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The value of risk-free cigarettes – do smokers underestimate the risk?

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Summary

The health risk of smoking is valued using the contingent valuation method, applied to a Swedish sample of smokers. The respondents were asked to put a value on newly developed cigarettes with no associated health risks. The average additional willingness to pay for the new cigarettes is estimated to be between 10 and 41 SEK per pack, where the variation is due to statistical method, discounting, and whether the open-ended or closed-ended question format is used. Using medical data on life shortening effects of smoking, the results indicate rather low values put on a lost life-year, compared to most existing estimates based on other methods. This may indicate that smokers do underestimate the health risk of smoking. There is also initial optimism-bias regarding people's own ability to quit smoking at will. However, there are remaining methodological questions and we found little or no sensitivity to scope. Copyright © 2003 John Wiley & Sons, Ltd.

Keywords cigarette consumption; value of a life-year; contingent valuation; biased risk perception; optimism-bias

JEL classification: I18; J17

Introduction

The purpose of this paper is twofold: firstly to estimate the subjective value smokers put on reduced health risks of smoking, and secondly to contribute to the discussion about whether smokers tend to underestimate or overestimate this risk. The (expected) value of the health benefits associated with reduced smoking cannot be directly observed from revealed market data, since there is no market for these health risks *per se*. Indirectly, the value put on health has been estimated by hedonic methods (see Viscusi [1] for an overview). The approach taken here is that of simply asking cigarette smokers for their maximum willingness to pay (WTP) for reducing their health risks from smoking. More specifically, respondents are asked for their WTP for newly developed risk-free cigarettes in a survey using the contingent valuation method (CVM). Other than being risk-free, the imagined cigarettes are identical to the respondent's currently preferred brands.

The validity of CVM is heavily debated. See, for instance, Kahneman and Knetsch [2], Diamond and Hausman [3] and Hausman [4] for critical views. However, some of the problems related to the CVM are not applicable to our study, since we are valuing a private good. Consequently there is no (or little) 'warm glow' (Andreoni [5,6]) or 'purchase of moral satisfaction' (Kahneman and Knetsch [2]) for contributing to an overall good social cause.

Still, the interpretation of the results from surveys such as ours is by no means straightforward due to possible after-rationalization, or cognitive dissonance (Akerlof and Dickens [7]),

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individual heterogeneity in processing risk information (Viscusi [8]; Viscusi *et al.* [9]), possible over-optimism (Weinstein [10]), time-inconsistent discounting of future health benefits, etc. Contrary to many earlier studies on valuing risk, we do not provide the respondents with any quantitative information about how dangerous smoking is in terms of the increased risk of getting lung cancer, etc. Instead we are genuinely interested in their *subjective* health-risk valuations, and the corresponding risk reductions. So, even though the perceived health risks differ, we can still find the *subjective* value respondents put on them. Nevertheless, there are remaining methodological problems. For example, it is a non-trivial cognitive task to answer survey questions of this sort, and it is known from other studies that many people tend to apply various kinds of heuristic choice rules.

It is well documented that people in general are quite poor at dealing with low-probability events (e.g. Viscusi [11]; Hammit and Graham [12]; Slovic [13]), and hence also low-probability *health* risks. Hammit and Graham [12] provide a survey of 25 CVM studies on health protection (but with no references to smoking-related health risks), without finding a single one with adequate WTP sensitivity with respect to the magnitude of the risk reduction. However, their survey only concerns small risk changes. We ask smokers for their WTP for a considerable health risk reduction, equivalent to cutting cigarette consumption in half or quitting. Hence, if one believes that the insensitivity to scope problem typically found in risk-related CVM studies are primarily a result of individuals' inability to deal systematically with small risks, then one would expect this problem to be smaller in our study. However, as we will see, this turns out not to be the case. Whether insensitivity to scope is inherent in the CVM methodology, irrespective of application to risk or something else, is debated (e.g. Kahnemann and Knetsch [2]; Carson [14]; Krupnick *et al.* [15]).

On average, smokers die at an earlier age than non-smokers do, and it is not challenging to say that smokers are aware of this. But do smokers underestimate or overestimate the health risks? The empirical evidence is mixed. Some studies (e.g. Viscusi [16–18]) find that smokers (as well as non-smokers) overestimate the risk of getting lung cancer from smoking. The same goes for other smoking-related health risks. For example, Viscusi [17] finds that smokers' assessed life expectancy loss due to smoking is 9 years, which is an overestimation of expected life loss. Viscusi refers to the 1968 Report of the Surgeon General, which estimated the smoking-related life loss to 4 years for those smoking less than half a pack per day, and 8 years for heavy smokers. On the other hand there are studies such as Slovic [19,20] that provide considerable evidence that young smokers in particular severely underestimate the health risks associated with smoking, partly due to over-optimism with respect to their own ability to quit smoking at will (cf. Weinstein [10]). Moreover, Schoenbaum [21] finds, using the Health and Retirement Study (HRS), that heavy smokers' (more than 25 cigarettes per day) expectations of reaching the age of 75 are twice as high as actuarial predictions, while other groups have subjective expectations in line with the probability of surviving to the age of 75. However, one may object to these findings that the risk scale used in HRS is not a viable probability metric [22].

