Jones-Lee M, Chilton S. Valuing Safety: Principal Limitations of the J-Value Model. *International Journal of Business Continuity and Risk Management* 2017, 7(3), 222-232.

Copyright:

This is the authors' accepted manuscript of an article that has been published in its final definitive form by Inderscience Publishers, 2017

DOI link to article:

https://doi.org/10.1504/IJBCRM.2017.088809

Date deposited:

08/01/2018

Embargo release date:

11 June 2018

VALUING SAFETY: PRINCIPAL LIMITATIONS OF THE J-VALUE MODEL

Michael Jones-Lee* & Susan Chilton

Newcastle University Business School

5, Barrack Road, Newcastle upon Tyne NE1 4SE, UK

Abstract

During recent years advocates of the so-called "J-Value" approach to the valuation of safety have made vigorous attempts to persuade UK government and related agencies to adopt the approach as the basis for the appraisal of proposed safety projects. In particular, advocates of the approach argue that the Value of Preventing a Statistical Fatality (VPF) employed by the Department for Transport, the Health and Safety Executive and other UK public sector bodies is too low and should be replaced with the higher value of safety that its advocates claim is implied by the J-Value model. However, a recent review of the J-Value literature commissioned by the UK Health and Safety Executive concluded that the model underpinning the J-Value approach is "too simplistic" to warrant its use as the basis for public sector safety project appraisal. Amongst other things, the review argues that the approach's exclusive focus on the impact of a safety improvement on the remaining life expectancy of those who benefit from the improvement is too narrow to capture adequately the effect of all of the key factors that should be considered in determining the value of a safety improvement. The purpose of this paper is to consider this and other basic limitations of the J-Value approach in more detail.

Under the standard definition, the Value of Preventing a Statistical Fatality (VPF) - or, as it is alternatively referred to, the Value of Statistical Life (VSL) - is the sum total of the amounts that a large group of individuals would each currently be willing to pay for small reductions in their own risk of death which, taken over the group affected, would reduce the expected number of premature fatalities during the coming year by one and would hence prevent one "statistical fatality"[1].

In the UK, HM Treasury guidelines recommend the use of the Department for Transport (DfT) VPF in public sector policy appraisal. Currently the DfT VPF is set at £1.78m in 2015 prices and is based on the mean and median values (updated for inflation and growth in GDP per capita) from a stated-preference study carried out in 1997 designed to estimate individual willingness to pay for marginal reductions in the risk of premature death for a representative sample of the UK public – see Carthy *et al* (1998) and Department for Transport (2000). Prior to that, the value was based on the median results of a stated-preference willingness to pay study carried out in 1982 – see Jones-Lee *et al* (1985) - and was adopted by the DfT in 1988 following the recommendation of Dalvi (1988). In the UK, the VPF also includes an allowance for avoided medical and ambulance costs, as well as the avoided loss of net output associated with a premature fatality, where an individual's net output is defined as the discounted present value of his/her lifetime gross output minus his/her lifetime consumption and clearly constitutes a loss to the rest of society in the event of the individual's

---

*Michael Jones-Lee would like to thank the Leverhulme Trust for its support under the "Value" programme RP 2012-V-022.

[1] The willingness to pay approach to the valuation of safety was originally proposed in Drèze (1962). For a summary of more recent developments, see for example, Jones-Lee (1989) or Viscusi (1998).

premature death. However, this additional allowance amounts to only a small fraction (less than 10%) of the overall VPF.

Thus, the use of the willingness to pay-based VPF has a long history within UK policy making and has been subjected to - and continues to be subjected to - much scrutiny by the Health and Safety Executive (HSE) before the implementation of any new recommendations with respect to its usage. The VPF is also subject to ongoing review, updating and possible re-estimation – see, for example, Spackman *et al* (2011). Clearly, the fundamental objective of the willingness to pay approach to the valuation of safety is to provide public sector decision makers with a means of valuing mortality risk reductions in such a way as to reflect the preferences of members of society and the extent of their aversion to the prospect of premature death. By valuing the benefits of a safety improvement using a willingness to pay-based VPF, the aim is therefore to obtain an appropriate measure of the gain in welfare to those individuals who will ultimately bear the cost of implementing the safety improvement through taxation or regulatory restrictions, such as motorway speed limits[2].

