*Sea*TE: Subjective *ex ante* Treatment Effect of Health on Retirement

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What Is the Effect of Health on Work Near Retirement?

Longstanding question: **Vast literature, both microstructural and "reduced form"**.

- Recent reviews by Coile (2015), O'Donnell et al. (2015), Fisher et al. (2016), French and Jones (2017), Blundell et al. (2021).
- Increasing policy attention due to uncertain sustainability of social security systems (e.g., Coile (2018) and Berger et al. (2021) on the U.S.).

Sign theoretically ambiguous: **Mainly negative, but positive possible**.

- Multiple potential mechanisms, including preferences, productivity, financial incentives, horizon, ... (reviewed by Blundell et al. (2021)).
- And forms, e.g., expected vs. unexpected shocks, earlier vs. later changes, ...

No consensus on magnitude: **Hard to quantify empirically**.

- Reasons include selection, heterogeneity, measurement (e.g., justification bias vs. attenuation bias, subjective vs. objective health).
- Blundell et al. (2021) find that subjective and objective health can yield similar estimates; measurement-related biases are empirically small; accounting for initial conditions/background heterogeneity is most important.

An Overview of What We Do

Approach: **Ex ante, based on survey expectations**.

- We elicit **subjective probabilities of working** to future horizons (2 and 4 years) **under alternative hypothetical health states** in two US national studies (the Vanguard Research Initiative and the Health and Retirement Study).

Analysis: **Based on potential outcomes (POF)** & **dynamic programming (DP)**.

- We construct **within-person differences in working probs across health states** and interpret as "Subjective *ex ante* Treatment Effects" (S*ea*TE) within POF.
  - **Large effect heterogeneity**: ∼30% zero & 70% negative S*ea*TE, with substantial "within" heterogeneity.
  - **Age and "unretirement" main predictors** of SeaTE (in VRI).

- We perform various **validations**.
  - Health-contingent (and unconditional) **work probabilities strongly predict work realizations** after 2 years, with **younger workers closer to rational**.

- We interpret S*ea*TE and its components within discrete choice DP, and derive **health-contingent values of working longer** from the choice probs.
  - **Heterogeneity in taste for work revealed by health-contingent work probs. induces bias in realization-based regression estimates**.

We Build On the Survey Expectations Literature

Review Papers

- Manski (2004, 2018), Attanasio (2009), Hurd (2009), Delavande et al. (2011a,b), van der Klaauw (2012), Armantier et al. (2013), Delavande (2014), Bruine de Bruin and Fischhoff (2017), Giustinelli and Manski (2018), Altig et al. (2020), ..., Elsevier Handbook of Economic Expectations (2022).

Treatment Effects Based on *Conditional* Expectations

- Arcidiacono, Hotz, Maurel, and Romano (2020) and Wiswall and Zafar (2021) consider Roy (1951)-type settings, where treatments are college students' HK decisions and outcomes are non/monetary returns to college majors/ occupations.
- Hudomiet, Hurd, and Rohwedder (2021) study causal determinants of retirement in the RAND's American Life Panel.

Subjective Choice Probabilities under *Incomplete* Scenarios

- Probabilistic version of stated choices/preferences, developed by Manski (1999) and implemented by Blass et al. (2010), Delavande and Manski (2015), ...

Determinants of Retirement from *Non-probabilistic* Stated Choices

- Kapteyn, van Soest, and Zissimopoulos (2007), van Soest and Vonkova (2014), Ameriks, Briggs, Caplin, Lee, Shapiro, and Tonetti (2020), ...

We Build On the Survey Expectations Literature (Cont.)

Unconditional Expectations of Work (and Health)

- McGarry (2004) regresses unconditional working probabilities on health (including survival probs) and other determinants of labor supply, in levels and first differences, among workers to avoid justification bias.
- van der Klaauw and Wolpin (2008) combine realizations and unconditional expectations of working and longevity to improve estimation efficiency.

Rationality of Expectations and Properties of Survey Expectations

- D'Haultfoeuille, Gaillac, and Maurel (2021) and Crossley, Gong, Stinebrickner, and Stinebrickner (2021) develop new RE tests exploiting info on high-order moments and find interesting heterogeneities.
- Various papers investigate measurement properties of percent-chance expectations and implications for inference (Bruine de Bruin and Fischhoff, 1999; Manski and Molinari, 2010; Zafar, 2011; Kleinjians and van Soest, 2014; Bruine de Bruin and Carman, 2018; Giustinelli, Manski, and Molinari, 2022a,b).

Roadmap

1. Interpretation of *Sea*TE: Within POF and discrete choice DP.
2. Survey Elicitation: VRI study; expectations battery; sample characteristics.
3. Analysis of *Sea*TE: *Sea*TE and its components; heterogeneity.
4. Validation Analyses: Internal consistency; credibility; panel analysis.
5. Simulation Exercise: Heterogeneity bias in simulated realizations.

(1) Interpretation of S*ea*TE within POF and DCDP

Starting Point: Treatment Effects in Realizations

Textbook Potential Outcomes with Binary Health and Labor Supply

- Potential treatments: $h_i \in \{\mathbf{H}igh, \mathbf{L}ow\} \equiv \{0, 1\}$.
- Potential outcomes: $d_i(h_i) \in \{\sim \mathbf{W}ork, \mathbf{W}ork\} \equiv \{0, 1\}$.
- Realized treatment: $z_i = \mathbf{1}\{h_i = \mathbf{L}ow\}$.
- Realized vs. Counterfactual outcomes: $d_i(z_i)$ vs. $d_i(1 - z_i)$.

