Journal of Environmental Economics and Management 59 (2010) 260–270

Contents lists available at ScienceDirect

Journal of Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

A quantile estimation approach to identify income and age variation in the value of a statistical life

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ARTICLE INFO

Article history:
Received 6 July 2009
Available online 4 January 2010

Keywords:
Value of a statistical life
Quantile regression
Income elasticity

ABSTRACT

In theory, heterogeneity in individual characteristics translates into variation in the marginal willingness to pay for a mortality risk reduction. Two dimensions of heterogeneity, with respect to income and age, have recently received attention due to their policy relevance. We propose a quantile regression approach to simultaneously explore these two sources of heterogeneity and their interactions within the context of the hedonic wage model, the most common revealed preference approach for obtaining value of statistical life estimates. We illustrate the approach using data from the Health and Retirement Study (HRS). We find that the impact of age on the wage–risk tradeoff varies across the wage distribution. This result indicates important interactions between age and income heterogeneity. Thus, the conventional mean hedonic wage regression, even when the mean effect is allowed to vary with age, masks important heterogeneity.

1. Introduction

The valuation of mortality risk reductions has implications for numerous policy arenas including transportation, occupational safety, food safety, and environmental quality because mortality risk reductions represent a large share of the estimated benefits of these policies. For example, for each of the three final air quality rules promulgated in 2004, reduced mortality risks represented approximately ninety percent of total monetized benefits [33]. Because the risk reductions associated with these policies are distributed non-uniformly across individuals, identifying variation in the willingness to pay for mortality risk reductions across individuals is policy-relevant.

An extensive literature examines various sources of heterogeneity in estimates of the marginal willingness to pay for a fatality risk reduction, the so-called value of a statistical life (VSL). Economic theory suggests factors that influence the magnitude of the tradeoffs including (but not limited to) preferences and ability to pay. The two potential sources of VSL heterogeneity that have received the most attention in the literature are due to age and income differences.

The hedonic wage model is the dominant approach to obtaining estimates of the VSL [40]. The empirical explorations of VSL heterogeneity within this framework often involve the inclusion of an interaction between the fatality risk measure and a variable that captures the relevant dimension of heterogeneity (e.g., age) as a regressor in the hedonic wage specification. Income heterogeneity is not amenable to this interaction technique with hedonic wage models. As Hammitt et al. [19] note, "because income (or the wage rate) is the dependent variable, it cannot be used as an explanatory variable, and so these studies typically do not provide information about income elasticity" (p. 1). Existing techniques for exploring

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doi:10.1016/j.jeem.2009.11.004

income heterogeneity of the VSL either rely on revealed preference data from several samples (e.g., hedonic wage meta-analyses) or on stated preference data.

We propose a quantile regression approach to examine income (i.e., wage) heterogeneity. To our knowledge, our framework represents the only approach to explore wage heterogeneity in the VSL within the structure of the hedonic wage model. By including additional controls to account for age heterogeneity, our empirical models also allow for a differential effect of age on the wage–risk tradeoff at different points in the wage distribution. This is important because numerous changes, some of which affect the jobs individuals choose and thus their income and/or their valuation of mortality risks, occur in parallel with aging [3,10,12,13,32]. Previous revealed preference applications that examine the impact of either wage or age heterogeneity on VSL estimates without controlling for the other source of variation are unable to isolate the specific influence of either source. Thus, such approaches may mistakenly attribute the observed variation in the VSL to a single dimension of heterogeneity when in fact the other source is at play.

Quantile regressions solve this identification problem and parse these two policy-relevant dimensions of heterogeneity. Our quantile results, based on data from the Health and Retirement Study (HRS), suggest that earnings heterogeneity contributes more to variation in VSL estimates than do differences in age. Our findings also indicate a differential effect of age on the wage–risk tradeoff across the wage distribution. While we find generally lower wage–risk tradeoffs among the older individuals in our sample at each wage quantile, the dampening effect of age on the wage–risk tradeoff is strongest at the lowest quantiles. Thus, the mean hedonic wage regression, even when we include an age–risk interaction term, masks important hetereogeneity.

