The Gorman Lectures, October 2008, UCL

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Canonical setup

Bellman equation: $U_t(s_t) = \max_{x_t} \left(u_t(s_t, x_t) + \beta \; \mathbb{E}_t \; U_{t+1}(s_{t+1}) \right)$

Law of motion: $s_{t+1} = f_t(s_t, x_t, \epsilon_t)$

Example

Bellman equation: $U_t(W_t) = \max_{c_t} \left(u(c_t) + \beta \; \mathbb{E}_t \; U_{t+1}(W_{t+1}) \right)$

Law of motion: $W_{t+1} = (1 + r_t)(W_t - c_t + y_t(\epsilon_t))$

Value function recursion

Approximation: $U_t(s) = \sum_i \phi_i(s) U_{i,t}$

Normalize: $\phi_i(\bar{s}_i) = 1$ and $\phi_j(\bar{s}_i) = 0$, $j \neq i$

Bellman: $U_{i,t} = \max_{x_t} \left(u_t(\bar{s}_i, x_t) + \beta \; \mathbb{E}_t \; U_{t+1}(f_t(\bar{s}_i, x_t, \epsilon_t)) \right)$

Stationary case

Bellman equation: $U(s) = \max_x \left(u(s,x) + \beta\ \mathbb{E}\ U(f(s,x,\epsilon))\right)$

Value function iteration: Start with arbitrary $U_{i,0}$

Iterate to convergence:

$$U_{i,\tau} = \max_x \left(u(\bar{s}_i,x) + \beta\ \mathbb{E}\ U_{\tau-1}(f(\bar{s}_i,x,\epsilon))\right)$$

Iteration is a contraction: See Judd, *Numerical Methods in Economics*, ch. 12

Markoff process

Family chooses $\bar{x}_i$ when $s = \bar{s}_i$ (policy function).

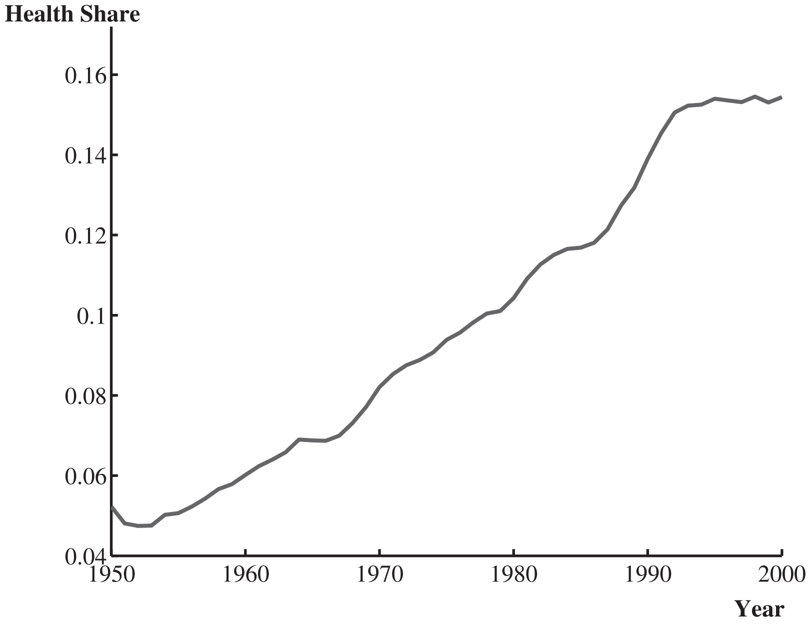
Transition probabilities:

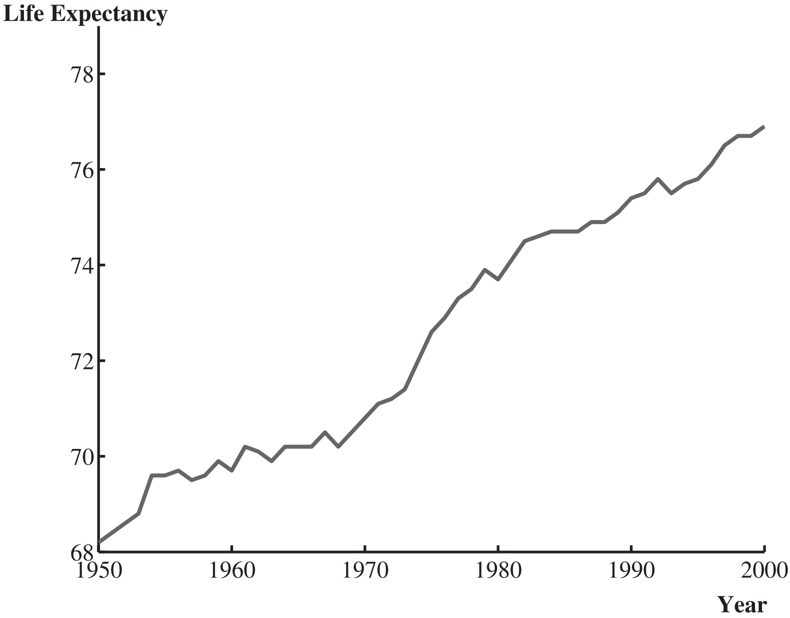
$$T_{i,i'} = \text{Prob} \left[\frac{\bar{s}_{i'-1} + \bar{s}_{i'}}{2} \leq f(\bar{s}_i, \bar{x}_i, \epsilon) < \frac{\bar{s}_{i'} + \bar{s}_{i'+1}}{2} \right]$$

Solve the linear system $pT = p$ and $\sum_i p_i = 1$ to find stationary probabilities p_i. Matrix inversion beats simulation.

THE VALUE OF LIFE AND THE RISE IN HEALTH SPENDING*

Robert E. Hall and Charles I. Jones


Health Share
0.16
0.14
0.12
0.1
0.08
0.06
0.04
1950
1960
1970
1980
1990
2000
Year


Life Expectancy
78
76
74
72
70
68
1950
1960
1970
1980
1990
2000
Year

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma},$$

$$x_{a,t} = f(h_{a,t};\ a,\ t).$$

$$V_t(N_t) = \max_{\{h_{a,t}, c_{a,t}\}} \sum_{a=0}^{\infty} N_{a,t} u(c_{a,t}, x_{a,t}) + \beta V_{t+1}(N_{t+1}) \tag{12}$$

subject to

$$\sum_{a=0}^{\infty} N_{a,t}(y_t - c_{a,t} - h_{a,t}) = 0, \tag{13}$$

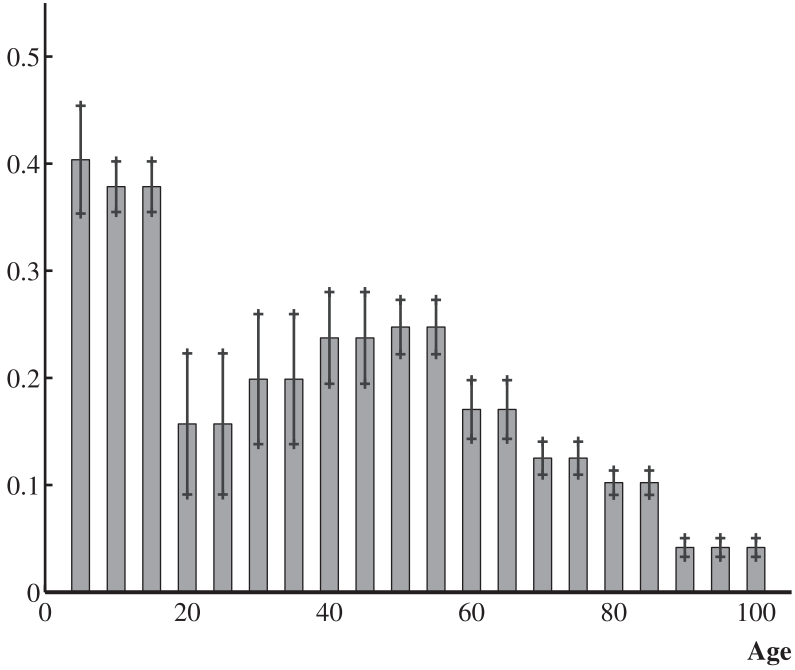
$$N_{a+1,t+1} = \left(1 - \frac{1}{x_{a,t}}\right) N_{a,t}, \tag{14}$$

