Online Appendix

Estimating Equilibrium in Health Insurance Exchanges:
Price Competition and Subsidy Design under the ACA

Contents

A Demand Model: Parametric Assumptions

The premium coefficient $\alpha_t(\mathbf{z})$ is allowed to vary across year, and across seven 6-years-wide age bins, and linearly with income. The coefficient on actuarial value $\beta_t(\mathbf{z},\theta)$ is log-normally distributed with year-age-bin-specific parameters.

Letting $A^1 = \{26, ..., 31\}$, $A^2 = \{32, ..., 37\}$, ..., $A^6 = \{56, ..., 61\}$, $A^7 = \{62, 63, 64\}$,

$$\alpha_t(\mathbf{z}) = \begin{cases} \alpha_t^{0,1} + \alpha_t^{1,1} z^{\text{Inc}} & \text{if } z^{\text{Age}} \in A^1 \\ \alpha_t^{0,2} + \alpha_t^{1,2} z^{\text{Inc}} & \text{if } z^{\text{Age}} \in A^2 \\ ... \\ \alpha_t^{0,7} + \alpha_t^{1,7} z^{\text{Inc}} & \text{if } z^{\text{Age}} \in A^7 \end{cases};$$

all parameters are year-specific.

The coefficient on actuarial value is log-normally distributed with year-age-bin-specific parameters:

$$\beta_t(\mathbf{z},\theta) = \begin{cases} e^{\beta_t^1 + \sigma_t^1 \theta}, & \text{if } z^{\text{Age}} \in A^1 \\ ... \\ e^{\beta_t^7 + \sigma_t^7 \theta}, & \text{if } z^{\text{Age}} \in A^7 \end{cases}, \text{ where } \quad \theta \sim G(\theta) = \mathcal{N}(0,1);$$

$\mathcal{N}$ indicates the standard normal distribution, θ and $\mathbf{z}$ are independent:

$$G_{mt}(\mathbf{z},\theta) = G_{mt}(\mathbf{z})G(\theta).$$

The term $\boldsymbol{\mu}_t(\mathbf{z})\mathbf{x}_{jmt}$ is equal to

$$\boldsymbol{\mu}_t(\mathbf{z})\mathbf{x}_{jmt} = \begin{cases} \mu_t^{0,1} + \mu_t^{1,1} z^{\text{Inc}} + \mu_t^{2,1} z^{\text{Age}} + \mu_t^{3,1} \text{HMO}_{jmt} + \boldsymbol{\mu}_t^{4,1} \text{Insurer}_{jmt} & \text{if } z^{\text{Age}} \in A^1 \\ ... \\ \mu_t^{0,7} + \mu_t^{1,7} z^{\text{Inc}} + \mu_t^{2,7} z^{\text{Age}} + \mu_t^{3,7} \text{HMO}_{jmt} + \boldsymbol{\mu}_t^{4,7} \text{Insurer}_{jmt} & \text{if } z^{\text{Age}} \in A^7 \end{cases};$$

this allows the value of marketplace coverage to vary piecewise linearly by year, age, and income, and the value of each product to vary—with year-age-bin parameters—with the type of provider network and insurer brand. Lastly, I let γ_t to be a cubic function of ξ_{jmt}, specific to every year and every age bin:

$$\boldsymbol{\gamma}_t(\xi_{jmt};\mathbf{z}) = \begin{cases} \gamma_t^{1,1} \xi_{jmt} + \gamma_t^{2,1} \xi_{jmt}^2 + \gamma_t^{3,1} \xi_{jmt}^3 & \text{if } z^{\text{Age}} \in A^1 \\ ... \\ \gamma_t^{1,7} \xi_{jmt} + \gamma_t^{2,7} \xi_{jmt}^2 + \gamma_t^{3,7} \xi_{jmt}^3 & \text{if } z^{\text{Age}} \in A^7 \end{cases}.$$

B Estimation Steps

Estimation proceeds in steps.

First, I obtain $\widehat{\xi}_{jmt}$ as the residual of the OLS regression:

$$b_{jmt} = \lambda^{35} \int \mathbf{1}\left[z^{\text{Age}} \leq 35\right] dG_{mt}(\mathbf{z}) + \lambda^{\text{Tier}} + \lambda^{\text{Year}} + \lambda^{\text{Insurer}} + \xi_{jmt}.$$

The results are shown in Table A1.

Second, I obtain $\widehat{\eta}^{\text{Age}}$ the non-linear least squares regression of annual medical spending in the MEPS on age, geographic area, and year: this step finds the parameters that minimize

$$\frac{1}{N_{\text{MEPS}}} \sum_{\ell \in \text{MEPS}} \left\| Y_\ell - e^{\eta^{\text{Age}} \text{Age}_\ell + \text{Year}_\ell + \text{Region}_\ell} \right\|.$$

The results are shown in Table A5.

Then, taking $\widehat{\xi}_{jmt}$ and $\widehat{\eta}^{\text{Age}}$ as given, I estimate the demand parameters by simulated maximum likelihood on a subsample of 400,000 individuals. This is due to the very large sample size and the interest of keeping computation time within reason; the parameter estimates are robust to considering larger subsamples, at the cost of a (much) longer wait. For every year 2014-2017, and every age bin A^n, with $n = 1, ..., 7$, I draw 3,000 individuals and find the demand parameters that solve

$$\max_{\boldsymbol{\alpha}_t^n, \beta_t^n, \sigma_t^n, \boldsymbol{\mu}_t^n, \boldsymbol{\gamma}_t^n} \quad \sum_{i \in N_t^n} \ln \left(\frac{1}{1000} \sum_{s=1}^{1000} \frac{e^{-\alpha_t(\mathbf{z}_i) p_{ij(i)mt} + \delta_{j(i)mt}(\mathbf{z}_i, \theta_i^s)}}{1 + \sum_{k=1}^{J} e^{-\alpha_t(\mathbf{z}_i) p_{ikmt} + \delta_{kmt}(\mathbf{z}_i, \theta_i^s)}} \right),$$

where N_t^n is the set of sampled individuals in age bin A^n, year t, $j(i)$ is the choice of individual i, and θ_i^s is the s-th draw from $\mathcal{N}(0, 1)$ specific to individual i. The estimates are reported in Table A2 and Table A3. Standard errors are calculated using the variance-covariance matrix obtained as the inverse of the negative Hessian of the simulated log-likelihood function at convergence. The Hessian is calculated using numerical differentiation, the gradient is analytical.

