

Survival Probability, Health, & Preferences

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Overview

Subjective survival probabilities

- Evaluation: coherence, comparison with actuarial, updating
- Comparison with realized survival

Behavioral effects of subjective survival

- Value of enhanced survival (current & future)
- Aversion to financial risk

"Subjective" Probability

Health-risk probabilities are "subjective"

- Individual risk differs from population average
 - Only population average is observable
- Often extrapolated from animal experiments or observational human data
 - Causality is uncertain

Subjective probability = quantitative measure of degree of belief

- Individuals can attach different probability to same event

"Objective" Probability

"Objective randomness" is not stochastic but chaotic (e.g., coin toss, roulette wheel)

- Deterministic process
- Sensitively dependent on initial conditions (butterfly flapping wings in China may cause hurricane in Atlantic)

Insufficient information about initial conditions precludes prediction

→ All probabilities are subjective

Disagreement about Probability

Individuals can hold different probabilities

- Inadequate evidence to choose among them

Update probabilities as evidence accumulates

- "When somebody persuades me that I am wrong, I change my mind. What do you do?" - John Maynard Keynes
- Ultimately, probabilities should converge
 - Coin toss, roulette wheel
 - "In the long run we are all dead."- John Maynard Keynes

Subjective Survival

Several studies investigate general-population perceptions of mortality risk

- Hamermesh 1985
- Hurd & McGarry 1995, 2002
- Viscusi & Hakes 2003
- Liu, Tsou, & Hammitt 2007

Subjective Survival

(Liu, Tsou, & Hammitt, 2007)

Investigate subjective probabilities of living to age 75 (P75) and 85 (P85)

Coherence

- $P85 < P75$
- Increase with age
- Decrease with chronic disease

Comparison with actuarial probabilities

Response to new information

Data

(Taipei residents, 40-65 yrs old)

2001 panel survey (700 respondents)

- Wave 1: in-person interview
- Wave 2: telephone interview 2-3 months later after medical examination

2002 survey (930 respondents)

- Similar to Wave 1

P75 & P85 elicited on 0-100 scale, normalized to 0-1

- "Using any number from 0 to 100, where 0 means absolutely no chance and 100 means absolute certainty, what do you think are the chances of you living to age 75 (85)?"

P75

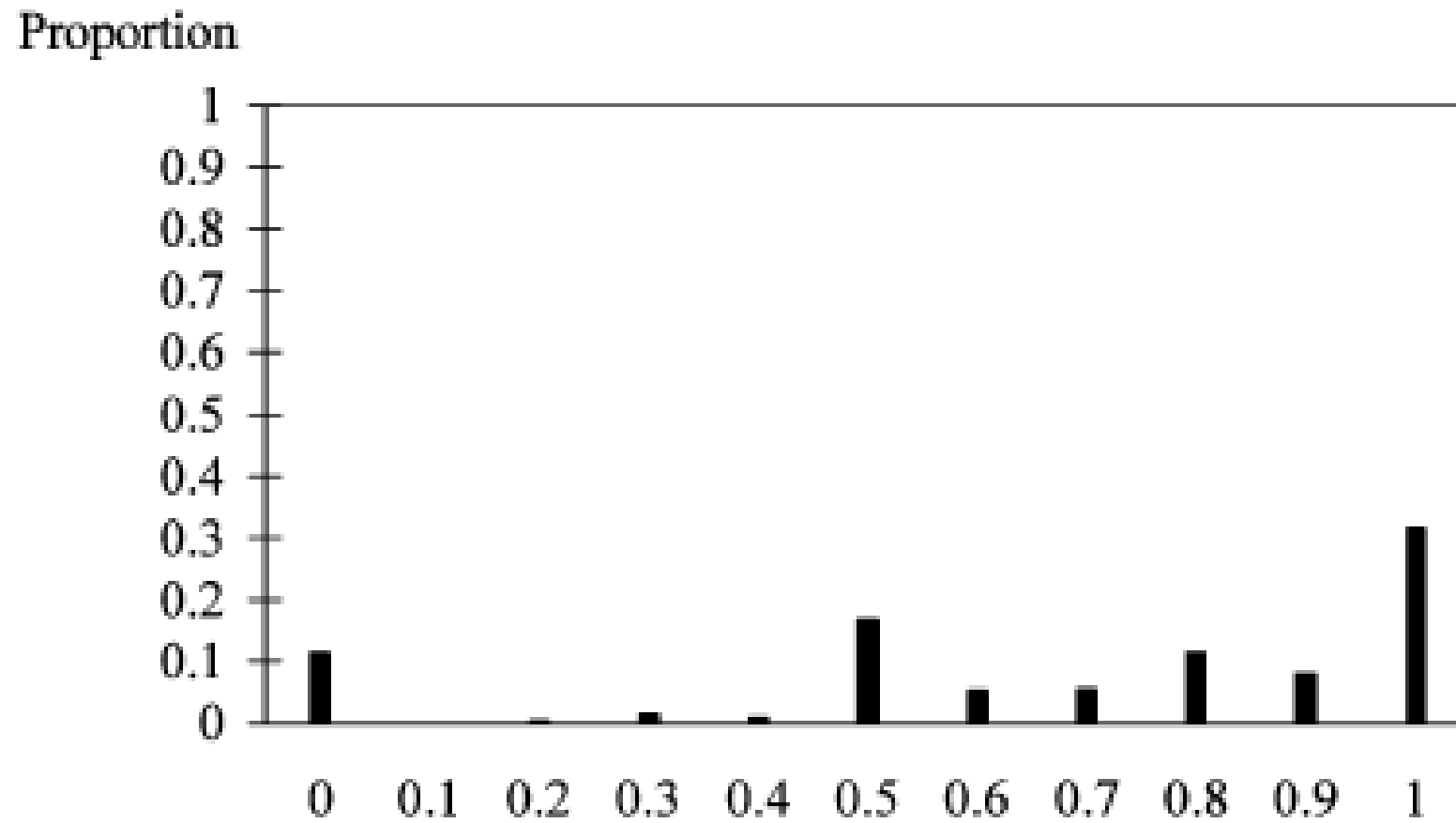


Figure 1. Subjective Probability of Survival to 75.