One important feature of the VPF is that since the risk reductions that prevent one statistical fatality would produce gains in each affected individual's current life expectancy which, summed across the group affected, will be effectively equal to average remaining life expectancy for members of the group, it appears that the VPF can therefore alternatively be regarded as aggregate current willingness to pay for marginal gains in life expectancy that sum to average remaining life expectancy for the group concerned. However, if the VPF is to be defined in this way then it is necessary to ensure that the gains in life expectancy being valued are the result of reductions in the risk of death during the coming year, rather than delayed risk reductions that will be effective only in later years of life but which will produce the same gains in current life expectancy. This is essentially because there are clear theoretical and empirical grounds for believing that the typical individual will not be indifferent between the various different types of perturbation in his/her survival function that would give rise to the same gain in life expectancy and would actually have a marked preference concerning the timing of the risk reduction – see, for example, Johannesson *et al* (1997), Nielsen *et al* (2010), Hammitt and Tunçel (2015) and Jones-Lee *et al* (2015). If, in fact, the gains in life expectancy being valued are the result of delayed risk reductions, then it is important to distinguish any VPF derived from these valuations from the figure based on current-period risk reductions since, according to both theory and empirical evidence, the VPFs can be expected to differ significantly – see, for example, Jones-Lee (1989, Ch3) and McDonald *et al* (2016).

From a conceptual point of view, the J-Value model developed by Thomas and co-authors s (see, for example, Thomas *et al* (2006) and Thomas and Vaughan (2013, 2014)) is essentially based on this "value of gains in life expectancy" approach to the valuation of safety and, during recent years, in a number of published papers and public presentations, they have made vigorous attempts to persuade UK government departments and related agencies to adopt their model as the basis for the appraisal of proposed safety projects e.g. Thomas *et al* (2006) and Thomas and Vaughan (2013, 2014). However, as argued in Spackman (2009), the manner in which Thomas *et al* actually model the typical individual's preferences concerning physical risk suffers from serious limitations and is, in particular , "… too simplistic to be a competitor to the methods now established in the UK and elsewhere for the valuation of fatality risks."- see Spackman (2009), pi. In particular, in Appendix A of his report Spackman argues that an individual's valuation of a reduction in the risk of premature death may well depend on factors over and above the impact of the risk reduction on his/her remaining life expectancy. Although Spackman does not spell this out, one such factor is clearly the nature of the small change in the survival function that gives rise to the gain in life expectancy. The principal purpose of this paper is to deal in more detail with this particular limitation of the J-Value model, though various other deficiencies in the model are also highlighted.

1. The basic J-Value model

As a basis for the development of their J-Value approach to the cost-benefit analysis of a proposed safety project, Thomas and his co-authors derive the typical individual's annual willingness to pay over the remainder of his/her lifetime for a marginal gain in remaining life expectancy from what is essentially a simple income-leisure choice model - see, for example, Thomas *et al* (2006). In particular, the model effectively involves maximisation of what they refer to as the average individual's "life-quality index", Q, (which is basically lifetime expected utility), with $Q = Y^{\alpha} L$, $0 < \alpha < 1$ - where Y is annual income and L is expected lifetime leisure - subject to the constraint that expected lifetime leisure and expected total time spent working must sum to remaining life expectancy. This constraint implies that Y and L must satisfy the condition $YE = (E – L)w$ where w is the wage rate per year of working time[2] and E is remaining life expectancy[3]. Under Thomas *et al*'s specification of the life-quality index function, the individual's coefficient of financial relative risk aversion[4] is equal to $1- \alpha$.