Given the difficulty of communicating risk estimates, as discussed by Hammit and Graham [12] and Corso *et al.* [23], an alternative is to investigate whether people behave *as if* they underestimate or overestimate the risks involved. In our case we are interested in whether people are willing to pay more or less to reduce or eliminate the risks of smoking, compared to what is found in other studies on risk reductions. Given the WTP for a specific risk reduction, we can calculate the value per expected lost life-year (VOLY) by using available average dose–response functions. We choose to focus on the Shaw *et al.* [24] estimate of an average loss of life due to smoking of 6.5 years, or 11 min per cigarette. This figure is admittedly somewhat uncertain, but it is in line with other fairly recent estimates as well. We then compare our findings to other available estimates of value per life-years, enabling us to judge whether people on average, implicitly in their (hypothetical) choices, tend to overestimate or underestimate the health risks of smoking.

Empirical analysis

The data

The data were gathered using a questionnaire that was mailed to 935 individuals in the counties of Norrbotten and Västerbotten in northern Sweden, in the fall of 2000. All subjects had been identified as smokers in a previous study within the WHO MONICA Project [25]. The sample was identified in a study on the health effects of moist snuff by Kjell Asplund at Umeå University Hospital, from whom we obtained the sample register. The questionnaire consists of four parts: (i) questions on smoking habits, health risks, social context of the smoking behavior and attitudes towards anti-smoking policies, (ii) a choice experiment evaluating hypothetical policies, (iii) a contingent valuation experiment on health risks associated with smoking and (iv) socioeconomic questions. Seven questionnaires were returned as undeliverable because the individuals had moved. The overall response rate was 57%, or 527 respondents. After removing pipe-smokers and those who had quit smoking 452 observations remained. Table 1 below provides the summary statistics of the data used.

We can see that more than 40% of the respondents want to quit smoking (including those who either desire switching to snuff or other nicotine replacements, or by quitting with all nicotine). Roughly 10% experienced reported health problems related to their own smoking. The mean cigarette consumption reported, 12 per day, is somewhat less than the benchmark of 16 cigarettes per day typically assumed for British male smokers in several studies. The average age of 52 is rather high, which is presumably partly explained by a higher response rate among older people, but also by the fact that the sample was identified from a previous study. The equivalent after-tax household income is adjusted for number of children in the household, and appears to be somewhat lower than for an average Swedish household and the same applies to the fraction of university-educated respondents. (We employ the equivalence scale used by the National Tax Board (RSV) in Sweden. The scale assigns the first adult the value of 0.95, the following adults are set at 0.7 and each child at 0.61 units.)

Of particular interest is that almost 60% perceive considerable health risks from their own smoking, and that only 3% believe that there are no health risks. Hence, according to these figures it appears safe to say that most smokers are well aware of the health risks of smoking. Whether they perceive it in a rational way is of course another issue to be investigated below.

The survey

After some pre-tests, a pilot survey was sent to 100 individuals (smokers). Here, we solely used open-ended WTP questions which enabled us to find reasonable bids for the dichotomous choice (DC), or closed-ended, WTP questions. In the final version of the questionnaire, respondents were asked a closed-ended question followed by an open-ended question. The former is typically recommended in the CVM literature (e.g. Arrow *et al.* [26]) based on the incentive compatibility properties, and since it more closely resembles a real-market situation. There are also, however, closed-ended problems including limited information per respondent, which often makes the estimations quite sensitive with respect to specification, and possible yea-saying problems (Boyle *et al.* [27]). Open-ended questions naturally provide much more information per respondent, and the combination of open-ended and closed-ended questions makes it possible to compare the results without violating the advantages of using

Table 1. Summary statistics of the sample

	Mean	Std	Min	Max
Accepting the WTP bid	0.40	0.49	0	1
Monthly per-adult equivalent household income, after tax, in SEK per month	10 342	4369	385	36 471
Number of cigarettes smoked per day in the last month	13	6	0	40
Has specific health problems related to smoking	0.12	0.32	0	1
Desire to quit smoking	0.43	0.50	0	1
At least one completed semester at university level	0.19	0.39	0	1
Age of respondent	52	10	20	76
Males	0.41	0.49	0	1
Self-perceived risk of smoking is considerable	0.62	0.49	0	1
No self-perceived risks of own smoking	0.03	0.16	0	1

closed-ended questions. Moreover, open-ended questions make it possible to identify protest zero-bid responses.