Lastly, I minimize the distance between observed and model-predicted expected average claims for each jmt combination as a function of demand estimates and remaining unknown cost parameters:

$$\min_{\eta^{WTP}, \boldsymbol{\phi}} \; \frac{1}{N_J} \sum_{jmt} \left\| \ln \left(\frac{AC_{jmt} \widehat{Q}_{jmt}}{AV_j^S} \right) - \phi_{jmt} - \ln \left(\sum_i \frac{1}{1000} \sum_{s=1}^{1000} e^{\eta(\mathbf{z}_i, \theta_i^s)} \widehat{q}_{jmt}(\mathbf{z}_i, \theta_i^s) \right) \right\|;$$

where N_J is the number of plans for which I observe average claims as reported in the RRF, θ_i^s is the s-th draw from $\mathcal{N}(0, 1)$ specific to individual i, and $\widehat{Q}_{jmt}$, $\widehat{q}_{jmt}(\mathbf{z}_i, \theta_i^s)$ are calculated using the demand estimates. Nonlinear minimization is only required with respect to η^{WTP}: $\boldsymbol{\phi}$ enters the moment linearly, and can therefore be obtained through a simple orthogonal projection for any value of η^{WTP}. The estimates are reported in Table A6, standard errors are bootstrapped, repeating the minimization step using 100 independent draws of demand parameters.

C Risk Adjustment Formula

I apply the ACA risk adjustment formula described in Pope et al. (2014).

Following Section 5, risk adjustment for each plan j is calculated as

$$RA_{jmt}(\mathbf{b}_{fmt}, \mathbf{b}_{-fmt}) = Q_{jmt} \underbrace{\frac{\sum_k R_{kmt}}{\sum_k Q_{kmt}}}_{\substack{\text{average premium}\\ \text{in region-year}}} \left(\text{Relative Risk}_{jmt} - \text{Relative Adjustment}_{jmt}\right);$$

where

$$\text{Relative Risk}_{jmt} \equiv \frac{IDF_j AV_j^S Q_{jmt}^{-1} \int L_{mt}(\mathbf{z},\theta) q_{jmt}(\mathbf{z},\theta) dG_{mt}(\mathbf{z},\theta)}{\left(\sum_\ell Q_{\ell mt}\right)^{-1} \sum_k IDF_k AV_k^S \int L_{mt}(\mathbf{z},\theta) q_{kmt}(\mathbf{z},\theta) dG_{mt}(\mathbf{z},\theta)}, \quad \text{and}$$

$$\text{Relative Adjustment}_{jmt} \equiv \frac{IDF_j AV_j^S Q_{jmt}^{-1} \int \text{Adj}(z^{\text{Age}}) q_{jmt}(\mathbf{z},\theta) dG_{mt}(\mathbf{z},\theta)}{\left(\sum_\ell Q_{\ell mt}\right)^{-1} \sum_k IDF_k AV_k^S \int \text{Adj}(z^{\text{Age}}) q_{kmt}(\mathbf{z},\theta) dG_{mt}(\mathbf{z},\theta)}.$$

The relative risk measure is the ratio of a product-specific average expected cost to the region-year average, where it is important to notice that $L_{mt}(\mathbf{z},\theta) \neq L_{jmt}(\mathbf{z},\theta)$.

In particular, I set $L_{mt}(\mathbf{z},\theta) = L_{jmt}(\mathbf{z},\theta) e^{-\boldsymbol{\phi}^3 \text{Insurer}_{jmt}}$: risk adjustment payments depend on differences in risk selection, and on differences across regions and years, but not on differences in insurer-specific cost functions.

The induced demand factors IDF_j vary across metal tiers, as indicated in Pope et al. (2014): this is equal to 1 for Bronze, 1.03 for Silver, 1.08 for Gold, and 1.15 for Platinum. The relative adjustment measure is calculated in a similar way, but rather than average expected cost it considers average premium adjustments; $\text{Adj}(z^{\text{Age}}) = \text{Adjustment}(z^{\text{Age}})$.

The risk adjustment model is applied at the region-year level mt, rather than the entire state-year. This ensures the computational tractability of equilibrium simulations at the region-year level, in which each insurer faces a multi-product pricing problem. Linking risk adjustment payments across regions would require each insurer to consider more than seventy products at the same time, which would not be feasible.

An alternative approach can be found in Saltzman (2021), who simplifies the model by considering fixed regional adjustments to premiums. For my analysis, it is important to consider separate pricing problems across regions, since regional composition and number of competing insurers are relevant determinants of equilibrium, and of the effect of different subsidy designs.