Individual-Level Treatment Effect (ITE) – **Logically unobservable ex post**

$$d_i(L) - d_i(H) = z_i \cdot [d_i(L) - d_i(H)] + (1 - z_i) \cdot [d_i(L) - d_i(H)] = \Delta_i$$

$$\Delta_i = E[\Delta_i] + [\upsilon_i(L) - \upsilon_i(H)]$$

Average Treatment Effect (ATE) – **Hard to recover due selection & heterogeneity**

$$ATE(L - H) = E[d_i(L) - d_i(H)] = E[\Delta_i]$$

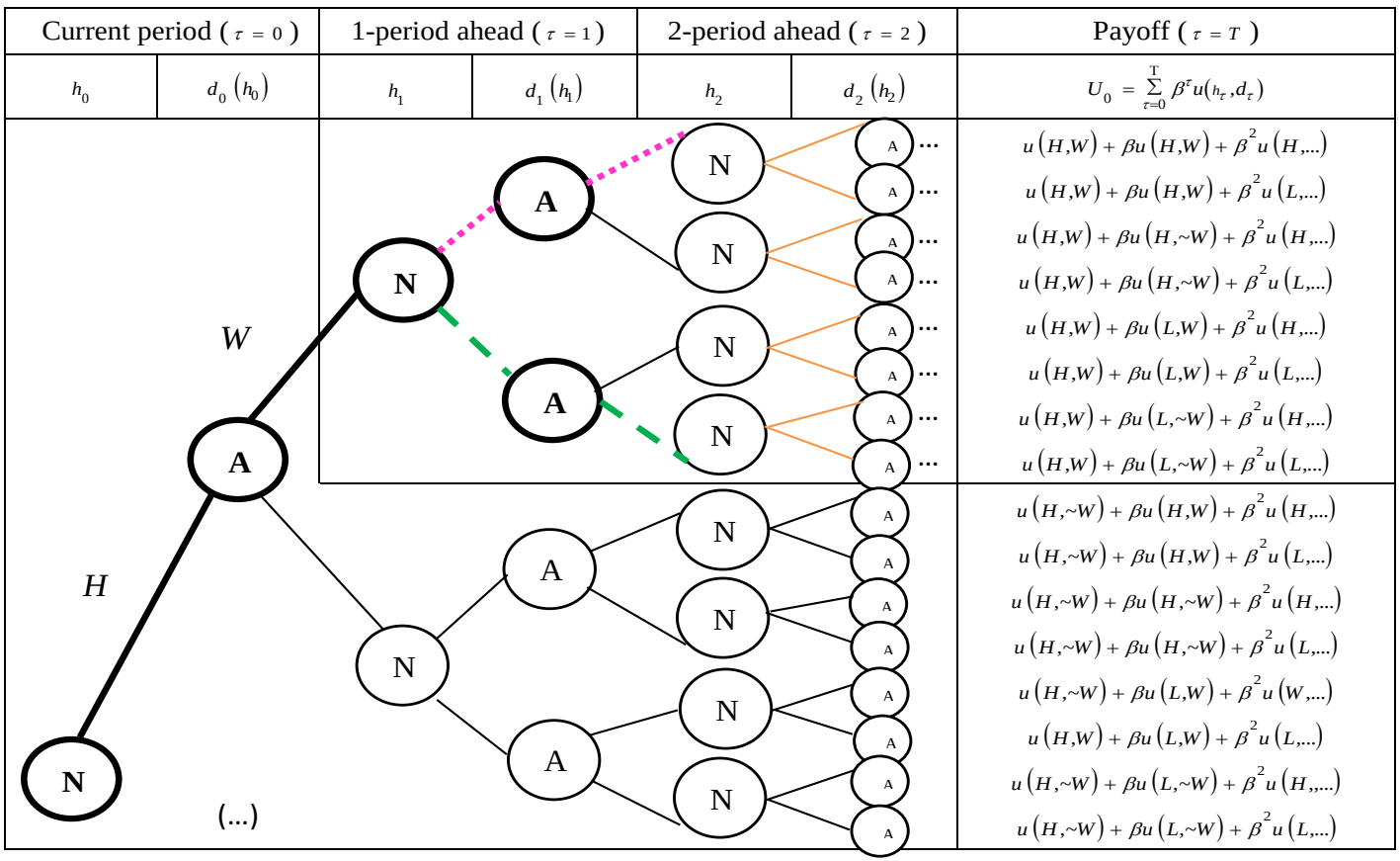
$$E[d_i|z_i = 1] - E[d_i|z_i = 0] = ATE(L - H) + \{E[\upsilon_i(L)|z_i = 1] - E[\upsilon_i(H)|z_i = 0]\}$$
$$+[1 - P(z_i = 1)] \cdot \{E[\upsilon_i(L) - \upsilon_i(H)|z_i = 1] - E[\upsilon_i(L) - \upsilon_i(H)|z_i = 0]\}$$

Actual and Counterfactual Paths on a Health-Work Tree

Tree: Extensive-form of game between **A**gent (d_{it}) and **N**ature (h_{it}).

Illustration: Initially **healthy (H)** & **working (W)** (thickened solid path).

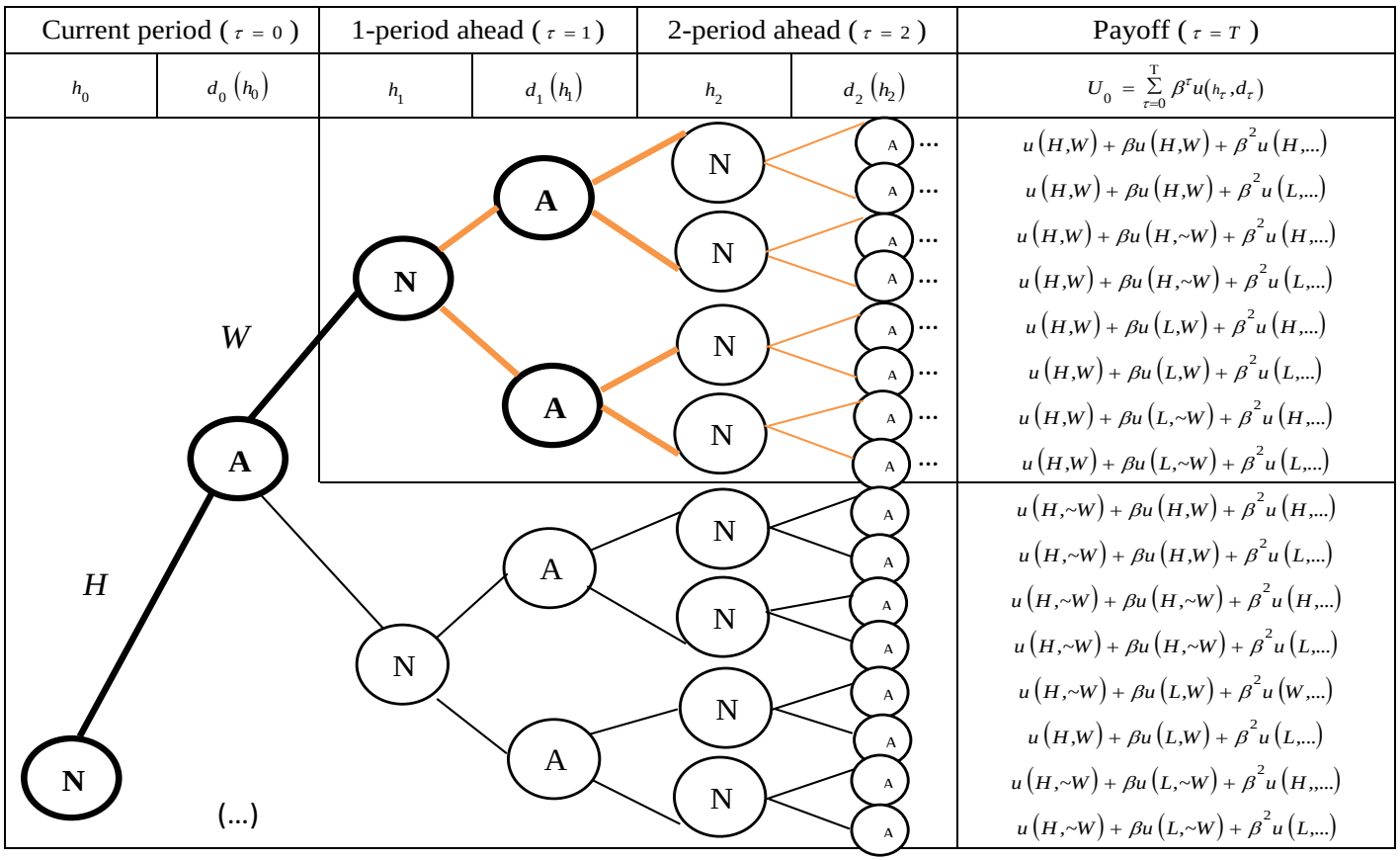
Ex Post: Paths are **actual** (dashed) or **counterfactual** (dotted).



