average rates of time preference across risk-taking subgroups (as defined by smoking status) indicates a selection effect that operates based, in part, on individuals' implicit rates of time preference.

4. See Munasinghe and Sicherman (2006) and Huston and Finke (2003).

5. A review of these studies and the hedonic wage literature more generally appears in Viscusi and Aldy (2003).

6. These estimates, to be discussed below, are reported in Viscusi and Hersch (2008).

answers to hypothetical questions, which are subject to survey bias. Their estimates of the average implicit discount rates are in a range of 2%–12%, a range more in line with market rates than other measured rates of time preference of 30% or more.[7] This paper generalizes the empirical methodology to account for the heterogeneity in discount rates across smokers and nonsmokers.

Section II develops the empirical framework for the analysis. A simple model of discounted lifetime utility for which workers select their optimal job risk provides the basis for developing an empirical approach to estimating discount rates based on workers' choices from the wage-offer curve. Section III describes the data set used for the analysis and the market wage estimates. The derivation of the rates of time preference for smokers and nonsmokers appears in Section IV. The concluding Section V indicates that the rates of time preference for both smokers and nonsmokers are below the rates of 30% or more found for some consumer choices. However, smokers' rates of time preference are roughly double those of nonsmokers, consistent with their decisions to incur the greater long-term risks posed by their smoking behavior.

II. EMPIRICAL FRAMEWORK

A. Model of Occupational Risk

Viscusi and Moore (1989) develop a multi-period model of occupational risk in which the utility maximizing worker selects a job risk p_{j} from the available market-offer curve. This risk is combined with the individual's background mortality risk p_{m}, which varies with age and smoking status, to give an aggregate probability of survival $(1-p)$ in a given period t given by $1-p_{\mathrm{j}}-p_{\mathrm{m}}=1-p$. The risk of death in a given period is usually very small, especially for job risks. The ex ante probability that both fatality risks would occur in a given year is, therefore, vanishingly small. As a result, we ignore the potential for overlap of background risks and job-related death risks in any particular period. Also, as a simplification, we let p be constant over time.[8] For the sake of model tractability, we assume that the preferences of the individual are time invariant, that no bequests are made, and that workers are risk averse. Thus, we assume that the wage $w(p_{\mathrm{j}})$ and utility function $U(w(p_{\mathrm{j}}))$ are time invariant and that the utility function satisfies $U_{\mathrm{w}}>0$ and $U_{\mathrm{ww}}<0$. Additionally, we assume that the market opportunities curve offers higher wages for greater risk due to the participating firms' costs of making workplaces safer, so that $(\partial w/\partial p_{\mathrm{j}}>0)$.

The model also assumes an infinite time horizon, though workers do of course face a risk of death each year. For the typical worker with a reasonable discount factor β, this assumption should not affect the results significantly. The present value of utility t years in the future $\beta^t U(w)$ becomes increasingly minute as t increases.[9] We examine potential bias from this simplification below.

The worker's objective function takes the following form:

$$(1)\qquad \underset{p_j}{\mathrm{Max}}\, V=U(w(p_{\mathrm{j}}))\sum_{t=1}^{\infty}\beta^{t-1}(1-p)^t$$

where $p=p_{\mathrm{j}}+p_{\mathrm{m}}$.[10] Thus, the worker chooses a job risk level to maximize expected discounted lifetime utility. And since

$$(2)\qquad \sum_{t=1}^{\infty}\beta^{t-1}(1-p)^t = (1-p)/[1-\beta(1-p)],$$

the problem can be rewritten as

$$(3)\qquad \underset{p_{\mathrm{j}}}{\mathrm{Max}}\, V=U(w(p_{\mathrm{j}}))\cdot(1-p)/[1-\beta(1-p)].$$

7. The series of studies using variations of this approach include Moore and Viscusi (1988), Viscusi and Moore (1989), and Moore and Viscusi (1990).

8. This is because p_{j} is a very small part of p, and p_{m} does not change rapidly over time for the age groups considered. In any case, it turns out that the variable $1-p$ has very little effect on the empirical results.

9. Since the average worker is 36, the true terminal T is on average 40 years in the future. For an individual with a time preference rate of 10% and an annual mortality risk of 3%, the lifetime utility will be overestimated by approximately $(1-p)\cdot U(w)\cdot[1/(1-\beta(1-p)-(1-\beta^T(1-p)^T)/(1-\beta(1-p)]=0.97\cdot U(w)\cdot[1/(1-0.90\cdot 0.97)-(1-0.90^{40}\cdot 0.97^{40})/(1-0.90\cdot 0.97)\approx 0.03\cdot U(w)$, which is 0.4% of total lifetime utility.

10. Theoretically, the utility function could also include a vector of other exogenous variables ($\boldsymbol{X}_2$), which could be influenced by p_{j}. Nevertheless, to demonstrate the dynamics of the basic empirical model, we assume that wages are only influenced by risk and $\partial \boldsymbol{X}_2/\partial p_{\mathrm{j}}=0$. We address the implications of relaxing this assumption in footnote 12 below. We also relax this assumption for the smoking and education variables in the estimates presented below.

