# Measuring Consumer Valuation of Limited Provider Networks

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Abstract:

We measure the breadth of insurance networks in the Massachusetts health insurance exchange. Using our measures, we estimate consumer willingness-to-pay for broad and narrow networks. We find that consumers have a wide range of plans available with dramatically different networks. While consumers value broader networks, their willingness-to-pay is smaller than the brand premium, indicating an additional role for brand preferences. Consumers place additional value on star hospitals, which may affect upstream negotiations. Finally, we find significant geographic heterogeneity in the value of broad networks.

## Introduction

Insurance plans that only allow coverage for a limited set of providers (often called "limited" or "narrow" network plans) are growing in popularity, especially in the new health insurance exchanges created by the 2010 Affordable Care Act. These networks, which can steer consumers to lower cost providers, have been proposed as a solution to rising health care costs.

Yet there is little evidence on how consumers value such plan provider coverage networks. While consumers have not typically had broad choice with respect to networks, that is changing with the creation of exchange. Variation in networks allows the economist to determine the value consumers place on plan attributes, including network breadth. There are at least two ways to examine consumer valuation of these networks. In the first method, consumers' value for the network can be built up from a model of consumer demand for providers. Once the demand system for the providers has been estimated, the value of various provider networks can be simulated. That is, consumers' valuation for insurance networks can be derived from their demand for health care providers. In the second method, we can measure consumers' demand for insurance networks directly from their choice of insurance plans.

This paper examines consumer valuation of provider coverage networks using data from the Massachusetts Health Insurance Exchange (HIX) and the Massachusetts All-Payer Claims Database (APCD). We use the APCD to develop a model of consumer demand for hospitals, and then use the model to value provider coverage networks. We then use choices from the HIX to determine the value consumers place on provider coverage network at the point of insurance choice.

While limited network plans have been brought to the fore by health reform and are receiving increased attention, they are not novel: managed care plans in the 1990s used limited provider choice as a method to reduce cost (Cutler, McClellan, and Newhouse 2000). Limited network insurance plans can reduce costs in a variety of ways: they can include only lower cost (per unit price) providers, they can include only lower utilization providers (i.e. variation in provider style), they can enable insurers to bargain more effectively with providers, and they can enable insurers to select a healthier pool of enrollees.[1] The focus of this paper, though, is not on how these plans lower costs but on how consumers value these plans.

[1] See Shepard (2014) for evidence of adverse selection on network breadth in the Massachusetts Commonwealth Care market. The Commonwealth Care market is distinct from the market we examine in our paper—Commonwealth Choice. Both are health insurance exchanges. Commonwealth Choice was the unsubsidized market that offered various tiers of plan quality (bronze, silver, gold). Commonwealth Care was the subsidized market that offered a single standardized benefit package but allowed variations in network breadth. Both were superseded by the ACA exchanges.

Our analysis builds on previous literature. For employer-sponsored health insurance, Ho (2006) estimates a model of hospital demand, and then a model of insurance plan choice conditional on the hospital network offered. We extend her model to an exchange setting, with posted prices and a wider variety of plans offered to individual consumers. More recently, Gruber and McKnight (2014) examines financial incentives for Massachusetts state employees to choose plans with limited networks that led about 10% of eligible employees to change switch plans. They find that switching to limited networks reduced spending on medical care, with the reduction attributable to both a change in the quantity of services used as well as the price paid per service.

In addition to the impact on costs, narrow networks have the potential to shape insurance markets in a number of ways. First, narrow networks may allow carriers to differentiate their products, allowing them to charge a premium in the absence of strong brand preferences (Starc 2014). On the other hand, the ability to sell a narrow network product may lower barriers to entry, and additional entrants can lower premiums (Dafny, Gruber, and Ody 2014). Finally, as mentioned above, narrow networks have the potential to affect upstream bargaining.

## 1. Data

We use data from the Massachusetts All-Payer Claims Database (APCD), the Massachusetts health insurance exchange (HIX) Commonwealth Choice program, the American Hospital Association, CMS's National Plan and Provider Enumeration System, and hand collected data on provider network coverage.