We Take an *Ex Ante* Approach

Ex ante: Paths are **potential**.

Our Approach: We ask the agent to predict their labor supply decisions if they reach certain health states (and their health transitions).



Treatment Effects in Expectations: *Sea*TE

Subjective *ex ante* Treatment Effect (*Sea*TE)

$$\text{SeaTE}(i,t,\tau) = E_{i,t-\tau}(\Delta_{it}) \equiv P_{i,t-\tau}[d_{it}(L)=1] - P_{i,t-\tau}[d_{it}(H)=1]$$

where

$P_{i,t-\tau}[d_{it}(h)=1] = i$'s prob at $(t-\tau)$ of working at t in health state h.

Some advantages

- Each individual is both "treatment" and "control".
- Unrestricted and directly measured heterogeneity.
- Variation is directly across (hypothetical) states.
- Can be "aggregated up" to get average effects.

Some key issues

- Are elicited state-contingent choice probs *ceteris paribus* wrt choice-relevant unspecified states?
- Are effects based on elicited subj expectations informative of objective ones? Are elicited probabilities rational?
- How about measurement error in elicited state-contingent choice probs?

Dynamic Programming (DP): *Primitives & State Partition*

Primitives – $u_{it}(s_{it}, d_{it})$ and $\pi_{it}(s_{i,t+1}|s_{it}, d_{it})$ (Markov).

Utility Functional – under additive time-separable utility:

$$U_{it} = \sum_{j=0}^{T} \beta^j u_{i,t+j}[(x_{i,t+j}, y_{i,t+j}, \varepsilon_{i,t+j}), d_{i,t+j}],$$

where:

State – $s_{it} = (x_{it}, y_{it}, \varepsilon_{it})$.

- Specified component, **fixed by us** & **known to R** at elicitation:
  - $\mathbf{x_{it}}$ – Health, $\mathbf{h_{it}} \in \{H, L\} \equiv \{0, 1\}$.

- Unspecified components, **not necessarily known to R (or us)** at elicitation:
  - $\mathbf{y_{it}}$ – Not necessarily orthogonal to x_{it} (e.g., wage).
  - $\boldsymbol{\varepsilon_{it}}$ – Orthogonal to x_{it} and y_{it}.

Decision – Labor supply, $\mathbf{d_{it}} \in \{\sim W, W\} \equiv \{0, 1\}$.

DP: *Optimal Solution, Predicted Solution, & SeaTE*

Optimal Decision Rule at t

$$\delta^*_{\mathbf{it}}(\mathbf{x_{it}}, \mathbf{y_{it}}, \varepsilon_{\mathbf{it}}) = \underset{d_{it} \in \{0,1\}}{\arg\max}\ u_{it}[(x_{it}, y_{it}, \varepsilon_{it}), d_{it}]$$
$$+\beta \sum_{x_{i,t+1}} \int_{\varepsilon_{i,t+1}} \int_{y_{i,t+1}} V^*_{i,t+1}[(x_{i,t+1}, y_{i,t+1}, \varepsilon_{i,t+1}), \delta^*_{i,t+1}(x_{i,t+1}, y_{i,t+1}, \varepsilon_{i,t+1})]$$
$$\cdot \pi^{\varepsilon}_{it}(\varepsilon_{i,t+1}|\varepsilon_{it}, d_{it}) d\varepsilon_{i,t+1} \cdot \pi^{y}_{it}(y_{i,t+1}|x_{it}, y_{it}, d_{it}) dy_{i,t+1} \cdot \pi^{x}_{it}(x_{i,t+1}|x_{it}, y_{it}, d_{it}).$$

From Perspective of $(t-1)$ – **R integrates over unspecified terms**

$$\mathbf{P_{i,t-1}}[\delta^*_{\mathbf{it}}(\mathbf{x_{it}}, \mathbf{y_{it}}, \varepsilon_{\mathbf{it}}) = \mathbf{1}] = \sum_{x_{it}} \int_{y_{it}} \int_{\varepsilon_{it}} \delta^*_{it}(x_{it}, y_{it}, \varepsilon_{it})$$
$$\cdot \pi^{\varepsilon}_{i,t-1}(\varepsilon_{it}|\varepsilon_{i,t-1}, d_{i,t-1}) d\varepsilon_{it} \cdot \pi^{y}_{i,t-1}(y_{it}|x_{it}, x_{i,t-1}, y_{i,t-1}, d_{i,t-1}) dy_{it}$$
$$\cdot \pi^{x}_{i,t-1}(x_{it}|x_{i,t-1}, y_{i,t-1}, d_{i,t-1})$$
$$= \sum_{x_{it}} \mathbf{P_{i,t-1}}[\delta^*_{\mathbf{it}}(\mathbf{x_{it}}, \mathbf{y_{it}}, \varepsilon_{\mathbf{it}}) = \mathbf{1}|\mathbf{x_{it}}] \cdot \pi^{\mathbf{x}}_{\mathbf{i,t-1}}(\mathbf{x_{it}}|\mathbf{x_{i,t-1}}, \mathbf{y_{i,t-1}}, \mathbf{d_{i,t-1}}).$$