2. Heterogeneity in the VSL

The topic of VSL heterogeneity with respect to age differences motivated a recent symposium in the *Review of Environmental Economics and Policy*. The introduction to the symposium describes the VSL–age relationship as "an issue of considerable controversy in policy circles and keen interest within the research community" [35, p. 169]. To illustrate the potential policy relevance of age variation in the VSL, Evans and Smith [11] mention four economically significant air quality rules for which mortality risk reductions for individuals over age 65 account for between 65% and 70% of the estimated total benefits. Robinson [33] notes that for policies that decrease particulate matter concentrations, roughly 80% of the mortality risk reductions accrue to individuals over age 65. Thus, adjustment to VSL estimates on the basis of age, as reported for example in the "alternative" benefit analyses of the *Clear Skies Initiative*, can give rise to vast differences in total monetized benefits [38].

Following the controversy surrounding the so-called "senior death discount", John Graham, then Administrator of the Office of Information and Regulatory Affairs, issued a memorandum discouraging the adjustment of VSL for age differences [16][1]. The U.S. Environmental Protection Agency's (EPA) recently revised *Guidelines for Preparing Economic Analyses* reiterate this recommendation and refer to the mixed theoretical and empirical findings with regard to the relationship between age and the VSL [39].[2]

The responsiveness of the VSL with respect to income variation has implications for inter-temporal and cross-country benefit transfers. The EPA's practice of longitudinal adjustment represents an example of the former. The EPA adjusts VSL estimates to account for anticipated income growth based on theoretical and empirical support for a positive income elasticity of the value of a statistical life (IEVSL).[3] Since many current policy changes result in reductions in future mortality risks, the IEVSL is often a central component in estimating the benefits of large-scale policy changes.

Evans and Smith [13] cite the prospective report on the costs and benefits of the Clean Air Act Amendments for 1990–2010 to illustrate the implications of this adjustment. The report includes a sensitivity analysis using IEVSL estimates of 0.08, 0.4, and 1.0, which result in VSL estimates for 2010 of $4.9, $5.3, and $6.3 million (in undiscounted 1990 dollars), respectively. Because mortality risk reductions represent a large fraction of the benefits of improved air quality, these VSL differences translate into drastically different aggregate benefit estimates.

To illustrate the implications of the IEVSL for cross-country benefit transfer, we present an example using parameters from [36] that estimates the mortality costs of air pollution in major Ukrainian cities. The lack of VSL estimates based on Ukrainian data necessitated the benefit transfer. The authors assume that the ratio of VSLs in Ukraine and in a group of higher income countries equals the ratio of associated per-capita incomes (i.e., the IEVSL is equal to one). With 22,000 deaths annually attributed to air pollution in Ukraine, they obtain an estimated annual mortality cost of air pollution of $2 billion (2004 dollars). Consider the implications of alternate assumptions about the IEVSL. Values of 0.08 and 0.4 (the same values used in the EPA report) imply estimated annual mortality costs of air pollution in Ukraine of $40.7 billion and $27.3 billion, respectively. The policy implications of different values of the IEVSL are striking.

Several empirical techniques exist for exploring the implications of age or income heterogeneity for VSL estimates. Aldy and Viscusi [3] and Krupnick [27] provide informative discussions of the empirical techniques that exist for exploring

[1] See Aldy and Viscusi [3], Robinson [33], and Evans and Smith [11] for more detailed discussions of the senior death discount.

[2] We received permission to cite this document from Kelly Maguire, National Center for Environmental Economics, U.S. Environmental Protection.

[3] The EPA does not, however, adjust for cross-sectional variation in income. See http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Mortality%20Risk%20Valuation.html#WhatAdjustments.