Table A1: *First Stage OLS Regression*

	b_{jmt}	b_{jmt}	b_{jmt}	b_{jmt}
	(1)	(2)	(3)	(4)
$\int \mathbf{1}\left[z^{\text{Age}} \leq 35\right] dG_{mt}(\mathbf{z})$	-7896.8	-8176.2	-6830.3	-5207.9
	(1500.1)	(1075.8)	(1031.7)	(896.1)
Bronze		-	-	-
Silver		802.0	784.9	752.9
		(42.12)	(40.25)	(36.86)
Gold		1521.5	1504.4	1472.4
		(51.25)	(47.59)	(42.96)
Platinum		2203.2	2186.0	2154.0
		(63.45)	(58.47)	(52.12)
Anthem			-	-
Blue Shield			114.8	29.14
			(64.75)	(55.16)
CCHP			184.3	152.8
			(76.62)	(58.56)
Contra Costa			-408.9	-55.47
			(160.5)	(155.3)
Health Net			22.81	-14.88
			(80.96)	(74.54)
Kaiser			-343.7	-358.5
			(49.55)	(46.38)
L.A. Care			-1074.5	-1108.5
			(82.11)	(91.31)
Molina			-1118.6	-1195.7
			(64.72)	(74.43)
Oscar			-274.6	-629.9
			(186.7)	(161.7)
Sharp			-492.7	-516.3
			(84.69)	(85.38)
United			227.4	245.5
			(119.3)	(123.3)
Valley			-306.3	-309.0
			(56.44)	(89.62)
Western			-119.3	-95.83
			(79.35)	(77.05)
2014				-
2015				139.3
				(43.43)
2016				335.1
				(46.35)
2017				899.4
				(54.05)
Constant	6105.8	5032.3	4766.0	3972.4
	(448.1)	(319.2)	(307.1)	(269.6)
F-statistic:	27.71	57.76	43.83	33.78

Note: The Table shows the OLS estimates from Equation (9), also see Appendix B. Robust standard error in parentheses. Each observation is a jmt combination (N=1382). The F-statistic corresponds to the rest of the null hypothesis in which the share of potential buyers younger than 35 has no effect on b_{jmt}.

Table A2: *Simulated Maximum Likelihood Estimates of Demand Parameters 2014-2015; see Appendix B*

t:	2014 Coverage						
A^k:	26-31	32-37	38-43	44-49	50-55	56-61	62-64
$\alpha_t^{0,k}$	2.044	1.816	1.460	1.687	1.424	1.381	1.066
	(0.253)	(0.262)	(0.209)	(0.200)	(0.158)	(0.143)	(0.113)
$\alpha_t^{1,k}$	-0.00125	0.000145	-0.000674	-0.000379	0.0000318	-0.000229	0.000189
	(0.00101)	(0.00101)	(0.000747)	(0.000763)	(0.000609)	(0.000535)	(0.000419)
β_t^k	-3.449	-3.359	-3.599	-3.151	-2.794	-2.672	-2.525
	(0.130)	(0.127)	(0.152)	(0.107)	(0.0804)	(0.0732)	(0.0663)
σ_t^k	0.798	0.814	0.784	0.696	0.590	0.605	0.527
	(0.0834)	(0.0781)	(0.0882)	(0.0673)	(0.0528)	(0.0455)	(0.0391)
$\mu_t^{0,k}$	-5.116	-6.087	-4.777	-12.01	-13.41	-13.64	0.00458
	(1.547)	(2.244)	(2.066)	(2.589)	(2.936)	(3.428)	(7.216)
$\mu_t^{1,k}$	0.0114	0.0133	0.00693	0.0113	0.0106	0.00785	0.0108
	(0.00203)	(0.00199)	(0.00159)	(0.00175)	(0.00157)	(0.00141)	(0.00139)
$\mu_t^{2,k}$	-0.0874	-0.0731	-0.0567	0.0731	0.0722	0.0715	-0.168
	(0.0524)	(0.0644)	(0.0501)	(0.0541)	(0.0549)	(0.0579)	(0.115)
$\mu_t^{3,k}$	-0.133	-0.160	0.257	-0.223	-0.351	-0.346	-0.498
	(0.161)	(0.176)	(0.164)	(0.157)	(0.147)	(0.139)	(0.133)
Anthem	–	–	–	–	–	–	–
Blue Shield	0.161	0.212	0.530	0.0982	0.222	0.0917	0.155
	(0.118)	(0.124)	(0.127)	(0.117)	(0.102)	(0.0969)	(0.0867)
CCHP	-0.667	-0.639	-0.600	-1.123	-0.158	-0.260	-0.190
	(0.377)	(0.420)	(0.436)	(0.499)	(0.330)	(0.356)	(0.323)
Contra Costa	-1.230	-20.04	-1.679	-0.597	-18.97	-18.78	-1.696
	(1.042)	(10347.4)	(1.036)	(0.759)	(6049.9)	(5822.6)	(1.028)
Health Net	0.0670	-0.0934	0.111	0.443	0.0612	0.0488	-0.105
	(0.136)	(0.152)	(0.141)	(0.122)	(0.122)	(0.113)	(0.113)
Kaiser	0.505	0.204	-0.116	0.458	0.571	0.478	0.526
	(0.208)	(0.231)	(0.209)	(0.213)	(0.196)	(0.187)	(0.179)
L.A. Care	-1.114	-1.032	-0.853	-0.763	-0.846	-1.378	-1.923
	(0.302)	(0.304)	(0.265)	(0.273)	(0.264)	(0.287)	(0.348)
Molina	-2.264	-4.255	-2.936	-2.598	-2.675	-2.490	-3.198
	(0.424)	(1.024)	(0.490)	(0.489)	(0.450)	(0.369)	(0.484)
Oscar	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sharp	-0.688	-0.0365	-1.271	-0.923	-0.305	-0.427	-0.356
	(0.491)	(0.422)	(0.613)	(0.613)	(0.455)	(0.424)	(0.381)
United	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Valley	-20.23	-1.765	-1.474	-19.12	-1.946	-1.724	-1.696
	(8900.2)	(1.035)	(0.744)	(6447.9)	(1.026)	(0.739)	(0.736)
Western	-0.926	-1.325	-22.40	-0.824	-2.102	-1.562	-0.866
	(0.620)	(0.749)	(23983.9)	(0.620)	(1.021)	(0.735)	(0.485)
$\gamma_t^{1,k}$	0.265	-0.0506	-0.232	0.404	0.148	-0.225	-0.186
	(0.212)	(0.242)	(0.222)	(0.222)	(0.207)	(0.203)	(0.198)
$\gamma_t^{2,k}$	-0.274	-0.249	-0.231	-0.454	-0.154	-0.195	-0.204
	(0.159)	(0.199)	(0.164)	(0.178)	(0.149)	(0.141)	(0.133)
$\gamma_t^{3,k}$	-0.452	-0.215	-0.224	-0.460	-0.575	-0.360	-0.462
	(0.135)	(0.157)	(0.132)	(0.145)	(0.128)	(0.118)	(0.116)