Half of the respondents stated WTP for replacing 50% of the ordinary cigarettes, while the other half stated WTP for 100% replacement, enabling us to make an external test of the sensitivity to scope. The wording of the scenario was (additional text given in the 50% version shown in brackets):

> The purpose of this section is to find out what value you put on a totally risk-free cigarette.
>
> Imagine that you have been randomly chosen to try a new type of cigarette that has been developed by Swedish researchers. Everybody else will continue smoking ordinary cigarettes, and unless you do not want to, no one will know that you now use a new totally risk-free type.
>
> [Imagine that you have been offered to change half of the cigarettes you smoke today to new cigarettes that do not produce any negative health effects. The cigarette packs look exactly the same as the ones you usually buy. The only difference is that half of the cigarettes are the new risk-free type. The ordinary type in the pack is identical to the kind you normally smoke.]
>
> The risk-free cigarette has the same taste as the cigarette you normally smoke. It also looks the same, gives you the same feeling of satisfaction, and neither you nor those around you can distinguish it from an ordinary cigarette. Further, it is also addictive in the same way as ordinary cigarettes, and is perceived in the same way by those around you in terms of smoke, smell, eye irritations, etc. However, it is completely harmless for you as well as for those around you.
>
> [It is known that reduced smoking implies reduced health risks. For instance, if you previously smoked 20 cigarettes per day, and now replace 10 of them with the new risk-free type, you also cut your health risks from smoking in half.]
>
> Note that it has been proven that the new cigarettes are totally harmless. If you think that this sounds unrealistic, we ask that you answer as if you accept this as a fact. The only problem with the new cigarette is that it is more expensive that the ordinary ones.

After this introduction the first question was asked (In the 50% version 'all' were replaced by 'half' and '10', respectively.):

> Imagine that you could buy a pack of cigarettes where all of the cigarettes are risk-free, for the rest of your life. Would you be willing to pay an additional SEK X per pack of 20 cigarettes, where all of them are of the new risk-free type?
>
> (Note: We ask you to consider that your income is limited, and your money must cover many other items)
>
> — — Yes ⇐ Go to question 2a
>
> — — No ⇐ Go to question 2b

A respondent could face one of five possible bids: 3, 5, 10, 20 and 40 SEK (in addition to the price of a package of cigarettes, or about 35 SEK), for the improvement of either a 50 or 100% replacement of ordinary cigarettes by the new risk-free ones. The use of the same bid-vector for both 50 and 100% replacement, along with a split sample, imply a rather strong sensitivity-to-scope test. If, on the other hand, we had used either a within-sample test where the same respondents would answer both a 50 and a 100% replacement WTP question, or had used lower bids in the 50% case, it is hard to imagine that a scope-test (in terms of statistical significance) would not have been passed. However, we believe that the value of such a test would have been close to zero.

If respondents answered 'yes' to the above question, they were asked to state their maximum WTP in this open-ended question:

> You are *willing* to pay an additional SEK X per pack [where half of the cigarettes are] of the new risk free type. Now we wonder how much you are willing to pay, at a *maximum*?
>
> I am *willing* to pay... SEK per pack of the new risk free type *for the rest of my life*.

Similarly, if they answered 'no' they instead faced the following question:

> You are *not willing* to pay an additional SEK X per pack [where half of the cigarettes are] of the new risk free type. Now we wonder how much you are willing to pay, at a *maximum*?
>
> I am willing to pay... SEK per pack of the new risk free type *for the rest of my life*.

Identifying protest zero-responses

The open-ended questions were used to identify respondents with zero WTP (which turned out to

Table 2. Stated reasons for zero willingness-to-pay for risk-free cigarettes

	Lack of resources	Do not believe in the scenario	Small health risks	Get rid of other things besides health risks	Other reasons (protests)	Other reasons (not protests)
50 and 100% replacement (n =185)	24 (13.0%)	112 (60.5%)	3 (1.6%)	23 (12.4%)	12 (6.4%)	11 (6.0%)

Table 3. Probit regression of giving a protest zero-response

	Coeff.	Std
Constant	−0.980**	0.38
After-tax equivalent household income in 10 000 SEK per month	0.013	0.16
50% risk reduction	−0.199	0.13
Specific health problems related to smoking	−0.433**	0.22
Desire to quit smoking	0.315**	0.14
University	−0.144	0.18
Age	0.013*	0.01
Male	−0.210	0.14

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

be as many as 41%), since one would believe that almost all would value a drastic risk reduction positively. As expected, however, a large majority of the zero-responses can be categorized as protest responses, and not as if they truly have a zero WTP.

To sort out protest zero-responses, respondents are asked about their reasons for stating zero WTP, as reported in Table 2. The zero-responses which were motivated by lack of resources to pay for a risk-free cigarettes, or by low perceived health risks or some of the explicitly stated motives under ‘other reasons’ are treated as ‘true zeros,’ while the remaining zero-responses, almost 80%, are treated as protest zeros.

