Demand Estimation: Choice Frictions

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Outline: Previously

- Discrete choice models
  - Logit and nested logit
  - BLP
  - Variations

Standard Discrete Choice

- The utility specification in the standard discrete choice framework (e.g., BLP):

$$u_{ijt} = x_{jt}\beta_{it} - \alpha p_{jt} + \xi_{jt} + e_{ijt} \tag{1}$$

  - Rely on observing demand using revealed preference
  - Assume that consumers have complete information about p_{jt}, ξ_{jt}, the availability of products $j \in \{1, ..., J\}$ etc.
  - No uncertainty, no risk aversion, no mistakes in choices etc.
  - Is this realistic?
  - How does it matter for estimating demand and welfare?

Outline

- Two additional topics to consider in welfare analysis:
  - What if we abandon complete information?
  - What if consumers have misperceptions about product value?
  - How can we estimate demand/welfare if choices no longer reveal true valuations?

Revealed Preference Approach

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  - Choices are made after some information is revealed
    - E.g. buy insurance after the health risk is realized (adverse selection)
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    - Welfare conclusions based on observed choices vary with the information that individuals have while making those choices

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    - Welfare conclusions based on observed choices vary with the information that individuals have while making those choices
  - Behavioral constraints or choice frictions
    - E.g., limited information, misperceptions, inattention, inertia, cognitive limitations $\rightarrow$ perceived value differs from true value

Why Do We Care?

- Choice frictions appear in many markets and sectors of the economy
- Consumers make often seemingly bad choices
- For example, patients buy branded drugs, instead of cheaper generics, despite the fact that they are bioequivalent (work in the same way)
- Consumers lose money by not switching away from expensive electricity contracts
  - Because they lack information or are unaware of cheaper alternatives?
  - Because they have misperceptions about generics?
  - Because they have inertia or switching costs?

Why Do We Care?

- Policy question: should we use laws, defaults etc to reduce choice frictions?
- Are behavioral constraints/choice frictions welfare relevant or not?

Choice Frictions: True vs. Perceived Value (Handel et al., 2019)

- Individuals vary on willingness to pay w_i (say, for health insurance)
- Choice frictions enter the model as a distortion to an individual's willingness to pay
- The friction, denoted by f_i, results from, for example, limited information about risks or coverage, or decision biases at the time of purchase

Choice Frictions: True vs. Perceived Value (Handel et al., 2019)

- w_i: perceived value of product (determines demand)
- $v_i = w_i - f_i$: true value of product (welfare relevant)
- So f_i determines the difference between true value v_i and perceived value w_i, affecting individuals differently
- Even if true and perceived value are equal on average, true and perceived value may differ conditional on choice (since demand depends only on perceived value)

Demand with Choice Frictions (Handel et al., 2019)

- Demand: buy if perceived value exceeds price: $w_i \geq P$

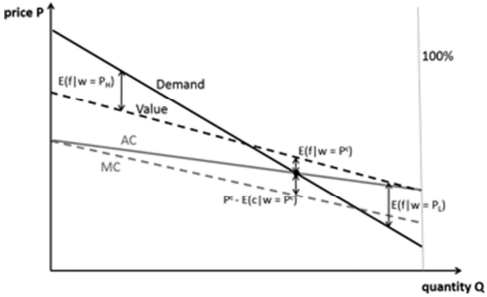
$$D_w(P) = 1 - F_w(P).$$

- The demand curve shows what individuals are willing to pay at a given price P based on the perceived value w_i
- However, true utility is maximized by buying if $v_i = w_i - f_i \geq P$

Demand with Choice Frictions (Handel et al., 2019)

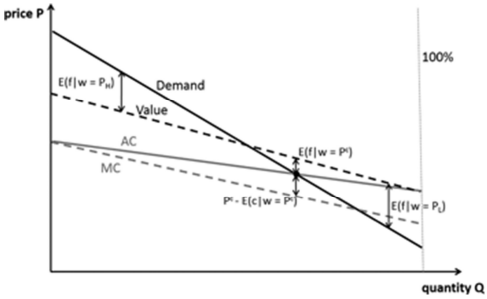
- Simple section effect: if perceived and true values for a product differ, on average those who buy the product will tend to over-estimate value ($f_i > 0$) and those who don't buy will under-estimate it ($f_i < 0$)
- If we treat demand curve as value curve (i.e. use revealed preference), overstate surplus for those who bought the product and understate potential surplus for those who did not buy the product