Taking the first-order condition yields:

$$(4)\quad (\partial U/\partial w\cdot\partial w/\partial p_j)\cdot(1-p)/[1-\beta(1-p)] = U(w(p_j))\cdot\beta(1-p)/[1-\beta(1-p)]^2 + U(w(p_j))/1-\beta(1-p).$$

Equation (4) indicates that occupational fatality risk is chosen such that the marginal discounted lifetime utility of increased wages equals the marginal discounted disutility from the associated loss of life expectancy.

Rearranging terms to solve for the compensating differential value $\partial w/\partial p_j$ results in:

$$(5)\quad \partial w/\partial p_j = U(w(p_j))/(\partial U/\partial w)\cdot[1/(1-p)+\beta/(1-\beta(1-p))].$$

Below, we introduce a functional form of U that allows for the efficient estimation of individual utility in a system of equations.

B. The Empirical Model

As Equation (5) demonstrates, empirical estimation of utility requires that wages be modeled as a function of the implicit price of risk $\partial w/\partial p_j$. The data set we are using does not contain any variables that are adequate proxies for this variable. Therefore, we estimate this equation using the two-stage estimation procedure developed by Viscusi and Moore (1989). In the first stage, we estimate the implicit price of risk in a labor market equation using a method Kahn and Lang (1988) suggested for the estimation of structural hedonic systems. In the second stage, this constructed variable is utilized in a wage equation reflecting individual preferences toward the labor market and other factors likely to affect the wages an individual may command.

The general empirical model is derived from Equation (5) above. First, we assume a standard log wage specification as the individual's utility function and substitute this functional form into Equation (5), yielding[11]:

$$(6)\quad \partial w/\partial p_j = \ln w/(1/w)\cdot[1/(1-p)+\beta/(1-\beta(1-p))].$$

Rearranging terms and simplifying the term in brackets results in the log wage equation:

$$(7)\quad \ln w = [(1-p)-\beta(1-p)^2]\cdot(1/w)\cdot\partial w/\partial p_j.$$

Because $\partial \ln w = 1/w \times \partial w$, this can be expressed as:

$$(8)\quad \ln w = [(1-p)-\beta(1-p)^2]\cdot\partial \ln w/\partial p_j.$$

Equation (8) can be simplified further by setting $(1-p)^2$ equal to $(1-p)$. This greatly simplifies the empirical estimation and is justified because observed small values of p result in $1-p$ and $(1-p)^2$ being practically identical, with both approximately equal to 1.0.

To identify the model, a vector of exogenous variables, $\boldsymbol{X}_2$, as well as an error term are added. The vector $\boldsymbol{X}_2$ includes indicators of an individual's distinct tastes and preferences (including smoking status) and other variables influencing an individual's ability to compete in the labor market. Finally, using i to denote the individual-specific nature of the utility function yields the wage function[12]:

$$(9)\quad \ln w_i = (1-\beta)(1-p_i)\cdot\partial \ln w_i/\partial p_j + \phi' X_{2i} + \varepsilon_{2i}.$$

Equation (9) is an almost estimable form of a wage equation that approximates the worker's discount rate as $(1-\beta)$.[13] Before this equation can be estimated, however, an individual-specific implicit price of risk ($\partial \ln w_i/\partial p_j$) must be estimated. To do so, we first estimate the market wage equation. This allows us to obtain a market opportunities locus for $\partial \ln w_i/\partial p_j$. As the wage-offer curve is concave with respect to risk due to the increasing marginal cost of employer safety measures and the availability of technology substitutes, linear estimation of the variable $\partial \ln w_i/\partial p_j$ is not

11. We explore the effect of alternative functional forms for U in the empirical analysis below.

12. If we relax the assumption that $\partial \boldsymbol{X}_2/\partial p_j = 0$, as suggested in footnote 10, the fully identified empirical equation would be: $\ln w_i = (1-\beta)(1-p_i)\cdot\partial \ln w_i/\partial p_j + (1-\beta)(1-p_i)\cdot(\partial \ln w_i/\partial \boldsymbol{X}_{2i})(\partial \boldsymbol{X}_{2i}/\partial p_j) + \phi' \boldsymbol{X}_{2i} + \varepsilon_{2i}$. To specify such a model, however, is not useful for our purposes. Although, theoretically, such a set of relationships may exist, such a full specification would undermine our goal of examining the relationship between smoking and time preference because the smoking effect would be scattered across correlates of smoking. Below, for illustrative purposes, we do examine and discuss the effect of one correlate of smoking (education) on time preference.

13. The actual value measured is $(1-\beta) = r/(1+r) \approx r$ for small values of r. The rates reported are the true value of r.

appropriate. Instead, using a method suggested by Kahn and Lang (1988) and used by Viscusi and Moore (1989), we use labor market differences in geographically distinct regions to map out a locus of opportunities, which are then used to estimate the implicit price of risk.