### *1.a HIX Choices*

The Massachusetts HIX was created by the 2006 health reform and was a model for the ACA HIXs. The HIX is described in detail in Ericson and Starc (2012a, 2012b). Our data is transaction-level data from Nov 2009 -Feb 2010 for single individuals who purchase unsubsidized[2] insurance. This dataset captures only individuals who enroll in the HIX for the first time during this time period; it contains one observation per person, for the month in which they first enrolled.

Consumers pick a plan from the set of plans available to them at posted prices, which vary by age, zip code and family size. Plans were grouped into tiers of actuarial value (bronze, silver, and gold); the actuarial values of the tiers is slightly different from the ACA's tiers. Six insurers offer plans on the HIX during our time frame, and must offer a plan in each tier. In the 2009 the plans were simply grouped into tiers; beginning January 2010, the cost-sharing characteristics were standardized within seven product tiers: Gold, Silver-High, Medium and

[2] In this time period, subsidized insurance was offered in the separate Commonwealth Care market.

Low, and Bronze-High, Medium, and Low. Standardization unbundled the choice of plan into a choice of cost-sharing characteristics (tier), and a choice of insurer (with a provider coverage network and premium specific to that insurer). Standardization and its effect on choice are described in more detail in Ericson and Starc (2013).

To identify price sensitivity, we use the fact that preference are continuous in age but prices jump and round numbered ages (e.g. 30, 35, 40, etc.) We discuss, justify, and apply this identification strategy in detail in Ericson and Starc (forthcoming).

*1.b Hospital Claims and Coverage*

We examine provider coverage networks for acute-care hospitals for adults in Massachusetts. Using the 2012 American Hospital Association (AHA) database, we select the set of general medical and surgical hospitals, excluding long-term care, rehabilitation, children's, and Veterans Affairs hospitals. We are left with a list of 60 hospitals.

We then hand-collected data on whether each hospital was in network[3], for all six carriers in our HIX data from the Connector website. In addition, we separately coded Fallon Select and Fallon Direct plans, an early forerunner of limited network plans.

We then use the APCD data to construct "admission events" for six diagnosis categories: cardiac, cancer, neurological, digestive, labor, and newborn baby. We use the ICD-9 diagnosis codes in Ho (2006), reproduced in Table A.1. We use all commercial payers (e.g. excluding MassHealth, Medicare) and select all claims that have either and admitting diagnosis or primary diagnosis in one (or more) of these categories. We keep only claims with admission dates between Jan 1st, 2009 and Dec 31st, 2011. We link these claims to our list of acute care hospitals based on the National Provider Identifier (NPI) with further details in the appendix.

We aggregate claims into 30 day "admission events." If an individual's first admission is on date *t,* we group all of their claims with admission dates between *t* and *t+30* into one admission event. An individual can have multiple admission events: someone with 3 claims with admission dates *t, t+15,t+40* would have two admissions events: a *t* to *t+30* admission event and a *t+40* to *t+70* admission events. For each admission event, we assign the hospital based on the modal hospital over the claim lines; similarly we assign the modal admitting diagnosis and primary diagnosis.

## 2. Construction of Network Measures

[3] Circa 2013, the Connector had a web-based tool that allowed users to restrict search results to plans that included that hospital in network.

*2.a. Covered Fraction of Admission Events*

We quantify the breadth of insurer-hospital networks in a number of ways. In order to account for differences in demand across hospitals, we utilize the APCD data. First, we construct a measure of the fraction of admissions that would be covered by a carrier network. The results are in Table 1, and confirm our priors. BCBS offers the most generous network, with 98% of hospitals in network. Health New England is omitted as it only covers part of the state. The Tufts Select network, an early narrow network, has the lowest coverage measure. Fallon Select's network is broader than Fallon Direct. We can further decompose the measures by individual diagnosis, but all of the measures are highly correlated. The second column constructs a similar measure that restricts to academic medical centers.