Demand vs. Value Curve (Handel et al., 2019)



- The demand curve $D(P)$ orders individuals based on their willingness to pay based on w_i
- $MC(P) = E(c_i|w_i = P)$: the marginal cost function (i.e., expected cost of production to buyers at the margin of buying or not at price P, $w_i = P$) ´
- $AC(P) = E(c_i|w_i \geq P)$: the average cost function
- $V(P) = E(v_i|w_i = P)$: the marginal value function

Demand vs. Value Curve (Handel et al., 2019)



- The competitive equilibrium: the intersection of the demand curve and the average cost curve (AC)
- To evaluate total welfare, we need the value of insurance relative to its cost and thus compare the value curve (rather than the demand curve) to the marginal cost curve (MC)
- Frictions create a difference between the demand curve and the value curve

Estimation and Identification

- How do we estimate true valuations?
- What the demand would be in absence of all choice frictions?
- How do we identify choice frictions?

Modeling Assumptions

- We need to modeling assumptions to identify departures from the standard demand model of complete information (e.g., BLP)
  - Is the individual making a mistake when he seems healthy and is buying very comprehensive and expensive insurance?
  - Or is he very risk averse?
  - Or has private information he has a higher health risk than expected?

Modeling Assumptions

- Need simplifying assumptions (like in any model)
- E.g. specify a particular source of frictions
  - Uncertainty
  - Switching costs
  - Other behavior constrains
- Possibly together with heterogeneity e.g. in risk preferences or type
- Modeling choices motivated by institutional features / descriptive evidence

Current Best Practice

- Using data and institutional information, identify possible choice frictions and departures from the standard demand model.
  - Start with descriptive results
  - Add assumptions as needed, progress on this
  - Can even exploit quasi-experimental variation to affect choice frictions (laws, defaults etc.)

Literature: Some Examples

- Choice frictions (information, hassle costs)
  - Handel et al. (2019): a general framework to study insurance market equilibrium in the presence of choice frictions
  - In the empirical application, use survey data on information frictions and perceived hassle costs as specific sources of choice frictions
- Switching costs/inertia
  - Handel (2013): consumer inertia in a choice model of health insurance
  - Hortaçsu et al. (2017): a model of retail choice in the electricity market with two sources of inertia: search frictions/inattention and a brand advantage that consumers afford the incumbent
  - Luco (2019): switching costs and competition in a private pension system
    - Identify two sources of switching costs: the cost of evaluating financial information and the cost of the bureaucratic process when switching

Literature: Role of Behavior Biases / Consumer Mistakes

Jason Abaluck, Jonathan Gruber (2011) *Choice Inconsistencies among the Elderly: Evidence from Plan Choice in the Medicare Part D Program.* American Economic Review, Vol. 101, No. 4: pp. 1180-1210.

Big Question

- Are individuals making choices that are inconsistent with optimization under full information?
- Is it beneficial for individuals' welfare to allow them to choose across a wide variety of options that meet their needs ("more is better"), as suggested by standard economic theory?
- Should we constraint them to a limited (and possibly better) set of choices being made by the government?
- Setting: the choices of elders across a large number of health insurance options in the U.S.