P85

Proportion

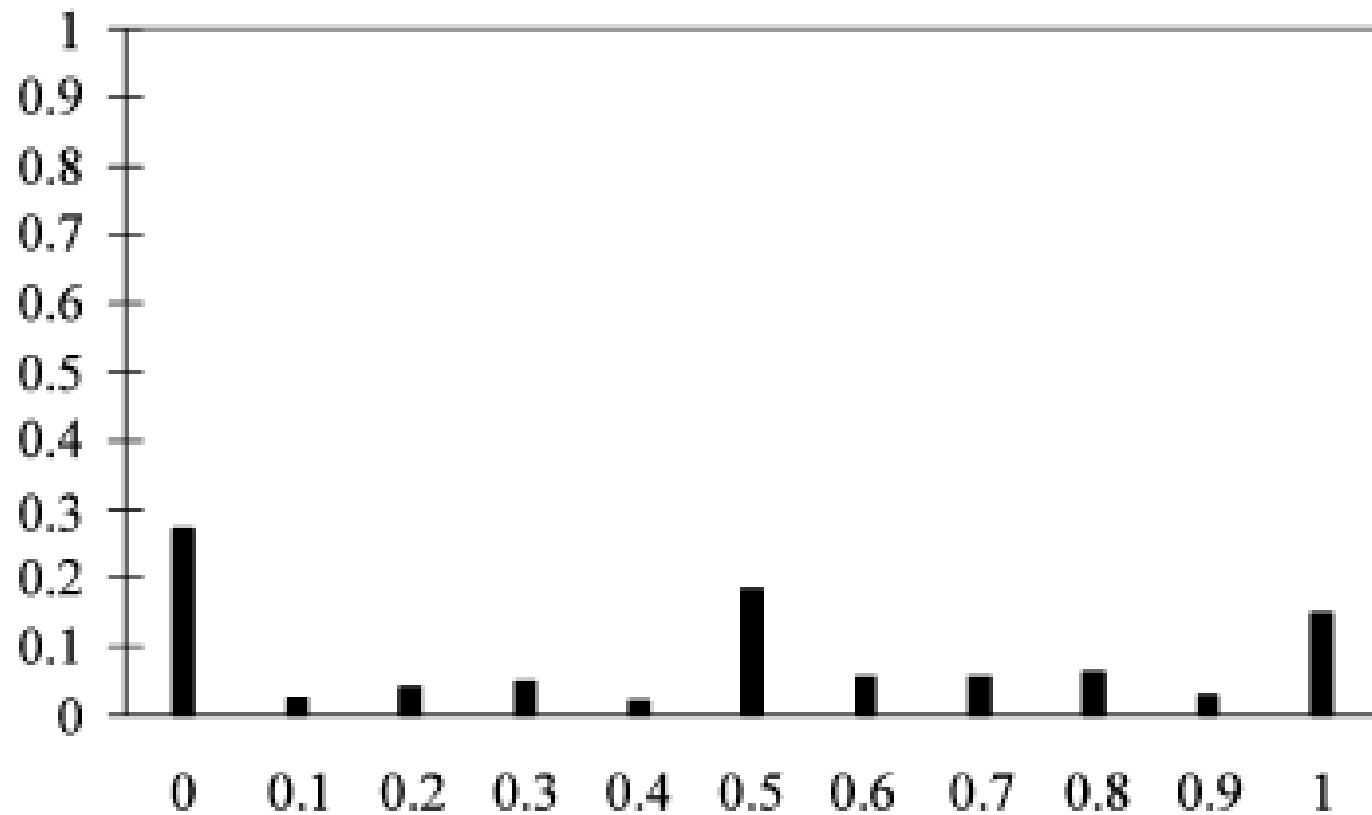


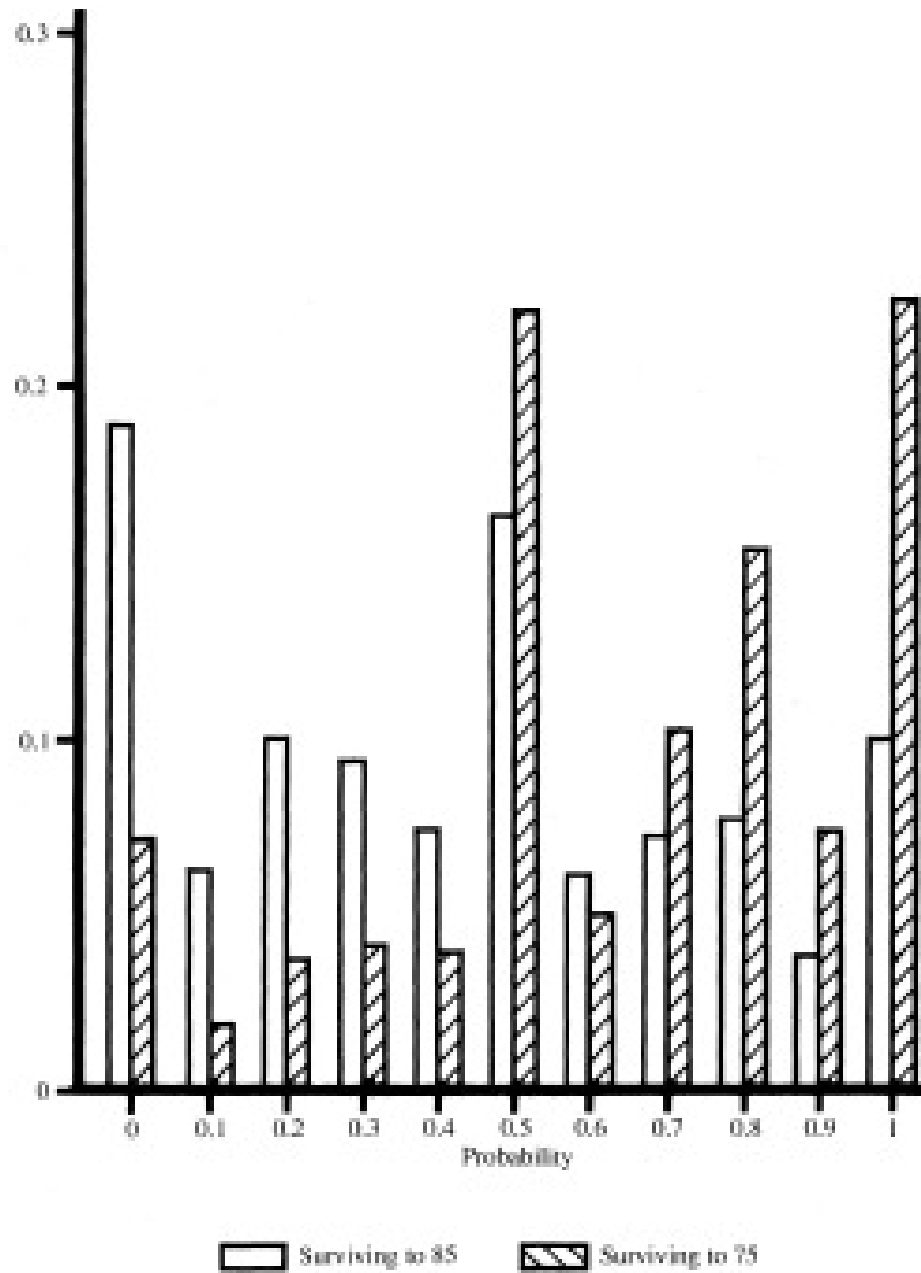
Figure 2. Subjective Probability of Survival to 85.