Based on this model, using – in our view - an unnecessarily circuitous analytical procedure[5], Thomas *et al* then derive the individual's annual willingness to pay, V, for a marginal relaxation, δE, in the total time constraint (i.e. a marginal gain, δE in life expectancy) as $V = Y(1 – x)\delta E/xE$, where x is the fraction of time spent working – see Thomas *et al* (2006) equations (8) and (14). Precisely the same result applies if E and L are defined on a discounted basis. For a large group of n individuals like the one under analysis, the VPF implied by the J-Value model can then be computed as the discounted present value of aggregate annual willingness to pay (summed over the affected group) for a marginal gain, δE, in each individual's life expectancy where, taken across the group of n people affected, these marginal gains sum to average remaining life expectancy, E, for individuals in the

---

[2] Thus, for example if the wage rate is set at, say, £15 *per hour* then w would be £15 x 24 x 365 = £131,400 *per annum*.

[3] For the sake of clarity, we have used the standard notation for income, leisure and other variables, rather than the somewhat unconventional notation used by Thomas *et al*.

[4] For a formal definition of the coefficient of relative risk aversion, see Arrow (1971).

[5] While the argument presented in Thomas *et al* (2006) takes about two pages to derive the key results, these can actually be obtained in a few lines using the method of Lagrange multipliers to maximise Q subject to the total time constraint re-expressed as $E – [Lw/(w – Y)] = 0$, with the Lagrange multiplier giving the effect on the maximand of a marginal increase in E. Since the effect on the maximand of a marginal increase in Y can be inferred directly, it is then a straightforward matter to obtain the expression for annual willingness to pay for a marginal increase in E from the first-order conditions for a constrained maximum. In addition, while Thomas *et al* base their analysis on the "Cobb-Douglas" specification of Q as a function of Y and L, it is a straightforward matter to show that the result $V = Y(1-x)\delta E/xE$ for the individual's annual willingness to pay for a marginal gain in life expectancy is, in fact, *completely independent* of the precise specification of the function Q(Y,L), provided that the function is broadly well-behaved in the sense that it implies continuous, smooth, downward-sloping and strictly convex Y vs L indifference loci. The intuitive explanation for Thomas *et al*'s result is then quite simple. Thus, suppose that the individual is offered a marginal increase, δE, in remaining life expectancy. If the individual is to maintain his/her annual income then a fraction, x, of this increase would have to be spent working, so that the gain in lifetime leisure would be (1-x)δE. Since the total time constraint can be expressed as $Y = w – L(w/E)$ it follows that for any well-behaved specification of the maximand , Q(Y,L), at the optimum the individual's marginal rate of substitution of annual income for lifetime leisure will be equal to w/E. The individual's annual willingness to pay, V, for the gain (1-x)δE in lifetime leisure will therefore be such that $V = (1-x)\delta Ew/E$ which, since $Y = xw$, can be re-expressed as $V = Y(1-x)\delta E/xE$, which is precisely the same as the Thomas *et al* result. It should, however, be noted that Thomas *et al*'s Cobb-Douglas specification, $Q = Y^{\alpha} L$, does imply a specific result for the optimal fraction, x, of time spent working with, in particular, $x = \alpha/(1+\alpha)$.

group, so that $n\delta E = E$. Under the J-Value model, the VPF for a group of individuals like the one under analysis is therefore equal to the discounted present value of an annuity $nV = nY(1-x)\delta E/xE$, which with $n\delta E = E$ simplifies to $nV = Y(1-x)/x$ *per annum*, summed over remaining life expectancy, E, for individuals in the group. In Thomas *et al* (2006) it is assumed that for the UK, on average, x = 0.125 and remaining life expectancy is 41.19 years. Thomas *et al* then apply these values for x and E in their J-Value analysis, so that at a zero discount rate, the implied VPF is equal to 288.33Y. With Y set equal to the current UK average per capita annual disposable income of roughly £18,000, this would yield a VPF of £5.19 million. For a proposed safety improvement that is expected to prevent s statistical fatalities, the J-Value (or "Judgement"-Value) - which is essentially the cost/benefit ratio - would then be computed as $J = C/[s(5.19 \times 10^6)]$, where £C is the cost of the safety improvement. In fact, Thomas *et al* also consider the implications of applying an annual discount rate of 2.5%, in which case discounted average life expectancy is 25.6 years and the implied VPF is £3.23 million.