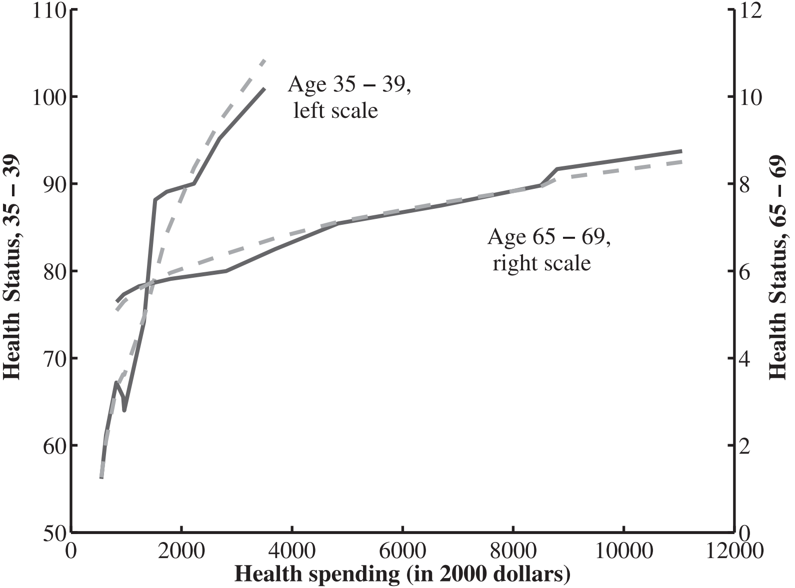
$$N_{0,t} = N_0, \tag{15}$$

$$x_{a,t} = f(h_{a,t}; a, t). \tag{16}$$

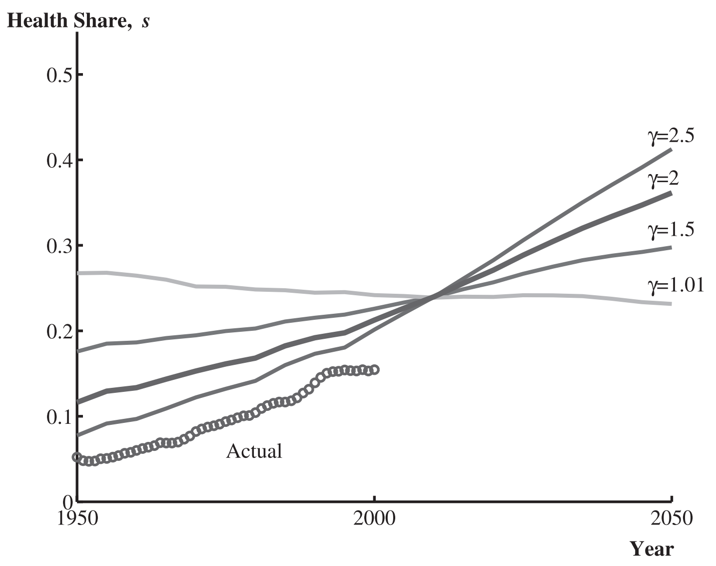
$$y_{t+1} = e^{g_y} y_t. \tag{17}$$

$$\log \tilde{x}_{a,t} = \log A_a + \theta_a \, (\log z_t + \log h_{a,t} + \log w_{a,t}).$$


0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
Age



Age 35 – 39,
left scale
Age 65 – 69,
right scale
Health Status, 35 – 39
Health Status, 65 – 69
Health spending (in 2000 dollars)
110
100
90
80
70
60
50
12
10
8
6
4
2
0
0
2000
4000
6000
8000
10000
12000



Health Share, s
0.5
0.4
0.3
0.2
0.1
0
1950
2000
2050
Year
γ=2.5
γ=2
γ=1.5
γ=1.01
Actual

American Economic Review 2008, 98:3, 1083–1102
http://www.aeaweb.org/articles.php?doi=10.1257/aer.98.3.1083

The Interaction of Public and Private Insurance: Medicaid and the Long-Term Care Insurance Market

By Jeffrey R. Brown and Amy Finkelstein*

(1) $$\max_{C_{s,t}} \sum_{t=1}^{T} \sum_{s=1}^{5} \frac{Q_{s,t}}{(1+\rho)^t} U_s(C_{s,t} + F_{s,t}),$$

$$W_{t+1} = (W_t + A_t + \min\left[B_{s,t}, X_{s,t}\right] - P_{s,t} - X_{s,t} - C_{s,t})(1 + r).$$

$$W_{t+1} = [W_t - \max(W_t - \underline{W}, 0) + (\underline{C}_s - C_t)](1 + r).$$

$$\text{(A3)} \qquad \underset{C_{s,t}}{Max} V_{s,t}\left(W_t; A\right) = \underset{C_{s,t}}{Max} U_s\left(C_{s,t} + I_{s,t}^M \cdot F_{s,t} + \left(1 - I_{s,t}^M\right) \cdot \alpha_s \cdot F_{s,t}\right) + \sum_{\sigma=1}^{5} \frac{q_{t+1}^{s,\sigma}}{\left(1+\rho\right)} V_{\sigma,t+1}\left(W_{t+1}; A\right)$$

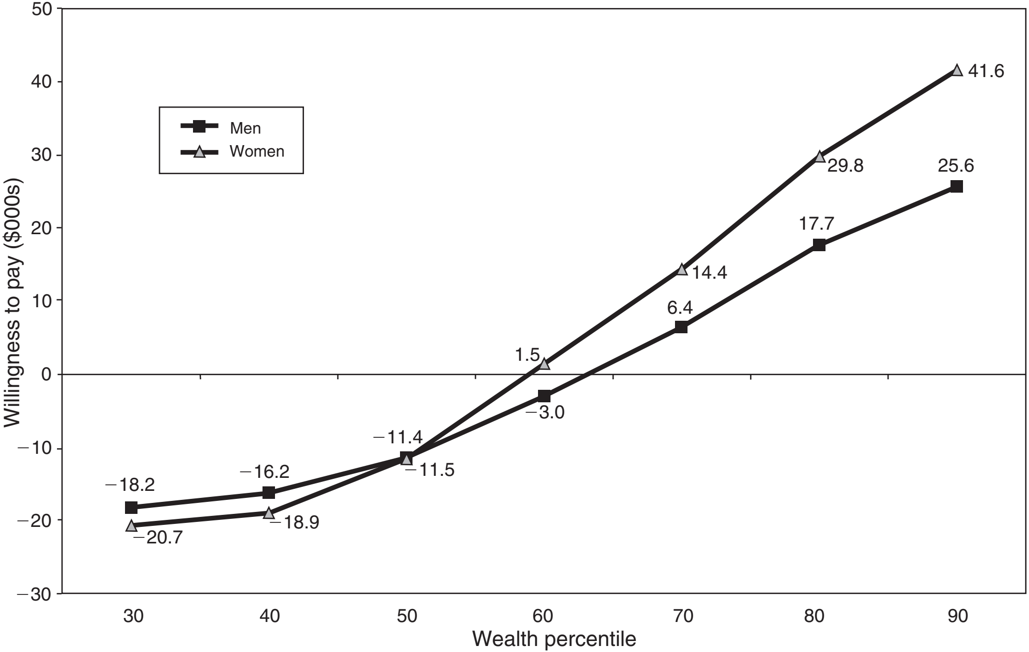


FIGURE 1. WILLINGNESS TO PAY FOR PRIVATE LTC INSURANCE
($100 daily benefit, market load)

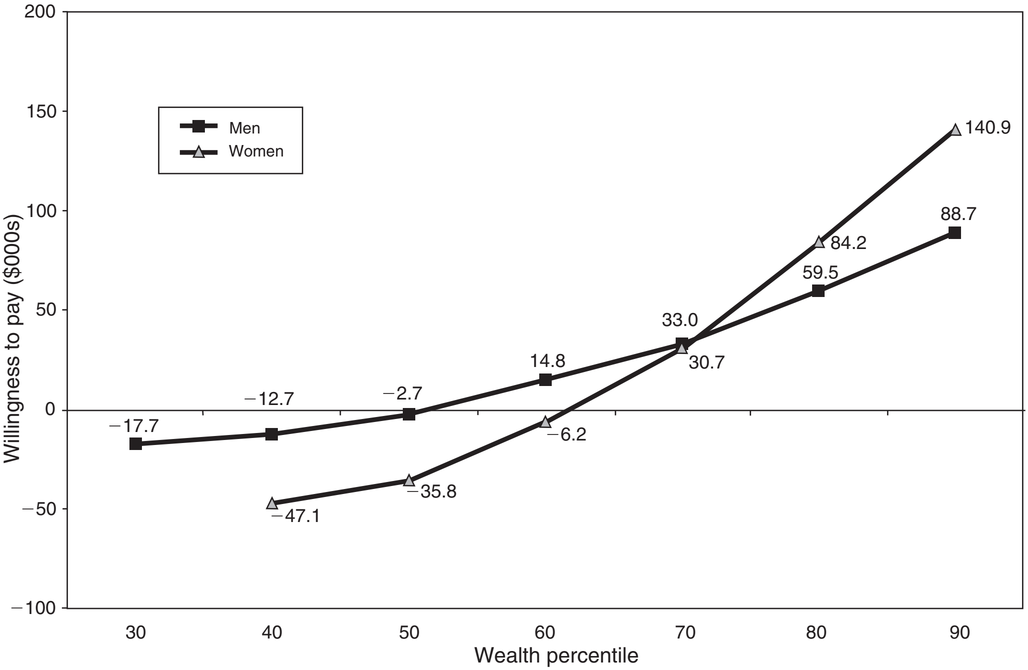


FIGURE 2. WILLINGNESS TO PAY FOR PRIVATE LTC INSURANCE
(Comprehensive benefit, zero load)