Setting: Medicare Part D

- The Medicare Modernization Act of 2003 added the Part D prescription drug benefit to the Medicare program
  - One of the most significant expansions of public insurance programs in the U.S.
  - Available for elderly (age 65 or older) and disabled individuals
- Dozens of private insurers were allowed to offer a wide range of products with varying prices and product features
  - Perhaps most well known was the extent to which plans covered a coverage gap (the "donut hole"), a temporary limit on what the drug plan will cover for drugs
  - While in the coverage gap, individuals are responsible for a percentage of the cost of your drugs (e.g., 25%)

Setting: Medicare Part D

- Complex choice situation
- The typical elder in the data faces a choice of over 40 stand-alone drugs plans
- The potential for cognitive failures rises at older ages, which may affect their ability to make choices

Medicare Plan Comparison

SORT PLANS BY

Lowest drug + premium cost

Showing 10 of 28 drug plans

SilverScript SmartRx (PDP)

Aetna Medicare | Plan ID: S5601-178-0

Star rating:

MONTHLY PREMIUM

$7.30

Includes: Only drug coverage

YEARLY DRUG & PREMIUM COST

$65.70

Only includes premiums for the months left in this year when you don't enter any drugs

DEDUCTIBLE

$445.00

Drug deductible

Add to compare

Plan Details

Aetna Medicare

SilverScript SmartRx (PDP)

Plan type: Drug plan (Part D)

Plan ID:S5601-178-0

Enroll

Overview

PREMIUM

Total monthly premium
$7.30

DEDUCTIBLE

Drug plan deductible
$445.00

Navigate this page

Plan Details

Below, swipe left and right to view more info.

Tiers	Initial coverage phase	Gap coverage phase	Catastrophic coverage phase
Preferred Generic	$0.00 copay	Generic drugs: 25% Brand-name drugs: 25%	Generic drugs: $3.70 copay or 5% (whichever costs more) Brand-name drugs: $9.20 copay or 5% (whichever costs more)
Generic	$19.00 copay		
Preferred Brand	$46.00 copay		
Non-Preferred Drug	49%		
Specialty Tier	25%		

- To lower costs, many plans place drugs into different "tiers"
- Generally, a drug in a lower tier will cost a patient less than a drug in a higher tier
- Three stages: deductible (if applicable), initial coverage, coverage gap ("donut hole"), and catastrophic coverage (low copayment amount set by Medicare)

Data

- Information on almost one-third of all third-party prescription drug transactions in the U.S. from the Wolters Kluwer (WK) Company
- Focus on transactions for individuals aged over age 65 during 2005–2006
- Linked to a comprehensive set of information from the Centers for Medicare and Medicaid Services (CMS) on the Part D plans available to each person in the dataset

Construction of Cost Variables

- The total enrollee costs of Part D can be decomposed into:
  - Premiums: known for certain at the time of plan choice
  - The distribution of out-of-pocket costs given the information available at the time when plans are chosen

Estimating Distribution of Out-of-Pocket Costs

- However, challenging to estimate the distribution:
  - observe only realized out-of-pocket costs for the chosen plan
  - observe only a single realization of out-of-pocket costs for each individual, making it impossible to estimate the variance
  - do not observe all the available information (later on this)

Estimating Distribution of Out-of-Pocket Costs

- To determine what each individual's realized costs would be for each plan in their choice set, assume that the set of 2006 claims is fixed and would remain constant had the individual in question chosen a different plan
- That is, assume no moral hazard
- To estimate the distribution (e.g., variance), sample realized costs from individuals who are "identical" to the individual in question at the time when the plan choice is made

Facts on Plan Choice

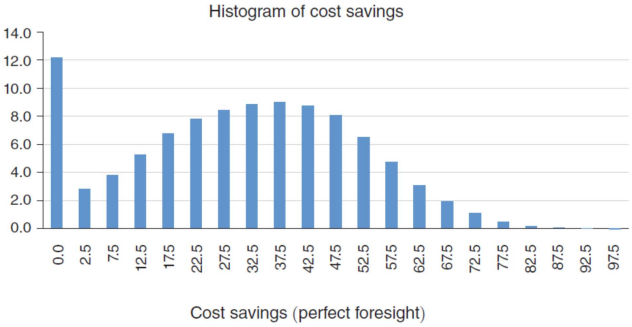


FIGURE 1. HISTOGRAM OF COST SAVINGS FROM SWITCHING TO LOWEST-COST PLAN (*Percents*)

- Only 12.2 percent of individuals choose the lowest-cost plan
- On average, individuals could save 30.9 percent of their total Part D spending by choosing the lowest-cost plan rather than the plan they chose