2. Inadequacy of exclusive focus on gains in life expectancy

Prima facie, the J-Value model would therefore appear to provide a simple and direct means of estimating a willingness to pay-based VPF without the need to carry out a relatively complicated and demanding stated-preference or revealed-preference study of the type employed to date in the UK, USA and other countries that apply the willingness to pay approach to the valuation of safety - see, for example, Jones-Lee (2015), Viscusi and Aldy (2003) and OECD (2012).

However, it is clear that the J-Value model is based on the implicit assumption that the effect of a safety improvement on an individual's lifetime expected utility can be adequately captured by the impact of the improvement on the individual's remaining (possibly discounted) life expectancy. As such, the J-Value model is inherently incapable of taking account of the fact that a given gain in life expectancy can, in principle, be generated by any one of a variety of different types of perturbation, or very small changes, in an individual's survival function (or, equivalently, her vector of future hazard rates[6]) and as already noted, there are both theoretical and empirical grounds for believing that the typical individual will have clear preferences over these different types of perturbation.

Thus for example, consider a situation in which an individual aged 40 is informed that in the UK for a person of his/her age the probability of death during the coming year is about 14 in 10,000, while if he/she were to survive to the age of 80 the probability of death during the coming year would rise to roughly 660 in 10,000 [7]. Suppose that the individual is then asked which of the two risks he/she would prefer to have halved. In spite of the fact that the probability of the 40-year old surviving to age 80 is only about 0.63, his/her gain in undiscounted life expectancy resulting from a halving of the hazard rate at age 80 would actually be about *six times larger* than the gain resulting from a halving of the risk of death during the coming year[8]. Indeed, for annual discount rates up to and including 6%, the gain resulting from the later risk reduction would exceed that resulting from the earlier risk

[6] Where the hazard rate for a given year is the probability of death during that year, conditional on having survived to the beginning of the year.

[7] These are the approximate UK hazard rates averaged over males and females.

[8] Given that the 40-year old's remaining life expectancy is approximately 40 years, then a halving of his/her hazard rate for the coming year would result in a gain of life expectancy of 0.5 x 0.0014 x 40 = 0.028 years. In turn, if the individual were to survive to the age of 80 then his/her remaining life expectancy would be approximately 8 years. Given that the 40-year old's probability of surviving to age 80 is about 0.63, then a halving of his/her hazard rate at age 80 would result in a gain in his/her current life expectancy of 0.5 x 0.066 x 0.63 x 8 = 0.166 years.

reduction even with life expectancy calculated on a discounted basis[9]. In Thomas *et al* (2006) the annual discount rate is actually set at 2.5%, in which case the gain in discounted life expectancy resulting from a halving of the hazard rate at age 80 would be more than three times larger than the gain in discounted life expectancy resulting from a halving of the hazard rate at age 40 so that, according to the J-Value model, the individual would express a clear preference for the delayed risk reduction. But empirical evidence suggests that it is very much more likely that the typical 40-year old would have a marked preference for the current risk reduction – see, for example, Johannesson and Johansson (1996, 1997).

In short, the fundamental conceptual limitation of the J-Value model is that it focuses exclusively on the increase in life expectancy resulting from a reduction in the hazard rate for any given year and, as a result, is incapable of taking account of the very much higher degree of fear or dread with which most people view the prospect of immediate (or very early) death relative to premature death in later years of life. To put it simply, focusing exclusively on the impact on life expectancy as a means of capturing the effect of a safety improvement is similar to considering only the effect on mean wealth in the assessment of the quality of a financial investment, when what is clearly also required in the latter case is information concerning anticipated effects on the variance and other moments of the wealth probability distribution. In short, there is nothing that distinguishes the situation modelled by Thomas *et al* from the completely unrealistic scenario in which an individual knows *for certain* how long he/she will continue to survive and must then decide how much he/she is willing to pay per annum for a marginal "end-of-life" addition to that known remaining survival time.

