When Should There Be Vertical Choice in Health Insurance Markets?

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July 13, 2022

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Motivation

Choice (and product variety) in markets is often thought of as broadly desirable.

- Consumers able to closely match with the socially efficient choice by revealed preference.

However, in markets with selection (e.g. health insurance) the privately optimal choice may not align with the socially optimal choice.

- Due to asymmetric information, prices may not be set at marginal costs.

Research Question

How much vertical choice should regulators allow in health insurance markets?

- In insurance markets where moral hazard and adverse selection are present, how much consumer choice is socially optimal?

Unique contribution: focuses on the financial dimension of insurance to determine when and how choice over varying levels of coverage is desirable.

Paper Overview

1. Develop a theoretical model of a two-stage health insurance market:
    - Consumers first purchase health insurance (over discrete choice set) under uncertainty of future health.
    - Then upon realizing stochastically-determined health states, consumers decide the amount of healthcare to utilize.
2. Parameterize and estimate consumer utility and distribution of health states.
3. Estimate and decompose the private and socially relevant components of household willingness-to-pay:
    - Compartmentalize WTP to determine the social surplus generated by allocating consumers to varying levels of financial coverage.
4. Counterfactual analysis:
    - Compare various market designs to establish welfare and distributional effects.

Presentation Outline

Key Ingredients

In order for vertical choice to be efficient, we require three basic ingredients:

1. Moral hazard spending,
2. Risk aversion,
3. Consumer heterogeneity.

Without each, the optimal contract would simply be 1) the highest coverage-level for all households, 2) the lowest coverage-level for all households, or 3) a unique contract solving the representative household's problem, respectively.

In all three instances, vertical choice is inefficient.

Setup

- Set of contracts $X = \{x_0, x_1, ..., x_n\}$, x_0 contract provides no insurance.
- Consumers characterized by $\theta = \{F, \psi, \omega\}$, F is the distribution of health states, ψ is risk aversion, ω indicates preferences for healthcare utilization.
- Consumers value healthcare utilization and residual income. Upon realizing health state, $l \sim F$, consumers choose healthcare spending $m^*(l, \omega, x) = \arg\max_m (b(m; l, \omega) - c_x(m))$, where b is a financial private valuation of spending and c_x is out-of-pocket healthcare cost.
- Thus, conditional expected utility prior to realization of their health state is given by:

$$U(x, p, \theta) = \mathbb{E}[u_\psi(\hat{y} - p - c_x^*(l, \omega, x) + b^*(l, \omega, x)) \mid l \sim F] \tag{1}$$

  - Where u_ψ represents consumer preferences, l is the health state drawn from distribution F, p is the premium, $\hat{y}$ is initial income, $c_x^*(l, \omega, x)$ is the indirect out-of-pocket cost, and $b^*(l, \omega, x))$ is the indirect benefit of healthcare utilization.

Willingness-to-Pay and Social Surplus

$$v(I,\omega,x) = \underbrace{b^*(I,\omega,x) - b^*(I,\omega,x_0)}_{\textit{Benefit of moral hazard spending}} - \underbrace{(c_x^*(I,\omega,x) - c_x^*(I,\omega,x_0))}_{\textit{Cost of moral hazard spending}} \tag{2}$$

$$WTP(x,\theta) = \underbrace{\mathbb{E}[c_{x_0}^*(I,\omega,x_0) - c_x^*(I,\omega,x_0) \mid I]}_{(1)} + \underbrace{\mathbb{E}[v(I,\omega,x) \mid I]}_{(2)} + \underbrace{\Psi(x,\theta)}_{(3)} \tag{3}$$

Insurer costs given by $k_x(m) = m - c_x(m)$.

$$\begin{aligned} SS(x,\theta) &= WTP(x,\theta) - \mathbb{E}[k_x^*(I,\omega,x) \mid I] \\ &= \underbrace{\Psi(x,\theta)}_{(3)} - \underbrace{\mathbb{E}[k_x^*(I,\omega,x) - k_x^*(I,\omega,x_0) - v(I,\omega,x) \mid I]}_{(4)} \end{aligned} \tag{4}$$

1. Expected reduction in out-of-pocket cost (holding behavior constant),
2. Expected payoff from moral hazard spending,
3. Value of risk protection,
4. Social cost of moral hazard.

Private vs. Social Optimality

Socially optimal contract solves:

$$x^{eff}(\theta) = \arg\max_x SS(x, \theta).$$

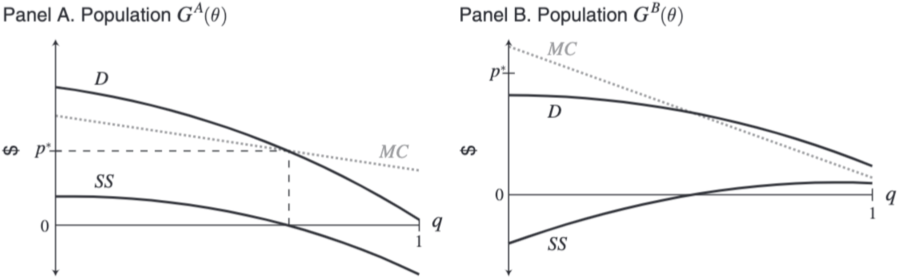
Given premiums p_x, privately optimal contract solves:

$$x^*(\theta, p_x) = \arg\max_x (WTP(x, \theta) - p_x).$$

Regulator observes distribution of consumer types and sets premiums p_x to maximize social welfare:

$$W(p_x) = \int SS(x^*(\theta, p_x), \theta) dG(\theta). \tag{5}$$

Two-Contract Example



- With two contracts (high vs. low coverage), the marginal social surplus (SS) from enrollment in the high coverage contract is demand minus marginal cost.
- Key difference: in population A, marginal SS is increasing in marginal WTP (i.e. D). Thus, there exists p^* that sorts consumers into high and low contracts.
- When $p \neq MC$ (i.e. $CS \neq SS$), efficiency of vertical choice is determined by whether SS crosses zero from above.

Data

1. **Market:** Public schools employees in Oregon from 187 school districts.
2. **Insurers:** Moda (PPO), Providence (PPO), and Kaiser (HMO).
   - Within insurer, plans differentiated only by coverage level, not network.
3. **Timeframe:** 2008 to 2013 (Providence 2008 - 2011).
4. **Key fields:** Employees' plan menus, realized plan choices, plan characteristics, claims, demographics (age, gender, ZIP, family type), health risk score, employee occupation type.