US Health & Retirement Study

Respondents aged 51 – 60 plus spouses

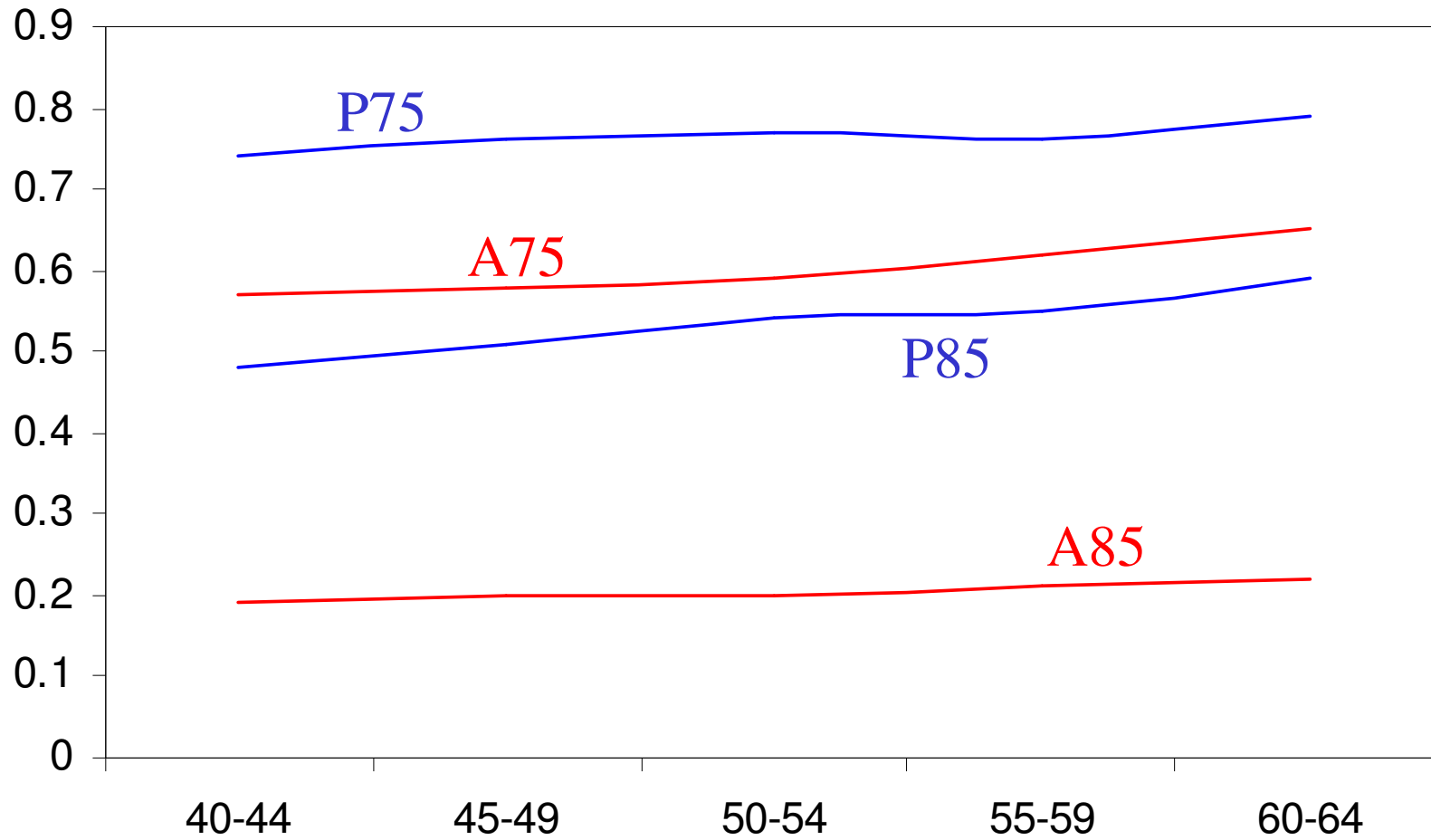
Scale: 0 – 10

(Hurd & McGarry 1995)

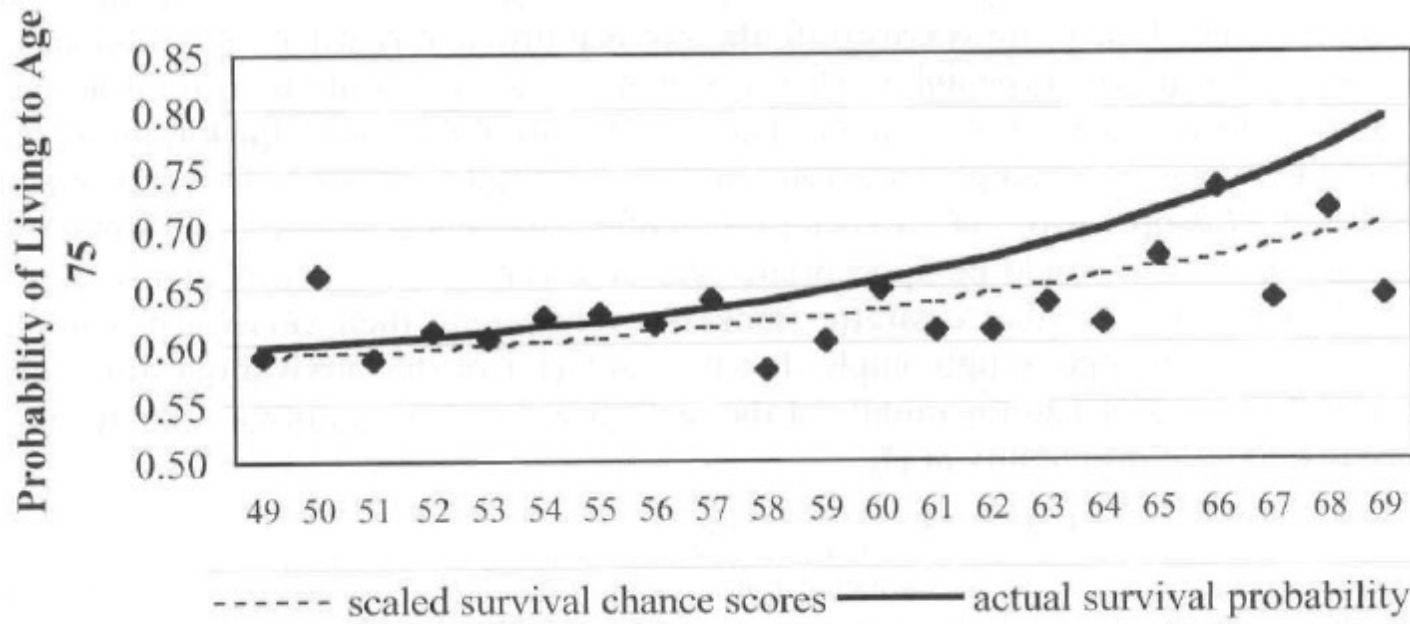


Men

Taiwan



P75



Men
USA

Viscusi
& Hakes
2003

ig. 1. Survival probabilities to age 75 and survival chance scores for white males, by age.

P85

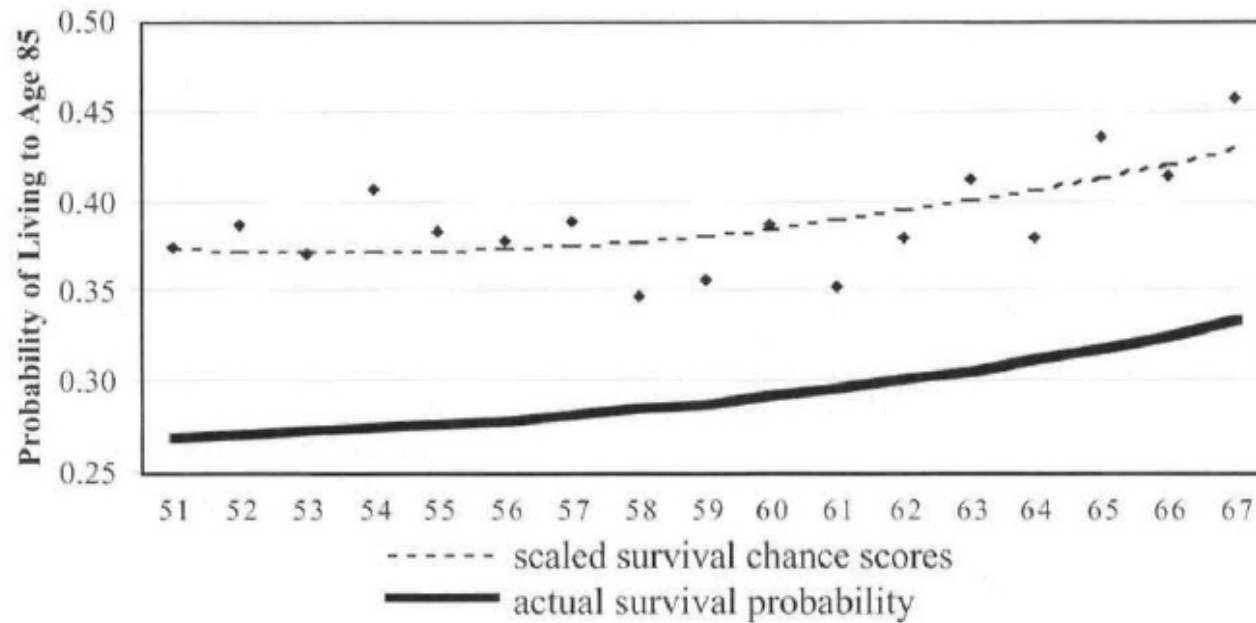
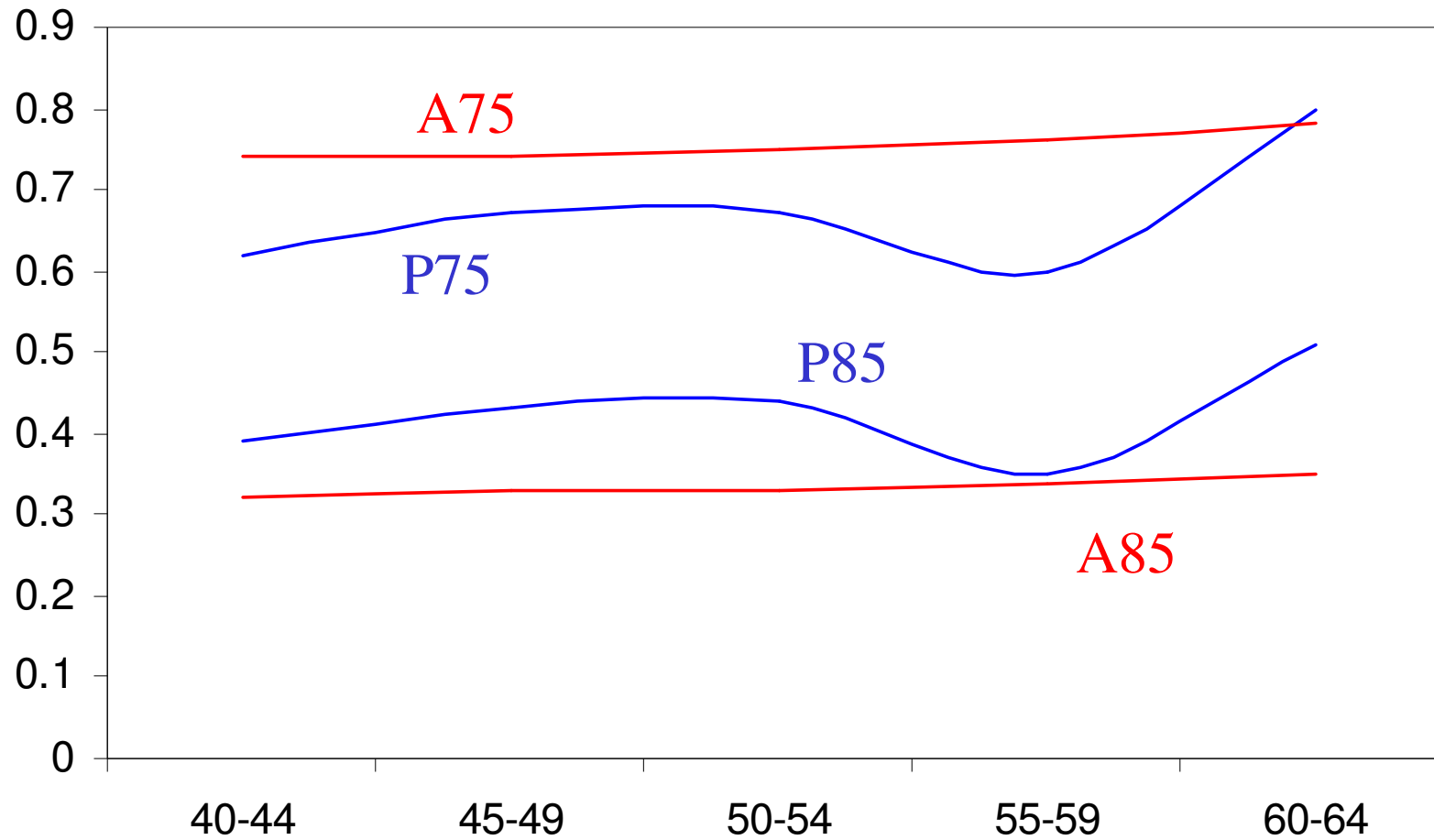