The model developed by Kahn and Lang (1988) was based on the realization that different markets have different distributions of consumers and firms. Therefore, an exogenous characteristic can affect the marginal price of the good in question without affecting the structure of the supply and demand equations themselves. This is true because, while distributional differences lead to different equilibrium outcomes, the relationship between marginal prices, consumers' attributes, and demands for specific product characteristics is not affected. Consequently, regional variables are good estimators because they indicate different points on the opportunity locus but are not likely to be determinants of wages in their own right.[14]

The wage equation used to define the opportunity locus is:

$$(10)\quad \ln w = \sum_{n=1}^{4} (\kappa_n R_{\mathrm{ni}} p_{\mathrm{j}} + 0.5\theta_n R_{\mathrm{ni}} p_{\mathrm{j}}^2) + \delta' X_{1\mathrm{i}} + \varepsilon_{1\mathrm{i}},$$

which is the integral of the hedonic wage equation

$$(11)\quad \partial \ln w/\partial p_{\mathrm{j}} = \sum_{n=1}^{4} (\kappa_n R_{\mathrm{ni}} + \theta_n R_{\mathrm{ni}} p_{\mathrm{j}})$$

that Kahn and Lang (1988) posit as an efficient estimator of $\partial \ln w_{\mathrm{i}}/\partial p_{\mathrm{j}}$. The vector $X_{1\mathrm{i}}$ consists of those variables that shift the market constraint.[15] The four R_n variables are regional dummy variables indicating residence in either the Northeast, South, Midwest, or West. The error term $\varepsilon_{1\mathrm{i}}$ reflects unobserved wage determinants.

The estimation of Equation (10) yields predicted values of $\partial \ln w_{\mathrm{i}}/\partial p_{\mathrm{j}}$ that can be used to estimate Equation (9).

C. Heterogeneous Rates of Time Preference

To this point, the model we employ makes it possible to calculate the rate of time preference for a given population. It is not, however, suited yet for examining differences in time preference across subgroups of a heterogeneous population. In particular, the model must permit the implied discount rate to vary by smoking status. There are two methods that can be used to do so. The first method assumes a universally applicable wage-offer curve. The second method recognizes potential differences in smokers' market opportunities.

The first approach is the method suggested by Viscusi and Moore (1989), which redefines the discount rate as a function of exogenous individual characteristics. Within our analysis of smoking behavior, the discount rate satisfies

$$(12)\quad 1 - \beta = (1 - \beta)_{\mathrm{B}} + \beta_S S_{\mathrm{i}} + \varepsilon_{3\mathrm{i}}$$

where $(1-\beta)_{\mathrm{B}}$ is the base discount rate, β_{S} is the effect of smoking status on the discount rate, S_{i} is a dummy variable for smoking status, and $\varepsilon_{3\mathrm{i}}$ is a measure of individual heterogeneity not captured by the model. Substituting Equation (12) into Equation (9) leads to

$$(13)\quad \ln w_{\mathrm{i}} = (1-\beta)_{\mathrm{B}}(1-p_{\mathrm{i}})\cdot\partial \ln w_{\mathrm{i}}/\partial p_{\mathrm{j}} + \beta_{\mathrm{S}} S_{\mathrm{i}}(1-p_{\mathrm{i}})\cdot\partial \ln w_{\mathrm{i}}/\partial p_{\mathrm{j}} + \phi' X_{\mathrm{i}} + \varepsilon_{4\mathrm{i}},$$

which is estimable.[16]

A key point to note regarding this methodology is that the derivation of labor demand curves in the first stage assumes a homogeneous labor market facing smokers and nonsmokers alike. The market opportunities locus is assumed to be fixed, and, consequently, all individual-specific wage differences are seen as coming from the supply side of the labor market. If differences in risk attitudes lead to worker productivity differences (i.e., due to higher accident rates), this may not be an accurate representation of the actual labor market. The easiest way of correcting this is by including smoking status as an independent variable in vector $X_{1\mathrm{i}}$ of Equation (10). This may not, however, reflect all of the interactive effects of smoking with other wage determinants. If not, the market opportunities

14. The example Kahn and Lang (1988) used estimated prices for a uniform good. Wages are not as stable as prices are across regions because there are regional differences in wages that are not picked up by standard wage equation variables. To correct for this problem, we added a state-specific PCI variable.

15. Relevant variables include race, sex, education, marital status, smoking status, industry of employment, and union affiliation.

16. In effect, Equation (13) relaxes the assumption that $\partial X_2/\partial p_{\mathrm{j}} = 0$ for the smoking variable. In our estimates below, we also relax this assumption for education to demonstrate the effect of this smoking covariate on individual rates of time preference.

locus equations for nonsmokers and smokers can be estimated separately as:

$$(14)\quad \ln w(s) = \sum_{n=1}^{4} (\kappa_n R_{\mathrm{ni}} p_{\mathrm{js}} + 0.5\theta_n R_{\mathrm{ni}} p_{\mathrm{js}}^2) + \delta' X_{1\mathrm{si}} + \varepsilon_{1\mathrm{si}}$$

and

$$(15)\quad \ln w(\mathrm{ns}) = \sum_{n=1}^{4} (\kappa_n \mathrm{R}_{\mathrm{ni}} p_{\mathrm{j(ns)}} + 0.5\theta_n R_{\mathrm{ni}} p_{\mathrm{j(ns)}}^2) + \delta' X_{1\mathrm{(ns)i}} + \varepsilon_{1\mathrm{(ns)i}},$$

where w(s) is the smoker's wage and w(ns) is the nonsmoker's wage.