Facts on Plan Choice

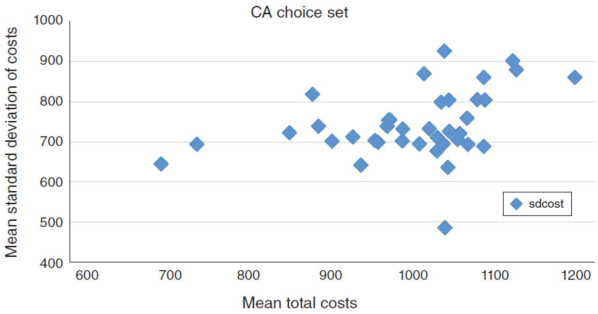


FIGURE 2. AVERAGE MEAN AND STANDARD DEVIATION FOR EACH PDP PLAN IN CALIFORNIA

- However, individuals who are highly risk averse may choose plans with higher mean expenditure to protect themselves against variance in expenditure
- There are still plans that dominate others in terms of both cost and variance

Facts on Plan Choice

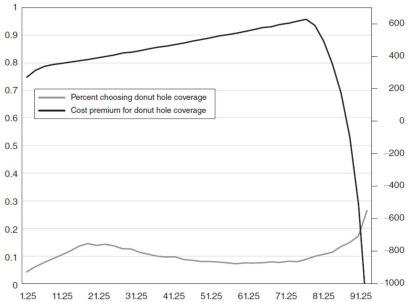


Figure 3. Percent Choosing Donut Hole Coverage and Added Cost by Expenditure Quantile

- The cost of donut hole coverage is rising with expenditures until the point when individuals become likely to enter the donut hole
- The percentage choosing donut hole coverage is flat throughout the spending distribution (how can we rationalize this?)

Base Model of Part D Plan Choice

First specify a constant absolute risk aversion (CARA) utility model with a normally distributed cost C and wealth W

$$U(C) = -\exp(-\gamma(W - C)), \text{ where } C \sim N(\mu, \sigma^2).$$

- Expected indirect utility is just

$$u(\mu, \sigma) \equiv E(U(C)) = -\alpha \exp(\gamma\mu + \frac{1}{2}\gamma^2\sigma^2),$$

where $\alpha = -\exp(-\gamma W)$ is a constant

Base Model of Part D Plan Choice

Using a first-order Taylor expansion around $(\mu', \sigma^{2\prime})$:

$$u(\mu, \sigma) \approx u(\mu', \sigma^{2\prime}) - \alpha\gamma u(\mu', \sigma^{2\prime})(\mu - \mu') - \frac{1}{2}\alpha\gamma^2 u(\mu', \sigma^{2\prime})(\sigma^2 - \sigma^{2\prime})$$

Base Model of Part D Plan Choice

After dropping constant terms, can rewrite the equation as

$$u = \alpha\gamma u(\mu', \sigma^{2\prime})(\pi + \mu^*) - \frac{1}{2}\alpha\gamma^2 u(\mu'^*, \sigma^{2\prime})\sigma^{2\prime}$$

where

- Costs = premium + out-of-pocket costs: $C = \pi + OOP$
- $var(C) = var(OOP) = \sigma^2$ (since π is known for any plan)
- $\mu = E(C) = \pi + E(OOP) = \pi + \mu^*$

Assume that W is constant across all states of the world: the only risk facing individuals is uncertainty about the distribution of OOC.

Base Model of Part D Plan Choice

This maps into a conditional logit model of plan choice where the utility of individual i from choosing plan j is given by:

$$u_{ij} = \pi_j \beta_0 + \mu^*_{ij} \beta_1 + \sigma^2_{ij} \beta_2 + x_j \lambda + q_{b(j)} \delta + e_{ij}$$

where

- $\beta_0 = \beta_1$
- $\gamma = 2\beta_2/\beta_1$, i.e. the risk aversion coef. equals to the ratio of the coefficients on the variance of costs (σ^2_{ij}) and the coefficient on the average out-of-pocket costs (μ^*_{ij})
- x_j: financial plan characteristics
- $q_{b(j)}$: plan quality index + other non-financial aspects