TABLE 2—MEDICAID: IMPLICIT TAX AND COMPLETENESS OF COVERAGE

Wealth percentile	Medicaid share of expected present discounted value (EPDV) of total long-term care expenditures: No private insurance	Medicaid share of expected present discounted value (EPDV) of total long-term care expenditures: With private insurance	Implicit tax on private insurance	Net load on private insurance	Willingness to pay for actuarially fair (0 load) policy to top up Medicaid ($ thousands)
	(1)	(2)	(3)	(4)	(5)
Panel A: Men					
10th	0.98	0.52	0.998	1.00	0.0
20th	0.89	0.44	0.952	0.98	0.0
30th	0.80	0.41	0.840	0.92	3.3
40th	0.71	0.37	0.737	0.87	9.8
50th	0.60	0.32	0.594	0.80	19.6
60th	0.46	0.26	0.426	0.71	35.2
70th	0.32	0.20	0.272	0.64	51.0
80th	0.17	0.12	0.107	0.55	74.1
90th	0.07	0.05	0.035	0.52	100.9

TABLE 2—MEDICAID: IMPLICIT TAX AND COMPLETENESS OF COVERAGE

Wealth percentile	Medicaid share of expected present discounted value (EPDV) of total long-term care expenditures: No private insurance (1)	Medicaid share of expected present discounted value (EPDV) of total long-term care expenditures: With private insurance (2)	Implicit tax on private insurance (3)	Net load on private insurance (4)	Willingness to pay for actuarially fair (0 load) policy to top up Medicaid ($ thousands) (5)
Panel A: Men					
10th	0.98	0.52	0.998	1.00	0.0
20th	0.89	0.44	0.952	0.98	0.0
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50th	0.60	0.32	0.594	0.80	19.6
60th	0.46	0.26	0.426	0.71	35.2
70th	0.32	0.20	0.272	0.64	51.0
80th	0.17	0.12	0.107	0.55	74.1
90th	0.07	0.05	0.035	0.52	100.9
Panel B: Women					
10th	0.99	0.55	0.999	1.00	0.0
20th	0.93	0.50	0.992	0.99	0.0
30th	0.88	0.46	0.946	0.94	2.3
40th	0.80	0.43	0.854	0.85	11.5
50th	0.72	0.38	0.767	0.75	29.7
60th	0.60	0.33	0.618	0.60	58.3
70th	0.45	0.24	0.470	0.44	86.3
80th	0.24	0.15	0.194	0.15	122.8
90th	0.08	0.06	0.054	0.00	166.3

Notes: Private insurance policy in columns 1–4 has a $100 daily benefit cap. Implicit tax is the decrease in Medicaid expenditures associated with having private insurance, as a percentage of the private insurance benefits (see equation (5)). Net load is the gross load plus the ratio of the decrease in the EPDV of Medicaid expenditures associated with having private insurance to the EPDV of the premiums of this private policy (see equation (6)). For gross loads, we use the current market loads of 0.50 for men, and −0.06 for women.

Sources and Mechanisms of Cyclical Fluctuations in the Labor Market

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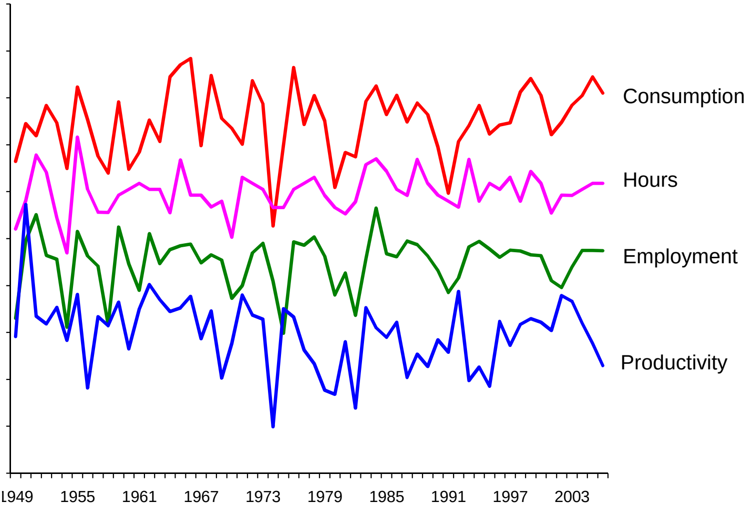
Growth rates



General framework

Hours: $h(\lambda, w)$

Consumption: $c_e(\lambda, w)$ and $c_u(\lambda, w)$

Employment rate: $n(\lambda, w)$

Search and matching

$$n = \frac{\phi(\theta)}{s + \phi(\theta)}$$

$$q(n) = \phi(\theta(n))/\theta(n)$$

Employment contract

Employers pay workers w_t for each hour of work in period t

Employers collect an amount y_t from a new worker

Technology, hours, and capital

$$F(H_t, K_t, \eta_t)$$

$$\frac{\partial F(nh, K)}{\partial H} = w_t$$

$$\frac{\partial F(nh, K)}{\partial K} = r_t$$

Market tightness—zero profit

$$q(n)y = \gamma$$

Family preferences and decisions

$$n_t U(c_{e,t}, h_t) + (1 - n_t) U(c_{u,t}, 0)$$

$$\begin{aligned}
V(W_t, \eta_t) = \\
&\max_{h_t, c_{e,t}, c_{u,t}} \{ n_t U(c_{e,t}, h_t) + (1 - n_t) U(c_{u,t}, 0) + \\
&\mathbb{E}\ \delta V((1 + r_t)[W_t - n_t c_{e,t} - (1 - n_t) c_{u,t}] - \\
&\qquad \phi(n_t)(1 - n_t) y_t + w_t n_t h_t, \eta_{t+1}) \}
\end{aligned}$$

State variables

$$\lambda_t = \frac{\partial V}{\partial W_t} = \delta(1 + r_t)\ \mathbb{E}\ \frac{\partial V}{\partial W_{t+1}}$$

$$w_t = \frac{\partial F(nh, K)}{\partial H}$$

Hours and consumption

$$U_h(c_{e,t}, h_t) = -\lambda_t w_t$$

$$U_c(c_{e,t}, h_t) = \lambda_t$$

$$U_c(c_{u,t}, 0) = \lambda_t$$

These define $c_e(\lambda_t, w_t)$, $h(\lambda_t, w_t)$, and $c_u(\lambda_t)$

Compensation bargain

Markoff assumption: $y(\lambda, w)$

Reservation level in utility:
$U(c_e, h) - U(c_u, 0) + \lambda(-c_e + c_u + w_t h_t)$

in purchasing power:
$R(\lambda, w) = \frac{U(c_e,h) - U(c_u,0)}{\lambda} - c_e + c_u + w_t h_t$

Nash bargain: $y(\lambda, w) = (1 - \nu) R(\lambda, w)$

Employment function

$$n(y(\lambda_t, w_t))$$

or

$$n(\lambda_t, w_t)$$

Frisch properties

Intertemporal substitution in consumption, $C_1(\lambda p, \lambda w)$

Frisch labor-supply response, $H_2(\lambda p, \lambda w)$

Consumption-hours cross effect, $C_2(\lambda p, \lambda w)$

Informative priors centered on

Frisch elasticity of consumption demand: -0.5

Frisch elasticity of hours supply: 0.9

Frisch cross-elasticity of 0.3

Priors

Parameter	*Interpretation*	*Mean*	*Lowest value*	*Highest value*
$\beta_{c,c}$	Frisch own-price elasticity of consumption	-0.50	-0.6	-0.4
$\beta_{c,h}$	Frisch cross-price elasticity of consumption	0.30	0.0	0.6
$\beta_{h,h}$	Frisch wage elasticity of hours	0.90	0.8	1.0
$\beta_{n,\lambda}$	Elasticity of employment with respect to λ	0.50	0.0	1.0
$\beta_{n,w}$	Elasticity of employment with respect to w	1.00	0.0	2.0
σ^2_{λ}	Variance of latent λ	2.15	0.3	4.0
σ^2_{w}	Variance of latent w	2.15	0.3	4.0
ρ	Correlation of λ and w	-0.70	-0.9	-0.5
σ^2_{c}	Variance of consumption noise	1.00	0.5	1.5
σ^2_{h}	Variance of hours noise	0.30	0.2	0.4
σ^2_{n}	Variance of employment noise	0.25	0.1	0.4
σ^2_{m}	Variance of productivity noise	0.75	0.3	1.2