III. WAGE EQUATION ESTIMATES

A. The Data

The empirical analysis utilizes several data sources. The primary database used is the Current Population Survey: Tobacco Use Supplement (CPS) (U.S. Bureau of the Census 1995–2004). The CPS is a national probability sample of the civilian noninstitutionalized population. Although each year over 100,000 individuals were selected to be interviewed for the CPS, only a small subset of these persons answered questions that could be used to calculate an individual's hourly wage. To ensure a sample size sufficiently large to measure small wage-risk trade-offs, we aggregate data from CPS surveys collected between 1992 and 2001. The advantage of CPS over other large data sets with tobacco use data, such as the National Health Interview Survey and the Medical Expenditure Panel Survey, is that it is larger, has good wage data, and includes publically available state identifiers, which facilitate the use of more precise risk and income measures.

Fatality data from the National Traumatic and Occupational Fatality (NTOF) surveillance system serve as our job risk measure (NIOSH 2001).[17] The NTOF is a continuing program instituted by the National Institute for Occupational Safety and Health (NIOSH) that records all occupational fatalities and breaks them down by industry group and state. As many as 510 state/industry risk combinations are possible from this data. However, the actual number of combinations we use is less than 400 due to our restrictions on the data set and data significance problems (as determined by NIOSH). To minimize the influence of year to year fluctuations, we use the average death risk over the NTOF surveillance period for which there are more recent reports of state-industry risks (1991–1995).[18] These data are merged with the CPS by the worker's industry and state of residence.

We also matched other variables to workers in the data set using data from the Bureau of Economic Analysis data on state-specific per capita income (PCI) (U.S. Bureau of Economic Analysis 2002) and an overall mortality rate figure from National Center for Health Statistics (NCHS) life tables (Arias 2004).

The sample is restricted in a manner that is consistent with many studies in the literature. In particular, the sample is limited to full-time private-sector workers not in the agriculture, forestry, and fishing industries. Wages are restricted to those making more than \$2 an hour but less than \$100,000 a year.[19] The sample is further limited to include only workers between the ages of 18 and 65 and omits those with less than a first-grade education and whose union status was not determined. Persons whose smoking status was not determined are also omitted. These limitations resulted in a reduction of the sample of working persons with positive hourly wages from 102,829 to 42,184 workers.

The descriptive statistics for the full sample and the blue-collar subsample appear in Table 1.[20] The standard wage equation variables all have values that are consistent with the literature. In the full sample, individuals have average wages of \$11.23 an hour, have 12.5 years of schooling, are 37.6 years old, and

17. The NTOF measure is preferable to the corresponding Bureau of Labor Statistics (BLS) fatality measure because it is a less aggregated measure and is a census of all workplace fatalities as opposed to the BLS' random sampling of businesses.

18. NIOSH collects more recent NTOF fatality data, but these data have not been reported in the detailed form (state and industry fatality rates) required by our analysis.

19. The latter of these restrictions is imposed by the CPS.

20. Blue-collar workers are defined as those with CPS occupational classification codes of 400 or greater. All workers other than those employed in managerial, professional, technical, sales, and administrative support occupations are assumed to be blue-collar workers. There are 24,376 workers in the blue-collar subsample.

TABLE 1
Descriptive Statistics (Means and Standard Errors)

Variables	Male Blue-Collar	Full Sample
Hourly wage	11.89	11.23
	(5.40)	(5.83)
Job fatality risk (per 100,000)	6.97	4.93
	(7.23)	(5.95)
Mortality risk (per 100,000)	3,351.2	2,712.3
	(3,048.2)	(2,714.4)
Current smoker	0.35	0.30
	(0.48)	(0.46)
Northeast region	0.20	0.20
	(0.40)	(0.40)
South region	0.30	0.30
	(0.46)	(0.46)
Midwest region	0.28	0.27
	(0.45)	(0.45)
West region	0.23	0.22
	(0.42)	(0.42)
Education	11.97	12.54
	(2.06)	(2.15)
White	0.87	0.85
	(0.34)	(0.36)
Male	—	0.54
	—	(0.50)
Married	0.62	0.57
	(0.49)	(0.49)
Age	37.33	37.58
	(11.36)	(11.41)
Experience	19.36	19.04
	(11.64)	(11.70)
White-collar worker	—	0.42
	—	(0.49)
Union member	0.27	0.19
	(0.45)	(0.39)
State PCI	34,668	34,803
	(5,746)	(5,875)

have 19.0 years of working experience.[21] Furthermore, 85% of the sample members are white, 54% are male, and 57% are married. As one would expect, those in the blue-collar sample have less education, are more likely to be men, and are more likely to belong to a union.

The job fatality risk of 4.9 per 100,000 workers is lower than the rate of 7.8 reported in Viscusi and Moore (1989) but higher than the 1991–1995 national average of 4.4 reported by NIOSH.[22] A continuing secular decline in national worker fatality rates is responsible for the former disparity, whereas the exclusion of government and agricultural workers from our analysis results in the latter discrepancy. The overall mortality risk is 2,712 fatalities per 100,000 workers. Each individual is matched with a mortality rate pertinent to the person's age, sex, and race. Although it would be appropriate to specify mortality rates by smoking status as well, the NCHS does not collect this information. The mathematical structure of the estimation problem suggests that this lack of mortality risk information based on smoking status may result in a slight upward bias of the estimated compensating differential $((1 - p)\partial \ln w_i/\partial p_j)$, which, in turn, leads to a minor dampening of the magnitudes of $(1 - \beta)_B$ and β_S.