Oregon Educators Benefit Board (OEBB) and insurers contract to determine the state-level master list of plan menus and premiums each year.

Plan menus for each school district are then set by benefits committees and subsidies are determined through bargaining agreements with teachers' unions.

Contracts Heavily Subsidized, Moda Largest Insurer in the Market

TABLE 1—PLAN CHARACTERISTICS, 2009

Plan	Actuarial value	Avg. employee premium ($)	Full premium ($)	Deductible ($)	OOP max. ($)	Market share
Kaiser–1	0.97	688	10,971	0	1,200	0.07
Kaiser–2	0.96	554	10,485	0	2,000	0.11
Kaiser–3	0.95	473	10,163	0	3,000	< 0.01
Moda–1	0.92	1,594	12,421	300	500	0.27
Moda–2	0.89	1,223	11,839	300	1,000	0.05
Moda–3	0.88	809	11,174	600	1,000	0.11
Moda–4	0.86	621	10,702	900	1,500	0.10
Moda–5	0.82	428	9,912	1,500	2,000	0.13
Moda–6	0.78	271	8,959	3,000	3,000	0.04
Moda–7	0.68	92	6,841	3,000	10,000	0.01
Providence–1	0.96	2,264	13,217	900	1,200	0.07
Providence–2	0.95	1,995	12,895	900	2,000	0.02
Providence–3	0.94	1,825	12,683	900	3,000	0.01

- Actuarial value is the ratio of insured to total household spending.
- Moda has on average over 70% of market share.

Few Households Switch Insurers, Kaiser Omitted from Principal Analysis

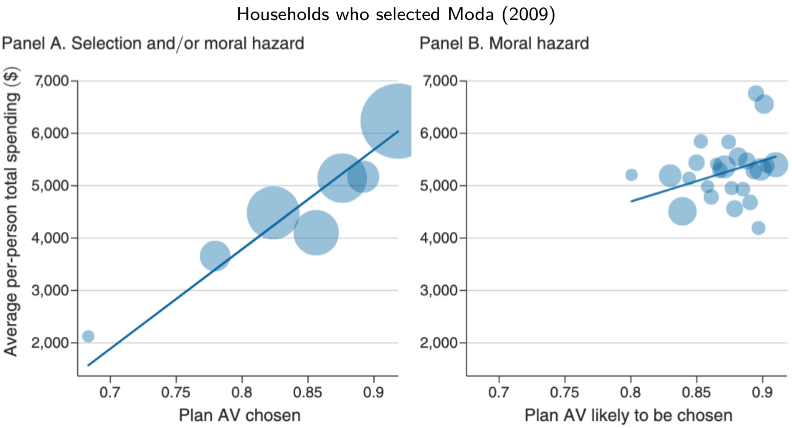
Table 2—Household Summary Statistics

	Full sample	Excluding Kaiser
Number of households	44,562	34,606
Number of enrollees	117,934	92,244
Percent of households with children	0.49	0.49
Enrollees per household, mean (median)	2.57 (2)	2.60 (2)
Enrollee age, mean (median)	39.8 (37.8)	40.4 (38.7)
Premiums		
Employee premium ($), mean (median)	880 (0)	843 (0)
Full premium ($), mean (median)	11,500 (11,801)	11,582 (11,801)
Household health-care spending		
Total spending ($), mean (median)	10,754 (4,620)	11,689 (5,173)
Out-of-pocket ($), mean (median)	1,694 (1,093)	2,054 (1,540)
Switching (percent of household-years)		
Forced to switch plan	0.20	0.21
insurer	0.01	0.02
Unforced, switched plan	0.17	0.20
insurer	0.03	0.03

- 78% of households always choose Moda/Providence, 19% always choose Kaiser, only 3% switch between.
- Average household premium only $880, median $0.

Sample Construction

Exogenous Variation in Plan Menus is Key



- Decentralized determination of plan menus (by OEBB and benefits' committees) provides exogenous variation in plan menus for employees.
- Conditional logit model of household plan choice (right panel) reaffirms pattern of higher spending when employees are offered higher coverage.

Actual Sources of Variation in Plan Generosity

Possible issue: are plan menus actually independent of household unobservables (conditional on observables)?

1. School districts could chose plan menu generosity based on unobserved employee information, or
2. Households could choose which school district to work in based on health benefit generosity.

However, lack of correlation between plan menu generosity and observables (e.g. household risk score) indicate little risk of substantial endogeneity.

Menu Generosity & Health Scores

Conditional logit model identifies some of the variables actually driving variation in menu generosity.

Conditional Logit Results

Parametrizing Household Utility

Following established literature in healthcare spending, household k's valuation of m given state l:

$$b(m; l, \omega_k) = (m - l) - \frac{1}{2\omega_k}(m - l)^2. \tag{6}$$

Therefore, to maximize private value the households solves:

$$m^*_{jt}(l, \omega_k) = \arg\max_m (b(m; l, \omega_k) - c_{jt}(m)). \tag{7}$$

Taking FOCs yields $m^* = \omega(1 - c) + l$ and $b^* = \frac{\omega}{2}(1 - c^2)$, where c is the coinsurance rate for linear out-of-pocket cost function $c(m)$.

ω_k, household preferences for healthcare utilization, allows us to isolate the induced incremental spending for a household going from none to full insurance.

Example with Moral Hazard

Parametrizing Household Utility

Thus, the household maximizes expected utility by choosing plan j^* s.t.:

$$j^*_{kt} = argmax_{j \in J_{kt}} \underbrace{\int -exp(-\psi_k z_{kjt}(l)) dF_{kft}(l)}_{U_{kjt}}, \tag{8}$$

where ψ_k is a coefficient of absolute risk aversion, F_{kft} is the distribution of health states faced by insurer $f(j)$, and z_{kjt} is the payoff upon realizing state l, where:

$$z_{kjt}(l) = -p_{kjt} + \alpha^{OOP}(b^*_{jt}(l, \omega_k) - c^*_{jt}(l, \omega_k)) + \delta^{f(j)}_{kj} + \gamma^{inertia}_{kjt} + \beta X_{kjt} + \sigma_\epsilon \epsilon_{kjt}. \tag{9}$$

- p_{kjt}: net household premium.
- α^{OOP}: out-of-pocket cost valuation parameter.
- $b^*_{jt}(l, \omega_k) - c^*_{jt}(l, \omega_k)$: payoff from optimal healthcare utilization.
- $\delta^{f(j)}_{kj}$: insurer FEs interacted with household characteristics.
- $\gamma^{inertia}_{kjt}$: previous-year plan and insurer FEs interacted with household.
- X_{kjt}: additional covariates (e.g. HRA/HSA and dental contributions, etc.).
- ϵ_{kjt}: household-plan-year idiosyncratic shock (magnitude σ_ϵ estimated).