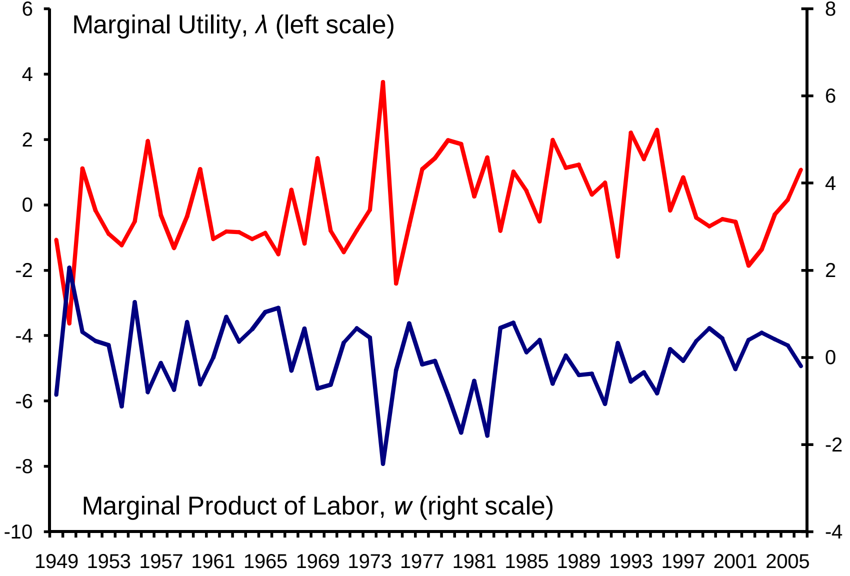
Covariances and Correlations

	Consumption	*Hours*	*Employment*	*Productivity*
Covariances				
Consumption	2.08	0.54	1.03	0.81
Hours		0.76	0.63	0.10
Employment			1.26	0.27
Productivity				2.37
Correlations				
Consumption	1.000	0.511	0.702	0.363
Hours		1.000	0.645	0.075
Employment			1.000	0.159
Productivity				1.000

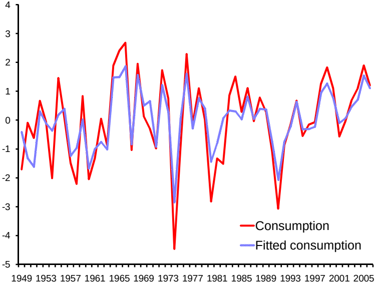
Posterior Distribution

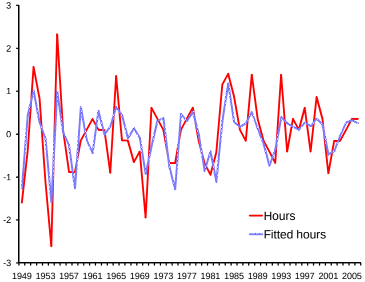
Parameter	*Interpretation*	*Prior mean*	*Prior standard deviation*	*Posterior mean*	*Posterior standard deviation*
$\beta_{c,c}$	Frisch own-price elasticity of consumption	-0.50	0.12	-0.49	0.07
$\beta_{c,h}$	Frisch cross-price elasticity of consumption	0.30	0.36	0.53	0.09
$\beta_{h,h}$	Frisch wage elasticity of hours	0.90	0.12	0.95	0.06
$\beta_{n,\lambda}$	Elasticity of employment with respect to λ	0.50	0.61	0.73	0.15
$\beta_{n,w}$	Elasticity of employment with respect to w	1.00	1.21	1.60	0.33
σ^2_{λ}	Variance of latent λ	2.15	2.24	3.58	0.72
σ^2_{w}	Variance of latent w	2.15	2.24	1.14	0.57
ρ	Correlation of λ and w	-0.70	0.24	-0.72	0.13
σ^2_{c}	Variance of consumption noise	1.00	0.61	1.18	0.23
σ^2_{h}	Variance of hours noise	0.30	0.12	0.35	0.05
σ^2_{n}	Variance of employment noise	0.25	0.18	0.25	0.11
σ^2_{m}	Variance of productivity noise	0.75	0.55	1.15	0.12

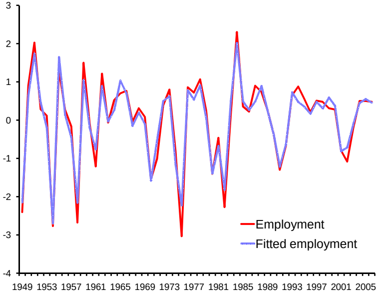
Inferred Growth

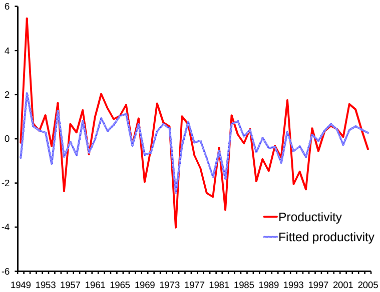


Actual and Fitted Values









The Burden of the Nondiversifiable Risk of Entrepreneurship

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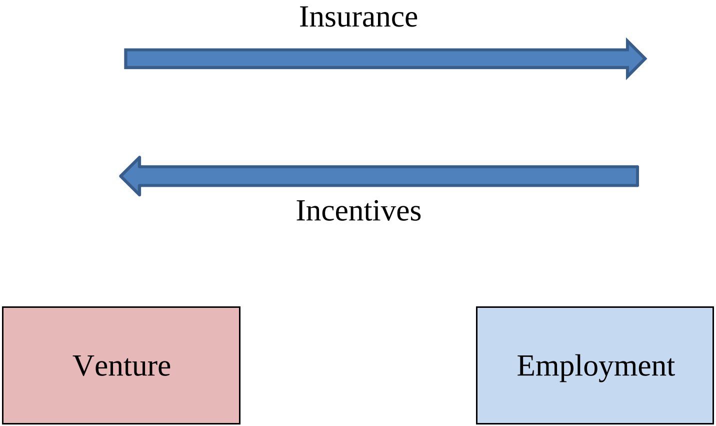
Basic Contract Forms



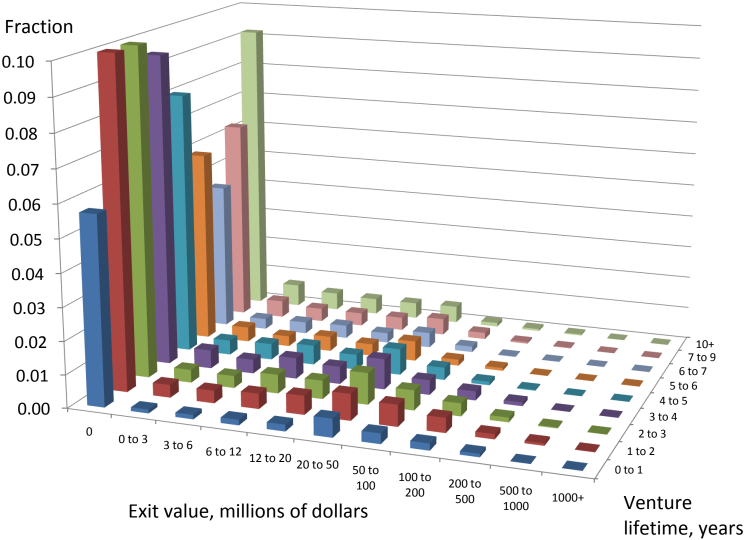
Data

Exits of venture-backed companies: 20,961

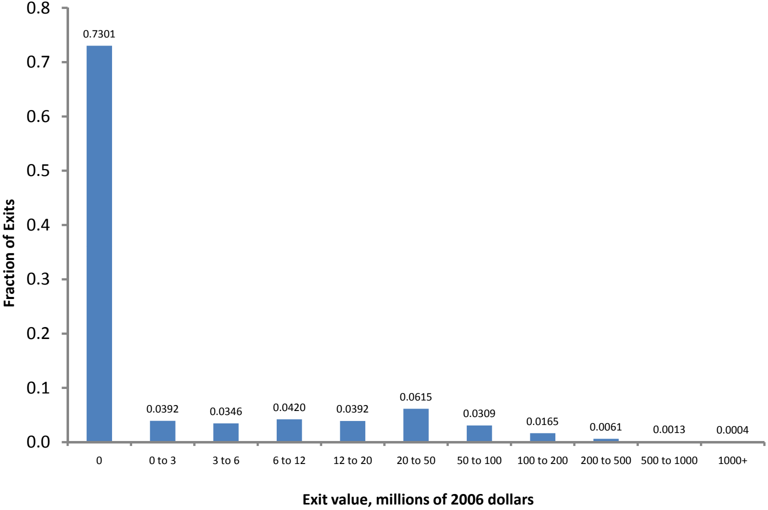
- IPOs: 2,010
- Acquisitions: 5,329
- Known failed: 3,180
- Imputed as failed: 3,904