Implication for *SeaTE* – **Total effect** (e.g., through utility and productivity)

$$\mathbf{SeaTE(i,t,1)} = P_{i,t-1}[\delta^*_{it} = 1|h_{it} = 1] - P_{i,t-1}[\delta^*_{it} = 1|h_{it} = 0].$$

- Hudomiet et al. (2021) find no evidence of "filling in" of unspecified aspects of a scenario that may be related to those specified, supporting a *ceteris paribus* interpretation of *SeaTE*.

(2) Survey Elicitation

Measuring Expectations in the VRI

We fielded a battery of Qs in the Vanguard Research Initiative (VRI) and in the Health and Retirement Study (HRS), eliciting respondents' subjective probabilities that they will work in 2 and 4 years under alternative health scenarios, plus their unconditional working probabilities and health probabilities.

Vanguard Research Initiative (VRI): Survey-administrative linked dataset on older U.S. wealthholders.

- Recruited respondents in 2013 were account holders at Vanguard with \$10,000+ in financial assets, aged 55+, and web-survey eligible.
- As of December 2015, approx. 3,000+ respondents had completed 4 surveys, each on a different aspect of retirement decision-making: (S1) Wealth; (S2) Long-term care; (S3) Transfers; (S4) Labor.
- Our analysis is mainly based on S4, but uses covariates from all waves.
- We also observe realized labor supply and health after 2 years in 2017 (S6) and after 4-1/2 years in 2020 (S7).

Main Features of Expectations Battery

Question Eligibility: Working respondents.

Response Scale: Any percent-chance value in 0-100.

Prediction Horizons: 2 and 4 years.

Health States: Standard 5-point scale for self-reported health (**E**xcellent, **V**ery **G**ood, **G**ood, **F**air, **P**oor).

- Health specified at 3 different levels to save survey time and sequence of questions depends on current health (TO).
  - **97% of respondents reported being in high health at S4**.
- For analysis, collapsed to binary health: **H**igh (E, VG, G) and **L**ow (F, P).

Samples:

1. 2-year horizon: 970 Rs, aged 57-81, working, in high health (TO).
2. 4-year horizon: 839 Rs, with a positive prob of working in 2y (TO).

Battery Example: *2-Year Horizon & R in Good Health*

Unconditional Working

- What are the chances that you will be **working** for pay 2 years from now?

Unconditional Health

- What are the chances that your **health will be fair or poor** 2 years from now?
- What are the chances that your **health will be very good or excellent** 2 years from now?

Working Fixing Health

- **If your health is very good or excellent** 2 years from now, what are the chances that you will be **working** for pay?
- **If your health is good** 2 years from now, what are the chances that you will be **working** for pay?
- **If your health is fair or poor** 2 years from now, what are the chances that you will be **working** for pay?

(3) Analysis of S*ea*TE

How Does *Sea*TE Look Like Empirically?

Back to $\mathit{Sea}\mathrm{TE}(i,t,\tau) = p_{i,t-\tau}[d_{it}(L)=1] - p_{i,t-\tau}[d_{it}(H)=1]$.

Recall:

The sign is theoretically ambiguous.

Main mechanisms point to a negative effect of a negative health change on labor supply (e.g., through disutility of working in low health, lower productivity, etc.).

But a positive effect is theoretically possible (e.g., through employer-provided health insurance or needing money to pay for medical expenses).

Health-Contingent Working Probs and *Sea*TE

Working in Low Health, Working in High Health, and *Sea*TE (percent chance)

	2-Year Ahead			4-Year Ahead		
	Low	**High**	***Sea*TE**	**Low**	**High**	***Sea*TE**
Mean	41.9	70.5	-28.5	33	58.7	-25.7
Std. Dev.	36.1	36	27.9	34.4	39	27.6
Q25	5	50	-50	0	20	-50
Median	40	90	-25	20	68	-20
Q75	75	100	0	50	100	0
Observations		970			839	

Unpacking SeaTE

Working in Low Health, Working in High Health, and SeaTE (percent chance)

	2-Year Ahead			4-Year Ahead		
	Low	**High**	**SeaTE**	**Low**	**High**	**SeaTE**
Mean	41.9	70.5	-28.5	33	58.7	-25.7
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Median	40	90	-25	20	68	-20
Q75	75	100	0	50	100	0
Observations		970			839	

SeaTE: Negative, Zero, or Positive (fraction of responses, percent)

	2-Year Ahead	4-Year Ahead
Negative SeaTE	70.31	70.80
Zero SeaTE	28.45	28.25
Positive SeaTE	1.24	0.95

Unpacking Zero SeaTE (fraction of responses, percent)

	2-Year Ahead	4-Year Ahead
Never work	31.88	41.35
Always work	47.10	34.18
Maybe work	21.02	24.47
Observations	276	237

Unpacking Negative SeaTE (percent chance)

	2-Year Ahead	4-Year Ahead
Mean	-40.9	-36.8
Std. Dev.	24.1	25.1
Q25	-50	-50
Median	-40	-30
Q75	-20	-15
Observations	682	594

Predictors of *Sea*TE?