In Table 3, we see that those with ‘specific health problems related to smoking’ are less likely to provide a protest response, while those who have a wish to quit smoking are more likely to provide a protest zero response. Also, the older the respondent, the more likely he/she is to protest by stating a zero WTP.

In the subsequent analysis it is assumed that the remaining respondents ‘play along’ with the scenario. Still, we cannot rule out that some respondents with a positive stated WTP could be directly influenced by the scenario construction, and hence that their responses would be biased.

Discounting

Naturally, the positive health effects in terms of a longer life occur at the end of life. Since these health effects, in terms of additional days of life, occur later than the money spent to avoid the risk, one could argue in favor of using a positive discount rate to adjust for this discrepancy. Viscusi *et al.* [28] point to the fact that past studies may have overstated the public’s misperception of risk due to insufficient accounting for discounting and time lags before the risk of death appears.

Let the factor s denote how much the WTP should have been multiplied by if the health effects would have occurred at the same time as the money was spent (i.e. during all of the remaining days of life). Since the respondents are assumed to pay for the risk-free cigarettes for the rest of their lives, the discount factor s for an individual i can be written $s_i = (e^{rl_i} - 1)/rl_i$ where r is discount rate per year, and l is expected time left to live, i.e. $l_i = T_i - t_i$, where T_i is the expected age of death and t_i is the current age. We use 5% per year as the annual discount rate r. The factor s is positive for all respondents and hence it magnifies the value of health risks from smoking.

Open-ended WTP results

Table 4 below shows the results for the open-ended WTP question, which followed the dichotomous choice WTP question. We choose to present the results both with and without discounting.

The maximum WTP from the open-ended question ranges from SEK 10 to almost SEK 30, depending on whether one uses mean or median WTP, or whether one accounts for discounting

Table 4. Willingness-to-pay (open-ended) for risk-free cigarettes in addition to the price of SEK 35 per pack (protest zero-responses removed)

	Median	Mean	Std Dev.	Min	Max	No.of zeros(%)	*N*
All observations, 0% discount rate	10	12.94	15.37	0	100	16	286
100% replacement, 0%	10	13.07	16.07	0	100	18	132
50% replacement, 0%	10	12.82	14.81	0	100	15	154
All observations, 5% discount rate	16.94	28.89	35.89	0	218	16	286
100% replacement, 5%	16.13	29.76	38.48	0	218	18	132
50% replacement, 5%	17.46	28.13	33.62	0	218	15	154

effects or not. Since the discount factor is positive for all respondents, and hence magnifies the value of health risks from smoking, WTP increases when taking this into account. Note that both the mean and median values are more or less the same regardless of whether there is 100 or 50% replacement. There could be several reasons for this scope insensitivity. For example, some respondents 'count backwards' (see below) and their stated WTP is what they feel they can afford when other costs are withdrawn, i.e. they do not make tradeoffs between risk reductions and other goods. Alternatively, completely risk-free cigarettes may sound unrealistic, implying that the responses may be based on a somewhat vague 'major risk reduction' in both cases. Anchoring on the price of a cigarette is also possible since the WTP per pack of cigarettes was chosen as the payment vehicle. Finally, it is cognitively difficult to transform the perceived risk reductions into WTP figures, implying that many respondents may apply simplified 'heuristics;' see e.g. Slovic [13].

WTP from the dichotomous choice approach

Despite the attractiveness of the simple and direct open-ended approach, the DC approach, where individuals are asked to respond 'yes' or 'no' to a certain proposed bid, is as mentioned still most often recommended. The analysis here is based on a standard random-utility framework (McFadden [29]). Between the alternatives of accepting or not accepting the bid, the individual is assumed to choose the alternative with the highest perceived utility. Since utility is unobserved and the survey response is a binary variable, we define a binary response variable, y_i, i.e. the modeling utilizes the latent variable regression approach, where $y_i = 1$ means that the bid is accepted by individual i; consequently $y_i = 0$ means that the bid is not accepted. Aside from a systematic part of the utility function, V, there is a random term, ε, so that the utility derived for individual i from accepting the bid ($y_i = 1$) becomes

$$u_{i1} = V_{i1} + \varepsilon_{i1} \tag{1}$$

The probability of accepting equals the probability that the utility from accepting is greater than the utility of not accepting. Hence we have

$$\begin{aligned}\Pr(y_i = 1) &= \Pr(V_{i1} + \varepsilon_{i1} > V_{i0} + \varepsilon_{i0}) \\ &= \Pr(\varepsilon_{i1} - \varepsilon_{i0} > V_{i0} - V_{i1})\end{aligned} \tag{2}$$