*2.b Consumer Surplus from Hospital Choice Model*

We can take the claims data even more seriously and construct measures of network total expected consumer surplus from a network, which we will call the "hospital choice measure" for simplicity. By utilizing methods from the hospital merger literature (see Capps, Dranove and Satterthwaite 2003 and Gowrisankaran, Nevo, and Town, forthcoming), we can infer consumer valuations of networks from their choice of hospitals. These measures will more accurately capture the nonlinearities generated by "star" hospitals or systems who may bargain together.

To estimate the hospital choice measure, we assume that an individual *i* with diagnosis category *d* has utility of hospital *h* given by:

$$v_{idh} = \pi_{dh} + \lambda_d distance_{ih} + \epsilon_{idh},$$

where $\pi_{dh}$ is a hospital-diagnosis specific fixed effect, and $distance_{ih}$ is the distance (in miles) from the individual's zipcode to the hospital's address (see Empirical Appendix).[4] The diagnosis category corresponds to the six previously defined (cardiac, cancer, neurological, digestive, labor, and newborn baby). Given this model and the assumption that $\epsilon_{idh}$ takes on a type-I extreme value distribution we can estimate the parameters of this model from the data on hospital chosen, broken down by each diagnosis category, using a conditional logit model of choice.[5]

[4] This model could be generalized in a number of ways: for instance, we could allow $\pi$ to vary by more narrowly defined diagnosis categories (such as by ICD-9 code rather than by 6 groups). We could also allow the effect of distance to be non-linear.

[5] Note that our methodology implicitly assumes that individuals in the APCD data are not constrained from choosing a hospital by their insurance networks. However, individuals may have limited network insurance plans that do not cover certain hospitals, thereby removing it from the consumer's choice set, or tiered network plans that impose additional cost-sharing for certain hospitals. This likely biases down our estimate of the value of the highest utility-giving hospitals, since limited network plans typically exclude the hospitals for which there is higher demand. We believe the bias is relatively small, given that our time period of admissions predates the growth of limited network insurance plans and uses the commercially insured population.

Having estimated the parameters from the hospital choice model, we can then generate the consumer surplus from a given hospital network. We construct these measures separately for each diagnosis category, as the perceived quality of a hospital may vary by diagnosis. The consumer surplus of a network *j* for a diagnosis category *d* is then:

$$CS_{jd} = \log\left(\sum_h \pi_{dh} \mathbf{1}_{h\ in\ network\ j}\right),$$

where $\mathbf{1}_{h\ in\ network}$ is and indicator for whether the hospital is in *j's* network. We combine the diagnosis-specific consumer surplus measure into a single consumer surplus measure by equally weighting the different diagnosis categories, so we have $CS_j = mean(CS_{jd})$.

This measure $CS_j$ has no cardinal meaning in our context, since we do not include a price term in our hospital model.[6] We present $CS_j$ in Table 1. This variable is scaled differently than our % of admissions covered, but generates a similar ranking of network breadth.

Our goal is to consider a variety of different network measures, rather than relying on a single measure. We believe that these measures span across a range of assumptions about consumer behavior. We will show that all of these measures have similar implications for consumer valuation of networks.

## 3. Estimating Insurance Demand

We estimate models of the form:

$$u_{ij} = \alpha_i p_{ij} + f(age_i, p_{ij}) + \beta X_{ij} + \theta Network_j + \varepsilon_{ij}, \qquad \text{(Equation 1)}$$

where the utility of plan *j* for person *i* is given by $u_{ij}$, the premium (which varies by age) is given by $p_{ij}$, and the network measure for plan *j* is given by $Network_j$. We include a vector of other plan characteristics (tier, actuarial value) as $\beta X_{ij}$. The error term $\varepsilon_{ij}$ is assumed to take a Type-I extreme value distribution, giving a standard logit model of choice.