3. Other basic limitations of the J-Value model

Given its failure to take adequate account of the effect of uncertainty concerning the time of death, the J-Value model can therefore hardly be regarded as providing a satisfactory basis for the quantitative analysis of individual attitudes to physical risk[10]. It is also clear that in addition to its failure to take adequate account of uncertainty, the income-leisure choice model underpinning Thomas *et al*'s analysis is somewhat oversimplified and unrealistic. Thus for example, as noted in Spackman (2009), for many people, weekly working hours are largely predetermined, rather than being a matter of choice. This means that for such people, the work/leisure ratio is essentially parametric rather than being, as in the J-Value model, a key decision variable. For this reason alone the model can hardly be regarded as constituting a satisfactory basis for deriving a reliable quantitative estimate of the typical individual's valuation of a gain in life expectancy. But even if we set this limitation aside and consider a "perfect world" in which working hours are completely flexible and therefore a matter of individual choice, the J-Value model fails to take account of a number of other potentially important factors. Thus, for at least some people (including those in

[9] The gains in life expectancy would actually become equal at an annual discount rate of about 6.5%.

[10] Given that under the J-Value model, with $Q = Y^{\alpha} L$, the individual's valuation of a gain in life expectancy is inversely related to α and since with this specification of Q the individual's coefficient of financial relative risk aversion is equal to $1-\alpha$, Thomas *et al* appear to think that it is generally the case that an individual's coefficient of financial relative risk aversion can also be taken to indicate the individual's degree of aversion to physical risk – see, for example, Thomas and Vaughan (2013). However, this is most certainly not the case. In particular, under standard Expected Utility Theory, with more general specifications of an individual's underlying utility of wealth (or income) functions conditional on survival and death it transpires that the individual's coefficient of relative (or absolute) financial risk aversion gives no indication of the magnitude of his/her marginal rate of substitution of wealth for risk of death – see, for example, Jones-Lee (1989), Ch.3 or Viscusi (1998), Ch.5. In addition, empirical research strongly suggests that one cannot expect any close relationship between people's attitudes to physical and financial risk – see, for example, Weber *et al* (2002) or Soane and Chmiel (2005).

retirement), work does not constitute the only source of income and for a lot of us, work provides a sense of social contribution and achievement, thereby enhancing our overall sense of satisfaction, quite independently of the income that it generates. In contrast to other more sophisticated theoretical models underpinning the definition of the VPF - such as those developed in Jones-Lee (1989) or Viscusi (1998) - the J-Value model also completely ignores the issue of people's concern for the wellbeing of their surviving dependents in the event of their own premature death and the role of life-insurance, which clearly constitutes a further fundamental conceptual limitation of the model. In addition, the J-Value model fails to take account of the fact that many people display a considerably greater degree of fear or "dread" at the prospect of death by some causes - such as cancer - and may therefore be willing to pay substantially more to reduce the risk of death by such causes[11].

All things considered therefore, it is clear that contrary to the predictions of the J-Value model, two individuals of the same age with the same work/leisure balance, the same annual income and the same rate of time-preference could well have fundamentally different attitudes to physical risk and hence place significantly different values on a given reduction in their current or future probability of death by a particular cause. In addition, the same individual might well place very different values on a given reduction in the risk of death by two different causes. Thus, while it could be argued that a highly-simplified model such as that employed by Thomas *et al* might serve as the basis for a rough, "first-shot", *qualitative* analysis of an individual's valuation of time, viewed from a purely theoretical perspective it would seem rather difficult to defend the use of the model as a basis for deriving a reliable estimate of the *actual magnitude* of the typical individual's willingness to pay for a marginal gain in life expectancy generated by a reduction in the risk of premature death by a given cause.

A further basic limitation of Thomas *et al*'s application of the J-Value model is that in order to estimate the willingness to pay-based value of a safety improvement they substitute the UK national averages for life expectancy, fraction of time spent working and per capita income into the willingness to pay expression derived from the J-Value model. Thus, even setting aside the fundamental conceptual limitations of the model, Thomas *et al*'s approach to deriving the value of a safety improvement fails to take account of the fact that the arithmetic mean of a product or ratio will depend not only on the mean values of the variables constituting the product or ratio, but will also depend on the extent to which these variables are positively or negatively correlated. Furthermore, in the case of a ratio, even if the numerator and inverse of the denominator are uncorrelated, it is the *harmonic* mean of the denominator - rather than the arithmetic mean - that is required in order to compute the arithmetic mean of the ratio. Thomas *et al*'s failure to take account of these considerations could result in a significant difference between the value of safety that they derive from their J-Value model and the value that the model would actually imply if they had taken due account of them.