The smoking status variables reflect reasonable prevalence rates.[23] In particular, 30% of all workers are current smokers and 20% are former smokers.[24] The model outlined above suggests that if smokers do indeed have higher rates of time preference than do nonsmokers, we would expect them to choose riskier jobs at lower pay. As Figure 1 demonstrates, this is the case. For each subsample, smokers choose jobs with higher fatality rates and, in return, receive lower wages than do nonsmokers.

B. Market Wage Estimates

In the two-stage model developed above, the estimation of the market wage is the first-stage equation. Table 2 presents the results of evaluating Equation (10) for all male workers and for the male blue-collar subsample. The separate treatment of male blue-collar workers is justified by a significant F test ($F = 76.62$). All of the included variables have the expected signs, and most of these variables are significant.

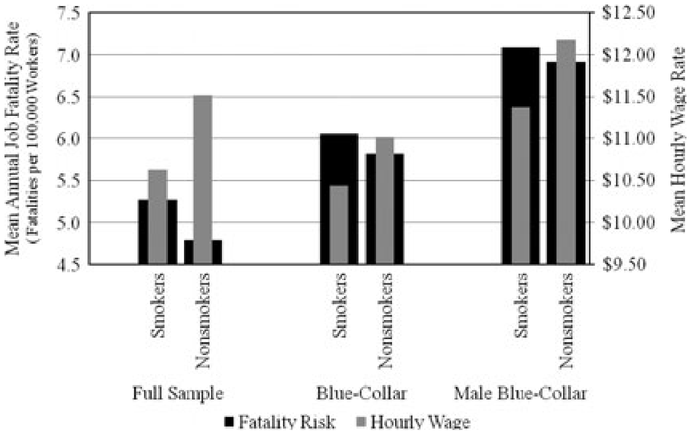
21. The CPS did not include an experience variable. This variable was estimated to be age–education–6. This is a standard technique in the literature.

22. Note that the 1/20,000 annual fatality risk estimate based on NTOF data is similar to the 1/25,000 fatality risk estimate using more recent data from the Bureau of Labor Statistics Census of Fatal Occupational Injuries.

23. We define current smokers as those who self-identify themselves as "some days" or "everyday" smokers in the CPS.

24. According to the NCHS (2006), the official smoking prevalence rate between 1992 and 2001 decreased from 25% to 23% for all persons aged 18 and older. The disparity between these figures and the prevalence found in our sample is largely due to our exclusion of elderly Americans, a large number of whom quit smoking for health reasons.

FIGURE 1
Risk and Wage Means for Select Subsamples



Of particular importance are the risk-region interaction variables. These interactions are the primary components used in the computation of the predicted implicit price of risk. The coefficients have the expected signs and are statistically significant. Wages increase with risk at a decreasing rate. These results are consistent with the theoretical hypothesis of a wage-offer curve that is concave with respect to risk.

The other variables included in Table 2 are those that shift the market opportunities locus. Smoking status is included in the market wage equation to reflect its potential effect on the wage-offer curve. The equation estimates indicate that smoking has a significant negative effect on wages, whereas being a former smoker has a significant positive effect on wages.

The coefficients for the remaining independent variables accord with expectations. Education, experience, and union membership all have a positive influence on wages. Similarly, being white and married increases one's wages. Finally, non-risk-related differences in regional wages as measured by the PCI of the state of residence are positively correlated with wages.

We noted above that specification in Table 2 may not be appropriate if the labor markets faced by smokers and nonsmokers are fundamentally different.[25] In such a case, separate estimation of wage-offer curves for smokers and nonsmokers, as reflected in Equations (14) and (15), is appropriate. A significant F test on a simple stratification by smoking status is consistent with these hypothesized differences ($F = 4.43$); however, this significance is likely an artifact of the correlation between smoking status and occupation type (which is shown to be justifiably separable above). Results for the smoker and nonsmoker subsamples of blue-collar males are displayed in Table 3. As in Table 2, all risk variables have the expected coefficients, and most are statistically significant. In some regions, smokers appear to command a somewhat smaller wage premium for risk. All other variables act in a manner similar to those in the full sample. More importantly, when the sample is restricted to include only blue-collar workers, an F test for the smoking status stratification yields a statistically insignificant value of 0.98. This suggests that smokers and nonsmokers face similar wage-offer curves and estimation of Equation (10), as illustrated in Table 2, is not likely to result in biased estimates.

IV. DERIVATION OF RATES OF TIME PREFERENCE

To derive predicted rates of time preference, the results of Equation (10) are used to estimate each individual's implicit price of risk ($\partial \ln w_i / \partial p_j$), which is then used as a regressor in Equation (9). However, prior to its inclusion as a regressor, the implicit price of risk must be transformed in two ways. First, in order

25. Viscusi and Hersch (2001) conclude that smokers and nonsmokers face a different opportunities locus based on their observed trade-offs between wages and nonfatal injury risks.