t:	2015 Coverage						
A^k:	26-31	32-37	38-43	44-49	50-55	56-61	62-64
$\alpha_t^{0,k}$	1.872	1.423	1.505	1.394	1.280	1.103	0.988
	(0.201)	(0.177)	(0.176)	(0.164)	(0.160)	(0.115)	(0.0960)
$\alpha_t^{1,k}$	-0.00277	-0.00153	-0.00159	-0.000982	0.000353	-0.000248	-0.000370
	(0.000699)	(0.000592)	(0.000607)	(0.000581)	(0.000625)	(0.000422)	(0.000353)
β_t^k	-3.664	-3.602	-3.480	-3.348	-2.856	-2.792	-2.711
	(0.152)	(0.148)	(0.136)	(0.120)	(0.0822)	(0.0741)	(0.0670)
σ_t^k	0.710	0.640	0.671	0.647	0.624	0.588	0.507
	(0.0896)	(0.0818)	(0.0792)	(0.0707)	(0.0510)	(0.0479)	(0.0428)
$\mu_t^{0,k}$	-0.131	-6.392	-3.123	-0.495	-5.284	-10.37	-2.109
	(1.254)	(1.479)	(1.870)	(2.190)	(2.962)	(2.944)	(6.173)
$\mu_t^{1,k}$	0.00431	0.00391	0.00480	0.00482	0.00697	0.00847	0.00575
	(0.00166)	(0.00152)	(0.00154)	(0.00141)	(0.00150)	(0.00124)	(0.00118)
$\mu_t^{2,k}$	-0.183	0.0250	-0.0722	-0.124	-0.0507	0.0354	-0.0937
	(0.0435)	(0.0406)	(0.0453)	(0.0468)	(0.0560)	(0.0497)	(0.0980)
$\mu_t^{3,k}$	-0.512	-0.913	-1.187	-1.116	-1.298	-1.520	-1.457
	(0.195)	(0.232)	(0.241)	(0.236)	(0.235)	(0.232)	(0.206)
Anthem	–	–	–	–	–	–	
Blue Shield	0.0709	0.169	0.0302	0.0266	0.0499	-0.0221	-0.0491
	(0.110)	(0.109)	(0.109)	(0.106)	(0.0986)	(0.0867)	(0.0842)
CCHP	-0.413	-1.033	-0.225	0.489	0.400	0.482	0.648
	(0.418)	(0.756)	(0.572)	(0.404)	(0.474)	(0.448)	(0.381)
Contra Costa	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Health Net	1.185	1.733	1.827	1.921	1.970	2.086	1.392
	(0.211)	(0.248)	(0.253)	(0.246)	(0.243)	(0.240)	(0.217)
Kaiser	0.638	0.775	1.071	0.946	0.872	1.088	1.278
	(0.196)	(0.236)	(0.245)	(0.241)	(0.242)	(0.238)	(0.213)
L.A. Care	-1.281	-0.655	-0.561	-0.401	-0.701	-1.265	-1.050
	(0.364)	(0.354)	(0.376)	(0.348)	(0.355)	(0.417)	(0.403)
Molina	-1.374	-1.306	-1.101	-1.118	-1.145	-0.892	-1.190
	(0.312)	(0.365)	(0.372)	(0.355)	(0.329)	(0.310)	(0.323)
Oscar	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sharp	-0.112	0.578	0.937	0.255	0.448	1.106	0.902
	(0.433)	(0.401)	(0.423)	(0.481)	(0.420)	(0.355)	(0.370)
United	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Valley	-21.32	-1.542	-20.03	-1.651	-1.130	-0.479	-0.196
	(17700.6)	(1.036)	(11383.2)	(1.037)	(0.761)	(0.568)	(0.559)
Western	-1.283	-1.195	0.265	-19.97	-2.100	-0.766	-0.352
	(0.617)	(0.753)	(0.461)	(8115.8)	(1.033)	(0.559)	(0.439)
$\gamma_t^{1,k}$	-0.100	-0.489	-0.155	-0.285	-0.898	-0.796	-0.121
	(0.196)	(0.202)	(0.208)	(0.207)	(0.219)	(0.191)	(0.192)
$\gamma_t^{2,k}$	-0.572	-0.392	-0.441	-0.528	-0.486	-0.369	-0.521
	(0.129)	(0.121)	(0.119)	(0.122)	(0.121)	(0.100)	(0.110)
$\gamma_t^{3,k}$	-0.226	-0.120	-0.231	-0.238	-0.197	-0.183	-0.214
	(0.0702)	(0.0678)	(0.0640)	(0.0647)	(0.0696)	(0.0569)	(0.0592)

Table A3: *Simulated Maximum Likelihood Estimates of Demand Parameters 2016-2017; see Appendix B*