	2-Year *Sea*TE			4-Year *Sea*TE		
Predictors	Coeff	SE	Signif	Coeff	SE	Signif
Constant	-0.154	0.061	**	-0.119	0.065	*
Age at Survey 4 (S4) (≤59 excluded)						
age in 60-61	-0.042	0.031		-0.037	0.032	
age = 62	-0.113	0.040	***	-0.054	0.041	
age in 63-64	-0.034	0.031		-0.033	0.033	
age = 65	-0.029	0.045		-0.110	0.051	**
age in 66-67	-0.017	0.037		0.029	0.039	
age in 68-69	-0.124	0.037	***	-0.080	0.040	**
age in 70-71	-0.120	0.046	***	-0.090	0.049	*
age ≥ 72	-0.095	0.034	***	-0.089	0.037	**
Gender						
female	0.004	0.021		-0.011	0.023	
Education (≤ HS excluded)						
some college	-0.000	0.044		-0.025	0.047	
college grad	0.014	0.042		-0.007	0.044	
other adv. degree	-0.038	0.045		-0.017	0.047	
MBA	-0.007	0.049		0.005	0.054	
JD, PhD, MD	-0.018	0.049		-0.071	0.053	
Occupation at S4 (management and professional excluded)						
operative	0.009	0.025		-0.007	0.027	
other services	-0.020	0.032		-0.019	0.034	
Job type at S4 (career excluded)						
bridge	0.004	0.022		-0.017	0.023	
Working status at S1						
completely retired	-0.108	0.036	***	-0.039	0.041	
Observations		970			839	
R^2		0.058			0.054	

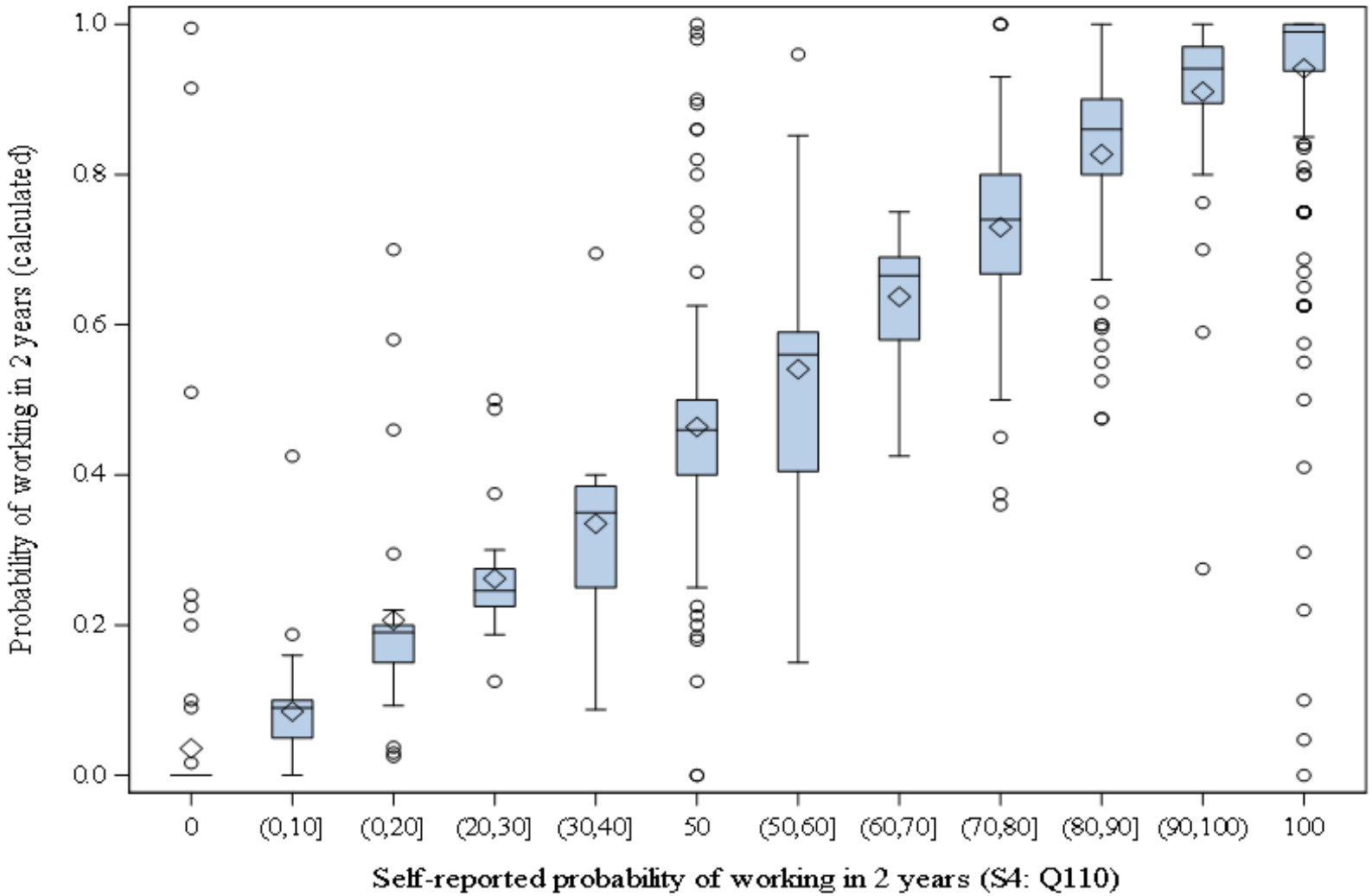
Predictors of *Sea*TE? (Cont.)

	2-Year *Sea*TE			4-Year *Sea*TE		
Predictors	Coeff	SE	Signif	Coeff	SE	Signif
Constant	-0.154	0.061	**	-0.119	0.065	*
Total HH wealth						
1st quintile	-0.035	0.033		-0.037	0.036	
2nd quintile	-0.039	0.032		-0.082	0.035	**
3rd quintile	-0.019	0.030		-0.031	0.032	
4th quintile	-0.041	0.029		-0.043	0.031	
Replacement rate						
1st quintile	-0.022	0.031		-0.025	0.034	
2nd quintile	0.002	0.031		0.027	0.033	
3rd quintile	-0.032	0.030		-0.025	0.032	
4th quintile	-0.024	0.030		-0.020	0.032	
Current salary						
1st quintile	-0.077	0.038	**	-0.044	0.041	
2nd quintile	-0.072	0.034	**	-0.042	0.036	
3rd quintile	-0.002	0.031		0.008	0.034	
4th quintile	-0.009	0.036		-0.005	0.032	
Marital status						
partnered	-0.011	0.024		-0.009	0.026	
Spouse's work status						
working	-0.012	0.023		-0.003	0.024	
Observations		970			839	
R^2		0.058			0.054	

(4) Validation Analyses

Internal Consistency: Law of Total Probability

$P_{i,a+2}(W) = P_{i,a+2}(W|H) \cdot P_{i,a+2}(H) + P_{i,a+2}(W|L) \cdot [1 - P_{i,a+2}(H)]$ (▸ TO-w, ▸ TO-h)



More Validation and Credibility Checks

More validation

- Working probs track well-documented peaks in retirement age (62/65/67).
- *Sea*TE distrib is very similar in HRS, while work & health probs are not (▸ TO).
- Hudomiet, Hurd, and Rohwedder (2021) find very similar results in the ALP.