TABLE 2
Market Wage Equations (Coefficients and Standard Errors)

Variables	Male Blue-Collar	Full Sample
Northeast × fatality risk	0.018***	0.013***
	(0.002)	(0.002)
Northeast × fatality risk^2 (÷1,000)	−0.473***	−0.271***
	(0.095)	(0.079)
South × fatality risk	0.004***	0.003***
	(0.001)	(0.001)
South × fatality risk^2 (÷1,000)	−0.022	−0.006
	(0.024)	(0.021)
West × fatality risk	0.015***	0.015***
	(0.001)	(0.001)
West × fatality risk^2 (÷1,000)	−0.215***	−0.212***
	(0.034)	(0.026)
Midwest × fatality risk	0.016***	0.015***
	(0.001)	(0.001)
Midwest × fatality risk^2 (÷1,000)	−0.343***	−0.302***
	(0.057)	(0.044)
Current smoker	−0.022**	−0.028***
	(0.005)	(0.004)
Education	0.036***	0.045***
	(0.001)	(0.001)
White	0.065***	0.054***
	(0.008)	(0.005)
Married	0.076***	0.055***
	(0.006)	(0.004)
Experience	0.023***	0.021***
	(0.001)	(0.001)
Experience^2 (÷1,000)	−0.357***	−0.323***
	(0.017)	(0.012)
Union member	0.241***	0.220***
	(0.006)	(0.005)
State PCI (÷10,000)	0.081***	0.093***
	(0.005)	(0.003)
Adjusted R^2	0.45	0.46
N	17, 395	42, 184

Notes: Occupational and survey year dummy variables and a constant term are included as regressors but not reported.

*Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level.

TABLE 3
Market Wage Equations (Coefficients and Standard Errors)

Variables	Blue-Collar Male Smokers	Blue-Collar Male Nonsmokers
Northeast × fatality risk	0.013***	0.020***
	(0.003)	(0.003)
Northeast × fatality risk^2 (÷1,000)	−0.281*	−0.548***
	(0.152)	(0.117)
South × fatality risk	0.002	0.005***
	(0.002)	(0.001)
South × fatality risk^2 (÷1,000)	0.021	−0.046
	(0.037)	(0.030)
West × fatality risk	0.015***	0.016***
	(0.002)	(0.002)
West × fatality risk^2 (÷1,000)	−0.188***	−0.237***
	(0.056)	(0.041)
Midwest × fatality risk	0.014***	0.017***
	(0.002)	(0.002)
Midwest × fatality risk^2 (÷1,000)	−0.312***	−0.354***
	(0.081)	(0.082)
Education	0.035***	0.037***
	(0.002)	(0.002)
White	0.061***	0.066***
	(0.014)	(0.010)
Married	0.068***	0.083***
	(0.009)	(0.007)
Experience	0.024***	0.023***
	(0.001)	(0.001)
Experience^2 (÷1,000)	−0.385***	−0.345***
	(0.030)	(0.021)
Union member	0.251***	0.237***
	(0.010)	(0.007)
State PCI (÷10,000)	0.085***	0.079***
	(0.009)	(0.006)
Adjusted R^2	0.43	0.45
N	6, 039	11, 356

Notes: Occupational and survey year dummy variables and a constant term are included as regressors but not reported.

*Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level.

to view the coefficient as the estimated discount rate, $\partial \ln w_i / \partial p_j$ must be multiplied by the individual's overall mortality risk $(1 - p)$. Next, we make adjustments by a factor α to account for the fact that w is measured as an individual's hourly rate, whereas p_j is the annual job fatality risk per 100,000 workers. This leads to an adjusted implicit price of risk, $\text{IW} = \alpha \times (1 - p_i) \times \partial \ln w_i / \partial p_j$.

To explore differences in the rate of time preference across subgroups, we interact the value of IW with the variable representing a subpopulation of interest (i.e., current smoker) and include it as another regressor. In addition, the equation includes an education/IW interaction variable to account for the possibility that the smoking interaction variable is merely reflecting educational differences.[26] The resulting predicted value(s) are used to estimate both Equations (9) and (13) from which $(1 - \beta)_B$ and β_S are directly estimated. Table 4 presents the results for the full sample.

Three specifications are included in Table 4, with each reflecting an alternative assumption for individual preferences and the degree of risk aversion. Failure to correctly specify the functional form can lead to biased estimates because, in this case, decisions based on risk preferences may be attributed incorrectly to time preference.

The first specification assumes the log wage form, which is the dominant format in the hedonic wage literature. As expected, education is negatively related to time preference, whereas smoking is positively related to time preference. Evaluated keeping education constant at 12 years, smokers have a rate of time preference of 12.6%, which significantly exceeds the rate of 9.7% estimated for nonsmokers. A higher rate of time preference for smokers and a lower rate of time preference for more educated individuals would be consistent with the theory put forth by Fuchs (1986) that the relationship between smoking and education is due to differences in time preference rather than differences in the ability to process risk information. However, this result is also consistent with the Becker and Mulligan (1997) theory that addictive behaviors increase discount rates whereas education has a negative effect on time preference.