t:	2016 Coverage							2017 Coverage						
A^k:	26-31	32-37	38-43	44-49	50-55	56-61	62-64	26-31	32-37	38-43	44-49	50-55	56-61	62-64
$\alpha_t^{0,k}$	1.559	1.237	1.204	1.304	1.142	1.070	0.740	1.443	0.992	1.282	0.804	1.248	0.832	0.610
	(0.165)	(0.153)	(0.155)	(0.144)	(0.126)	(0.111)	(0.0790)	(0.189)	(0.176)	(0.177)	(0.150)	(0.144)	(0.0940)	(0.0769)
$\alpha_t^{1,k}$	-0.00225	-0.000848	-0.000877	-0.000921	-0.0000514	0.000124	0.000100	0.0000552	0.00100	-0.000277	0.00162	0.000175	0.000765	0.000986
	(0.000573)	(0.000520)	(0.000554)	(0.000516)	(0.000483)	(0.000427)	(0.000297)	(0.000688)	(0.000651)	(0.000635)	(0.000542)	(0.000503)	(0.000342)	(0.000274)
β_t^k	-3.869	-3.596	-3.527	-3.284	-3.014	-2.678	-2.814	-3.533	-3.515	-3.282	-3.058	-2.861	-2.609	-2.631
	(0.169)	(0.146)	(0.131)	(0.103)	(0.0826)	(0.0638)	(0.0651)	(0.139)	(0.146)	(0.125)	(0.105)	(0.0847)	(0.0655)	(0.0665)
σ_t^k	0.728	0.602	0.605	0.634	0.639	0.585	0.512	0.688	0.644	0.595	0.534	0.627	0.497	0.493
	(0.0930)	(0.0792)	(0.0751)	(0.0625)	(0.0529)	(0.0429)	(0.0412)	(0.0801)	(0.0877)	(0.0772)	(0.0631)	(0.0542)	(0.0432)	(0.0434)
$\mu_t^{0,k}$	-2.130	-3.552	-7.690	-8.949	-10.28	-6.163	-2.049	-5.004	-6.033	-6.677	-10.09	-15.04	-18.53	-6.737
	(1.115)	(1.432)	(1.698)	(2.113)	(2.621)	(3.149)	(5.506)	(1.357)	(1.579)	(2.010)	(2.403)	(3.040)	(3.046)	(6.308)
$\mu_t^{1,k}$	0.00339	0.00591	0.00436	0.00334	0.00624	0.00386	0.00643	0.0117	0.0129	0.00819	0.0114	0.00808	0.00975	0.0114
	(0.00156)	(0.00148)	(0.00137)	(0.00136)	(0.00130)	(0.00127)	(0.00105)	(0.00183)	(0.00174)	(0.00167)	(0.00158)	(0.00144)	(0.00123)	(0.00116)
$\mu_t^{2,k}$	-0.0980	-0.0769	0.0392	0.0601	0.0548	-0.0300	-0.0911	-0.0524	-0.0341	-0.00944	0.0408	0.132	0.157	-0.0421
	(0.0376)	(0.0401)	(0.0402)	(0.0443)	(0.0488)	(0.0535)	(0.0873)	(0.0448)	(0.0439)	(0.0482)	(0.0500)	(0.0568)	(0.0508)	(0.0998)
$\mu_t^{3,k}$	-1.035	-1.314	-1.735	-1.960	-1.900	-1.658	-1.753	-1.826	-2.078	-2.474	-1.899	-2.720	-2.318	-2.500
	(0.224)	(0.287)	(0.318)	(0.333)	(0.302)	(0.245)	(0.256)	(0.224)	(0.282)	(0.294)	(0.247)	(0.301)	(0.226)	(0.229)
Anthem	–	–	–	–	–	–	–	–	–	–	–	–	–	
Blue Shield	0.201	0.340	0.402	0.317	0.142	0.139	0.250	0.204	0.486	0.384	0.430	0.695	0.589	0.526
	(0.106)	(0.117)	(0.110)	(0.102)	(0.0972)	(0.0888)	(0.0833)	(0.122)	(0.132)	(0.131)	(0.129)	(0.119)	(0.107)	(0.0970)
CCHP	-0.518	-0.617	0.698	-0.529	0.873	0.601	0.770	-0.797	1.162	1.048	0.169	1.544	1.440	1.401
	(0.519)	(0.658)	(0.542)	(0.797)	(0.460)	(0.381)	(0.404)	(0.763)	(0.487)	(0.577)	(0.543)	(0.508)	(0.406)	(0.423)
Contra Costa	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Health Net	0.141	0.961	1.381	1.650	1.523	1.062	1.484	1.341	2.591	2.555	2.303	2.988	2.273	2.530
	(0.252)	(0.300)	(0.327)	(0.340)	(0.307)	(0.252)	(0.260)	(0.275)	(0.333)	(0.328)	(0.292)	(0.333)	(0.258)	(0.256)
Kaiser	1.308	1.607	1.861	1.879	1.799	1.541	1.783	1.471	2.060	1.921	1.498	2.217	1.933	2.064
	(0.224)	(0.286)	(0.319)	(0.336)	(0.305)	(0.248)	(0.257)	(0.238)	(0.297)	(0.308)	(0.264)	(0.315)	(0.240)	(0.241)
L.A. Care	-1.985	-0.244	-0.565	0.295	0.0379	-0.787	-0.160	-1.164	0.337	0.521	-0.713	0.407	0.252	0.00327
	(0.617)	(0.422)	(0.545)	(0.432)	(0.410)	(0.391)	(0.364)	(0.471)	(0.401)	(0.396)	(0.445)	(0.404)	(0.317)	(0.349)
Molina	-0.0841	0.305	1.016	1.017	0.819	-0.0784	0.0724	0.608	1.336	0.989	0.957	1.208	0.717	0.531
	(0.265)	(0.320)	(0.336)	(0.352)	(0.321)	(0.275)	(0.287)	(0.258)	(0.317)	(0.331)	(0.286)	(0.341)	(0.266)	(0.271)
Oscar	-2.756	-21.15	-24.30	-3.095	-21.88	-4.096	-4.064	-2.776	-3.167	-4.015	-3.230	-4.169	-2.225	-3.063
	(0.586)	(6624.0)	(31060.8)	(0.715)	(8085.1)	(1.005)	(1.005)	(0.514)	(0.719)	(1.008)	(0.719)	(1.009)	(0.373)	(0.512)
Sharp	1.237	1.873	1.935	2.017	1.905	1.322	1.500	1.875	2.480	2.511	1.590	2.373	2.076	1.828
	(0.360)	(0.384)	(0.423)	(0.425)	(0.403)	(0.375)	(0.361)	(0.382)	(0.390)	(0.428)	(0.455)	(0.434)	(0.355)	(0.371)
United	-20.00	-2.742	-21.94	-19.65	-3.379	-2.776	-20.52	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	(4704.6)	(1.009)	(13678.6)	(3743.4)	(1.006)	(0.714)	(4597.2)							
Valley	-1.368	-19.55	-0.587	0.159	-19.95	-0.655	0.0953	-20.29	0.0779	-17.64	-25.39	0.136	-0.0102	-21.24
	(1.033)	(12550.4)	(1.058)	(0.796)	(13844.6)	(0.765)	(0.576)	(12117.7)	(0.785)	(5198.6)	(185282.2)	(0.676)	(0.523)	(18325.7)
Western	-0.592	0.506	-0.964	0.460	0.365	-1.154	-0.624	-0.0596	0.875	0.662	-0.169	1.330	0.908	1.036
	(0.554)	(0.484)	(1.056)	(0.567)	(0.494)	(0.634)	(0.567)	(0.517)	(0.516)	(0.602)	(0.574)	(0.472)	(0.378)	(0.378)
$\gamma_t^{1,k}$	0.450	0.518	0.679	0.411	0.578	0.136	0.425	0.313	-0.0136	0.429	0.165	-0.281	-0.402	-0.528
	(0.154)	(0.161)	(0.159)	(0.155)	(0.166)	(0.165)	(0.141)	(0.181)	(0.193)	(0.194)	(0.199)	(0.218)	(0.188)	(0.171)
$\gamma_t^{2,k}$	-0.254	-0.273	-0.220	-0.237	-0.502	-0.291	-0.387	-0.405	-0.679	-0.531	-0.711	-0.673	-0.413	-0.166
	(0.177)	(0.130)	(0.121)	(0.104)	(0.142)	(0.103)	(0.0973)	(0.137)	(0.171)	(0.146)	(0.157)	(0.203)	(0.142)	(0.117)
$\gamma_t^{3,k}$	-0.0400	-0.123	-0.167	-0.177	-0.189	-0.141	-0.224	-0.149	-0.153	-0.200	-0.191	-0.0518	-0.0389	-0.0740
	(0.129)	(0.0711)	(0.0646)	(0.0463)	(0.0843)	(0.0465)	(0.0460)	(0.0706)	(0.147)	(0.0572)	(0.0964)	(0.160)	(0.109)	(0.0705)