Testable Restrictions

$$u_{ij} = \pi_j \beta_0 + \mu^*_{ij} \beta_1 + \sigma^2_{ij} \beta_2 + x_j \lambda + q_{b(j)} \delta + e_{ij}$$

- $\beta_0 = \beta_1$, i.e. the coef. of premiums (π_j) = the coef. of the average out-of-pocket costs (μ^*_{ij})
  - Individuals should be willing to pay exactly one dollar in additional premiums for coverage, which reduces expected out-of-pocket costs by one dollar
  - Otherwise, they could switch to alternative plans with comparable risk (σ^2_{ij}) but lower total costs

Testable Restrictions

$$u_{ij} = \pi_j \beta_0 + \mu^*_{ij} \beta_1 + \sigma^2_{ij} \beta_2 + x_j \lambda + q_{b(j)} \delta + e_{ij}$$

- $\lambda = 0$: Individuals should not care about other financial characteristics x_j (cost sharing, donut hole coverage etc) per se; they should care only about these factors to the extent that they affect the distribution of out-of-pocket costs (μ^*_{ij} and σ^2_{ij})

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- $\beta_2 < 0$: holds if individuals are risk averse

Identification

- All of the plan characteristics may be endogenous due to unobserved demand factors
- Include all of the publicly available information that might be used by individuals to make their choices
- Also consider models with a full set of brand dummies, as well as a full set of interactions of state dummies with brand dummies
  - Use variation across plans offered by the same brands in a given state to identify the coefs. of plan characteristics
- If π_j is higher in regions where insurers anticipate more demand for plan j, the coefficient on π_j will be biased toward zero, making high premiums appear less undesirable than they actually are
- Would strengthen the conclusion that premiums are overweighted relative to out-of-pocket costs

Conditional Logit

TABLE 1—CONDITIONAL LOGIT RESULTS

	(1)	(2)	(3)	(4)
Premium	−0.4330***	−0.7663***	−0.4990***	−0.5218***
(hundreds)	(0.0029)	(0.0038)	(0.0061)	(0.0069)
OOP costs (realized)	−0.2127***	−0.1172***	−0.0961***	−0.0967***
(hundreds)	(0.1520)	(0.0015)	(0.0015)	(0.0016)
Variance	−0.0189***	−0.0004	−0.0006	−0.0005
(times 10^6)	(0.0027)	(0.0007)	(0.0007)	(0.0007)
Deductible	x	−0.2899***	−0.1628***	−0.1674***
(hundreds)		(0.0049)	(0.0067)	(0.0072)
Donut hole	x	3.023***	1.762***	1.865***
		(0.0181)	(0.0277)	(0.0303)
Generic coverage	x	0.4203***	0.3004***	0.2700***
		(0.0140)	(0.0175)	(0.0177)
Cost sharing	x	3.282***	1.189***	1.057***
		(0.0538)	(0.0741)	(0.0778)
Number of top 100 on form	x	0.0937***	0.0587***	0.0644***
		(0.0007)	(0.0017)	(0.0018)
Average quality	0.4091***	0.7398***	x	x
	(0.0032)	(0.0039)		
Brand dummies	No	No	Yes	No
Brand-state dummies	No	No	No	Yes
Risk index	10	0	0	0
Number of patients	95,742	95,742	95,742	95,742

Testable Restrictions

- $\beta_0 \neq \beta_1$: the coefficient on premium is an order of magnitude larger than the coefficient on out-of-pocket expenditures
- $\lambda \neq 0$: generalized plan characteristics enter the model highly significantly, even conditional on individual out-of-pocket risk
- $\beta_2 \approx 0$: individuals are not willing to pay more for plans with lower variance in expected spending

Alternative Explanations of Findings

- Results reflect consumer mistakes?
- Misspecification of out-of-pocket costs because of a failure to appropriately model the private information available to individuals at the time when they make their plan choice?
- Measurement error in out-of-pocket costs?