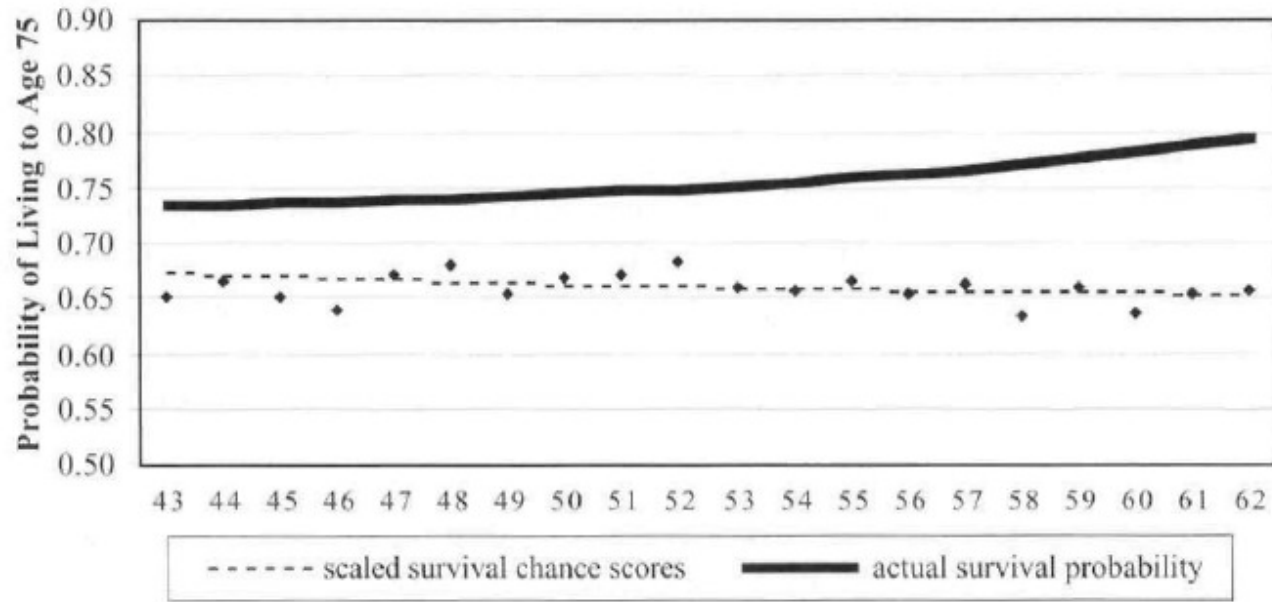
Fig. 3. Survival probabilities to age 85 and survival chance scores for white males, by age.

Women

Taiwan



P75



Women
USA

Viscusi &
Hakes
2003

Fig. 2. Survival probabilities to age 75 and survival chance scores for white females, by age.

P85

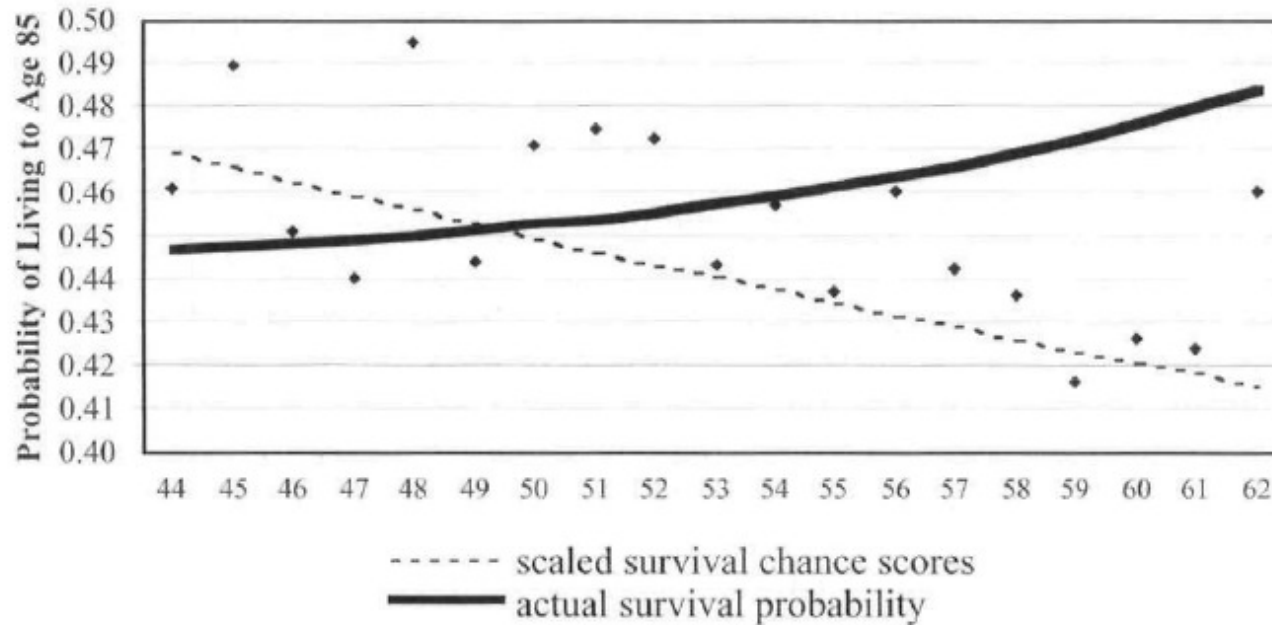


Fig. 4. Survival probabilities to age 85 and survival chance scores for white females, by age.