4. Some practical deficiencies of the J-Value analysis

[11] In fact, research carried out in the UK indicates that the prospect of death by some causes (such as cancer, fire in a public place and rail accidents) is indeed viewed by a majority of people with a considerably higher degree of fear or dread than most other causes. However, perhaps somewhat surprisingly, this research also indicated that as far as people's valuation of safety is concerned, in the case of cancer these dread effects appear to be largely offset by latency (i.e. delay in the onset of symptoms), while in the case of fire in a public place, rail accidents and some other highly-dreaded causes, dread effects are offset by low baseline risk – see, for example, Chilton *et al* (2006) and McDonald *et al* (2016).

In addition to its fundamental theoretical limitations, Thomas *et al*'s J-Value analysis also displays some more straightforward practical deficiencies. Thus, in order to take account of time-preference, Thomas *et al* apply an annual discount rate of 2.5%, which is close to the currently recommended UK public sector discount rate of 3.5%[12]. But in order to convert the typical individual's annual willingness to pay over the remainder of his/her lifetime for a marginal gain in life expectancy into a discounted present value reflecting his/her total current willingness to pay, what is clearly required is a discounted present value computed using the individual's *personal* rate of time preference[13]. In particular, with the annual rate of time preference set at 2.5%, the J-Value model produces an implied VPF that is about twice the figure currently used by the Department for Transport (DfT) and various other UK public sector bodies. This appears to form the basis for Thomas *et al*'s claim that the methodology underpinning the DfT VPF is such that "…the safety of UK citizens has not been and is not being protected properly" – see Thomas and Vaughan (2014)[14]. However, existing empirical evidence strongly suggests that the typical individual's personal annual rate of time preference lies in the region of 6-8% - see, for example Viscusi *et al* (1997), Cairns and van der Pol (2000) and McDonald *et al* (2016)[15]. Assuming that real income per capita can be expected to grow at roughly 2% per annum, then if the aim is to establish the typical individual's *personal* willingness to pay it would seem more appropriate to discount his/her future stream of annual willingness to pay for a marginal gain in life expectancy at a net rate in the region of 4-6%, rather than the 2.5% applied by Thomas *et al* which, though it is close to the Social Time Preference Rate used in public sector project appraisal in the UK, is clearly well below the rate at which the typical individual would in fact determine his/her personal current willingness to pay. With the annual discount rate set at the mid-point of the 4-6% range the J-Value model actually produces an implied VPF that is very much closer to the DfT figure. The actual magnitude of the VPF implied by the J-Value model is therefore highly sensitive to the assumed magnitude of the discount rate. In addition, Thomas *et al* derive the value of a gain in life expectancy by setting average annual income equal to GDP per capita. Given that an individual's actual willingness to pay for a safety improvement will almost certainly depend on his/her *disposable* income (i.e. income net of tax) - rather than gross income - a further downward adjustment to the VPF implied by Thomas *et al*'s analysis would seem to be called for, which would drive it even closer to the DfT figure of £1.78 million. All things considered, it would therefore appear that Thomas *et al*'s claim that application of the DfT VPF involves an undervaluation (and hence under-provision) of safety in the UK is quite simply without foundation.

[12] See, for example, H M Treasury (2003), Annex 6.

[13] While it can reasonably be argued that discounting at the social time-preference rate is appropriate when valuing the future benefits of a public sector project, if instead the objective is to arrive at an individual's *own* current valuation of a reduction in the current risk of death (which is what is required in order to derive the VPF), then the discount rate that should be applied to the future stream of annual payments that the individual would be prepared to make in order to finance the risk reduction is clearly the individual's *personal* rate of time-preference.

[14] Thomas and Vaughan also raise a number of questions concerning the validity of the empirical estimation procedure reported in Carthy *et al* (1998) on which the DfT VPF is based. However, in Chilton *et al* (2015) it is shown that Thomas and Vaughn's criticisms are, in the main, ill-founded and somewhat spurious.