Following our previous work (Ericson and Starc forthcoming), we identify $\alpha$ using discontinuities in pricing by age. Thus, we let price sensitivity vary continuously by age

[6] The absence of a price term means that the hospital-diagnosis quality fixed effect captures not only "quality" but quality net of price differences that an individual would pay. While our current methodology is insufficient for policy analysis that would examine the effect of changing cost-sharing by hospital, we believe that this is the right way to capture how consumers think about a hospital: they often do not know for sure what the price would be at two hospitals (nor the quality of the particular doctor they would see), but they would have a general sense of hospitals being higher or lower quality and higher or lower costs.

through the term $f(age_i, p_{ij})$; here we implement the interaction as a linear function; our previous work found this to be a reasonable choice.

We first estimate a version of Equation 1, in which in lieu of including a measure of the insurer's network in the utility model, we simply include an insurer-network specific fixed effect $\gamma_j$. This measure is plotted on the y-axis of Figure 1, with Blue Cross/Blue Shield's network's utility normalized to zero. On the x-axis of Figure 1, we plot one of our measures of network breadth, the percent of hospital admission events that would be covered by the insurer's network. It is encouraging that there is a clear relationship between our estimated utility of plan networks and the percent of admission events covered. The graph plots a linear fit, which has an $R^2$ of 0.75; with just these six points, we reject the null hypothesis of no linear relationship between the two measures at $p<0.05$.

The results of our basic choice models are in Table 2, Panel A. The model in the first column measures the breadth of networks using the percentage of hospital admissions that would be covered by a given plan; it ranges from zero to one. We can interpret the coefficient by dividing by the price coefficient and multiplying by differences in the network measure. For example, BCBS covers 59 percentage points more hospital admissions in the APCD data than the Tufts Select network.

We can calculate a consumer's WTP for network A versus B as follows:

$$WTP_{A,B} = \frac{\theta}{\alpha_i}(Network_A - Network_B)$$

Note that price sensitivity $\alpha$ varies by age, so WTP for networks will also vary by age. If we divide $\theta$ by age-specific $\alpha$ and multiply by 0.59, we have a measure of WTP for the BCBS network relative to the Tufts Select network. For a 30-year-old consumer, we estimate a WTP of \$67/month for the broader BCBS network; for the less price sensitive 60-year-olds, we estimate a WTP of \$122/month. [7] In Panel B of Table 2, mixed logit models— which estimate population heterogeneity in price sensitivity $\alpha_i$— imply similar valuations.

The hedonic regressions in Table 4 imply that compared to Tufts, BCBS charges \$51/month more for 30-year olds and \$137/month more for 60 year-olds, which lines up closely with our estimates of the WTP per month.

Previous research (Ho, 2006) implies that not all hospitals are valued equally by consumers. In order to account for a coarse measure of hospital quality, we adjust our network measure to only include academic medical centers. The measures based on all hospitals and academic medical centers nearly perfectly correlated. When we use as our network measure the % of

[7] We have also explored specifications allowing the coefficient on the network measure to vary by age. When we do so, the 60 year oldest have a $\theta$ that is 31% larger than 30 year olds; the estimated age trend in $\alpha$ is unchanged.

admission events to academic medical centers covered, our WTP for network breadth are virtually identical; we estimate a smaller coefficient on this network measure, which is offset by larger variation between networks in this measure (i.e. a difference of 81 percentage points for BCBS versus Tufts, compared to only 59 in the % of all admissions measure.)

Finally, we can use our consumer surplus measure from the hospital demand system, $CS_j$, as our network measure. While this measure is not directly interpretable, we can again form WTP for BCBS versus Tufts, as above. This specification implies a valuation for the broader BCBS network of $71/month for 30-year-olds and $128/month for 60-year olds. This result is remarkably similar to (but slightly higher than) the % of admissions measure.

Table 3 explores additional measures and geographic heterogeneity. First, we calculate a measure of network breadth that only considers hospitals within the consumer's hospital referral region (HRR). Similar to the academic medical center specifications, the implied valuations are slightly smaller. However, the more interesting analysis is in the second column. We show that network valuation is higher in the Boston HRR than in Worcester or Springfield. Given the set of hospitals in Boston, we think this is intuitive. It also has important implications for pricing across geographic regions.