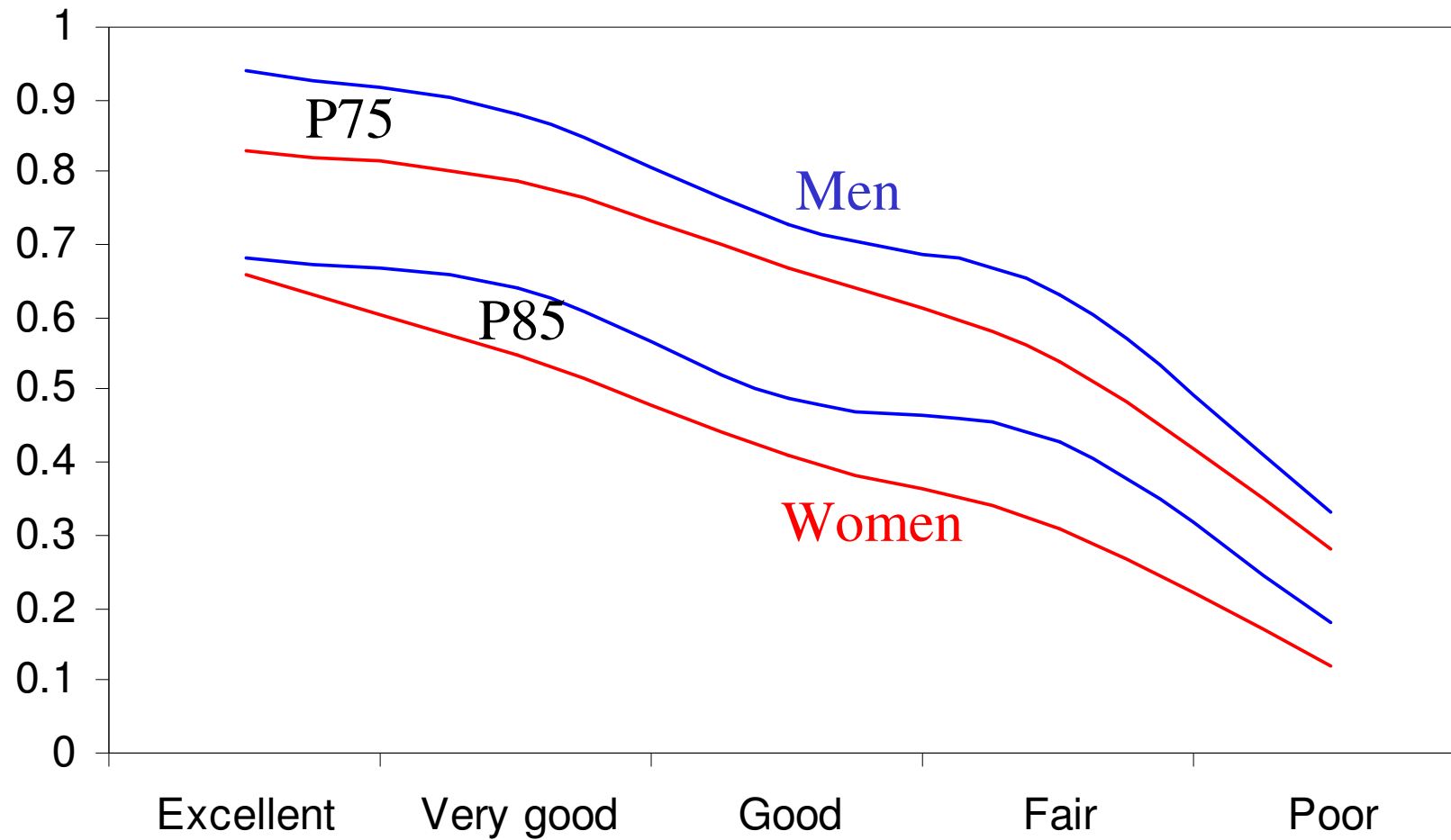
Summary: Perceived v. Actuarial

	Taiwan		US	
	P75	P85	P75	P85
Men	Over	Over	Under (close)	Over
Women	Under	Over	Under	Decrease w/ age

Regression of Perceived on Actuarial Survival = f(age, sex) (t-statistic)

	P75	P85	P85 – P75
Intercept	0.7 (11)	0.5 (12)	0.2 (1.4)
Slope	0.1 (1.1)	0.2 (0.2)	0.04 (0.1)

By Health Status



Determinants of Subjective Survival (regression)

Increasing convex function of age

Higher for men than women

Increases with income & education

Higher if parent still living (especially same-sex parent)

Decreases with poor health, chronic disease, obesity & depression

Subjective – actuarial

- Similar results except no effect of age

Response to Health Information (percent of respondents)

	P75	P85
$P_2 < P_1$	65	79
$P_2 > P_1$	25	14
$P_2 = P_1$	10	7

Response to Health Information

$$P_2 = \frac{P_1 + \gamma S}{1 + \gamma}$$

S = health information from medical exam (diagnoses, behavioral advice), scaled as probability

γ = precision of new information relative to precision of prior estimate

Response to Health Information

	P75	P85
S / P_1	0.7	0.5
γ	3	10

S decreases with number of adverse test results or topics of behavioral advice (e.g., lose weight, stop smoking)

Too much weight on new information (availability bias)?

Subjective Survival v. Realization

Longevity Expectations and Death: Can People Predict Their Own Demise?

- Smith, Taylor, & Sloan, AER 2001

Health and Retirement Study

- Respondents initially aged 51 – 60 (plus spouses), interviewed every 2 years (4 waves available)
- Elicited P75 (0 – 10 scale)

Subjective Survival v. Realization

Respondent died before	Wave 1	Wave 2	Wave 3
Wave 4	0.56	0.55	0.52
Wave 3	0.52	0.46	
Wave 2	0.44		
Respondent alive in wave 4	0.65	0.64	0.65

The diagram illustrates subjective survival probabilities over four waves. Red arrows show the progression of subjective survival for respondents who died before Wave 4: from 0.56 at Wave 1 to 0.55 at Wave 2, and from 0.52 at Wave 2 to 0.46 at Wave 3. A vertical red arrow also points from Wave 4 down to Wave 3. Blue double lines underline the row for respondents alive in Wave 4, with values 0.65, 0.64, and 0.65 across Waves 1, 2, and 3 respectively.

Survival and Behavior

Value of changing mortality risk

- Value per statistical life

Aversion to financial risk

Value per Statistical Life (VSL)

“L’Utilité Sociale d’une Vie Humaine” (Drèze 1962)