[15] It is worth noting that the McDonald *et al* paper addresses, from both a theoretical and empirical perspective, the question of the appropriate VPF to apply to cases of work-related cancer involving a significant latency delay (typically several years) between exposure to the cancer-inducing conditions and the onset of the cancer symptoms and eventual death. As such, this completely refutes Thomas' claim that "…the current VPF approach is unable to differentiate between death tomorrow and death in 40 years time."- see Thomas & Jones (2011).

But if - given an appropriate allowance for discounting and taxation - the J-Value model actually produces a VPF that is approximately the same as that employed by the DfT and other UK public sector bodies, why should the model not then be regarded as providing a legitimate basis for derivation of the VPF and future adjustments to the value? The answer is quite simply that, as already explained, the choice model underpinning Thomas *et al*'s derivation of the willingness to pay-based value of a safety improvement is subject to so many fundamental conceptual limitations that it cannot be taken to provide a satisfactory basis for the derivation of a reliable quantitative estimate of the VPF, even when appropriately modified to allow for discounting and taxation. The fact that, with appropriate modification for discounting and taxation, the J-Value model happens to produce a result that is similar to that obtained by a conceptually more defensible procedure is largely a matter of chance.

Finally, it is worth noting that in more recent work Thomas *et al* have modified their J-Value approach to include the potential environmental effects of nuclear hazards, as well as effects on human health and safety – see Thomas and Vaughan (2013). However, it is important to appreciate the fact that since environmental effects would be dealt with quite separately from effects on health and safety in a conventional cost-benefit analysis of the type carried out by UK government departments, such effects should not be treated as constituting part of the VPF implied by the Thomas model in any legitimate comparison with the DfT figure.

5. Conclusion

Overall, therefore, these comments would appear to substantially reinforce the conclusion of the Spackman Report that the J-Value model cannot be regarded as a plausible alternative to the procedures currently used in the UK and elsewhere to determine the level at which the VPF should be set for the valuation of a reduction in the risk of death by a given cause. In short, according to the J-Value model, in order to determine an individual's willingness to pay for a marginal reduction in his/her probability of death by any cause now or in the future, all that is required is information concerning his/her age; wage rate per unit of working time; proportion of time spent working and personal rate of time-preference. To put it bluntly, given the complexity of human nature, this is a gross over-simplification.

References

Arrow, K.J. (1971). *Essays in the Theory of Risk-Bearing.* Amsterdam, North-Holland.

Cairns, J.A. & van der Pol, M.M. (2000). The estimation of marginal rates of time preference in a UK – wide sample (TEMPUS) project. *Health Technology Assessment, 4*(1), 1 – 83.

Carthy, T., Chilton, S., Covey, J., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N. & Spencer, A. (1998). On the Contingent Valuation of safety and the safety of Contingent Valuation: Part 2 - The CV/SG "Chained" approach. *Journal of Risk and Uncertainty*, 17, 187 - 213.

Chilton, S., Jones-Lee, M., Kiraly, F., Metcalf, H. & Pang, W. (2006). Dread risks. *Journal of Risk and Uncertainty,* 33 (3), 165 – 182.

Chilton, S., Covey, J., Jones-Lee, M., Loomes, G., Pidgeon, N. & Spencer, A. (2015). Response to 'Testing the validity of the "value of a prevented fatality" (VPF) used to assess UK safety measures'. *Process Safety and Environmental Protection, 93,* 293 – 298.

Dalvi, M.Q. (1988). *The Value of Life and Safety: a Search for a Consensus Estimate*. London, Dept. for Transport.

Dept. for Transport (2000). Highways economic note No.1: 2000 valuation of the benefits of prevention of road accidents and casualties.

Drèze, J. (1962). L'utilité sociale d'une vie humaine. *Revue Francaise de Recherche Opérationnelle*, 23, 93-118.

Hammitt, J.K. & Tunçel, T. (2015). Preferences for life-expectancy gains: Sooner or later? *Journal of Risk and Uncertainty, 51* (1), 79 – 101.

HM Treasury (2003). *The Green Book : Appraisal and Evaluation in Central Government.* London, TSO.