Non-exited: 6,538

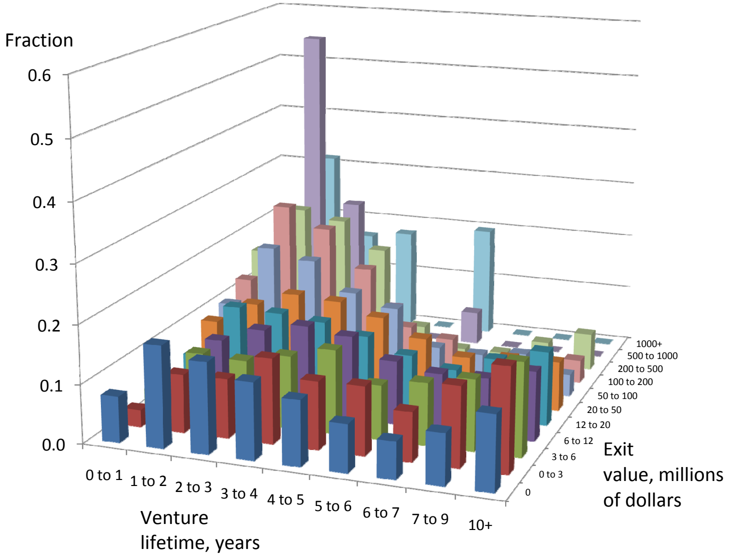
Joint Distribution of Venture Lifetime and Exit Value



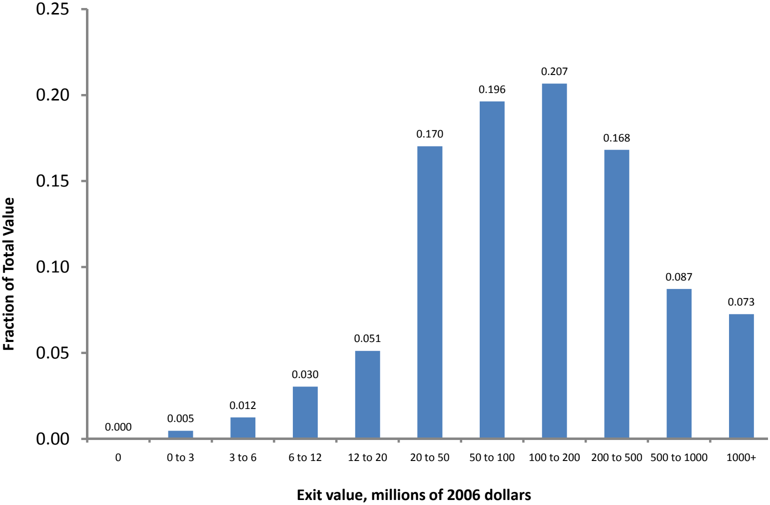
Marginal Distribution of Exit Value



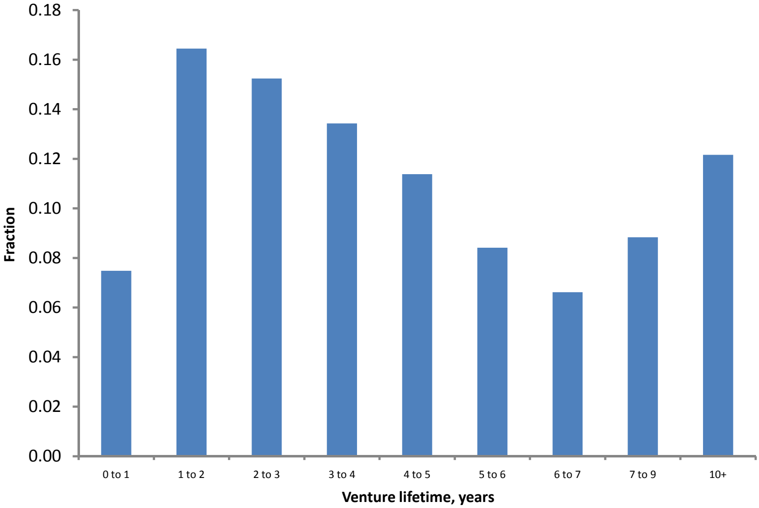
Conditional Distribution



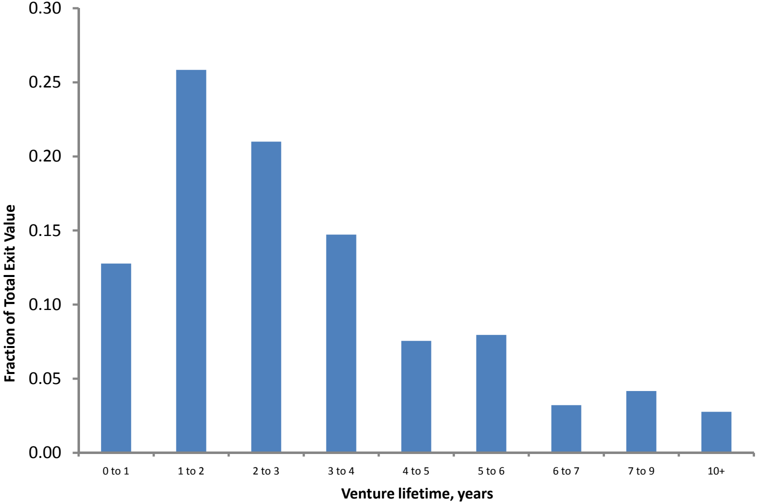
Fractions of Total Exit Value by Exit-Value Category



Marginal Distribution of Venture Lifetime



Fractions of Total Exit Value by Venture Lifetime



Entrepreneur's Attitude toward Risk

$$\mathbb{E} \sum_t \left(\frac{1}{1+r}\right)^t u(c_t)$$

$$U(W) = \frac{1+r}{r}\, u\left(\frac{r}{1+r}W\right)$$

Entrepreneur's Dynamic Program

$$U(W_t(A_t)) = \max_{c_t < A_t}\Big[u(c_t) + \frac{1}{1+r}\ (1-\pi_{t+1})U(W_{t+1}((A_t - c_t)(1+r) + w)) + \frac{1}{1+r}\pi_{t+1}\ \mathbb{E}_X\ U(W^*((A_t - c_t)(1+r) + X_{t+1}))\Big] \quad (1)$$