Finally, we include two alternative measures of network breadth: indicator variables for whether the closest hospital is in a network and whether Massachusetts General Hospital is in network. The Massachusetts hospital market has been subject to increased antitrust scrutiny due to the potential market power wielded by Partners. One salient measure of network quality to consumers may be whether a large, prominent teaching hospital – in our setting, Massachusetts General Hospital is an obvious example – is included in the network. By contrast, distance is an important determinant of hospital demand.

Both of these variables are positive and significant. The results imply that the average consumer is willing to pay $26 more/month for a plan with the closest hospital to their zipcode in network. A 30-year old[8] will also pay $56/month more for a plan with MGH in network, accounting for over 80% of the incremental value of the BCBS network. This effect persists, but is slightly smaller ($34/month) even once we control for the breadth of the overall network. This is consistent with a range of insights from the hospital demand literature: consumers are most likely to go to the hospital closes to them, and "star" hospitals can command a premium.

## 4. Discussion and Conclusion

The literature on insurance demand has largely focused on the financial features of plans, rather than their networks. However, from this literature, we know that consumers do not

[8] A 60-year old is roughly half as price sensitive, so these numbers can be multiplied by 2 to approximate a 60-year-old's WTP.

necessarily weight product characteristics as economic theory would predict (Abaluck and Gruber 2010). By contrast, this paper highlights the importance of non-pecuniary features of plans and flexibly measures the value consumers place on network breadth.

We find, not surprisingly, that consumers value broader networks using a variety of measures. However, networks alone cannot necessarily justify the brand premiums charged by firms. Furthermore, "star" hospitals are valued by consumers above and beyond the overall network. There is geographic heterogeneity in the importance of networks.

These results have important implications for the competitiveness of exchanges. In addition, narrow networks have the potential to reduce costs (Gruber and McKnight 2014). In addition to steering consumers to lower cost providers, narrow networks may allow insurers to negotiate lower rates. Future research should explore the effect on negotiates with upstream providers and expand the analysis to individual physicians and physician groups.