Households Distribution of Health States Are Approximately Log-Normal

- Assumption: Individuals face (shifted) log-normal distribution of health states,
$$\log(\tilde{l}^i + \kappa_{it}) \sim N(\mu_{it}, \sigma^2_{it}).$$
- Support $(-\kappa_{it}, \infty)$ captures the mass of individuals with zero spending.
- Since the majority of households are comprised of multiple individuals, households face the sum of state draws across all household individuals.
- However, there is no closed-form for the distribution of the sum of log-normal random variables.
- **Solution:** *Fenton-Wilkinson* approximation. This approach approximates the distribution of the sum of draws from independent log-normal distributions as a log-normal distribution.
- Along with parameter ϕ_f, which describes the exchange rate for states across insurers, the distribution F_{kft} of money-metric health states l at the household-level is described by,
$$l = \phi_f \tilde{l},$$
$$\log(\tilde{l} + \kappa_{kt}) \sim N(\mu_{kt}, \sigma^2_{kt}).$$

Identification Across Key Parameters

- Main goal is to distinguish between:
  1. Healthcare utilization preferences and private health information,
  2. Out-of-pocket cost valuation and risk aversion,
  3. Unobserved heterogeneity in risk aversion and moral hazard.

Strong positive correlation between ω and unobserved variation in μ_{kt} can be mostly explained by household characteristics, but positive residual correlation attributable to either moral hazard or private information on health (adverse selection).

Variation in choice within/across districts allows us to separate the two. Conditional on household observables,

- Moral hazard quantified by higher household healthcare spending when faced with more generous plan menus;
- Adverse selection, as well as magnitude σ_ϵ of shock ϵ_k, identified by households making different plan choices when faced with similar plan menus.

Identification Across Key Parameters

- Main goal is to distinguish between:
  1. Healthcare utilization preferences and private health information,
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α^{OOP} (out-of-pocket cost valuation) and ψ (risk aversion) impact preferences for higher coverage but do not impact spending.

Identification comes from observably differing households that face similar menus:

- α^{OOP} is the rate households trade premiums with out-of-pocket spending, holding uncertainty in out-of-pocket spending fixed;
- ψ is the degree of positive correlation between taste for higher coverage and uncertainty in out-of-pocket spending, holding expected out-of-pocket spending fixed.

Identification Across Key Parameters

- Main goal is to distinguish between:
  1. Healthcare utilization preferences and private health information,
  2. Out-of-pocket cost valuation and risk aversion,
  3. Unobserved heterogeneity in risk aversion and moral hazard.

Panel data allows us to observe the same households making different choices over time with changes to plan offerings and plan/household characteristics. However, *at most* five observations per household, therefore insufficient variation to non-parametrically back out distribution of ψ and ω.

Solution:

- Assume unobserved heterogeneity in risk aversion and moral hazard is normally distributed;
- Households making consistently different choices reflecting both high and low risk aversion (or moral hazard) for otherwise similar households is evidence enough of heterogeneity across these dimensions.

Estimating Household Parameters Using Fenton-Wilkinson

$\mu_{it}, \sigma_{it}, \kappa_{it}$ estimated using individual-level characteristics (such as health risk scores, gender, and age):

$$\mu_{it} = \beta^{\mu} X^{\mu}_{it},$$
$$\sigma_{it} = \beta^{\sigma} X^{\sigma}_{it},$$
$$\kappa_{it} = \beta^{\kappa} X^{\kappa}_{it}.$$

Using the *Fenton-Wilkinson* approximation methodology, household health state distributions are functions of individual-level parameters: Derivation

$$\sigma^2_{kt} = log\left[1 + \left[\sum_{i \in I_k} exp\left(\mu_{it} + \frac{\sigma^2_{it}}{2}\right)\right]^{-2} \sum_{i \in I_k} (exp(\sigma^2_{it}) - 1)(exp(2\mu_{it} + \sigma^2_{it}))\right], \tag{10}$$

$$\bar{\mu}_{kt} = -\frac{\sigma^2_{kt}}{2} + log\left[\sum_{i \in I_k} exp\left(\mu_{it} + \frac{\sigma^2_{it}}{2}\right)\right], \tag{11}$$

$$\kappa_{kt} = \sum_{i \in I_k} \kappa_{it}. \tag{12}$$

Additionally, parameters $\mu_{kt}, \omega_k, \log(\psi_k)$ are assumed to be jointly normally distributed:

$$\begin{pmatrix} \mu_{kt} \\ \omega_k \\ log(\psi_k) \end{pmatrix} \sim N\left(\begin{pmatrix} \bar{\mu}_{kt} \\ \beta^{\omega} X^{\omega}_k \\ \beta^{\psi} X^{\psi}_k \end{pmatrix}, \begin{pmatrix} \sigma^2_{\mu} & & \\ \sigma^2_{\omega,\mu} & \sigma^2_{\omega} & \\ \sigma^2_{\psi,\mu} & \sigma^2_{\omega,\psi} & \sigma^2_{\psi} \end{pmatrix}\right)$$

Model Estimated by Maximum Likelihood

- The likelihood function for household k is the density of observed total healthcare spending m conditional on observed plan choices:

$$LL_k = \sum_{j=1}^{J} d_{kjt} \sum_{s=1}^{S} W_s \prod_{t=1}^{T} f_m(m_{kt}|\theta, \beta_{kts}, c_{jt}, X_{kt}) L_{kjts} \tag{13}$$

  - $d_{kjt} = 1$ if household k chose plan j in year t (else $d = 0$).
  - W_s: simulated Gaussian quadrature weights for each simulation, $s \in S$.
  - f_m: pdf of total healthcare spending conditional on plan, parameters, and household observables.
  - L_{kjts}: conditional logit choice probabilities.

- See Appendix C.2 for details (or link below).