The systematic part of the utility function is assumed to be linear in the parameters within the interval considered:

$$V_i = \alpha + \beta^x f(x_i) + \beta^h h_i \tag{3}$$

where x is income, h is a health index and the β's are corresponding parameters. It is assumed that health and income are evaluated at the same moment in time, such as the present time. For the two cases where the individual accepts and does not accept, respectively, it can be written

$$V_{i1} = \alpha + \beta^x f(x_i^0 - s_i \Delta x_i) + \beta^h (h_i^0 + \Delta h_i) \tag{4a}$$

$$V_{i0} = \alpha + \beta^x f(x_i^0) + \beta^h h_i \tag{4b}$$

where Δx_i is the monetary WTP bid for the health improvement Δh_i for individual i; x_i^0 is the corresponding initial income; and s_i is the discount factor to adjust for the fact that the health effects, in terms of lost days of life, occur later than the money spent to avoid the risk. s then reflects how much the stated WTP should have been multiplied by if the health effects would have occurred at the same time as the money was spent. Substituting (4a) and (4b) into (2) implies

$$\begin{aligned}\Pr(y_i = 1) = \Pr(&\beta^x (f(x_i^0) - f(x_i^0 - s_i \Delta x_i)) \\ &- \beta^h \Delta h_i < \varepsilon_{i1} - \varepsilon_{i0})\end{aligned} \tag{5}$$

We will consider two different functional forms, $f(x_i) = x_i$ and $f(x_i) = \log(x_i)$, implying

$$\Pr(y_i = 1) = \Pr(\beta^h \Delta h_i - \beta^x s_i \Delta x_i > \varepsilon_{i1} - \varepsilon_{i0}) \quad (6a)$$

$$\Pr(y_i = 1) = \Pr\left(\beta^h \Delta h_i + \beta^x \log\left(1 - \frac{\Delta x_i}{x_i^0} s_i\right) > \varepsilon_{i1} - \varepsilon_{i0}\right) \quad (6b)$$

respectively. The corresponding predicted maximum WTP, or compensating variation (CV), for the health improvement Δh_i (normalized to one in the regressions) is in the linear case for an arbitrary individual i given by

$$\mathrm{CV}_i = \frac{\beta^h}{\beta^x} + \varepsilon_i \quad (7a)$$

where β^h is equal to the estimated intercept, and where β^x is the marginal utility of income, which is equal to minus the estimated coefficient for the bid. In the log-case we instead have

$$\mathrm{CV}_i = x_i^0 (1 - \mathrm{e}^{-(\beta^h + \varepsilon_i)/\beta^x}) \quad (7b)$$

Hence, the linear model predicts that the WTP for a health improvement is proportional to the health change, and is independent of initial income. The log-model, on the other hand, predicts that the WTP increases at a decreasing rate in the health change, and that it is proportional to initial income, implying an income elasticity of unity.

The standard assumption is that the error terms of (1) are i.i.d. normal with a variance of 0.5, so that the error difference ε is standard normal (with a variance of 1), implying that the parameters are estimated consistently with a binary Probit model (see e.g. Hanemann and Kanninen [30]). However, to assume constant variance of the error term with respect to the bid is quite restrictive, and may bias the estimated mean and median WTP in a non-negligible way (Halvorsen and Saelensminde [31]). In what follows we will still assume that ε has a zero mean and median, but that the error structure is heteroscedastic, so that the variance of the error term ε is allowed to vary with the bid. In the linear case we assume the variance to vary with the bid as follows:

$$\mathrm{var}(\varepsilon_i) = \mathrm{e}^{2\beta^z \Delta x_i} \quad (8a)$$

where β^z is a parameter to be simultaneously estimated (see Greene [31, p. 829]). In the log-case the variance is correspondingly assumed to vary with the transformation of the bid used in the regressions:

$$\mathrm{var}(\varepsilon_i) = \mathrm{e}^{2\beta^z \log(1 - \Delta x_i / x_i^0)} = (1 - \Delta x_i / x_i^0)^{2\beta^z} \quad (8b)$$

In both cases we see that in the limit, where the parameter reflecting heteroscedasticity goes to zero, the variance goes to one irrespective of the bid, and the distribution of the error term becomes standard normal.

To estimate the mean and median WTPs in the linear case is straightforward, since ε has a zero mean and median, as follows:

$$E(\mathrm{CV}) = M(\mathrm{CV}) = \frac{\beta^h}{\beta^x} \quad (9)$$

where the operator E denotes mean value, and M denotes median value. The mean and median WTPs for an individual in the log-case are slightly more complicated. We have