Credibility

- **Do people think conditionally?**
  - Cognitive interviews with HRS pre-test Rs suggest so. When thinking of prob of working past 62, many Rs spontaneously thought of health and other contingencies (▸ Quote).
- **Are the contingencies salient?**
  - People can have difficulty thinking through disjunctions, but making contingencies explicit improves quality of choice/probabilistic judgments (e.g., Shafir (1994), Martinez et al. (2019), Esponda and Vespa (2019)).
  - Working VRI and HRS Rs are accustomed to think about retirement and related issues (aging/health, work conditions/prospects, finances).
- **Measurement error in elicited probabilities?**
  - Arcidiacono, Hotz, Maurel, and Romano (2020) and Hudomiet, Hurd, and Rohwedder (2021) consider mean-zero measurement error.
  - Less rounding in exps for personal finances (Giustinelli et al., 2022a) and in cond vis-à-vis uncond probs (Giustinelli et al., 2022b).

Relating Probs to Realizations After 2 Years: All

	(1)	(2)	(3)
Constant	0.301	0.322	0.301
	(0.037)	(0.036)	(0.037)
Health-contingent work probability	**0.590**		**0.502**
	(0.047)		(0.191)
Unconditional work probability		**0.595**	**0.093**
		(0.048)	(0.197)
Observations	584	584	584
R^2	0.216	0.207	0.216
Test for no incremental predictive power of:			
Unconditional work probability (3 vs. 1), $\chi^2(1)$ [p-value]			0.00 [1.00]
Health-contingent probability (3 vs. 2), $\chi^2(1)$ [p-value]			6.70 [0.01]

Relating Probs to Reals After 2Y: By Age (▸ By Health)

	(1)	(2)	(3)
Health-contingent work probability			
≤ 59			
	0.730		0.823
60-61	(0.135)		(0.495)
	0.672		1.398
62	(0.135)		(0.652)
	0.860		0.474
63-64	(0.201)		(0.695)
	0.653		1.272
65	(0.124)		(0.595)
	0.659		-0.662
66-67	(0.192)		(0.551)
	0.639		0.804
68-69	(0.155)		(0.498)
	0.784		0.373
70-71	(0.149)		(0.810)
	0.100		0.057
≥ 72	(0.202)		(0.520)
	0.406		0.053
	(0.102)		(0.528)
Unconditional work probability			
≤ 59			
		0.695	-0.097
60-61		(0.136)	(0.495)
		0.637	-0.756
62		(0.138)	(0.664)
		0.896	0.420
63-64		(0.213)	(0.730)
		0.618	-0.641
65		(0.126)	(0.602)
		0.828	1.479
66-67		(0.203)	(0.579)
		0.641	-0.1889
68-69		(0.169)	(0.541)
		0.832	0.443
70-71		(0.158)	(0.859)
		0.107	0.051
≥ 72		(0.218)	(0.560)
		0.438	0.383
		(0.110)	(0.562)
Observations	584	584	584
R^2	0.261	0.253	0.275

(5) Simulation Ex on Heterogeneity Bias

Investigating the Gains of Measured Heterogeneity in Preference for Work

- We consider a mean linear reg with realizations data:

$$d_i = b_0 + b_1 \cdot h_i + e_i.$$

- We simulate health outcomes and labor supply decisions given health:

$$d_i = (1 - h_i) \cdot \mathbf{1}[\tilde{\nu}_i^H + \tilde{\varepsilon}_i] + h_i \cdot \mathbf{1}[\tilde{\nu}_i^L + \tilde{\varepsilon}_i],$$

where $\tilde{\nu}_i^H$ and $\tilde{\nu}_i^L$ are health-contingent values of working vs. not working that we derive from the health-contingent choice probs (by inversion, under normality of $\tilde{\varepsilon}$: TO).

- We consider 3 possibilities about $\pi_i^{\mathbf{h}}$:

(1) Fixed at sample mean ($\bar{\pi}^{\mathbf{L}} \simeq 0.16$) $\Rightarrow$ **no correlation** with value of work.

(2) Individual-specific health probs (TO) $\Rightarrow$ **empirical correlation**.

(3) Generated to have a **higher correlation** with value of work.

Results

Horizon	2-year Ahead			4-year Ahead		
Case	Uncorrelated	Empirical	Higher correlation	Uncorrelated	Empirical	Higher correlation
Constant	0.703	0.709	0.730	0.586	0.594	0.621
	(0.011)	(0.011)	(0.011)	(0.019)	(0.014)	(0.018)
Health h	-0.282	-0.305	-0.415	-0.254	-0.286	-0.371
	(0.040)	(0.039)	(0.039)	(0.040)	(0.035)	(0.039)
SEE	0.463	0.461	0.448	0.488	0.485	0.474
Sample size	970	970	970	839	839	839

(1) Uncorrelated case: Unbiased estimate ($\equiv$ average S*ea*TE).

(2) Empirical case: Biased, due to a positive correlation between value of work and staying in high health ($\equiv$ about 10% more health-related job transitions).

(3) High correlation case: Larger bias in hypothetical samples with more heterogeneity in health.

- Very similar results with controls.

Conclusion

- We have studied the effect of health on work among healthy older workers using data on individuals' subjective probabilities of working to specified future horizons under alternative health states.
- We have provided interpretations within POF and DP.
- We have found that the effect on work of a negative health transition is highly heterogeneous across older workers in the VRI and HRS. And that the implied (typically unobserved) heterogeneity in the value of work would induce non-negligible bias in regression estimates.
- We have documented that working probabilities strongly predict labor supply after two years.

Thank You!

Contact

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More on VRI

- Survey 4 co-investigators: John Ameriks (Vanguard), Andrew Caplin (NYU), Matthew Shapiro (Michigan), Joseph Briggs (FRB), Minjoon Lee (Carleton U), Chris Tonetti (Stanford GSB)

- Study website: http://ebp-projects.isr.umich.edu/VRI

Research support

- NIA P01-AG026571
- SSA RRC
- Vanguard Group Inc.