MLE Methodology

Approximately $1,500 of Moral Hazard Spending per Family

Variable	(1) Parameter	(1) SE	(2) Parameter	(2) SE	(3) Parameter	(3) SE
Employee premium ($000s)	−1.000[a]		−1.000[a]		−1.000[a]	
Out-of-pocket spending, $-\alpha^{OOP}$	−1.628	0.023	−1.661	0.024	−1.469	0.019
HRA/HSA contributions, α^{HA}	0.255	0.021	0.259	0.020	0.259	0.020
Vision/dental contributions, α^{VD}	1.341	0.024	1.302	0.022	1.209	0.021
Plan inertia intercept, γ^{plan}	4.763	0.060	4.431	0.056	4.630	0.063
Plan inertia × 1[Children], γ^{plan}	−0.129	0.039	−0.102	0.037	−0.138	0.038
Insurer inertia intercept, γ^{ins}	2.605	0.107	2.509	0.102	2.413	0.097
Insurer inertia × risk score, γ^{ins}	−0.074	0.083	−0.120	0.078	−0.037	0.080
Narrow network plan, $\nu^{NarrowNet}$	−2.440	0.155	−2.286	0.145	−2.334	0.151
Providence utiliz. multiplier, ϕ_P	1.022	0.018	1.072	0.017	1.063	0.002
Risk aversion intercept, β^{ψ}	−0.706	0.046	−1.018	0.059	−0.251	0.052
Risk aversion × 1[Children], β^{ψ}	0.005	0.031	−0.367	0.083	−0.361	0.050
Moral hazard intercept, β^{ω}					1.028	0.038
Moral hazard × 1[Children], β^{ω}					0.671	0.008
Std. dev. of private health info., σ_{μ}	0.683	0.002	0.331	0.064	0.225	0.005
Std. dev. of log risk aversion, σ_{ψ}	0.701	0.062	1.140	0.012	0.833	0.021
Std. dev. of moral hazard, σ_{ω}					0.281	0.013
Corr(μ, ψ), $\rho_{\mu,\psi}$	0.130	0.018	−0.365	0.049	0.227	0.005
Corr(ψ, ω), $\rho_{\psi,\omega}$					−0.137	0.042
Corr(μ, ω), $\rho_{\mu,\omega}$					0.062	0.017
Scale of idiosyncratic shock, σ_{ϵ}	2.313	0.025	2.160	0.023	2.116	0.024
Insurer × {Region, Age, 1[Child.]}	Yes		Yes		Yes	
Observable heterogeneity in health			Yes		Yes	
Number of observations	451,268		451,268		451,268	

- Moving a household that had not met deductible to plan where health state put them past out-of-pocket maximum would increase total healthcare spending (due to moral hazard) by 11.4% - 15.8%.

Notable Results

1. Coefficient of absolute risk aversion of 0.92 (in-line with literature).
2. Unobserved heterogeneity in risk aversion accounts for 93% of total variation.
   - Only 11% and 18% for μ_{kt} (mean of the monetary household health state distribution) and ω_k (moral hazard), respectively.
3. Average disutility from switching insurer/plan of $2,408/$4,562, respectively. Large estimates of inertia reflect the lack of voluntary (or involuntary) switching present in the data.
4. Households value out-of-pocket costs 47% more than plan premiums (similar result for vision/dental costs, while HSA/HRA dollars costs value 4x less than premiums).

Model Fit

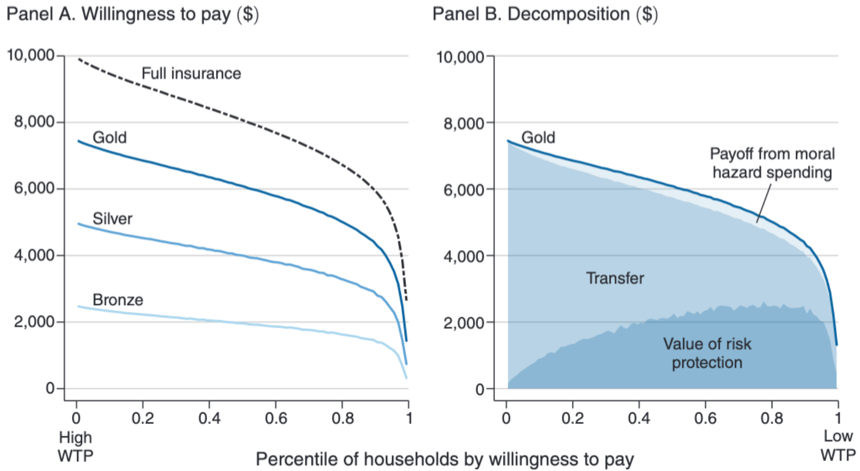
Evaluating Vertical Choice

- The empirical model considers all coverage levels, but graphical analysis is restricted to the following five contracts with varying actuarial values: Catastrophic (0.53), Bronze (0.61), Silver (0.72), Gold (0.86), Full-Insurance (1.00).

- This is done to focus on the relevant range of contracts given model estimates (from \$10,000 deductible & maximum out-of-pocket cost (Catastrophic $= x_0$) to \$0 out-of-pocket cost (Full-Insurance)).

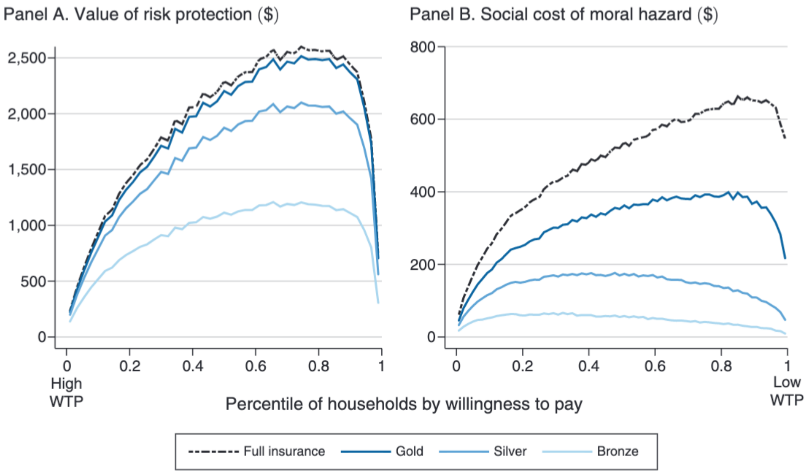
- Several additional simplifications to model:
  1. Use only first year each household appears in data,
  2. Fix $\phi_f = 1$ (Moda),
  3. Hold nonfinancials fixed, insurer fixed effects cancel,
  4. Remove inertia,
  5. Fix $\alpha^{OOP} = 1$,
  6. Ignore idiosyncratic shock ϵ_k for welfare analysis.