## References

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## Tables and Figures

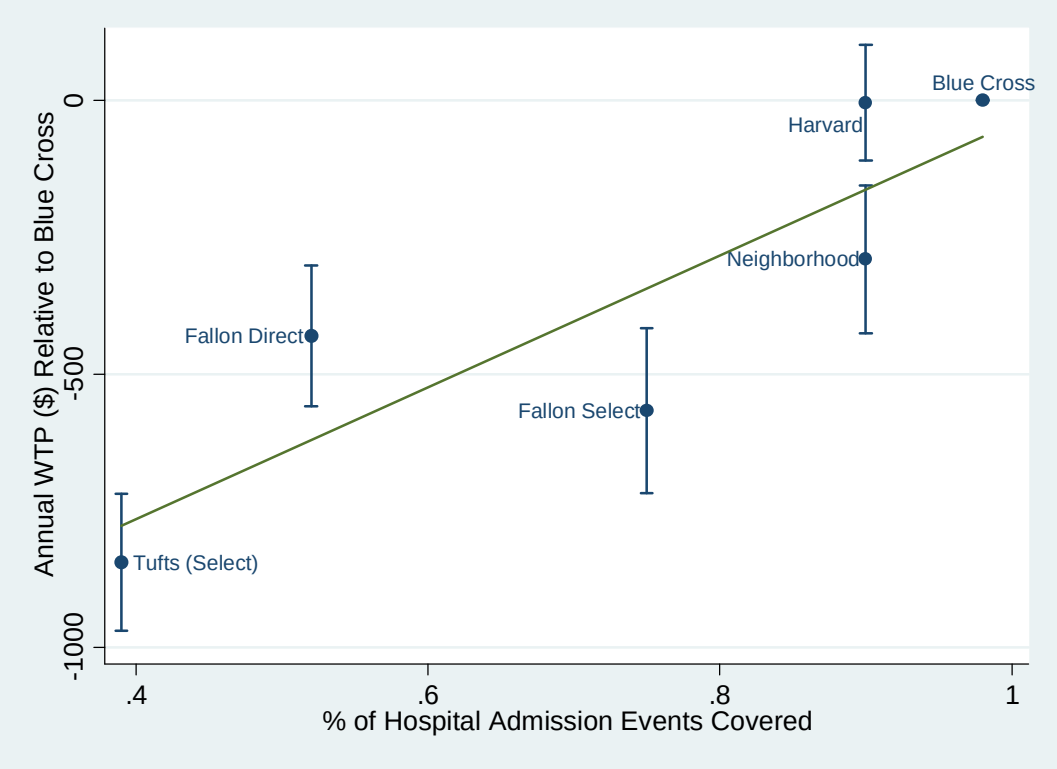



**Figure 1. Network Breadth and Estimates of Plan-Specific WTP From Insurance Choice.** Estimated from the following logit model: $u_{ij} = \alpha p_{ij} + \omega(age_i * p_{ij}) + \beta X_{ij} + \gamma_j + \varepsilon_{ij}$, where *X* includes actuarial value, tier, and year (2009 v 2010). "Annual WTP Relative to Blue Cross" for a 30-year old results from dividing the insurer-network fixed effect $\gamma_j$ by $(\alpha + 30\omega)$. The graph includes 95% confidence interval bars, calculated by the delta method, around each WTP measure. The line shows a linear fit of the WTP measure to percent of hospital admission events covered.

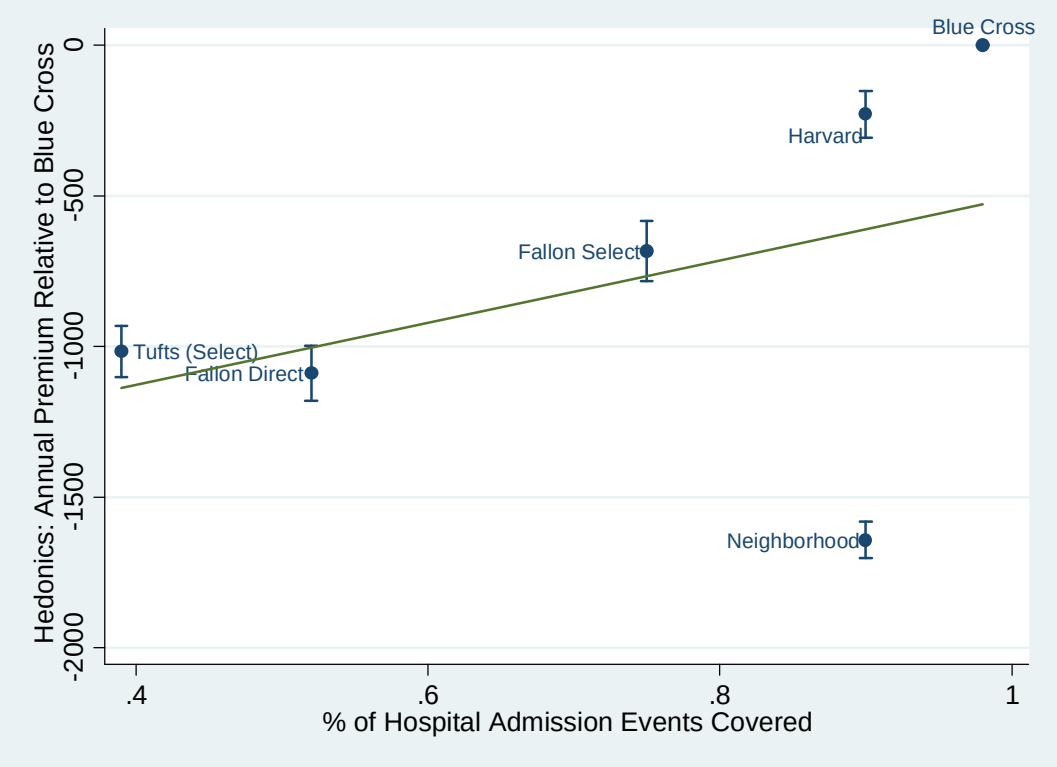



**Figure 2. Network Breadth and Hedonic Pricing Regressions.** Vertical axis plots average premium differences (annualized) between insurer-networks from the hedonic regression estimated in Table 4, Column 5. The graph includes 95% confidence interval bars, calculated by the delta method. The line shows a linear fit of the hedonic price differences measure to the percent of hospital admission events covered.