The second specification derives discount rates under the assumption that $U(w) = w^{0.3}$, as suggested by Viscusi and Moore (1989). The assumption that individuals are less risk averse than typically modeled leads to reduced rates of time preference for both smokers (10.6%) and nonsmokers (8.3%). Notably, the interaction term for smoking status and wage–risk trade-off rates is not statistically significant for the full sample under this assumption. For purposes of comparison, the third specification employs the (unrealistic) assumption of risk-neutral individuals. The effect on coefficients and significance found in the second specification is amplified in the third specification. Although rates of time preference for smokers and nonsmokers are further diminished under the restrictive assumption of risk-neutrality (and the significance of the difference between the two is similarly diminished), there is still a higher point of the rate of time preference for smokers. Table 5 presents parallel results for the male blue-collar subsample, which has been the focus of much of the literature on compensating differentials for job risk. Under reasonable assumptions (specifications 1 and 2), the average rate of time preference for these workers appears to be lower than in the full sample, though the difference is not statistically significant. The most noteworthy difference between the results in Tables 4 and 5 is that all specifications of the male blue-collar subsample demonstrate a significant positive relationship between smoking and time preference.

For purposes of comparison, we estimate discount rates for alternative samples and report their values in Table 6.[27] In panel A, we estimate rates of time preference based on the average educational level for the full sample (12.54 years). Assuming a comparable education level allows us to isolate the pure effect from smoking status and avoid any bias caused by educational differences. The estimated rates

26. To measure the difference for smokers, for example, the variables IW, IW × education, and IW × smoker would be included.

27. Given that the estimated rates of time preference for the log wage and the $\text{wage}^{0.3}$ specifications are not markedly different, we use the more common log wage specification for Tables 6 and 7.

TABLE 4
Implicit Price Equations (Full Sample)

Variables	**$(1-p)=0$ Log Wage**	**$(1-p)=0.3$ Wage$^{0.3}$**	**$(1-p)=1$ Wage**
Implicit price $(\partial w/\partial p_j)\times(1-p)$	0.185***	0.142***	0.034
	(0.047)	(0.048)	(0.062)
$(\partial w/\partial p_j)\times(1-p)\times$ education	−0.007**	−0.005	0.002
	(0.004)	(0.004)	(0.005)
$(\partial w/\partial p_j)\times(1-p)\times$ smoker	0.029*	0.023	0.011
	(0.016)	(0.016)	(0.017)
Implied discount rate (with high school education)			
Nonsmoker	9.7	8.3	5.4
Smoker	12.6	10.6	6.5
Education	0.042***	0.103***	50.130***
	(0.002)	(0.005)	(3.409)
Smoker	−0.049***	−0.117***	−51.823***
	(0.008)	(0.021)	(11.438)
White	0.036***	0.096***	52.507***
	(0.005)	(0.012)	(6.385)
Married	0.052***	0.124***	54.914***
	(0.004)	(0.009)	(5.106)
Age	0.042***	0.101***	44.726***
	(0.001)	(0.003)	(1.382)
Age^2	−0.0004***	−0.001***	−0.440***
	(0.0000)	(0.000)	(0.018)
Adjusted R^2	0.41	0.40	0.33

Notes: Ten occupational dummy variables, six survey year dummy variables, and a constant term are included as regressors but not reported.
*Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level.

range from 5.1% for male nonsmokers to 12.2% for blue-collar smokers.

A number of interesting phenomena are revealed in Table 6, which summarizes the implied rate of discount for different groups. Panel A presents results in which each group is evaluated by assuming the same educational level of 12.54 years. The first general result is that, in each case, smokers have the highest discount rate and never smokers have the lowest. The average rate is 12.2% for current smokers and 9.3% for nonsmokers. The differences between nonsmokers' and current smokers' discount rates are significant for all subpopulations. Somewhat unexpectedly, holding education constant, blue-collar workers do not exhibit significantly greater rates of time preference than white-collar workers. Also, women generally have higher rates of time preference than do men.[28]

Estimated discount rates representative of the actual mean educational attainment of the population subgroups we examined are presented in panel B of Table 6. Educational attainment averages from 11.83 years for blue-collar male

28. This is not to say that women are more shortsighted than are men. Rather, given the institutional structures of our society, it is likely that there is a selection bias that governs which women choose to be in the workforce. For example, it is possible that individuals (male and female) experience a decrease in their rates of time preference as they begin to have children (due their newly acquired concern for their children's futures, their children's utility functions become embedded in their own). At this stage, women are much more likely to leave the workforce (at least temporarily) to care for their children than are men. Therefore, the fact that there is a higher proportion of childless women in the workforce than men suggests that the estimated discount rate for women is likely to be biased upwards.

TABLE 5
Implicit Price Equations (Male, Blue-Collar Workers)

Variables	$(1 - p) = 0$ Log Wage	$(1 - p) = 0.3$ Wage$^{0.3}$	$(1 - p) = 1$ Wage
Implicit price $(\partial w/\partial p_j) \times (1 - 2p)$	0.266***	0.258***	0.236***
	(0.061)	(0.058)	(0.054)
$(\partial w/\partial p_j) \times (1 - 2p) \times$ education	−0.017***	−0.017***	−0.015***
	(0.005)	(0.005)	(0.005)
$(\partial w/\partial p_j) \times (1 - 2p) \times$ smoker	0.048**	0.043**	0.036*
	(0.020)	(0.020)	(0.020)
Implied discount rate (with high school education)			
Nonsmoker	6.4	6.0	5.3
Smoker	11.2	10.3	8.8
Education	0.040***	0.100***	48.409***
	(0.003)	(0.007)	(3.284)
Smoker	−0.060***	−0.146***	−70.050***
	(0.011)	(0.028)	(13.908)
White	0.067***	0.167***	78.575***
	(0.008)	(0.020)	(10.049)
Married	0.083***	0.193***	82.282***
	(0.006)	(0.015)	(7.854)
Age	0.047***	0.113***	49.994***
	(0.002)	(0.004)	(2.007)
Age^2	−0.0005***	−1.128***	−0.489***
	(0.0000)	(0.493)	(0.026)
Adjusted R^2	0.36	0.35	0.30