Marginal WTP for Coverage Above Catastrophic



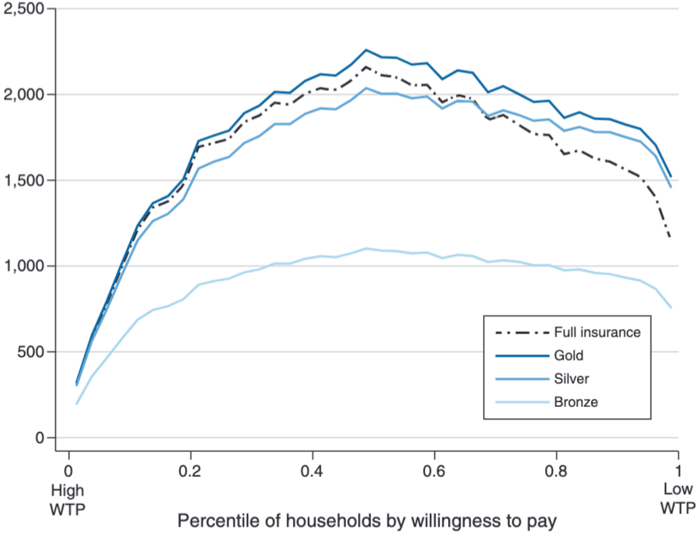
$$WTP(x,\theta_k) = \underbrace{\mathbb{E}\left[c^*_{x_0}(I) - c^*_x(I) \mid I\right]}_{(Transfer)} + \underbrace{\mathbb{E}\left[\frac{\omega_k}{2}(1 - c'_x(m^*(I,\omega_k,x)))^2 \mid I\right]}_{(Moral\ Hazard\ Payoff)} + \underbrace{\Psi(x,\theta_k)}_{(Risk\ Protection)}$$

Transfer Drops Out of Social Surplus Evaluation



$$SS(x, \theta_k) = \underbrace{\Psi(x, \theta_k)}_{(Risk\ Protection)} - \underbrace{\mathbb{E}\left[\frac{\omega_k}{2}(1 - c_x'(m^*(l, \omega_k, x)))^2 \mid l\right]}_{(Social\ Cost\ of\ Moral\ Hazard)}$$

The Gold Contract Provides Largest Social Surplus For All Levels of WTP



Choice is inefficient, and the Gold contract yields on average $1,514/household of surplus.

Vertical Choice Efficient When Contract Space is Denser

- Results hinge on whether higher willingness-to-pay consumers have a higher efficient level of coverage.
- Expanding contract space between Silver and Full-Insurance from just Gold to 20 contracts yields 4 optimal contracts: Gold (AV $= 0.86$), and 3 closest contracts (AVs $= \{0.84, 0.83, 0.81\}$).
- Average social surplus per household increased by only \$14 (\$1,528) over Gold alone, and only \$5 over optimal denser set contract (AV $= 0.83$).
- Note, this surplus gain is gross of any costs associated with designing or administering an expanded contract set (more on this later).

Results are (Fairly) Robust to Alternative Contract Designs and Populations

Contracts:

- A single contract is still optimal when considering five vertically differentiated contracts that have 1) no deductible, or 2) no coinsurance.
- However, vertical choice is efficient when the coinsurance region is extended (e.g. remove deductible, coinsurance rate cut in half, total spending region at which out-of-pocket cost met doubled).

▸ Robustness Specifications I

Populations:

- Estimating the model with Kaiser customers yields qualitatively identical results.
- Estimating the model with changes to the three key consumer parameters (moral hazard (ω), risk aversion (ψ), and distribution of health states (F)) again yields similar results.
  - Optimal menus feature vertical choice with dense contract sets and when risk aversion drives changes in WTP.

▸ Figures with Kaiser ▸ Robustness Specifications II

Across all iterations, welfare gains from vertical choice do not exceed \$10/household, implying the **benefits from vertical choice are negligible**.

Counterfactual Pricing Policies

1. Baseline: Regulated pricing with community rating,
2. Regulated pricing with type-specific prices,
3. Competitive pricing with community rating & mandate,
4. Competitive pricing with type-specific prices & mandate,
5. Premiums to support vertical choice.

Schemes (ii) and (iv) allow market segmentation across four consumer groups: 45+ with children, >45 with children, 45+ childless, and >45 childless.

Benchmark the various pricing schemes against the first best world, where premiums are set using all aspects of consumer type (unobservable to the insurer).

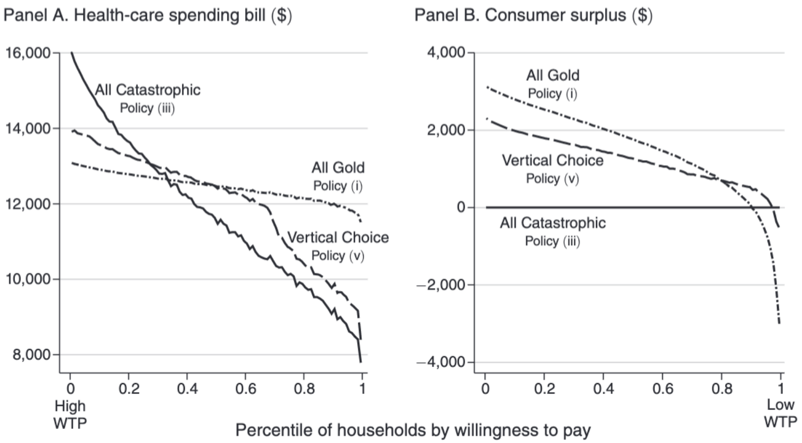
Regulated Pricing Nearly Achieves First Best Surplus

Table 4—Outcomes under Alternative Pricing Policies

	Policy	Percent of first best surplus		Potential contracts: Full	Gold	Silver	Bronze	Ctstr.
*	First best	1.000	*Q:*	0.06	0.75	0.19	< 0.01	–
			AC:	18.35	9.43	11.48	39.18	–
(i)	Regulated pricing with community rating	0.982	*Q:*	–	1.00	–	–	–
			AC:	–	10.62	–	–	–
(ii)	Regulated pricing with type-specific prices	0.989	*Q:*	–	0.98	0.02	–	–
			AC:	–	10.71	0.75	–	–
(iii)	Competitive pricing with community rating	0.000	*Q:*	–	–	–	–	1.00
			AC:	–	–	–	–	6.30
(iv)	Competitive pricing with type-specific prices	0.075	*Q:*	–	–	0.05	–	0.95
			AC:	–	–	4.95	–	6.41
(v)	Premiums to support vertical choice	0.796	*Q:*	0.01	0.07	0.63	0.28	0.01
			AC:	61.04	31.91	8.47	1.75	0.28

- The baseline scheme (i) does a good job approximating the first best outcome (0.982 * \$1,542 = \$1,514).
- Note, vertical choice would likely be necessary under (i) if the regulator needed to break even, as is necessary in the competitive pricing schemes.