Bonus Slides

Partition of the Health States for Survey Questions (BACK)

	Partition of future health state				
Current health	Excellent	Very Good	Good	Fair	Poor
Excellent					
Very Good					
Good					
Fair					
Poor					

Characteristics of 2-Year Sample (N = 970) (BACK)

Age at Survey 4 (S4)	**%**	**Occupation at S4**	**%**
≤ 59	22.9	Management and professional	71.75
60-61	14	Other services	17.32
62	6.7	Operative	10.96
63-64	13.4		
65	4.9		
66-67	8.5		
68-69	8.6		
70-71	5.2		
≥ 72	15.9		
Gender		**Total HH wealth in USD at S4**	
Female	37.01	First quintile	0 – 258,475
Male	62.99	Second quintile	258,475 – 533,739
		Third quintile	533,739 – 874,867
		Fourth quintile	874,860 – 1,583,538
		Fifth quintile	≥ 1,583,538
Race/ethnicity		**Replacement rate at S4**	
Non-Hispanic white	94.74	First quintile	0 – 24
Asian	2.68	Second quintile	24 – 39
Other	2.58	Third quintile	39 – 58
		Fourth quintile	58 – 87
		Fifth quintile	87 +
Marital status at S4		**Annual salary in USD at S4**	
Partnered	65.5	First quintile	0 – 12,000
Not partnered	34.5	Second quintile	12,000 – 45,714
		Third quintile	45,714 – 77,534
		Fourth quintile	77,534 – 117,000
		Fifth quintile	≥ 117,000
Educational attainment		**Working status at Survey 1**	
High school or less	5.77	Completely retired	9.48
Some college	14.95	Not completely retired	90.52
College graduate	38.97		
Other advanced degree	19.59		
MBA	7.94		
JD, PhD, MD	12.78		
Health status at S4		**Spouse's working status at S4**	
High (E, VG, or G)	100	Working (FT or PT)	48.85
		Not working	51.15
		Sample size	635
R's working status at S4			
Working (FT or PT)	100		
R's job type at S4			
Career	60.62		
Bridge	39.38		

Characteristics of 4-Year Sample (N = 839) (BACK)

Age at Survey 4 (S4)	**%**	**Occupation at S4**	**%**
≤ 59	24.4	Management and professional	71.99
60-61	14.3	Other services	17.04
62	7	Operative	10.97
63-64	13.3		
65	4.2		
66-67	8.7		
68-69	8.2		
70-71	5.2		
≥ 72	14.5		
Gender		**Total HH wealth in USD** at S4	
Female	36.83	First quintile	0 – 255,584
Male	63.17	Second quintile	255,584 – 537,700
		Third quintile	537,700 – 877,000
		Fourth quintile	877,000 – 1,559,059
		Fifth quintile	≥ 1,559,059
Race/ethnicity		**Replacement rate at S4**	
Non-Hispanic white	94.87	First quintile	
Asian	2.86	Second quintile	0 – 24
Other	2.26	Third quintile	24 – 39
		Fourth quintile	39 – 58
		Fifth quintile	58 – 88
			88 +
Marital status at S4		**Annual salary in USD at S4**	
Partnered	64.8	First quintile	0 – 13,000
Not partnered	35.2	Second quintile	13,000 – 47,000
		Third quintile	47,000 – 80,000
		Fourth quintile	80,000 – 120,000
		Fifth quintile	≥ 120,000
Educational attainment		**Working status at Survey 1**	
High school or less	5.96	Completely retired	7.97
Some college	13.83	Not completely retired	92.01
College graduate	38.38		
Other advanced degree	20.50		
MBA	8.46		
JD, PhD, MD	12.87		
Health status at S4		**Spouse's working status at S4**	
High (E, VG, or G)	100	Working (FT or PT)	49.07
		Not working	50.93
		Sample size	544
Working status at S4			
Working (FT or PT)	100		
Job type at S4			
Career	61.50		
Bridge	38.50		

2- & 4-Year Ahead Uncond Working Probabilities (BACK)

	Percent chance of working in 2 years (self-reported)	Percent chance of working in 2 years (calculated)	Percent chance of working in 4 years (calculated)
Mean	69.8	65.9	52.7
Std. Dev.	35.6	35.3	37
Q25	50	40	17
Median	90	80	50
Q75	100	98	90
Observations	970	970	839

2- & 4-Year Ahead Uncond Health Probabilities (B1, B2)

	Percent chance of High health in 2 years	Percent chance of Low health in 2 years	Percent chance of High health in 4 years	Percent chance of Low health in 4 years
Mean	83.4	16.6	76.5	23.5
Std. Dev.	16.5	16.5	19.5	19.5
Q25	75	5	70	10
Median	90	10	80	20
Q75	95	25	90	30
Observations	970	970	839	839

Realizations and Expectations (means) (BACK)

A. Conditional Working Probability Given Health, By Realized Health

	E	VG	G	F	P
E	0.506	0.216		0	
VG	0.574		0.124	0.006	
G	0.195		0.420	0.039	

B. Realized Working Status, By Realized Health

	E	VG	G	F	P
E	0.508	0.224		0	
VG	0.502		0.121	0.007	
G	0.103		0.452	0.058	

C. Unconditional Health Probability, By *ex ante* Health

	E	VG	G	F	P
E	0.792	0.107		0.101	
VG	0.728		0.114	0.158	
G	0.322		0.350	0.328	

D. Realized Health

	E	VG	G	F	P
E	0.689	0.312		0	
VG	0.818		0.175	0.007	
G	0.269		0.644	0.087	

People's "Mental Model" of Retirement

▸ BACK

▶ *Excerpt from an in-depth interview to a working 57 years old (pre-test) respondent in the U.S. Health and Retirement Study (HRS).*

I: Thinking about work in general and not just your present job, what is the **percent chance** that you will be working full-time after you reach 62?

R: [...] *Fifty.*

I: Tell me a little bit about **what you were thinking about** when you were trying to decide on the answer, please. Just think out loud if you will.