Johannesson, M., Johansson, P-O. & Löfgren, K-G. (1997). On the value of changes in life expectancy: Blips versus parametric changes. *Journal of Risk and Uncertainty, 15*, 221 – 239.

Johannesson, M. & Johansson, P-O. (1996). To be, or not to be, that is the question: An empirical study of the WTP for an increased life expectancy at an advanced age. *Journal of Risk and Uncertainty, 13*, 163 – 174.

Johannesson, M. & Johansson, P-O. (1997). Quality of life and the WTP for an increased life expectancy at an advanced age. *Journal of Public Economics, 65*, 217 – 226.

Jones-Lee, M.W. (1989). *The Economics of Safety and Physical Risk.* Oxford, Basil Blackwell.

Jones-Lee, M. (2015) Dealing with safety in UK public sector project appraisal. Chapter 5 in Mansfield, C. & Kerry Smith V. (2015). *Benefit-Cost Analyses for Security Policies.* Cheltenham, Edward Elgar.

Jones-Lee, M.W., Hammerton, M. & Philips, P.R. (1985). The value of safety: Results of a national sample survey. *The Economic Journal, 95*, 49 – 72.

Jones-Lee, M., Chilton, S., Metcalf, H. & Nielsen, J.S. (2015). Valuing gains in life expectancy: Clarifying some ambiguities. *Journal of Risk and Uncertainty, 51* (1), 1 -21.

Mc Donald, R.L., Chilton, S.M., Jones-Lee, M.W. & Metcalf, H.R.T. (2016). Dread and latency impacts on a VSL for cancer risk reduction. *Journal of Risk and Uncertainty*, *52* (2), 137 – 161.

Nielsen, J.S., Chilton, S. Jones-Lee, M. & Metcalf, H. (2010). How would you like your gain in life expectancy to be provided? An experimental approach. *Journal of Risk and Uncertainty, 41*(3), 195 – 218.

OECD (2012) *Mortality Risk Valuation in Environment, Health and Transport Policies.* Paris, OECD Publishing.

Spackman, M. (2009). *Review of the J-value Literature – Final Report. The Health and Safety Executive*. London, NERA Economic Consulting.

Spackman, M., Evans, A., Jones-Lee, M., Loomes, G., Holder, S., Webb, H. & Sugden, R. (2011). *Updating the VPF and VPIs: Phase 1: Final Report Department for Transport.* London, NERA Economic Consulting.

Soane, E. & Chmiel, N. (2005). Are risk preferences consistent? The influence of domain and personality. *Personality and Individual Differences, 38* (8), 1781 – 1791.

Thomas, P.J., Stupples, D.W. & Alghaffar, M.A. (2006). The extent of regulatory consensus on health and safety expenditure. Part 1: Development of the J-Value technique and evaluation of regulators' recommendations. *Process Safety and Environmental Protection, 84*(B5), 329 – 336.

Thomas, P. & Jones, R. (2011). Response to "Review of the J-Value Literature – Final Report [to] the Health and Safety Executive" by Michael Spackman, NERA Economic Consulting. PDF.

Thomas, P.J. & Vaughan, G.J. (2013). All in the balance : assessing schemes to protect humans and the environment. *Nuclear Future, 9*, 41 -51.

Thomas, P.J. & Vaughan, G.J. (2014). Testing the validity of the "value of a prevented fatality" (VPF) used to assess UK safety measures. *Process safety and Environmental Protection, 94*, 239 – 261.

Viscusi, W.K. (1998). *Rational Risk Policy.* Oxford, Oxford University Press.

Viscusi, W.K. & Aldy, J.E. (2003). The value of statistical life: a review of market estimates throughout the world. *Journal of Risk and Uncertainty, 27*, 5 – 76.

Viscusi, W.K., Hakes, J. K. & Carlin, A. (1997). Measures of mortality risks. *Journal of Risk and Uncertainty, 14,* 213 – 233.

Weber, E.U., Blais, A.R. & Betz, N.E. (2002). A domain-specific risk-attitude scale : Measuring risk perceptions and risk behaviors. *Journal of Behavioral decision Making, 15* (4), 263 – 290.