Modeling Private Information

- Develop a model of private information available to consumers at the time when they choose
- Can determine if individuals know more than the econometrician can predict given just their 2005 spending
- Evaluating whether their plan choices are responsive to the component of 2006 spending which is not known in 2005
  - For example, if a patient learns he has cancer just prior to choosing the 2005 plan, he would correctly forecast that his drug needs would likely exceed the average of those with similar 2005 spending

Modeling Private Information

The expected indirect utility can be written as:

$$u_{ij} = \pi_j \beta_0 + \beta_1 \underbrace{(C_{ij} - \nu_{ij})}_{\mu^*_{ij} = \mu_{ij} + \epsilon_{ij}} + (1-\tau)\sigma^2_{ij}\beta_2 + x_j\lambda + q_{b(j)}\delta + e_{ij}$$

where

- $C_{ij} = \mu^*_{ij} + \nu_{ij}$: the realized out-of-pocket costs of individual i upon enrolling in plan j (in 2006 data), with μ^*_{ij}: expected cost, ν_{ij}: noise term (*unknown* to the individual at the time of plan choice)
- Decomposition of expected costs: $\mu^*_{ij} = \mu_{ij} + e_{ij}$, where μ_{ij}: expected costs from 2005 data and e_{ij}: private info
- $1 - \tau$: change in the variance due to private info

Modeling and Identifying Private Information

$$u_{ij} = \pi_j \beta_0 + \beta_1 \underbrace{(C_{ij} - \nu_{ij})}_{\mu^*_{ij} = \mu_{ij} + \epsilon_{ij}} + (1-\tau)\sigma^2_{ij}\beta_2 + x_j\lambda + q_{b(j)}\delta + e_{ij}$$

- The (unknown) shock ν_{ij} has a posterior distribution conditional on the the realized costs (from 2006 data) and expected costs (from 2005 data): $f(\nu_{ij}|C_{ij}, \mu_{ij})$
  - Normally distributed, with mean $(1-\tau)(C_{ij} - \mu_{ij})$
- We can think of the model as one with a fixed coefficient β_1 for C_{ij} and random coefficient with mean $\beta_1(1-\tau)$ on $(C_{ij} - \mu_{ij})$
- Thus, τ is identified by the degree to which the coefficient on C_{ij} falls short of the coefficient on $C_{ij} - \mu_{ij}$
- $\tau = 0$: no private info, $\tau = 1$: perfect info about 2006 costs

Conditional Logit with Private Information

TABLE 3—RESULTS WITH PRIVATE INFORMATION

	Final sample	Restricted sample	Private info
Percent private information			0.5818***
			(0.0618)
Premium	−0.7383***	−0.7156***	−0.7489***
(hundreds)	(0.0038)	(0.0094)	(0.0132)
OOP costs (realized)	−0.1169***	−0.1040***	−0.1687***
(hundreds)	(0.0016)	(0.0039)	(0.0094)
Variance	−0.0026	−0.1103**	−0.8574***
(times 10^6)	(0.0014)	(0.0517)	(0.2947)
Deductible	−0.2677***	−0.3079***	−0.2767***
(hundreds)	(0.0014)	(0.1257)	(0.0137)
Donut hole	2.823***	2.805***	2.870***
	(0.0181)	(0.0490)	(0.0478)
Generic coverage	0.3066***	0.4743***	0.4784***
	(0.0143)	(0.0341)	(0.0347)
Full cost sharing	2.990***	3.391***	2.829***
	(0.0546)	(0.1417)	(0.1743)
Number of top 100 on form	0.0939***	0.0995***	0.1005***
	(0.0007)	(0.0019)	(0.0021)
Average quality	0.7167***	0.7418***	0.7512***
	(0.0039)	(0.0098)	(0.0095)
Brand dummies	No	No	No

Measurement Error

- The private information model can also be interpreted as correcting for a specific form of measurement error that arises from idiosyncratic variation across individuals in their knowledge about expected out-of-pocket costs at the time they choose their Part D plan
- Conclusions are therefore robust to controlling for idiosyncratic measurement error across individuals
- Also consider other forms of measurement error in out-of-pocket costs