Table A4: *Impact of Control Function on Demand Estimates*

	Coefficient on premium ($000/year) $\alpha_t(\mathbf{z}_i)$				WTP for 10% AV increase ($/year) $\beta_t(\mathbf{z}_i, \theta_i)/\alpha_t(\mathbf{z}_i)$			
Specification	Mean	P10	Median	P90	Mean	P10	Median	P90
Baseline, with Control Function	1.23	0.927	1.184	1.604	448.5	250.5	375.6	768.8
	(0.017)	(0.03)	(0.024)	(0.058)	(5.3)	(8.8)	(13)	(22.1)
No Control Function	1.219	0.909	1.166	1.602	429	237.8	341.1	761.7
	(0.017)	(0.028)	(0.027)	(0.054)	(5.8)	(8.4)	(13.2)	(22.6)

Note: The table shows the mean, median, and 10-th and 90-th percentiles of the estimated distribution of $\alpha_t(\mathbf{z}_i)$ and $\frac{\beta_t(\mathbf{z}_i,\theta_i)}{\alpha_t(\mathbf{z}_i)}$. The top panel shows the baseline results, which include the control function (third-degree polynomial in the residuals $\widehat{\xi}_{jmt}$ from column (4) in Table A1), and the estimates obtained omitting $\widehat{\xi}_{jmt}$. Standard errors in parentheses, obtained as the empirical standard deviation across 100 independent random draws of the demand parameters using the estimated variance-covariance matrix.

Table A5: *MEPS Annual Expenditure: Non-linear Least Squares*

	(1)	(2)	(3)
η^{Age}	0.0381	0.0379	0.0379
	(0.00214)	(0.00213)	(0.00213)
Constant	6.561	6.738	6.687
	(0.114)	(0.122)	(0.127)
Northeast		-	-
Midwest		-0.0973	-0.106
		(0.0624)	(0.0624)
South		-0.198	-0.202
		(0.0569)	(0.0567)
West		-0.293	-0.298
		(0.0656)	(0.0656)
2014			-
2015			0.0662
			(0.0578)
2016			0.0583
			(0.0584)
2017			0.0969
			(0.0580)

Note: Non-linear least squares parameter estimates from Equation (10). Standard errors in parentheses.

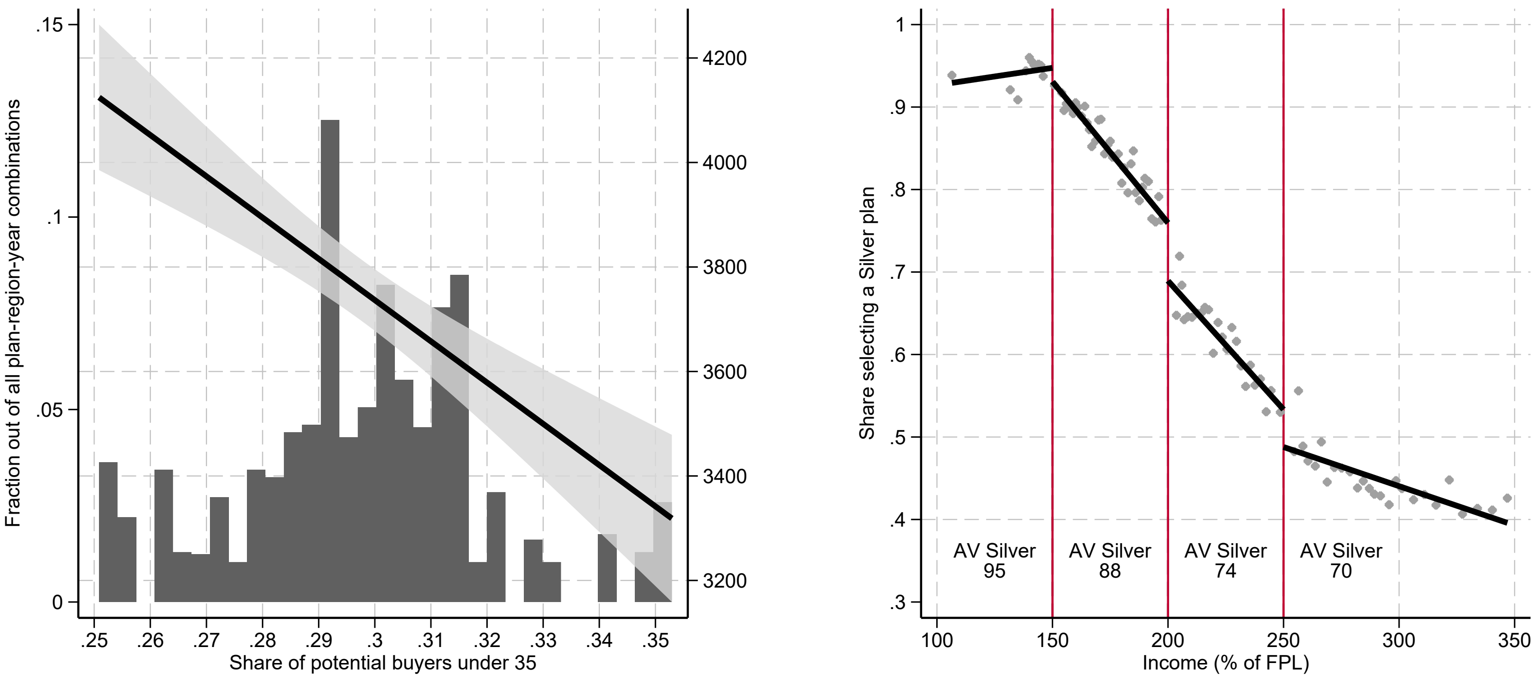
Table A6: *Other Cost Parameters: Non-linear Least Squares*