High WTP Consumers Gain the Most From Lack of Vertical Choice



- Healthcare spending bill = premiums + $\mathbb{E}$ [out-of-pocket costs] + evenly distributed tax.
- Population faces minimum healthcare spending of $11,723/household under "All Catastrophic" coverage.
- Panel B consumer surplus again relative to "All Catastrophic" coverage.

Appendix

Table A.2. Sample Construction

Criteria	2009	2010	2011	2012	2013
Individuals in membership file	161,502	162,363	156,113	156,042	157,799
Not eligible for coverage	7,370	8,265	8,422	8,719	8,388
Retiree, COBRA, or oldest member over 65	13,180	12,567	12,057	11,603	11,840
Partial year coverage	17,115	18,649	19,283	21,281	23,074
Covered by multiple plans	1,447	1,947	2,038	2,239	2,336
Opted out	3,241	4,205	4,321	4,576	4,529
Not in intact family	8,389	9,188	9,181	8,925	10,265
No prior year of data	6,175	3,947	2,455	3,104	3,702
Missing premium or contribution data	25,653	28,466	22,755	23,284	30,401
Final total	78,932	75,129	75,601	72,311	63,264

Return

Menu Generosity Not Responsive to Observed Health Risk Scores; Unlikely Unobserved Information Impacts Generosity

Table A.5. Plan Menu Generosity and Household Health

	2008	2009	2010	2011	2012	2013
Household risk score	-0.006	0.017	0.020	0.002	0.006	0.000
	(0.039)	(0.016)	(0.011)	(0.009)	(0.010)	(0.012)
Family type						
Employee alone	0.000†	0.000†	0.000†	0.000†	0.000†	0.000†
Employee + spouse	-1.389	-1.369	-1.498	-1.040	-1.626	-1.612
	(0.077)	(0.040)	(0.029)	(0.025)	(0.026)	(0.031)
Employee + child	-0.542	-0.634	-0.907	-0.616	-1.092	-0.937
	(0.084)	(0.053)	(0.039)	(0.031)	(0.031)	(0.037)
Employee + family	-1.792	-1.882	-1.804	-1.306	-2.147	-2.102
	(0.064)	(0.037)	(0.028)	(0.023)	(0.025)	(0.029)
Dependent variable mean	88.7	88.5	84.6	82.7	83.3	82.6
R^2	0.020	0.084	0.154	0.115	0.242	0.220
Number of observations	37,666	31,074	29,538	29,279	27,897	24,283

Return

Conditional Logit Model: Explaining Plan Menu Generosity

Some of the variables driving variation in menu generosity include:

1. Higher generosity for specific union affiliation,
2. Lower generosity for substitute/part-time employees,
3. Generosity decreasing in district house price index, and
4. Generosity decreasing in Republican party registration by district.

Table A.6. Explaining Plan Menu Generosity: 2008

	(1)	(2)	(3)	(4)
Household risk score	-0.006	0.016	0.011	0.025
	(0.039)	(0.039)	(0.038)	(0.040)
Family type				
Employee alone	0.000†	0.000†	0.000†	0.000†
Employee + spouse	-1.389	-1.374	-1.251	-1.085
	(0.077)	(0.083)	(0.083)	(0.085)
Employee + child	-0.542	-0.535	-0.478	-0.462
	(0.084)	(0.085)	(0.084)	(0.082)
Employee + family	-1.792	-1.819	-1.688	-1.437
	(0.064)	(0.071)	(0.071)	(0.074)
Part-time		-0.428	-0.448	-0.867
		(0.133)	(0.133)	(0.139)
Occupation type				
Admin.		-1.745	-1.883	-2.685
		(0.455)	(0.459)	(0.501)
Classified		-0.598	-0.469	-0.155
		(0.283)	(0.414)	(0.457)
Comm. coll. fac.		0.553	1.138	1.044
		(0.287)	(0.430)	(0.470)
Comm. coll. non-fac.		0.671	0.457	0.077
		(0.288)	(0.288)	(0.302)
Confidential		-2.759	-2.883	-3.133
		(0.855)	(0.856)	(0.915)
Licensed		0.001	1.645	1.628
		(0.278)	(0.459)	(0.505)
Substitute		-11.051	-9.312	-9.354
		(0.283)	(0.457)	(0.496)
Union affiliation				
AFT			0.251	-0.398
			(0.374)	(0.432)
IAFE			0.758	1.222
			(0.404)	(0.458)
OACE			2.671	1.617
			(0.389)	(0.449)
OEA			-1.799	-1.765
			(0.434)	(0.491)
OSEA			-0.086	-0.426
			(0.395)	(0.449)
District characteristics				
log(HPI)				-0.876
				(0.085)
Pct. Republican				-14.077
				(0.467)
Dependent variable mean	88.7	89.0	89.1	98.3
R^2	0.020	0.031	0.046	0.073
Number of observations	37,666	37,666	37,666	35,698

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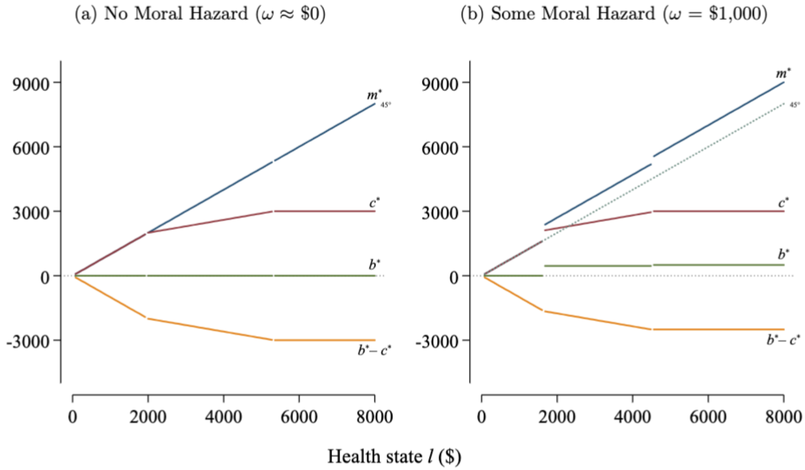
Return

Figure A.2. Healthcare Spending Choice Example



- Example contract with a deductible of \$2,000, a coinsurance rate of 30%, and an out-of-pocket maximum of \$3,000.