R: *I was thinking about my* ***health****, the way things are going in the* ***economy****, I don't know* ***IF*** *it's going to really pick up [...] There might be a chance of me working and there might be a chance that there won't be much* ***work*** *when I'm that age.* ***IF I'm in good health*** *[...] It's going to have to be later than 65,* ***IF my health is good where I can work****.*

HRS: PC of Working in L/H Health & *Sea*TE (BACK)

- HRS Rs are younger, less healthy (given age), less educated and affluent.
- Have higher avg prob of working (unconditionally and conditional on health).
- And higher avg prob of entering low health (difference is not large).
- Yet, *Sea*TE distribution is remarkably similar in HRS and VRI (esp. for *Sea*TE < 0).

	Working in Low Health	**Working in High Health**	***Sea*TE**
		2-Year Ahead	
Mean	54.9	81.5	-26.8
Std. Dev.	33.6	28.7	27.2
Q25	25	78	-50
Median	50	100	-20
Q75	80	100	0
		4-Year Ahead	
Mean	46.8	73.7	-26.9
Std. Dev.	33.7	32.5	27.4
Q25	15	50	-50
Median	50	90	-20
Q75	75	100	0

Note: Sample size is 480 for the 2-year sub-sample and 428 for the 4-year sub-sample.

HRS: Heterogeneity of *SeaTE* (BACK)

S*ea*TE: Negative, Zero, or Positive (fraction of responses, percent)

	2-Year Ahead	4-Year Ahead
Negative S*ea*TE	66.67	69.63
Zero S*ea*TE	31.67	27.80
Positive S*ea*TE	1.66	2.57
Observations	480	428

Unpacking Zero S*ea*TE (fraction of responses, percent)

	2-Year Ahead	4-Year Ahead
Never work	10.53	15.13
Always work	59.21	47.06
Maybe work	30.26	37.82
Observations	152	119

Unpacking Negative S*ea*TE (percent chance)

	2-Year Ahead	4-Year Ahead
Mean	-40.7	-39.1
Std. Dev.	22.6	24
Q25	-50	-50
Median	-40	-40
Q75	-20	-15
Observations	320	298

Relating Probs to Reals After 2Y: By Health (Back)

	(1)	(2)	(3)
Constant	0.219	0.243	0.222
	(0.079)	(0.772)	(0.079)
Health-contingent work probability			
Good	0.501		0.424
	(0.104)		(0.298)
Very Good	0.569		0.489
	(0.067)		(0.309)
Excellent	0.740		0.498
	(0.087)		(0.438)
Unconditional work probability			
Good		0.515	0.089
		(0.111)	(0.317)
Very Good		0.584	0.086
		(0.069)	(0.321)
Excellent		0.751	0.252
		(0.089)	(0.446)
Observations	584	584	584
R^2	0.248	0.240	0.248
Test for no incremental predictive power of:			
Unconditional work probability (3 vs. 1), $\chi^2(3)$ [p-value]			0.00 [1.00]
Health-contingent probability (3 vs. 2), $\chi^2(3)$ [p-value]			6.21 [0.10]

From DP: *Optimal Solution in Terms of Value Fns* (BACK)

ex ante (Integrated) Value Function

$$\overline{\mathbf{V}}^*_{\mathbf{it}}(\mathbf{x_{it}}) = \int_{\varepsilon_{it}} \int_{y_{it}} V^*_{it}[(x_{it}, y_{it}, \varepsilon_{it}), \delta^*_{it}(x_{it}, y_{it}, \varepsilon_{it})]$$
$$\cdot \pi^y_{i,t-1}(y_{it}|x_{it}, y_{i,t-1}, d_{i,t-1}) dy_{it} \cdot \pi^{\varepsilon}(\varepsilon_{it}) d\varepsilon_{it}$$
$$= \int_{\varepsilon_{it}} \int_{y_{it}} \Big\{ [u_{it}(x_{it}, y_{it}, d_{it}) + \varepsilon_{it}(d_{it})] + \beta \sum_{x_{i,t+1}} \overline{V}^*_{i,t+1}(x_{i,t+1})$$
$$\cdot \pi^x_{it}(x_{i,t+1}|x_{it}, y_{it}, d_{it}) \Big\} \cdot \pi^y_{it}(y_{it}|x_{it}, y_{i,t-1}, d_{i,t-1}) dy_{it} \cdot \pi^{\varepsilon}(\varepsilon_{it}) d\varepsilon_{it}.$$

Conditional Value Function

$$\nu_{\mathbf{it}}(\mathbf{x_{it}}, \mathbf{y_{it}}, \mathbf{d_{it}}) = u_{it}(x_{it}, y_{it}, d_{it}) + \beta \sum_{x_{i,t+1}} \overline{\mathbf{V}}^*_{\mathbf{i,t+1}}(\mathbf{x_{i,t+1}}) \pi^x_{it}(x_{i,t+1}|x_{it}, y_{it}, d_{it}).$$

Note: Assume additivity and serial independence of ε.

Optimal Solution in terms of ν_{it}

$$\delta^*_{it}(x_{it}, y_{it}, \varepsilon_{it}) = \underset{d_{it} \in \{0,1\}}{\arg\max} \, [\nu_{\mathbf{it}}(\mathbf{x_{it}}, \mathbf{y_{it}}, \mathbf{d_{it}}) + \varepsilon_{it}(d_{it})].$$

DP with no y: From *Single Crossing* to *Differenced Conditional Value Fns* (BACK)

Single Crossing Formulation

$$\delta_{it}^{*}(h) = \begin{cases} 1 & \text{if } 0 \leq \tilde{\nu}_{it}^{h} + \tilde{\varepsilon}_{it} \\ 0 & \text{otherwise,} \end{cases} \quad \text{with } h = H, L.$$

Where: $\tilde{\nu}_{it}^{h} = \nu_{it}^{h}(h, W) - \nu_{it}^{h}(h, \sim W)$ and $\tilde{\varepsilon}_{it} = \varepsilon_{it}(W) - \varepsilon_{it}(\sim W)$.

Elicited Conditional Probabilities of Working Given Health

$$P_{i,t-1}^{h} \equiv P_{i,t-1}[\delta_{it}^{*} = 1 | h_{it} = h], \quad \text{with } h = H, L.$$

CDF Functional Form for $\tilde{\varepsilon}_{it}$ – **normal**

$$P_{i,t-1}^{h} = \Phi(\tilde{\nu}_{it}^{h}), \quad \text{with } h = H, L.$$

Invert to Get Person-Specific (Differenced) Value of Work Given Health

$$\tilde{\nu}_{it}^{h} = \Phi^{-1}(P_{i,t-1}^{h}), \quad \text{with } h = H, L.$$