**Table 1: Network Measures By Plan**

| | % of Hospitals Admissions Covered | % of AMC Admissions Covered | % of Hospitals Admissions Covered, Boston HRR | Hospital Demand Model $CS_j$ |
|---|---|---|---|---|
| BCBS | 0.98 | 1.00 | 0.98 | 0.07499 |
| Fallon Direct | 0.52 | 0.36 | 0.59 | 0.06639 |
| Fallon Select | 0.75 | 0.64 | 0.76 | 0.06999 |
| Harvard | 0.90 | 0.86 | 0.95 | 0.07369 |
| Neighborhood | 0.90 | 0.88 | 0.96 | 0.07459 |
| Tufts (Select) | 0.39 | 0.19 | 0.38 | 0.05460 |

Note: Provider coverage network information as described in text. Weighting comes from number of inpatient episodes captured in the MA APCD for six diagnostic categories, as described in text.

**Table 2: Main Logit Specifications**

| **Panel A:** | **Conditional Logits** | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Premium | -0.0224*** | -0.0222*** | -0.0217*** |
| | (0.00112) | (0.00112) | (0.00112) |
| Premium*Age | 0.000230*** | 0.000227*** | 0.000223*** |
| | (2.06e-05) | (2.05e-05) | (2.05e-05) |
| Actuarial Value | 2.271*** | 2.232*** | 2.328*** |
| | (0.251) | (0.251) | (0.251) |
| % Admits Covered | 1.773*** | | |
| | (0.121) | | |
| % of AMC Admits Covered | | 1.299*** | |
| | | (0.0881) | |
| Hospital Demand Model $CS_j$ | | | 52.41*** |
| | | | (3.707) |

| **Panel B:** | **Mixed Logits** | | |
|---|---|---|---|
| Mean $\ln[-\alpha_i]$ | -3.814*** | -3.810*** | -3.841*** |
| | (0.0697) | (0.0847) | (0.0716) |
| Std. Dev. $\ln[-\alpha_i]$ | 0.431*** | 0.543*** | 0.439*** |
| | (0.0459) | (0.0625) | (0.0477) |
| Premium*Age | 0.000184*** | 0.000164*** | 0.000179*** |
| | (2.87e-05) | (3.35e-05) | (2.86e-05) |
| Actuarial Value | 2.978*** | 3.664*** | 3.014*** |
| | (0.267) | (0.270) | (0.267) |
| % Admits Covered | 1.532*** | | |
| | (0.125) | | |
| % of AMC Admits Covered | | -0.126 | |
| | | (0.0892) | |
| Hospital Demand Model $CS_j$ | | | 44.33*** |
| | | | (3.784) |

Note: Logit regressions as described in Equation 1. Also includes controls for tier (bronze, silver, gold). Mixed logits in Panel B allow for unobserved heterogeneity in price sensitivity by age. Sample: Choices of first-time enrollees on the Massachusetts HIX Nov. 2009 – Feb. 2010, one observation per person. Actuarial Value of plans measured from 0 to 1. N Person x Plan = 67,612 in all regressions.

**Table 3: Additional Logit Specifications**

| | Conditional Logits | | | | |
|---|---|---|---|---|---|
| Premium | -0.0221*** | -0.0220*** | -0.0204*** | -0.0211*** | -0.0239*** |
| | (0.00114) | (0.00114) | (0.00112) | (0.00116) | (0.00121) |
| Premium*Age | 0.00023*** | 0.00023*** | 0.00021*** | 0.00022*** | 0.00025*** |
| | (2.09e-05) | (2.08e-05) | (2.05e-05) | (2.07e-05) | (2.21e-05) |
| Actuarial Value | 2.346*** | 2.269*** | 2.178*** | 2.186*** | 2.804*** |
| | (0.255) | (0.255) | (0.251) | (0.251) | (0.257) |
| % of Admits Covered | | | | 0.736** | |
| | | | | (0.300) | |
| % of Admits Covered HRR | 1.178*** | 1.979*** | | | |
| | (0.0987) | (0.131) | | | |
| … *Springfield | | -1.583*** | | | |
| | | (0.325) | | | |
| … *Worchester | | -2.635*** | | | |
| | | (0.222) | | | |
| 1(MGH Covered) | | | 0.796*** | 0.495*** | |
| | | | (0.0522) | (0.132) | |
| 1(Nearest Hospital) | | | | | 0.422*** |
| | | | | | (0.0645) |
| N Person x Plan | 65,955 | 65,955 | 67,612 | 67,612 | 63,158 |