Notes: Five occupational dummy variables, six survey year dummy variables, and a constant term are included as regressors but not reported.

*Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level.

smokers to 12.68 years for the full sample of nonsmokers. Adjusting for these educational differences leads to a decline in estimated rates of time preference for nonsmokers and an increase in these rates for smokers. Consequently, the aggregate difference in discount rates between smokers and nonsmokers is a function of both smoking status and education. Also, when we allow average education to vary across samples, discount rates for blue-collar workers rise relative to their full-sample cohorts.

In Table 3, the coefficients for independent variables across smoking status were similar, though not the same. Therefore, to avoid imposing constraints on the coefficients by smoking status, we estimate the discount rates of nonsmokers and smokers separately to account for potential differences in the influence of independent variables across smoking status, as specified in Equations (14) and (15). In Table 7, the rates of time preference derived in this manner are found to be significantly higher for smokers and lower for nonsmokers. These differences are often quite stark. For the full sample, the rate of time preference for current smokers is 13.8%, as compared to 8.1% for nonsmokers. For males, current smokers have an average rate of discount of 11.5%, as compared to only 3.8% for nonsmokers. Blue-collar workers who smoke have a rate of time preference of 16.3%, which is over twice as high as the 7.8% rate for nonsmokers. These results strengthen the central finding that smokers have a higher rate of time preference than do nonsmokers.

V. CONCLUSION

Consistent with their greater risk-taking behavior with respect to cigarettes, workers who are smokers also exhibit much higher rates of time preference than do nonsmokers. The sample of all workers reveals estimated rates of time preference averaging 13.8% for smokers, as opposed to 8.1% for nonsmokers. Much of this difference is due to educational differences, but even when holding education constant there remains a significant discrepancy in intertemporal preferences by smoking status. These results are consistent with the overall relationships that have been hypothesized by different models

TABLE 6
Implied Rates of Time Preference

	Full Sample	Nonsmokers	Current Smokers
Panel A: Estimated rates of time preference for workers with 12.54 years of education			
Blue-collar workers			
Total ($n = 24,376$)	10.0	8.8	12.1**
Males ($n = 17,395$)	7.2	5.5	10.3**
All workers			
Total ($n = 42,184$)	10.1	9.3	12.2*
Males ($n = 22,925$)	6.2	5.1	8.5*
Panel B: Estimated rates of time preference based on each subsample's mean education			
Blue-collar workers			
Total	10.8	9.6	12.9**
Males	8.2	6.3	11.5**
All workers			
Total	10.2	9.2	12.4*
Males	6.4	5.1	9.1*
		Mean years of education	
Blue-collar workers			
Total	11.91	11.95	11.84
Males	11.97	12.05	11.83
All workers			
Total	12.54	12.68	12.21
Males	12.37	12.53	12.06

Notes: In all cases, the implied rate of time preference is significantly greater than 0. Reported significance in the final column represents the significance between smokers and nonsmokers, derived using Equation (5).
*Significance at the 10% level; **significance at the 5% level.

TABLE 7
Implied Rates of Time Preference
(Standard Errors)

	Full Sample	Nonsmokers	Current Smokers
Blue-collar workers			
Total	10.8***	7.8***	16.3***
	(0.8)	(1.0)	(1.5)
Males	8.2***	5.0***	15.1***
	(1.0)	(1.2)	(1.9)
All workers			
Total	10.2***	8.1***	13.8***
	(0.8)	(0.9)	(1.3)
Males	6.4***	3.8***	11.5***
	(1.0)	(1.2)	(1.7)

*Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level.

with respect to rates of time preference and risk taking. However, the results cannot distinguish whether the results are due to exogenous differences in intertemporal preferences, endogenous differences, or intertemporal preferences in which hyperbolic discounting or time inconsistency may play a role.

The findings do, however, shed light on recent estimates of the private mortality cost to smokers. Estimated at a 3% discount rate, the private mortality cost per pack of cigarettes to smokers is $222 for men and $94 for women, based on the results in Viscusi and Hersch (2008). These estimates are quite high. However, at interest rates of 14%, which is smokers' average rate of time preference for years of life, the mortality cost per pack drops to under $24 for men and $6 for women. For the 16% rate of time preference for blue-collar smokers, the costs per pack drop to $18 for males and $4 for females. The labor market estimates of rates of time preference based on fatality risks on the job consequently provide a basis for assessing how smokers may perceive the subjective value of the considerable mortality risks of smoking. Although smokers incur more substantial mortality risks than nonsmokers, these decisions stem in part from different rates of time preference with respect to years of life.

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