◂ Return

Fenton-Wilkinson Approximation (Part 1)

- Assumption: Individuals face (shifted) log-normal distribution of health states,

$$\log(\tilde{I}^i + \kappa_{it}) \sim N(\mu_{it}, \sigma_{it}^2).$$

- Moment-matching conditions for the distribution of the household health state $\tilde{I}$:

$$\mathbb{E}(\tilde{I} + \kappa_{kt}) = \sum_{i \in I_k} \mathbb{E}(\tilde{I}^i + \kappa_{it}),$$

$$Var(\tilde{I} + \kappa_{kt}) = \sum_{i \in I_k} Var(\tilde{I}^i + \kappa_{it}),$$

$$\mathbb{E}(\tilde{I}) = \sum_{i \in I_k} \mathbb{E}(\tilde{I}^i),$$

where the third moment-matching condition is needed for sufficient moments to estimate the "shift" parameter, κ_k.

Fenton-Wilkinson Approximation (Part 2)

- Under the *Fenton-Wilkinson* assumption that $\tilde{I} + \kappa_k$ is distributed approximately log-normal, plug in the mean and variance of a log-normal distribution:

$$exp(\mu_{kt} + \frac{\sigma_{kt}^2}{2}) = \sum_{i \in I_k} exp(\mu_{it} + \frac{\sigma_{it}^2}{2})$$

$$(exp(\sigma_{kt}^2) - 1)(exp(2\mu_{kt} + \sigma_{kt}^2)) = \sum_{i \in I_k} (exp(\sigma_{it}^2) - 1)(exp(2\mu_{it} + \sigma_{it}^2))$$

$$exp(\mu_{kt} + \frac{\sigma_{kt}^2}{2}) - \kappa_{kt} = \sum_{i \in I_k} exp(\mu_{it} + \frac{\sigma_{it}^2}{2}) - \kappa_{it}$$

- Solving for the household-level parameters yields:

$$\sigma_{kt}^2 = log\left[1 + \left[\sum_{i \in I_k} exp\left(\mu_{it} + \frac{\sigma_{it}^2}{2}\right)\right]^{-2} \sum_{i \in I_k} (exp(\sigma_{it}^2) - 1)(exp(2\mu_{it} + \sigma_{it}^2))\right],$$

$$\bar{\mu}_{kt} = -\frac{\sigma_{kt}^2}{2} + log\left[\sum_{i \in I_k} exp\left(\mu_{it} + \frac{\sigma_{it}^2}{2}\right)\right],$$

$$\kappa_{kt} = \sum_{i \in I_k} \kappa_{it}.$$

Return

Maximum Likelihood Estimation Methodology (Part 1)

- The MLE selects the parameter values that maximize the conditional pdf of households' observed total healthcare spending given plan choices.
- Using Gaussian quadrature with 27 support points, $\beta_{kts}(\theta) = \{\psi_{ks}, \mu_{kts}, \omega_{ks}\}$ denotes the simulated points, and W_s the weights, for the set of parameters to be estimated.
- Optimal predicted healthcare spending $m^*_{jt}(l, \omega_{ks}) = \max(0, \omega_{ks}(1 - c'_{jt}(m^*)) + l)$ allows one to back out the health state l_{kjts} that yields spending m_{kt} under ω_{ks}:

$$l_{kjts} : \begin{cases} l_{kjts} < 0 & \text{if } m_{kt} = 0, \\ l_{kjts} = m_{kt} - \omega_{ks}(1 - c'_{jt}(m_{kt})) & \text{if } m_{kt} > 0. \end{cases}$$

1. Since $l_{kjts} = \phi_f \tilde{l}_{kjts}$ implies $\tilde{l}_{kjts} = \phi_f^{-1} l_{kjts}$, and $\phi_f > 0$, the probability that $l_{kjts} < 0$ is equal to the probability that $\tilde{l}_{kjts} \leq \kappa_{kt}$.
2. When $m_{kt} > 0$, define $\lambda_{kjts} = \phi_f^{-1} l_{kjts} + \kappa_{kt}$. Then, the density of m_{kt} is the density of λ_{kjts}.

- Let Φ denote the standard normal CDF. Thus, the conditional pdf of m given plan, parameters, and household characteristics is given by:

$$f_m(m_{kt}|\theta, \beta_{kts}, c_{jt}, X_{kt}) = \begin{cases} \Phi\left(\frac{log(\kappa_{kt}) - \mu_{kt}}{\sigma_{kt}}\right) & \text{if } m_{kt} = 0, \\ \phi_f^{-1}\Phi'\left(\frac{log(\lambda_{kjts}) - \mu_{kt}}{\sigma_{kt}}\right) & \text{if } m_{kt} > 0. \end{cases}$$

- Probability of plan choices: given θ and β_{kts}, distribution of l_{kjtsd} with D = 30 support points given by:

$$l_{kjtsd} = \phi_f(exp(\mu_{kts} + \sigma_{kt} Z_d) - \kappa_{kt}),$$

  - Where Z_d is a vector approximating a standard normal distribution using Gaussian quadrature with associated weights W_d.
  - Privately optimal m_{kjtsd} then calculable for each health state realization.
- Define the stop-loss level of total spending (the boundary between coinsurance region and out-of-pocket max) as $A = C^{-1}(O - D(1 - C))$, where D = deductible, C = coinsurance, and O = out-of-pocket maximum.
- Then optimal private spending falls into one of the three regions (coinsurance, stop-loss, out-of-pocket max) depending on realized l and given ω, with relevant cutoffs for each region:

$$Z_1 = D - \frac{\omega(1-C)}{2},\ Z_2 = O - \frac{\omega}{2},\ Z_3 = A - \omega\left(1 - \frac{C}{2}\right).$$

  - Where $Z_1 \leq Z_2 \leq Z_3$ whenever $D \leq O$ and $C \in [0,1]$.
- Optimal spending m^* thus given by:

$$\text{If } A - D > \frac{\omega}{2} : m^* = \begin{cases} \max(0, l) & l \leq Z_1, \\ l + \omega(1 - C) & Z_1 < l \leq Z_3, \\ l + \omega & Z_3 < l; \end{cases} \quad \text{Else} : m^* = \begin{cases} \max(0, l) & l \leq Z_2, \\ l + \omega & Z_2 < l. \end{cases}$$

* All plans in data have $A - D > \frac{\omega}{2}$, thus only the left panel is directly relevant to this setting.