Note: Logit regressions as described in Equation 1. Also includes controls for tier (bronze, silver, gold). Sample: Choices of first-time enrollees on the Massachusetts HIX Nov. 2009 – Feb. 2010, one observation per person. Actuarial Value of plans measured from 0 to 1.

**Table 4: Hedonic Pricing Regressions**

| | Age 30 Prices | | Age 60-65 Prices | |
|---|---|---|---|---|
| AV | 105.9*** | 124.1*** | 214.7*** | 206.1*** |
| | (2.720) | (1.431) | (4.493) | (2.418) |
| Silver | 86.19*** | 83.87*** | 143.5*** | 145.7*** |
| | (0.618) | (0.323) | (1.021) | (0.546) |
| Gold | 191.7*** | 187.4*** | 321.1*** | 324.0*** |
| | (0.898) | (0.471) | (1.483) | (0.796) |
| % of Admits Covered | 52.63*** | | 133.0*** | |
| | (1.009) | | (1.667) | |
| …Fallon Direct | | -32.58*** | | -100.2*** |
| | | (0.470) | | (0.793) |
| …Fallon Select | | 0.849** | | -43.43*** |
| | | (0.356) | | (0.602) |
| …Harvard | | 29.86*** | | -14.55*** |
| | | (0.334) | | (0.564) |
| …Neighborhood | | -108.2*** | | -218.8*** |
| | | (0.360) | | (0.609) |
| …Tufts | | -51.32*** | | -137.1*** |
| | | (0.361) | | (0.610) |
| N Plan x Zipcode | 61,744 | 61,744 | 61,744 | 61,744 |
| R2 | 0.712 | 0.922 | 0.735 | 0.925 |

Note: Dependent Variable: Monthly Premium. Sample: Prices of plans on the Mass HIX, Nov. 2009 – Feb. 2010. Regressions include month fixed effects and zipcode fixed effects.

# Empirical Appendix

| CATEGORY | ICD-9 CODES (PRIMARY OR ADMITTING DIAGNOSIS) |
|---|---|
| **CARDIAC** | 393-398; 401-405; 410-417; 420-429 |
| **CANCER** | 140-239 |
| **NEUROLOGICAL** | 320-326;330-337;340-359 |
| **DIGESTIVE** | 520-579 |
| **LABOR** | 644, 647, 648,650-677, V22-V24, V27 |
| **NEWBORN BABY** | V29-V39 |

Table A.1. Definition of Diagnosis Categories From Ho (2006).

**A1. Construction of Claims**

From the APCD, we keep claims whose service provider is located in Massachusetts. We then merge each claim's Service Provider National Provider Identifier (NPI) with the CMS's National Plan and Provider Enumeration System Downloadable file (NPPES 2014-07-13 edition). To link these claims to hospitals, we keep matched APCD- NPPES records that have a National Uniform Claim Committee healthcare taxonomy code beginning in 282 (a broad category that includes General Acute Care Hospitals, but also other hospitals; see http://www.wpc-edi.com/reference/ for more details). We additionally hand select hospitals (Heywood, Marlborough, St Vincent, St. Anne's) based on the NPPES Provider Organization Name that were included in our AHA-identified hospital list but did not meet our taxonomy code criteria. Based on the NPI, Provider Organization Name, and Provider Business Practice Location fields, we hand link these records to our AHA-identified hospitals.