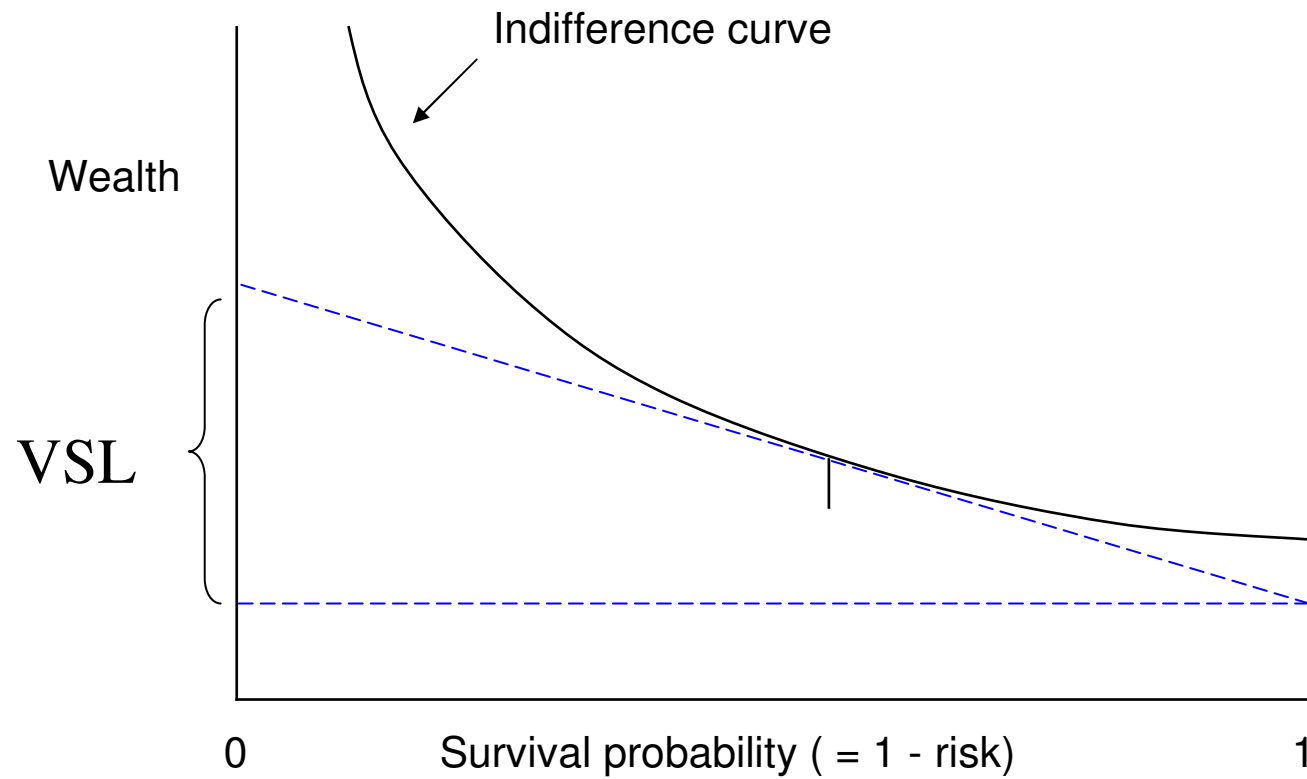
“The Life You Save May Be Your Own” (Schelling 1968)

“The Value of Changes in the Probability of Death or Injury” (Jones-Lee 1974)

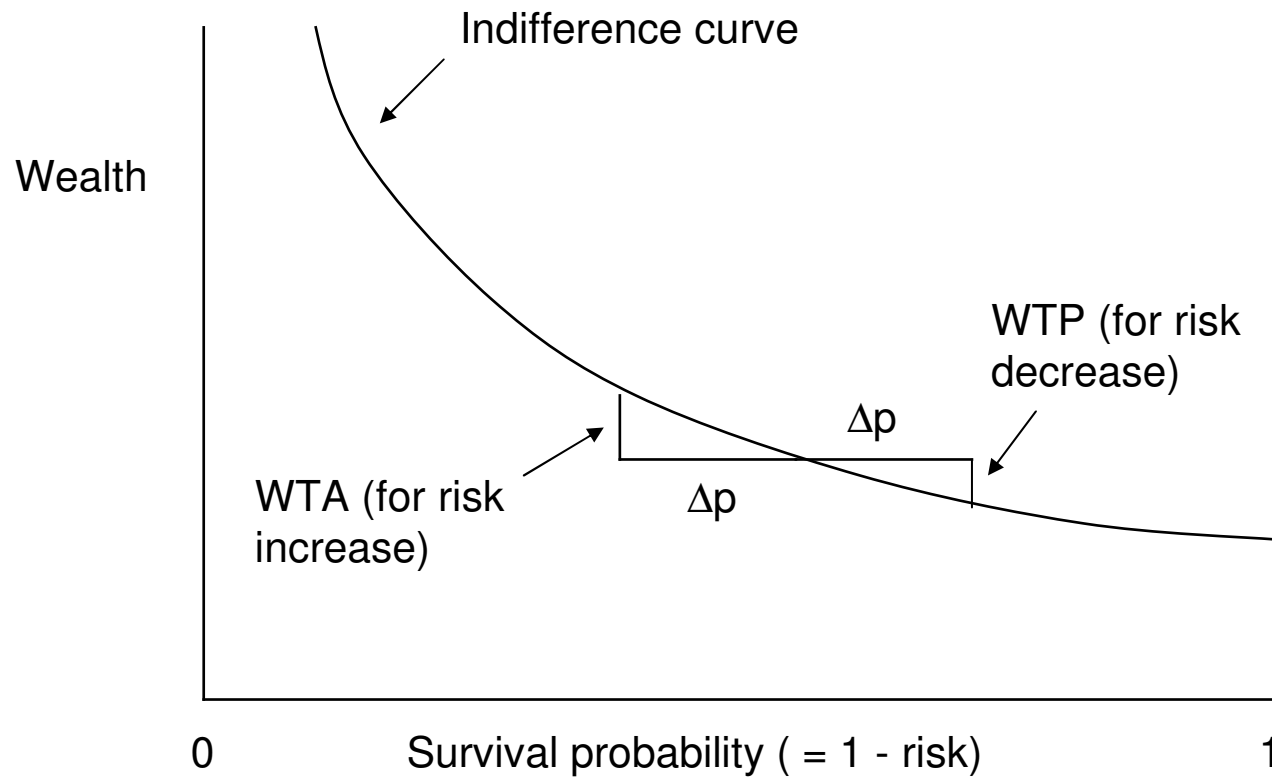
Ex ante problem is

- Own willingness to pay (WTP)
- For small change in own mortality risk
- Within specified time period (e.g., current year)

$$VSL = slope$$



$$VSL \approx \frac{WTP}{\Delta p} \approx \frac{WTA}{\Delta p}$$



Standard Model (single period)

$$EU = (1 - p) u_a(w) + p u_d(w)$$

p = mortality risk (probability)

$u_a(w)$ = utility if survive period with wealth w

$u_d(w)$ = utility if die in period with wealth w

$$VSL = \left. \frac{dw}{dp} \right|_{EU=c}$$

Value per Statistical Life

$$VSL = \left. \frac{dw}{dp} \right|_{EU=c} = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)} = \frac{\Delta u(w)}{Eu'(w)}$$