Maximum Likelihood Estimation Methodology (Part 3)

- Using predicted privately optimal healthcare spending m^*_{kjtsd}, household expected utility (in certainty equivalent units of utility) from enrolling in plan j given by:

$$U^{CE}_{kjts} = \bar{z}_{kjts} - \frac{1}{\psi_k} log\left(\sum_{d=1}^{D} exp\Big(-\psi_k\big(z_{kjts}(l_{kjtsd}) - \bar{z}_{kjts}\big)\Big) W_d\right),$$

  - Where $\bar{z}_{kjts} = \mathbb{E}[z_{kjts}(l_{kjtsd}) \mid d]$.

- Conditional logit choice probabilities thus given by:

$$L_{kjts} = \frac{exp(U^{CE}_{kjts}/\sigma_\epsilon)}{\sum_{i \in J_{kt}} exp(U^{CE}_{kits}/\sigma_\epsilon)}.$$

- Lastly, the likelihood function for household choices and spending is given by:

$$LL_k = \sum_{j=1}^{J} d_{kjt} \sum_{s=1}^{S} W_s \prod_{t=1}^{T} f_m(m_{kt}|\theta, \beta_{kts}, c_{jt}, X_{kt}) L_{kjts},$$

with corresponding log-likelihood function for parameters θ given by:

$$LL(\theta) = \sum_{k=1}^{K} log(LL_k).$$

Return

Predicted Plan Choices and Spending Distributions Fit Well With Data

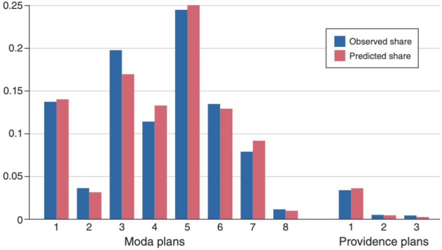


FIGURE 3. MODEL FIT: PLAN CHOICES

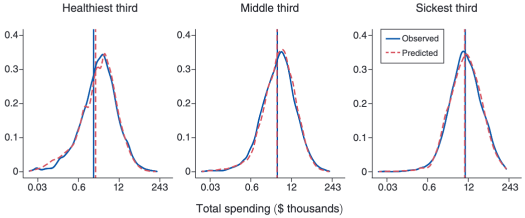


FIGURE 4. MODEL FIT: HEALTH-CARE SPENDING, BY TERTILE OF HOUSEHOLDS BY RISK SCORE

Return

Table A.9. Outcomes Under Alternative Sets of Potential Contracts

Allocation at First Best (*FB*) and under the Optimal Menu (*Opt*)

	Metal-tier Contracts				
	Full	Gold	Silv.	Brnz.	Ctstr.
FB:	0.06	0.75	0.19	<0.01	–
Opt:	–	1.00	–	–	–

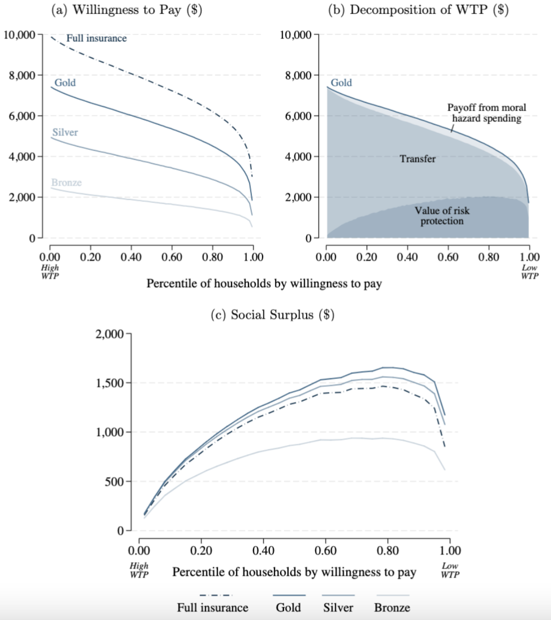
	No Deductible				
	Full	25%	50%	75%	Ctstr.
FB:	0.31	0.65	0.03	<0.01	–
Opt:	–	1.00	–	–	–

	No Coinsurance Region				
	Full	$2.5k	$5.0k	$7.5k	Ctstr.
FB:	–	0.82	0.17	0.01	–
Opt:	–	1.00	–	–	–

	Extended Coins. Region				
	Full	12.5%	25%	37.5%	50%
FB:	0.66	0.31	0.01	0.01	–
Opt:	0.82	0.16	0.02	–	–

Return

Figure A.8. Results from Full Sample Parameter Estimates (Including Kaiser)



Return

Table A.11. Outcomes Under Different Distributions of Consumer Types

			Outcomes at First Best (FB) and at the Optimal Menu (Opt), among:						
		Metal-tier contracts						Dense contracts	
Parameter Estimates		Full	Gold	Silv.	Brnz.	Ctstr.	SS (\$)	Offer choice?	Δ SS (\$)
Main estimates	*FB:*	0.06	0.75	0.19	<0.01	–	1,542		34
	Opt:	–	1.00	–	–	–	1,514	Yes	14
1. Double mean ω	*FB:*	–	0.29	0.64	0.07	–	1,091		42
	Opt:	–	–	1.00	–	–	1,069	Yes	4
2. Halve mean ω	*FB:*	0.39	0.61	<0.01	–	–	1,855		10
	Opt:	0.61	0.39	–	–	–	1,842	Yes	11
3. Double mean ψ	*FB:*	0.30	0.68	0.02	–	–	2,184		18
	Opt:	0.46	0.54	–	–	–	2,162	Yes	15
4. Halve mean ψ	*FB:*	–	0.35	0.63	0.02	<0.01	919		18
	Opt:	–	–	0.98	–	0.02	915	Yes	2
5. Increase var. ω	*FB:*	0.07	0.74	0.18	0.01	–	1,539		33
	Opt:	–	1.00	–	–	–	1,531	Yes	9
6. Increase var. ψ	*FB:*	0.13	0.64	0.21	0.02	<0.01	1,487		30
	Opt:	0.04	0.76	0.19	0.01	–	1,463	Yes	16
7. Fix F	*FB:*	0.06	0.83	0.11	–	–	1,410		17
	Opt:	–	1.00	–	–	–	1,407	Yes	6
8. Fix F and ω	*FB:*	0.16	0.67	0.17	–	–	1,457		14
	Opt:	0.14	0.68	0.18	–	–	1,456	Yes	12
9. Fix F and ψ	*FB:*	0.17	0.72	0.11	–	–	1,568		16
	Opt:	–	1.00	–	–	–	1,559	No	4

Return