$$U(W^*(A)) = \frac{1+r}{r}\ u\left(\frac{rA + w^*}{1+r}\right)$$

Parameters

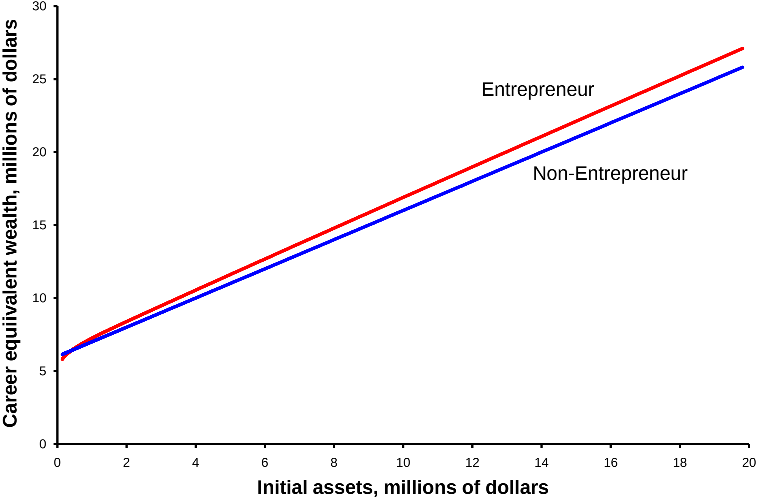
Constant relative risk aversion: 2

Venture salary: $w = \$150,000$

Post-venture compensation: $w = \$300,000$

Starting assets: $A_0 = \$1$ million

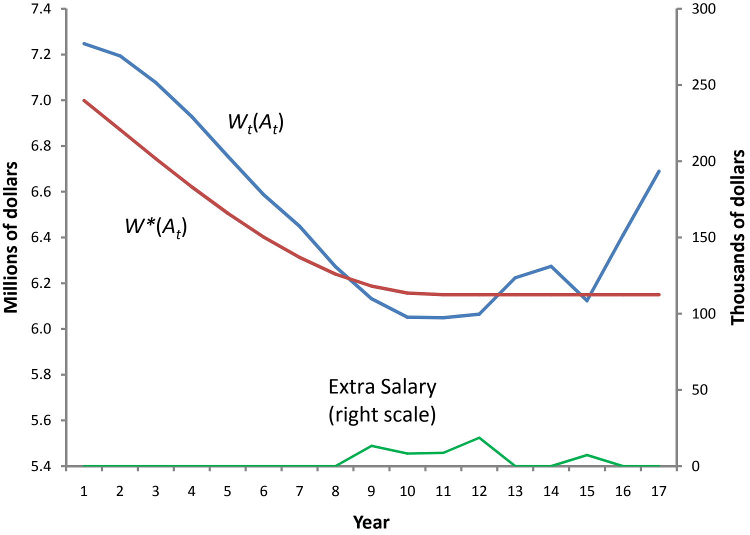
Certainty-Equivalent Career Wealth



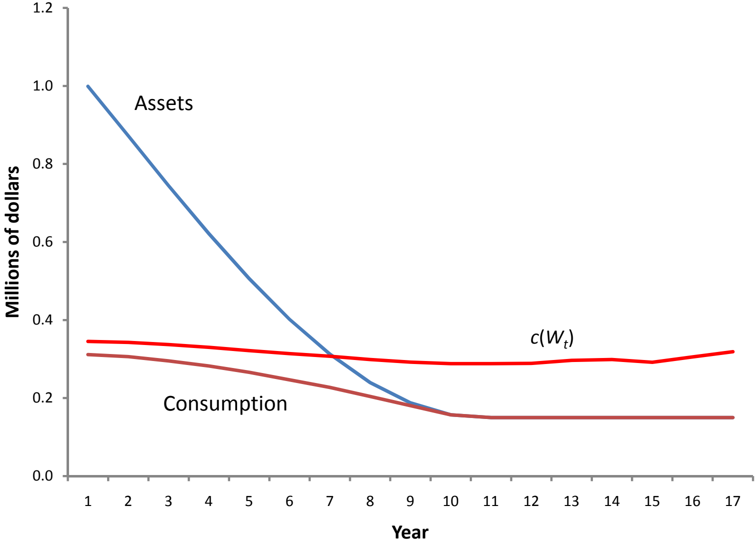
Certainty-Equivalent Value of the Venture Opportunity

Coefficient of relative risk aversion, γ	*Compensation at non-entrepreneurial job, thousands of dollars per year*	*Certainty-equivalent of entrempreurial opportunity, millions of dollars*		
		Assets at beginning, millions of dollars		
		1	5	20
0	300	4.4	4.4	4.4
0	600	3.3	3.3	3.3
0	2,000	-1.9	-1.9	-1.9
0.9	300	1.2	1.6	2.3
0.9	600	0.1	0.7	1.3
0.9	2,000	-9.0	-5.5	-3.7
2	300	0.2	0.6	1.3
2	600	-1.7	-0.3	0.3
2	2,000	-20.7	-10.2	-4.9

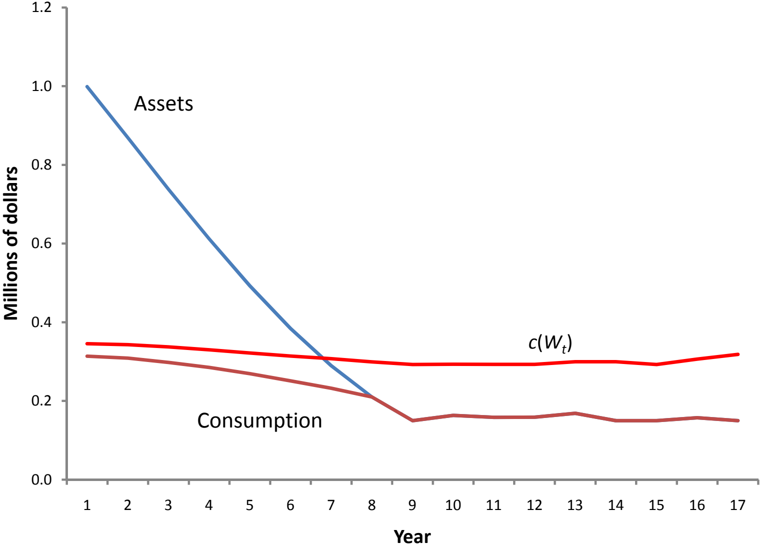
Values Prior to Exit



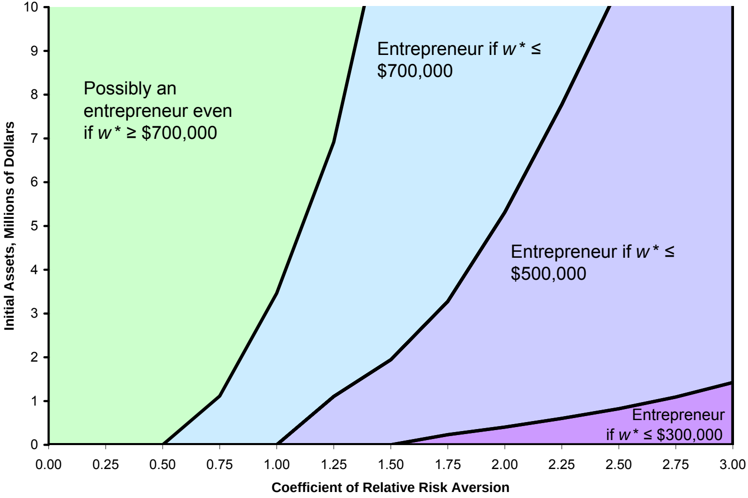
No Extra Salary



With Extra Salary



Sorting


Initial Assets, Millions of Dollars
10
9
8
7
6
5
4
3
2
1
0
Possibly an entrepreneur even if w* ≥ $700,000
Entrepreneur if w* ≤ $700,000
Entrepreneur if w* ≤ $500,000
Entrepreneur if w* ≤ $300,000
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
Coefficient of Relative Risk Aversion

Equity Depletion from Government-Guaranteed Debt

Robert E. Hall
Stanford.edu/∼rehall

Prompt corrective action?

Federal Regulators Close ANB Financial

WSJ 5/10/08

By Damian Paletta And Paulo Prada

WASHINGTON—Federal regulators closed ANB Financial Friday, marking the third financial institution to fail this year amid what regulators have warned might be a tumultuous time.

The $2.1 billion bank, of Bentonville, Ark., is the second-biggest federally insured bank to fail since 2001. ANB, which opened in 1994, had touted itself as one of the first Internet banks. As of Friday afternoon, the bank's Web site was no longer working.

The biggest recent failure was NetBank, a $2.5 billion Alpharetta, Ga., bank that was closed last year and also struggled with an Internet banking model.

The Federal Deposit Insurance Corp. said ANB's nine offices would reopen Monday as branches of Pulaski Bank and Trust Co., with deposits transferred to that bank.

ANB came under regulatory scrutiny in June 2007 as its assets grew but its capital shrank, in part because of a surge in delinquent loans. The Office of the Comptroller of the Currency, which regulates ANB, required the company to hire a new senior loan officer and raise capital, among other things.

In January, the bank and its parent company, **ANB Bancshares** Inc., entered into a separate regulatory agreement with the Federal Reserve Bank of St. Louis, consenting to improve its capital.

The bank's delinquent loans and leases surged to $394 million at the end of 2007, up from $40 million at the end of 2006. It had roughly 200 employees. The OCC blamed "unsafe and unsound practices" for the bank's failure.

ANB had $1.8 billion in deposits as of Jan. 31. Pulaski is taking on $212.9 million of ANB's insured nonbrokered deposits and will buy $235.9 million of the bank's assets. The FDIC said the failure would cost its federal deposit insurance fund $214 million.

Bank regulators have publicly warned that the rate of insolvent banks is expected to pick up this year. The FDIC is recruiting retired employees to help handle an increased workload.

There have been two other bank failures so far in 2008, both small Missouri banks. Three banks failed in 2007, following a record two-year span in which no banks failed.

Prompt corrective action?

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Prompt corrective action?