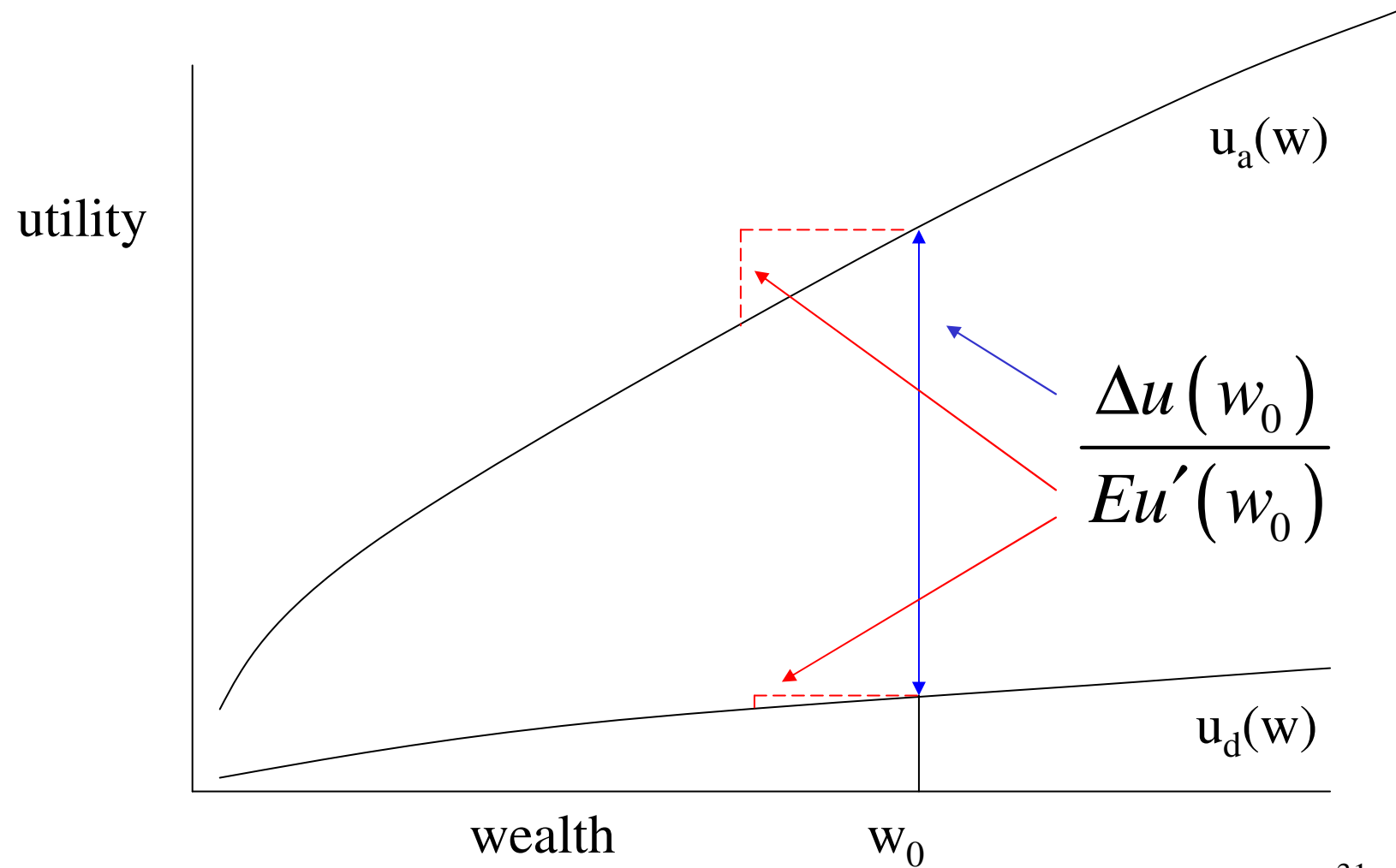
Assume

$$u_a(w) > u_d(w)$$

$$u'_a(w) > u'_d(w) \geq 0$$

$$u''_a(w) \leq 0, u''_d(w) \leq 0$$

$$VSL = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)} = \frac{\Delta u(w)}{Eu'(w)}$$



Effect of Wealth

$$VSL = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)}$$

As wealth (w) increases

- Numerator increases ($u'_a > u'_d$)
- Denominator decreases ($u''_a, u''_d \leq 0$)
- VSL increases

Effect of Baseline Risk

$$VSL = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)}$$

As risk (p) increases

- Numerator unaffected
- Denominator decreases ($u'_a > u'_d \geq 0$)
- VSL increases (dead-anyway effect)

Effect of Health is Ambiguous

$$VSL = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)} = \frac{\Delta u(w)}{Eu'(w)}$$

If survival is in good health rather than poor

- Δu is higher
- Eu' may be higher

Effect of Life Expectancy is Ambiguous

$$VSL = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)} = \frac{\Delta u(w)}{Eu'(w)}$$

If survival is with long life expectancy

- Δu is higher
- Eu' may be higher
 - Investment horizon, future earnings

Effect of Life Expectancy

Lifecycle models suggest VSL rises then falls with age

$$\text{Max } V = \sum_{t=0}^{\infty} s(t) \left(\frac{1}{1+r} \right)^t u(c_t)$$

subject to budget constraint based on earnings (can save, may be able to borrow)

VSL proportional to discounted life expectancy if utility constant over time

Peak VSL somewhere between 25 and 65?

- Sensitive to assumptions about discounting (Shepard & Zeckhauser, 1984; Ng, 1992)

Empirical Evidence of Variation

Life expectancy (controlling for age)

- Little evidence

Health

- Some evidence that VSL is larger for people with cancer, heart, lung disease
 - Krupnick et al. 2002 CV, Smith et al. 2002 wage differential

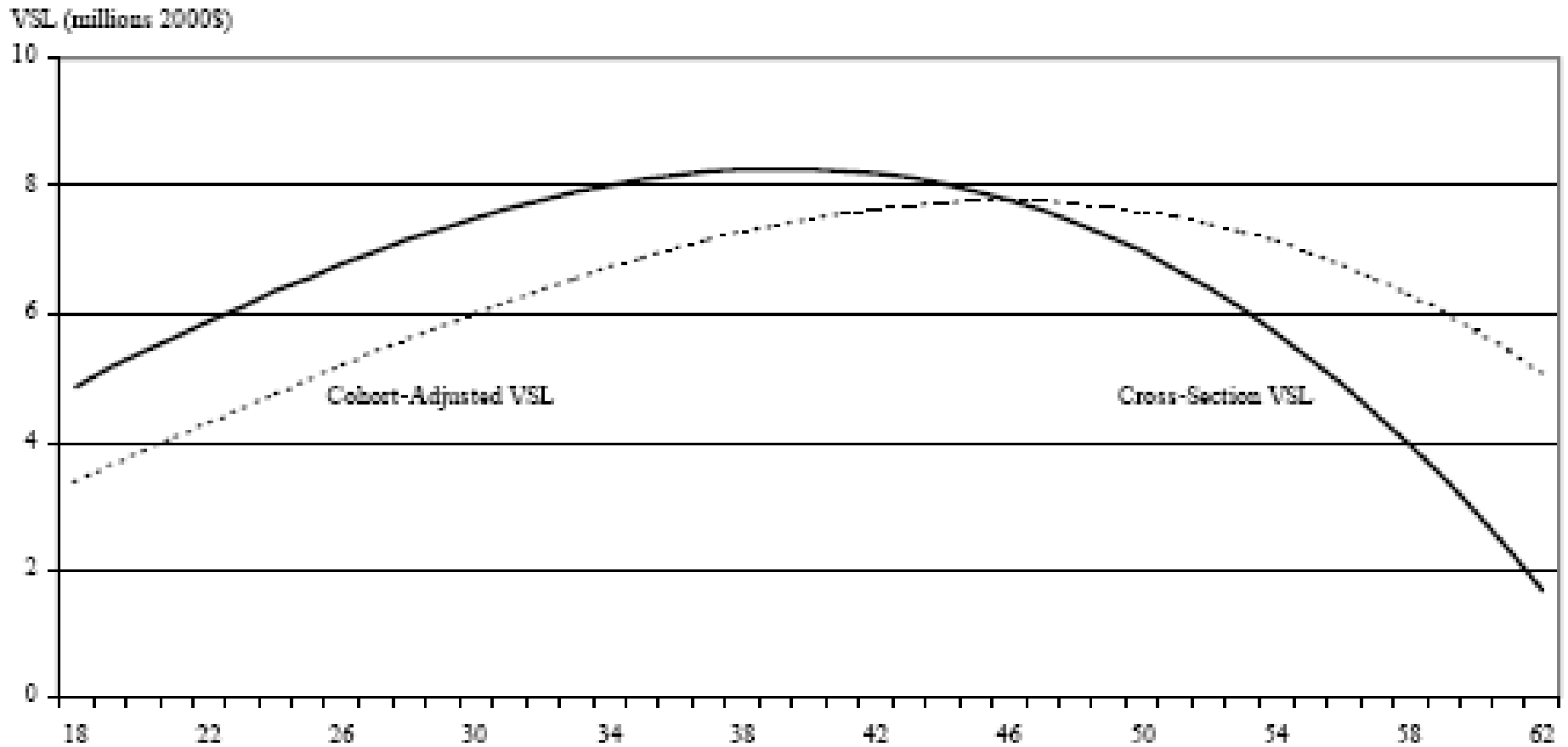
Variation with Age

Contingent Valuation

- VSL smaller at “old” than “middle” age
- Falls 20 – 40 percent from age 40 to 70
 - Krupnick (2007)

Compensating wage differential

- Inverted U, modest decrease at older ages
- Studies limited to age 65 or so
 - Aldy & Viscusi (2007)



Aldy & Viscusi, Adjusting the value of a statistical life for age and cohort effects, Rev Econ Stat (in press)

VSLY and Age

If VSL follows inverted U

- VSLY must fall with age over younger ages (where VSL increases)
- VSLY may rise, fall, remain constant over older ages (where VSL decreases)
- (VSL = value per statistical life year)

Concerns about Empirical Estimates

Inadequate controls for wealth

- Ratio of wealth to income rises with age (mean net worth / mean income increases from 4 at age 40 to 12 at age 70)
- Cross-sectional estimates ignore secular increase in income (cf. cohort estimates)

Wage-differential studies have limited sample

- Exclude older people
- Healthy worker and other biases?