η^{WTP} ($100/year for +10% AV)	0.0699		
	(0.0152)		
Constant	5.561		
	(0.233)		
ϕ_m:		$\boldsymbol{\phi}^3$:	
Region 1 (see note)	-	Anthem	0.402
			(0.019)
Napa, Sonoma, Solano, Marin	0.151	Blue Shield	0.373
	(0.018)		(0.021)
Sacramento, Placer, El Dorado, Yolo	0.387	CCHP	−0.181
	(0.013)		(0.034)
San Francisco	0.215	Health Net	0.48
	(0.014)		(0.024)
Contra Costa	0.137	Kaiser	0.359
	(0.011)		(0.038)
Alameda	0.202	L.A. Care	0.018
	(0.019)		(0.022)
Santa Clara	0.113	Molina	−0.196
	(0.017)		(0.029)
San Mateo	0.177	Western	0.34
	(0.018)		(0.032)
Santa Cruz, Monterey, San Benito	0.237	Other	-
	(0.237)		
San Joaquin, Stanislaus, Merced, Mariposa, Tulare	0.171		
	(0.015)		
Madera, Fresno, Kings	0.199	ϕ_t:	
	(0.015)		
San Luis Obispo, Santa Barbara, Ventura	−0.036	2014	-
	(0.026)		
Mono, Inyo, Imperial	−0.064	2015	0.157
	(0.026)		(0.054)
Kern	0.06	2016	0.17
	(0.027)		(0.068)
Los Angeles 1 (see note)	0.057	2017	0.286
	(0.025)		(0.085)
Los Angeles 2 (see note)	0.161		
	(0.023)		
San Bernardino, Riverside	−0.096		
	(0.03)		
Orange	0.02		
	(0.016)		
San Diego	0.14		
	(0.02)		

Note: Non-linear least squares cost parameters of Equation (6). See Appendix B for details.

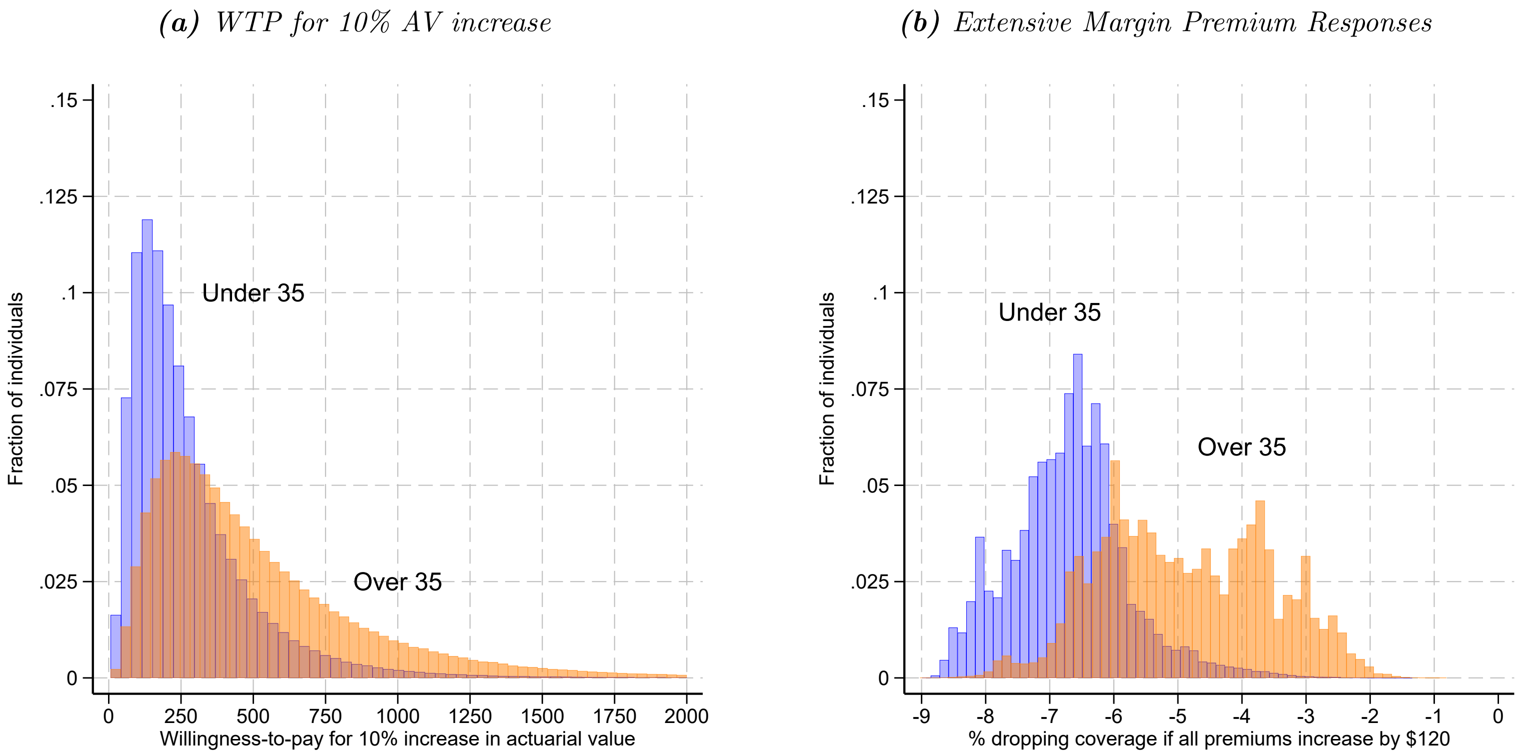
Figure A1: *Demand Identification: Control Function and Actuarial Value Discontinuities*