$$\begin{aligned} E(\mathrm{CV}_i) &= x_i^0 E(1 - \mathrm{e}^{-((\beta^h + \varepsilon_i)/\beta^x)}) \\ &= x_i^0 (1 - \mathrm{e}^{-\beta^h/\beta^x} E(\mathrm{e}^{-\varepsilon_i/\beta^x})) \\ &= x_i^0 (1 - \mathrm{e}^{-\beta^h/\beta^x} \mathrm{e}^{(1/2\beta^{x2})\mathrm{var}(\varepsilon_i)}) \\ &= x_i^0 \left(1 - \mathrm{e}^{-\left(\frac{\beta^h}{\beta^x} - \frac{(1 - \Delta x_i / x_i^0)^{2\beta^z}}{2\beta^{x2}}\right)}\right) \end{aligned} \quad (10)$$

and

$$\begin{aligned} M(\mathrm{CV}_i) &= x_i^0 M(1 - \mathrm{e}^{-(\beta^h + \varepsilon_i)/\beta^x}) \\ &= x_i^0 (1 - \mathrm{e}^{-\beta^h/\beta^x}) \end{aligned} \quad (11)$$

We follow the standard approach in the literature and calculate the median and mean WTP for the sample evaluated at the sample mean of the population; see e.g. Haab and McConnell [33]. We see then that the expressions for mean and median are fairly similar. If β^x is much larger than β^h, and $\frac{1}{2}(1 - \Delta x_i / x_i^0)^{2\beta^z}$ is of a similar order of magnitude (or not much larger) as β^h, the difference between the estimated mean and median is negligible. That turns out to be the case here, as is easily verified by the parameter estimates provided in Tables 5 and 6. Therefore we will only present the estimated median in the tables. (Remember that the mean and median values are *theoretically* identical in the linear case.)

In Table 5 we present the regression results with a zero discount rate, divided between those who received 50% risk reduction and those who

Table 5. Parameter estimates (standard errors in parentheses) and estimated WTP: scope sensitivity between 50 and 100% substitution with risk-free cigarettes

	Linear model 6(a) Whole sample	Linear model 6(a) Only 100%	Linear model 6(a) Only 50%	Log model 6(b) Whole sample	Log model 6(b) Only 100%	Log model 6(b) Only 50%
Intercept	1.286*** (0.247)	0.880*** (0.304)	1.767*** (0.403)	1.157*** (0.228)	0.722*** (0.207)	1.410*** (0.304)
Bid	−0.082*** (0.024)	−0.053* (0.028)	−0.118*** (0.041)			
Log(1-bid/income)				723.303*** (208.933)	399.452*** (122.443)	868.480*** (267.820)
Corresponding heteroscedasticity term for bid variable	0.027** (0.012)	0.012 (0.020)	0.038*** (0.014)	−228.368** (99.732)	−47.115 (46.465)	−258.686*** (99.046)
Median WTP	15.6*** (2.3)	16.7*** (4.5)	14.9*** (2.6)	16.5*** (2.5)	18.0*** (3.4)	17.2*** (2.9)
Number of individuals	303	139	164	283	127	156
Log likelihood	−174	−84	−89	−167	−78	−87
Restricted log likelihood	−207	−96	−111	−194	−88	−106

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

received 100% risk reduction questions. As expected, the higher the offered bid, the lower the probability of bid acceptance. The estimated median (and hence mean) WTP is between 15 and 20 SEK per pack of cigarettes, independent of whether all cigarettes were replaced with risk-free ones, or just 50% of them. The insensitivity to scope is also indicated by a Likelihood Ratio test for the linear model, which shows that we cannot reject the pooled sample specification (LR-stat = 3.2), and hence that there is no sensitivity to scope. The variance of the estimated median WTP is calculated using the delta method; see e.g. Greene [32].

In Table 6 we present estimated WTPs when assuming an implicit discount rate of 5%. The WTP can then be interpreted as how much the respondent would have been willing to pay if the expected time gained would appear at the same time as the money is paid for the cigarettes, instead of in the future. This interpretation may not be perfectly straightforward, since a prolonged life by necessity occurs at the end of life, but one can imagine the value of extending each year by additional days.

Compared to Table 5, we see in Table 6 that WTP increases due to the positive discount rate. Hence, estimated WTPs are greater when assuming that the lost time would occur today, rather than in the future. There is still no sensitivity to scope.

We see that the WTP figures arising from the dichotomous choice question are slightly above the values obtained from the open-ended question, as is typically found in the literature. The mean differences found here are, however, smaller than in most previous research. One reason is that we have no split sample between DC and open-ended respondents, and also that those who have said yes to a certain bid may feel obliged to state a value in the open-ended question which is at least equally as large. Further, Halvorsen and Saelensminde [31] find that correcting for heteroscedasticity in the bid variable, as we did, typically reduces the WTP difference between dichotomous choice and

Table 6. Parameter estimates (standard errors in parentheses) and estimated WTP assuming that the reduced health effects occur at the same time as the money is spent