Effects of Health and Longevity on Financial Risk Tolerance (with Kevin Haninger, Nicolas Treich)

Collect information on financial risk aversion in
CV surveys of WTP to reduce health risk

- Questions from Health and Retirement Study (Barsky et al. 1997)
- Effects of financial risk aversion on monetary value of health risk
- **Effects of health and life expectancy on aversion to financial risk**

Survey Question

Question 1

Suppose that you are the only income earner in the family and that you have a good job guaranteed to give you your current income every year for life. You are given the opportunity to take a new and equally good job for life with a 50-50 chance that it will either double your income or cut it by a third. Would you take the new job?

- Yes
- No

Note: Measures relative risk tolerance (= 1 / relative risk aversion)

Question 1

Suppose that you are the only income earner in the family and that you have a good job guaranteed to give you your current income every year for life. You are given the opportunity to take a new and equally good job for life with a 50-50 chance that it will either double your income or cut it by a third. Would you take the new job?

- Yes → Skip to Question 2
- No → Skip to Question 3

Question 2

Suppose the chances were 50-50 that it would either double your income or cut it by half. Would you take the new job?

- Yes → Group IV, **most risk tolerant**
- No → Group III

Question 3

Suppose the chances were 50-50 that it would either double your income or cut it by a fifth. Would you take the new job?

- Yes → Group II
- No → Group I, **least risk tolerant**

Theory

Effects of life expectancy

- Time diversification (smooth consumption shocks over remaining lifetime)
- Lifetime income (risk to income in all future years increases with life expectancy)

Effects of health

- Not previously studied?
- Depends on $u(h, c)$

Life Expectancy: Two Effects

Time diversification

- Chance of losing €1000 this year
 - Live 1 year: reduce consumption €1000 per year
 - Live 10 years: reduce consumption €100 per year
 - If risk averse toward annual consumption, second case is less harmful

Lifetime income

- Chance of losing €1000 every year
 - Live 1 year: lose €1000
 - Live 10 years: lose €10 000
 - Second case yields larger loss

Effects of Health

Health may affect

- Life expectancy
- Income
- Medical expenses
- Risk tolerance of instantaneous utility
- **Marginal utility of consumption**

We consider only last effect

Utility of Health and Consumption

$$u(h, c) = ?$$

$$u_c(c) + u_h(h)$$

- Additive separability
- $\partial u / \partial c$ independent of health

$$u(c - m[h])$$

- Monetary loss
- Poor health increases $\partial u / \partial c$

$$u_h(c)$$

- Health-state dependent
- Arbitrary effect of health on $\partial u / \partial c$

$$h u(c)$$

- $h > 0$ (so $\partial u / \partial c > 0$), $h = 1$ for full/perfect health
- QALY (quality-adjusted life year)
- Poor health decreases $\partial u / \partial c$

– Empirically supported (Viscusi & Evans 1990, Sloan et al. 1998)

Summary of Theoretical Results

In general, effects of life expectancy and health on risk tolerance are ambiguous

Exceptions: No effects for

- Perfect consumption smoothing
- HARA utility functions
 - Harmonic absolute risk aversion, e.g., logarithmic, power, exponential, quadratic

Survey Sample

Internet panel (Knowledge Networks)

Representative of general US adult population

- Recruited to panel by random-digit dialing

2795 respondents / 4481 recruited = 62%

2751 usable responses

- 39 did not answer risk-tolerance questions
- 5 did not answer health questions

Survey Sample

Variable	Mean (SD)
Age	45 yrs (16)
Life expectancy*	35 yrs (14)
Male	47%
Household income	\$48 000 (36 000)
Married	54%
Child in household	38%

* Note: life expectancy calculated from age, sex, race, (health category), correlation with age = -0.98

Survey Instrument

Self-reported health

- Excellent – Very good – Good – Fair – Poor
- Visual Analog Scale (VAS)
 - 100 = perfect health, 0 = equivalent to dead
- Health Utilities Index (HUI)
 - Classify health on 8 domains with 5 or 6 levels each
 - Vision, Hearing, Speech, Ambulation, Dexterity, Emotion, Cognition, Pain

Tolerance for lifetime income risk

- Four ordered categories (double-bounded dichotomous-choice)

Self-Assessed Health

Category	Distn (%)	VAS	HUI
		Mean (SD)	Mean (SD)
Excellent	12	0.93 (0.08)	0.93 (0.10)
Very good	35	0.85 (0.08)	0.89 (0.13)
Good	36	0.73 (0.12)	0.79 (0.17)
Fair	14	0.57 (0.16)	0.60 (0.26)
Poor	3	0.39 (0.16)	0.36 (0.30)

Risk Tolerance

Least risk tolerant	Reject both gambles	54%
	Reject 1 st and accept 2 nd gamble	15%
	Accept 1 st and reject 2 nd gamble	15%
Most risk tolerant	Accept both gambles	16%

Risk Tolerance Increases with Life Expectancy

LE (yrs)	Distn (%)	Accept 1 st gamble	Reject both Least Tolerant	Reject 1 st , Accept 2 nd	Accept 1 st , Reject 2 nd	Accept both Most Tolerant
< 10	3	22	64	14	8	14
10-20	13	27	62	11	14	13
20-30	20	26	60	14	14	12
30-40	24	29	56	15	14	15
40-50	20	36	49	15	18	18
50-60	17	36	43	21	18	18
> 60	2	37	48	16	16	21 ₅₅

Risk Tolerance Increases with Health (Category)

Category	Distn (%)	Accept 1 st gamble	Reject both Least Tolerant	Reject 1 st , Accept 2 nd	Accept 1 st , Reject 2 nd	Accept both Most Tolerant
Excellent	12	34	47	19	19	15
Very good	35	30	51	18	15	15
Good	36	31	57	12	15	16
Fair	14	30	56	14	14	16
Poor	3	27	67	6	11	16

Risk Tolerance Increases with Health (HUI)

HUI	Distn (%)	Accept 1 st gamble	Reject both Least Tolerant	Reject 1 st , Accept 2 nd	Accept 1 st , Reject 2 nd	Accept both Most Tolerant
0.8 – 1.0	60	32	51	17	16	16
0.6 – 0.8	20	32	54	15	17	15
0.4 – 0.6	8	29	56	15	13	16
0.2 – 0.4	4	22	69	8	9	13
0.0 – 0.2	2	20	70	11	9	11
< 0	3	28	71	1	15	13

Ordered Logit Regression

(risk tolerance; $p < .01$, $< .1$)

Double bounded

Life expectancy	0.016 (0.003)		0.014 (0.003)
Health (HUI)		0.89 (0.18)	0.66 (0.19)

Single bounded

Life expectancy	0.013 (0.003)		0.012 (0.003)
Health (HUI)		0.66 (0.21)	0.48 (0.21)

Ordered Logit Regression

(risk tolerance; $p < .01$, $< .1$)

Variable	Double bounded	Single bounded
Life expectancy	0.019 (0.003)	0.015 (0.004)
Health (HUI)	0.48 (0.20)	0.38 (0.22)
Male	0.32 (0.08)	0.21 (0.09)
Black	0.33 (0.13)	0.41 (0.14)
Education	0.029 (0.016)	0.006 (0.02)
Income (\$1000)	0.001 (0.001)	0.001 (0.001)
Household size	-0.097 (0.03)	-0.12 (0.04)
Head of household	-0.18 (0.11)	-0.25 (0.12)

Previous Literature

Stated preferences

- Barsky et al. (1997), Health and Retirement Study, ages 51 – 60 plus spouses
 - Risk tolerance increases with age through 60s, decreases for small sample > 70
 - Risk tolerance higher for men, blacks, more educated
 - U-shaped relationship to income
- Guiso and Paiella (2001)
 - Risk tolerance decreases with age

Revealed preferences

- Guiso et al. (2002), Ameriks and Zeldes (2001)
 - Share of financial portfolio in risky assets increases with age

Conclusions

Risk tolerance positively associated with

- Life expectancy
 - Mixed results in literature
- Health
- Diversification, ability to overcome adverse financial shocks?
- Young and healthy take bigger financial risks
 - Investments, insurance, job choice?