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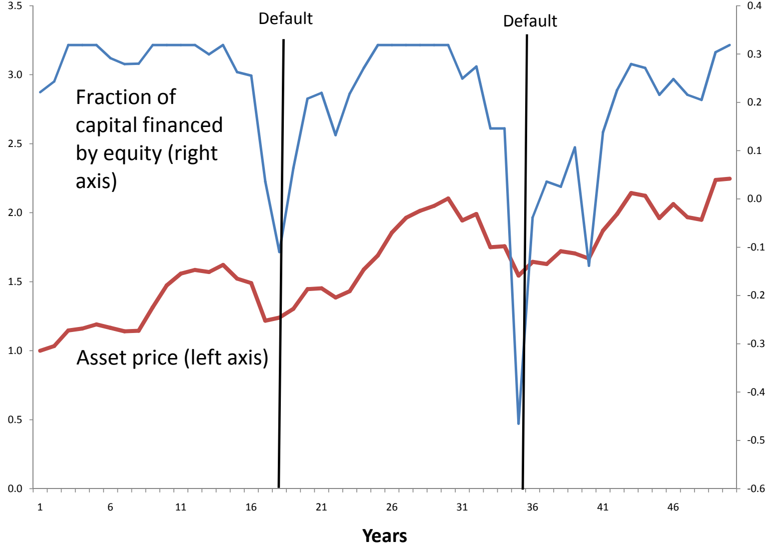
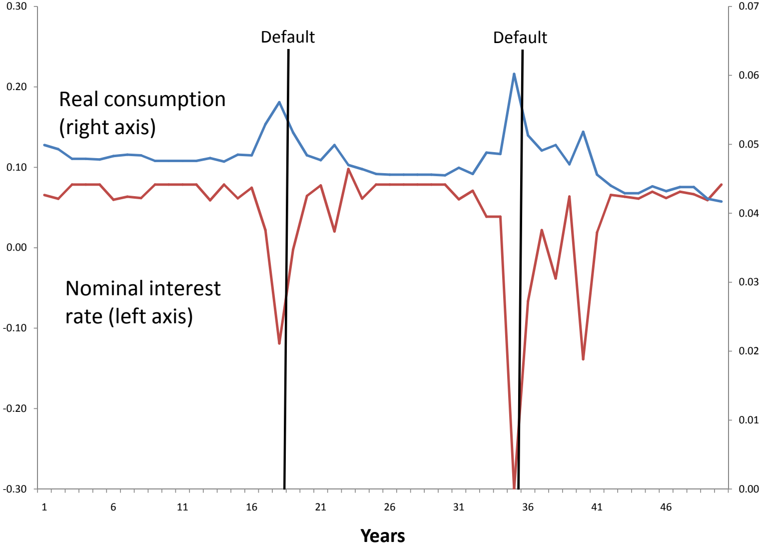
Example of a History From the Model



Example of a History From the Model



Basic growth model

$$\hat{K}' = (1+r)(\hat{K} - c)$$

$$V(\hat{K}) = \max_c \frac{c^{1-\gamma}}{1-\gamma} + \beta V(\hat{K}')$$

$$V(\hat{K}) = V\hat{K}^{1-\gamma}$$

$$V\hat{K}^{1-\gamma} = \max_c \frac{c^{1-\gamma}}{1-\gamma} + \beta V\hat{K}'^{1-\gamma}$$

Path

Assume: $(1+r)\beta = 1$

$$c = \frac{r}{1+r}\hat{K}$$

Debt

$$\text{Invest } \frac{D}{1+r_d}$$

$$\text{Repay } D$$

Capital requirements

$$D \leq (1 - \alpha)pK$$

unless earlier debt is greater

but $D \leq pK$

Thus,

$$D = \min(p(1+r)K, \max(\hat{D}, (1-\alpha)p(1+r)K))$$

$$Q = pK - \frac{D}{1+r_d}$$

$$\text{Return: } \max(p'(1+r)K - D, 0)$$

Laws of motion

$$\hat{K}' = (1 - z')(1 + r)K + z'\frac{D}{p'}$$

$$\hat{D}' = (1 - z')D$$

Consumer's dynamic program

$$V\left(\frac{\hat{D}}{p\hat{K}}\right)\hat{K}^{1-\gamma} = \max_c \left(\frac{c^{1-\gamma}}{1-\gamma} + \ \mathbb{E}\ \frac{1}{1+r} V\left(\frac{\hat{D}'}{p'\hat{K}'}\right)\hat{K}'^{1-\gamma}\right)$$

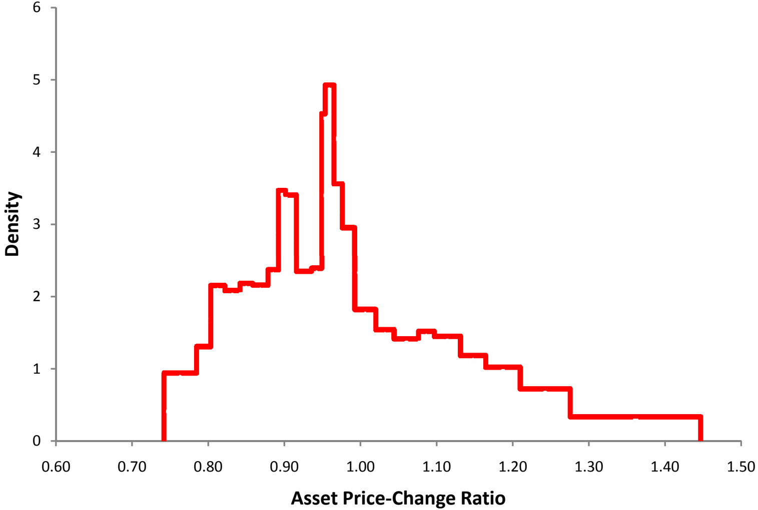
Calibration

$$\gamma = 2$$

$$r = 0.05$$

$$\alpha = 30 \text{ percent}$$

Distribution of Annual Price Change Ratio



The chance of free consumption

$$V\left(\frac{\hat{D}}{p\hat{K}}\right)\hat{K}^{1-\gamma} = \max_c \frac{c^{1-\gamma}}{1-\gamma} +$$

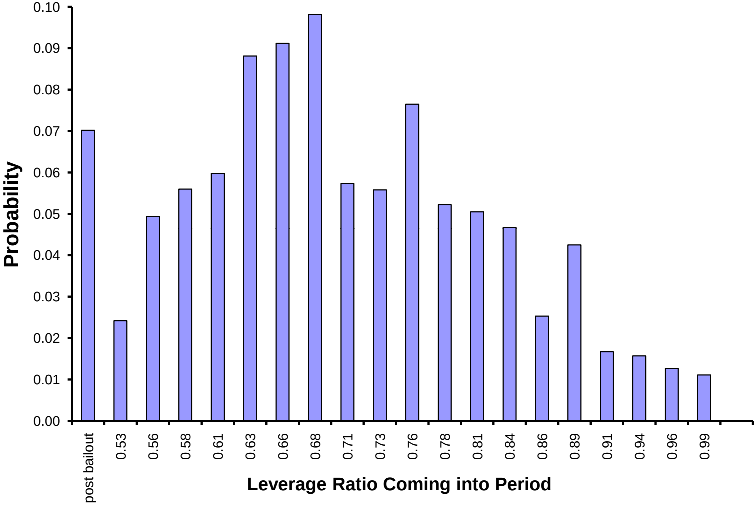
$$\mathbb{E}\ \frac{1}{1+r}\{(1-z')V\left(\frac{\hat{D}'}{p'\hat{K}'}\right)[(1+r)(\hat{K}-c)]^{1-\gamma} +$$