	Linear model 6(a) Whole sample	Linear model 6(a) Only 100%	Linear model 6(a) Only 50%	Log model 6(b) Whole sample	Log model 6(b) Only 100%	Log model 6(b) Only 50%
Intercept	1.076*** (0.199)	0.834*** (0.248)	1.371*** (0.322)	0.842*** (0.210)	0.579*** (0.195)	1.101*** (0.259)
Bid* discount factor	−0.030*** (0.008)	−0.024** (0.010)	−0.038*** (0.014)			
Log(1-bid*disc. factor/income)				209.461*** (80.832)	139.664*** (52.228)	282.664*** (98.168)
Corresponding heteroscedasticity term for bid variable	0.0093** (0.005)	0.0066 (0.006)	0.013* (0.007)	−60.100 (47.737)	−15.228 (25.162)	−92.236** (42.769)
Median WTP	35.9*** (5.3)	34.8*** (7.9)	35.9*** (7.0)	41.4*** (8.3)	41.4*** (9.8)	41.3*** (8.2)
Number of individuals	303	139	164	283	127	156
Log likelihood	−180	−86	−93	−174	−80	−92
Restricted log likelihood	−207	−96	−111	−194	−88	−106

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

open-ended format. Again, we find no sensitivity to scope.

We also ran a number of regressions with interaction effects based on personal characteristics. These revealed rather small differences between different groups; for example, we found no significant gender or education effects. Further, the inclusion did not in any major way affect the estimated WTP, and to save space we do not report these results here.

How did the respondents think?

We asked the respondents six follow-up questions about how they made their choices and provided the WTP numbers, and the answers are summarized in Table 7. We see that 63% respond that they had weighed benefits of risk-free cigarettes against other benefits, as is predicted by economic theory. However, several respondents (33%) seem to have relied, partly or totally, on the cognitively easier strategy of *counting backwards*, i.e. by calculating what is left when they have deducted fixed costs, indicating that some respondents do not make tradeoffs between reduced health risks and other goods. Some (22%) also report a low WTP due to a wish to quit anyway.

Implicit value of life-year

The expected number of minutes lost due to smoking an additional cigarette may depend on many variables such as the age of smoking initiation, the number of cigarettes smoked per day, as well as individual genetic and lifestyle factors. Following Gruber [34] and Gruber and Köszegi [35], we use an estimate of loss of life years caused by smoking. Shaw *et al*. [24] report an average value of 11 min of life lost per cigarette, corresponding to 3.67 h of life lost per cigarette pack, or 0.00042 years per cigarette pack, or that

Table 7. Arguments for WTP for risk-free cigarettes without protest zeros

	%
Agreeing to trade between risk-free cigarettes and other goods	63
WTP is explained by money left after fixed costs	33
Low WTP due to low perceived health risks from smoking	11
Agreeing to pay more if respondent had more money	28
Low WTP because of the respondent wanting to quit anyway	22
High WTP due to the fact that respondents would be helped to quit by higher price	26

Table 8. Average implicit value of life-year for a major risk reduction in USD (USD 1 ≈ SEK 10.6)

	Average VOLY using maximum WTP in open-ended follow-up question	Average VOLY using dichotomous choice format
Discount rate 5% 100% replacement	3600–6700	7800–9300
Discount rate 0% 100% replacement	2300–2900	3800–4100
Discount rate 5% 50% replacement	7900–12 700	16 200–18 600
Discount rate 0% 50% replacement	4500–5800	6700–7800

smokers die 6.5 years earlier than non-smokers. The calculation by Gruber is instead based on estimates from Viscusi [1] on value-of-life-year and the estimate by Manning *et al*. [36] using 7 min per cigarette. This figure can be compared to Gruber and Köszegi [35], who use the fact (Cutler *et al*. [37]) that smokers die on average 6.1 years earlier.

The estimate by Shaw *et al*. [24] is based on the difference in life expectancy between male smokers and non-smokers, and on the fact that the median male smoker starts smoking at age 17 and smokes 16 cigarettes per day until the average male smoker dies at age 71. Shaw *et al*. further assume that each cigarette makes the same contribution to death. Nordlund *et al*. [38] conclude that men and women have similar relative risks of smoking-related cancers at equal levels of smoking.

We present the value of a life-year (VOLY) for 50 and 100% replacement separately, assuming that 50% corresponds to cutting cigarette consumption in half, and 100% equals quitting. If the additional WTP per pack of risk-free cigarettes with 100% risk reduction is 10 SEK, we get 10/(0.000418569) SEK/year = 23 891 SEK per year, or about USD 2250 per year. Using this approach we get the results in Table 8.

The value of a life-year ranges from USD 2300 to 7800 when we do not use a positive discount rate, and from USD 3600 to 18 600 with a 5% discount rate. Bearing in mind that many protest-responded due to a perceived unrealistic scenario, it is possible that many (non-protest) responses reflect a major risk reduction, other than the one specified. If so, the result from the 50% replacement categories would be more reliable. The values in Table 8 can be compared to the results of other studies.