Random Coefficients

- The independence of irrelevant alternatives assumption may imply unrealistic elasticities and will lead to inconsistent estimates if preferences are heterogeneous across the population
- Robustness for including normally distributed random coefficients on included characteristics

Random Coefficients Logit

TABLE 4—RANDOM COEFFICIENTS RESULTS

	(1)	(2)	(3)
Premium (hundreds)	−0.7156*** (0.0094)	−0.7677*** (0.0111)	−0.7354*** (0.0841)
Standard deviation of premium	x	0.2940*** (0.0560)	0.2659*** (0.0330)
OOP costs (realized) (hundreds)	−0.1040*** (0.0039)	−0.1091*** (0.0052)	−0.1193*** (0.0171)
Standard deviation of OOP costs	x	0.0001 (0.0003)	0.0226 (0.0506)
Variance (times 10^6)	−0.1103*** (0.0517)	−0.1486 (0.0926)	−0.0866 (0.1237)
Standard deviation of variance	x	0.2035*** (0.0685)	0.2603 (0.1769)
Deductible (hundreds)	−0.3079*** (0.1257)	−0.2524*** (0.0107)	−0.2354 (0.1903)
Standard deviation of deductible	x	x	0.2922*** (0.1452)
Donut hole	2.805*** (0.0490)	2.775*** (0.0630)	2.523*** (0.3538)
Std. deviation of donut hole	x	x	0.8078 (0.5997)
Generic coverage	0.4743*** (0.0341)	0.4845*** (0.0427)	−0.0037 (0.2320)
Standard deviation of generic coverage	x		1.106*** (0.5108)

Counterfactual

- What if premiums and out-of-pocket costs were equally weighted?
- Evaluate welfare in conditional logit models when positive and normative utility functions fail to coincide
- The normative (welfare-relevant) utility function sets restrictions on preferences ($\beta_0 = \beta_1$, $\lambda = 0$), unlike the positive utility function u_{ij}
  - Also assumes that e_{ij} do not matter for welfare
  - True, if e_{ij} are a result of optimization mistakes

Counterfactual

The welfare of consumer i in plan j:

$$W_{ij} = \frac{1}{\beta_0}(\beta_0(\pi_j + \mu^*_{ij}) + \sigma^2_{ij}\beta_2 + q_{b(j)}\delta).$$

- This metric omits from welfare other plan financial characteristics, non-financial brand characteristics, and the error term
- Appropriate if π_j, μ^*_{ij}, σ^2_{ij} and $q_{b(j)}$ capture all welfare relevant factors of plans
- Other factors could matter only heuristically because consumers are unable to calculate, or unwilling to spend the time to calculate, the welfare metric above

Counterfactual

- The foregone welfare for individual i at time in plan j (chosen according to the maximization of the positive utility function) is given by

$$FW_i = W_{ijt} - W_i^*$$

  where $W_i^* = \max_j W_{jt}$ is the welfare for the best plan.
- Consumer mistakes led to a welfare loss equivalent to 27 percent of out-of-pocket expenditures on plan premiums and prescription drugs in 2006
- If there were some intervention that would make individuals fully informed and fully rational, this is the amount by which their utility could be improved (in partial equilibrium)

Policy Implications

- Policies that could realize some of these gains:
  - Information about costs
  - Increase doctors' or pharmacists' role in plan choice
- How about restricting choice set?
  - If restricted to the plans on the "efficient frontier", there are sizeable welfare gains for seniors (in partial equilibrium)
  - If smaller choice set, individuals may be better able to compare alternatives
  - However, restricting the size of the choice set may lower competitive pressure on the supply side (in general equilibrium)

Additional Considerations

- The results have raised further questions
- Do violations of the restrictions reflect:
  - optimization mistakes made by consumers,
  - a rejection of the parametric model for utility,
  - some combination of the two?
- Later (non-parametric) evidence suggest that welfare-reducing mistakes may be smaller as previously suggested (Ketcham et al., 2016)
- Yet, robust to alternative normative assumptions highlighting the role of brand fixed effects and unobservable characteristics (Abaluck and Gruber, 2016)

Questions?

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