$$z'V(0)\cdot\left(\frac{\hat{D}}{p}\frac{p}{p'}\right)^{1-\gamma}\}$$

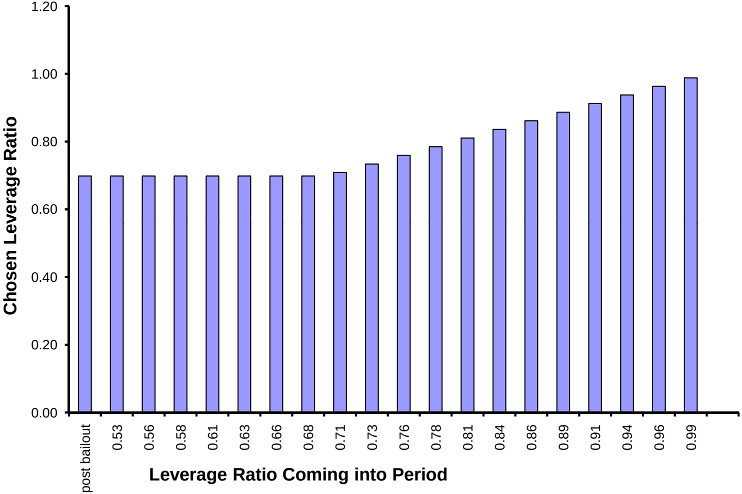
Euler Equation

$$\int_{p^*}^{\infty} c'(p'/p)^{-\gamma} dF(p'/p) = c^{-\gamma}$$

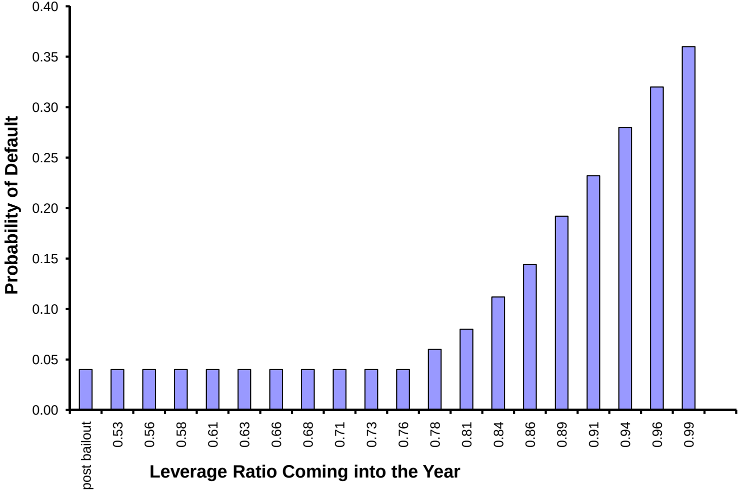
Distribution of Leverage Ratio



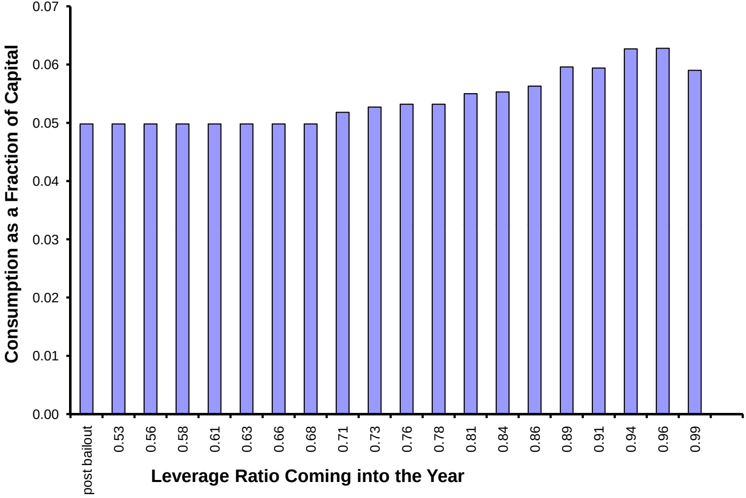
Chosen Leverage Ratio



Probability of Default as a Function of the Leverage Ratio



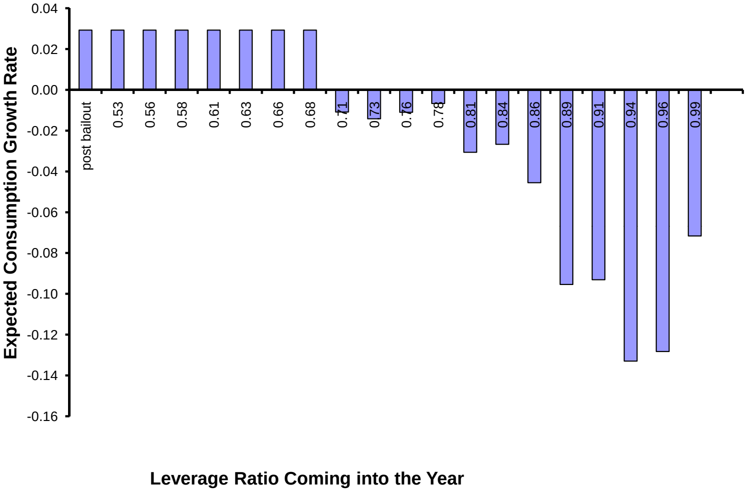
Consumption/Capital Ratio as a Function of the Leverage Ratio



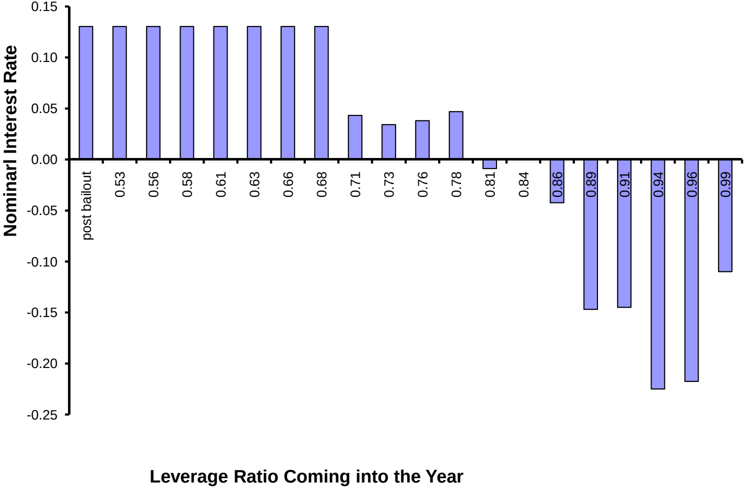
Nominal interest rate on debt

$$\frac{1+r_d}{1+r}\ \mathbb{E}\ \frac{p}{p'}\left(\frac{c'}{c}\right)^{-\gamma} = 1$$

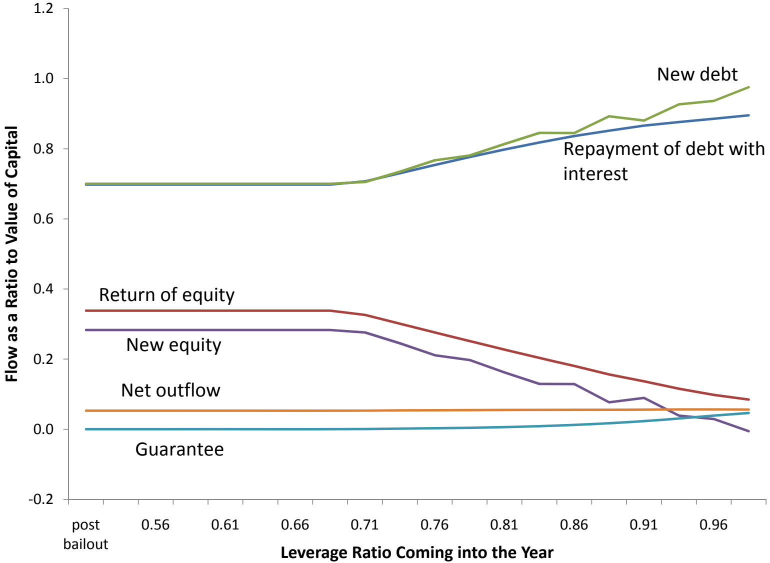
Consumption Growth Rate as a Function of the Leverage Ratio



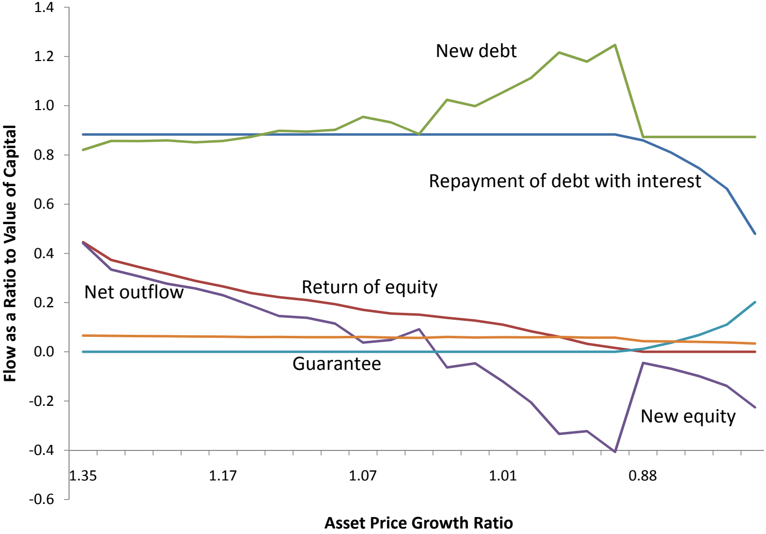
Nominal Interest Rate as a Function of the Leverage Ratio



Expected Flows as Functions of the Leverage Ratio



Flows as Functions of the Price Ratio when Prior Leverage is 0.85



Consumption in Four Cases