A number of VOLY estimates are calculated from value of life estimates, using different discount rates and adjustments for a varied quality of life at different ages. Dardis and Keane [39] use VOLY estimates between USD 25 000 and 75 000 based on value of life estimates from Fisher *et al*. [40] and Shepard and Zeckhauser [41]. In a similar way, but instead using value of life figures from Viscusi [1] along with figures of the time lost from smoking in Manning *et al*. [36], Gruber [34] and Gruber and Köszegi [35] calculate internal costs of smoking to be roughly USD 30 per pack of cigarettes, which corresponds to a value of life-year of USD 115 000. Cutler and Richardson [42], using the overview given by Tolley *et al*. [43], use USD 100 000 (1990 dollars) per life-year as a benchmark estimate. Value-of-life-year ranges from USD 70 000 to USD 175 000 in their overview.

Ippolito and Ippolito [44] derive value of life-years from increased information about the risks of smoking based on revealed-preference data. They find a mean value of life-year saved estimate of USD 5700 (1980 dollars) for smokers, which is of a similar order of magnitude as our figures. They also find that smokers behave more 'risky' than non-smokers, implying a lower value of life-year, which is consistent with a great deal of other empirical evidence (see e.g. Viscusi *et al*. [9]) or that smokers face a lower and flatter wage offer curve compared to non-smokers, indicating that smokers are less efficient in the production of safety (Viscusi and Hersch [45]). Tengs *et al*. [46] summarized the cost-effectiveness of more than 500 potential life-saving interventions in the US; the median intervention cost was USD 42 000 per life-year saved. However, since no relation between cost-effectiveness and actual implementation was found it is obviously not possible to derive a single implicit value per life-year saved; instead the results indicate large potential efficiency gains (Tengs [47]; Tengs and Graham [48]).

Using methods similar to CVM, Cropper *et al*. [49] and Johannesson and Johansson [50] estimate the public's priorities among different age groups, finding that saving a life of a high age has a much lower weight than others. The importance of quality of life is also highlighted in the study by Johnson *et al*. [51], which analyzes the preferences for longevity among smokers aged 50–64 using a choice-experimental approach. They use four different classes of quality of life, and find that smokers have quite a large WTP for improved longevity if quality of life is good, but that the WTP is actually negative if quality of life is poor. In general, they find that WTP is more sensitive to changes in quality of life than changes in longevity expectations.

The only study to our knowledge that explicitly tries to calculate the value of a life-year at an advanced age is Johannesson and Johansson [52], who find very low values compared to the ones mentioned above. They estimate the average WTP for a life extension of 1 year in a random sample of Swedes, given that they had already survived to age 75, to be less than USD 1500 (framed as an insurance premium for using a new medical program or technology). A given explanation for this relatively low estimate is that the respondents' own predictions regarding the quality of life at this age are rather bleak. Their CV question was posed as a one-time-only payment, which may also have biased the result downwards.

Even though we cannot draw an unambiguous conclusion that smokers either under- or overestimate the adhering health risks from smoking, our implicit values per remaining life-year are in the lower range compared to most previous studies, which may indicate that smokers do after all underestimate the health risks.

It should also be noted that the sample consists of experienced smokers, and even if many of them do not underestimate the health risk today, they may still have underestimated the health risks, or overestimated their own ability to quit, when they started to smoke. To make a crude test of the latter hypothesis we included the following question: *When you started smoking, did you then believe that you would still be smoking today?* This is of course a non-trivial question to answer, and it may be difficult to remember that far back. Nevertheless, it turned out that as many as 86% answered *no* to this question, indicating that optimism-bias may have been an important issue *when they started smoking*.

Concluding remarks

Contrary to most previous studies discussing whether or not smokers underestimate the health risks of smoking, we do not present any quantitative risk information for smokers to value, nor do we ask smokers to quantify the risk. Instead, we are interested in whether smokers behave *as if* they underestimate the risk, which we test in a CV framework by asking them how much they would pay for newly developed risk-free cigarettes. Our results are equivalent to rather low value-of-life-year estimates compared to other studies, implying that smokers may after all tend to underestimate the health risk of smoking. Still, there are even lower values in the literature, so we cannot reject the hypothesis that smokers make a rational valuation of the health risks either. We also find evidence of initial optimism-bias regarding people's own ability to quit smoking at will.

There are many reasons to be careful when using our findings here for policy purposes and, as is common with survey methods, there are remaining methodological problems. First, we found no significant sensitivity to scope when using an external test. Second, there is evidence that some respondents do not seem to make tradeoffs between reduced health risks and other goods, as predicted by economic theory. Nevertheless, this study presents implicit value-of-life-year estimates based on a new methodology, which involves large risk reductions rather than small ones, and we believe that it is interesting to compare the order of magnitudes of the results to existing empirical evidence.

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