(a) *Share of under-35 and base premiums* ***(b)*** *Cost-sharing reductions and AV discontinuities*



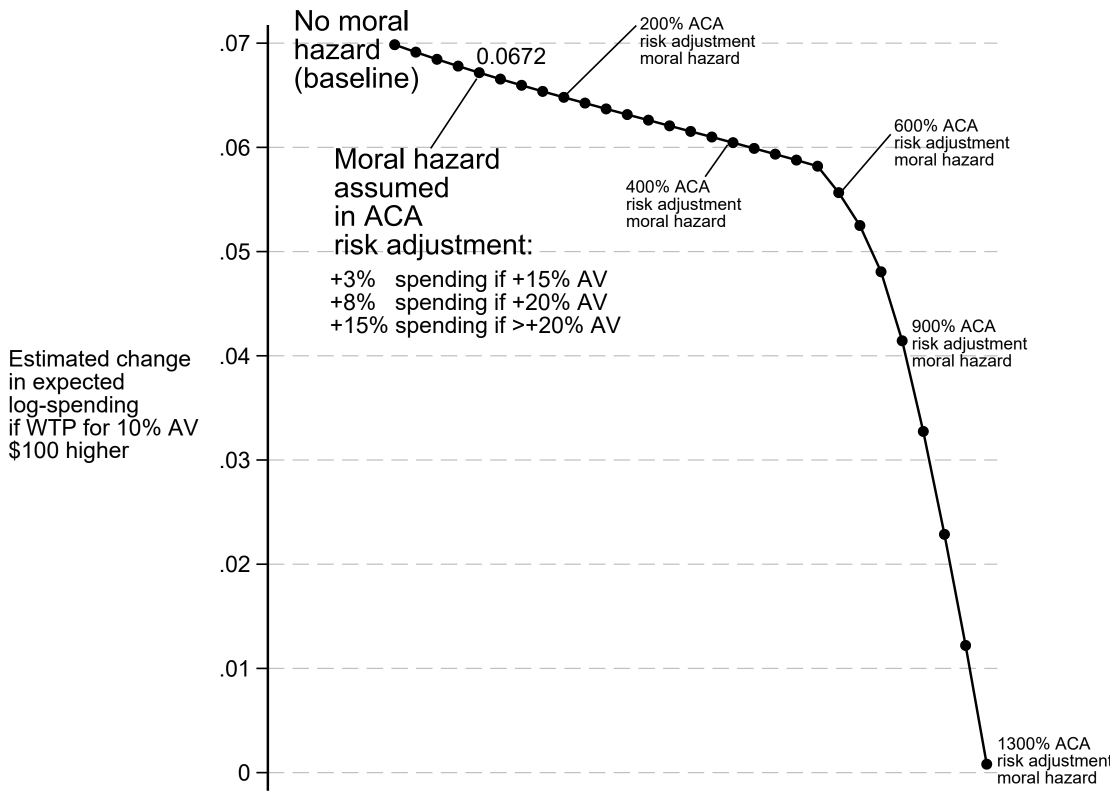
Note: The figure illustrates the variation underlying identification of premium and actuarial value coefficients. The left panel shows the histogram of the share of potential buyers younger than 35 for each jmt combination in the data. The figure also plots the linear relationship between b_{jmt} (measured on the right vertical axis) and the instrument, $\int \mathbf{1}\left[z^{\text{Age}} \leq 35\right] dG_{mt}(\mathbf{z})$, with confidence intervals. See also Table A1. The right panel is a binned scatter plot of the share of enrollees selecting a Silver plan as a function of income (as % of FPL). The linear relationship between the two variables is allowed to vary discontinuously at the three cutoff values corresponding to the discontinuity in actuarial value of Silver plans due to cost-sharing reductions (c.f. Section 2).

Figure A2: *Demand Heterogeneity*



Note: Histograms of the estimated distribution of annual willingness-to-pay for a 10% increase in actuarial value, $\beta_t(\mathbf{z}_i, \theta_i)/\alpha_t(\mathbf{z}_i)$, and % change in probability of purchasing coverage if all annual premiums increase by \$120. The figure pools across all individuals in 2014-2017 Covered California, divided between under- and over-35.

Figure A3: *Estimated* η^{WTP} *varying assumptions on moral hazard*



Note: The figure shows the estimated value of the adverse selection parameter η^{WTP} for different values of the moral hazard parameter ζ (see Section 7). The main results in the paper are obtained assuming $\zeta = 0$ (no moral hazard). The ACA risk adjustment model corresponds to $\zeta = 1$. $\zeta = 4$ (with results shown Table 9) corresponds to "400% ACA risk adjustment moral hazard".