ESTIMATES OF U.S. POSTAL DEMAND ELASTICITIES DERIVED FROM A RANDOM-COEFFICIENTS DISCRETE-CHOICE NORMAL MODEL

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Conventional Demand Models

- Poorly suited to estimate elasticities in markets with many similar products
  - Automobiles, Breakfast Cereals, Postal Products
- Conventional Model
  - Employs a demand model for each product
  - Should include the price of all relevant products
- Brings rise to familiar econometric problems
  - Burdensome data requirement
  - Prices of many products are highly correlated
  - Cross-Price elasticity estimation requires large sample size with sufficient variation

Conventional Postal Demand Models

- These problems are not unfamiliar to postal practitioners
  - (US) data are typically quarterly national aggregates from 1971 to present
  - Real postal rates tend to change together due to inflation and coordination imposed by price cap regulation
  - U.S. Postal Service products divide into at least 15 different categories with distinct hedonic properties
- Typically, models are fit including only **own-price** data
  - Avoids multicolinearity problems
- Result is an incomplete set of postal price elasticity estimates

A BLP Solution?

- Berry *et al* (1995) introduce a Random-Coefficient Discrete-Choice Logit Model
  - Individual choice model used to estimate demand in a differentiated products market
  - Requires only market-level data
  - Known to produce cross-price elasticities that reflect realistic substitution patterns
- Current "model du jour" in the Industrial Organization literature
  - Largely based on the version presented by Nevo (2000, 2001)
  - Has yet to be tried in the Postal Sector

The Guts of the Model

$$U_{ij} = \xi_j + \left(Y_i + C_i - P_j\right)\left(\alpha + \Pi_y D_i\right) + X_j\left(\beta + \Pi_x D_i\right) + Z_j\gamma_j + \varepsilon_{ij}$$

- Linear Utility Function
  - Two Mean-Centered Disturbances
  - Random Coefficients
    - Gains or losses to household *i* when purchasing and consuming product *j*

BLP: The Good and the Bad

- Good News!
  - Model conforms well to economic theory
  - Is not overly restrictive with respect to price elasticity estimates
- Bad News
  - Model was designed for "big ticket" items
    - Requires distribution of mean-centered demographic variables and measurements of hedonic properties
- Worse News
  - We do not observe indirect utility, individual income, or consumer surplus
  - Fitting the model involves integrating out all of the random terms except for the mean disturbance
  - BLP/Nevo requires a simulation to extract mean indirect utilities by matching market share data (slow!)
- Much Worse News
  - BLP/Nevo is itself an algorithm
  - Repeated calculation of mean indirect utilities is required to fit the model (may take days or weeks to run)

A Modified BLP Solution!

- We discovered a way to revise the model and greatly simplify/speed up the estimation process
- We replace the demographic variables with their principal components
  - The transformation forms a linear combination of variables that are *iid* N(0,1)
- With this change
  - The simulation is replaced with a single-variable numerical integration
  - The estimation method is replaced with a Newton-Raphson method
  - Model can now be fit in under 12 hours with a moderately-sized postal application
- We will ultimately split this paper in two
  - Paper # 1 – Model and Methodology (Sections 1-6)
  - Paper # 2 – Postal Application (Sections 7,8, and Appendix)

U.S. Postal Service Application – The Data

- We fit the model using both a fixed-weight index (FWI) and revenues per piece (RPP)
- Model was fit using 40-year time series PFY 1972 to PFY 2011
- Hedonic properties are taken from Pearsall and Trozzo (2011)
  - Measures are based on the U.S. Postal Service mail stream during PFY 2009
- Demographic variables suggested by conventional econometric studies of U.S. postal demand
  - Pearsall (2005, 2011) and Thress (2012)

Postal Application-Definitions

j	Product (Postal Service Categories)
0	Outside Good
1	First-Class Single-Piece Ltrs, Flats, & Pcls
2	First-Class Presort Ltrs, Flats, & Pcls
3	First-Class Single-Piece Cards
4	First-Class Presort Cards
5	Priority Mail
6	Express Mail
7	Periodicals In-County
8	Periodicals Outside County
9	Standard non-Carrier-Route Ltrs, Flats & Pcls
10	Standard Carrier-Route Ltrs, Flats & Pcls
11	Parcel Post and Parcel Select
12	Bound Printed Matter
13	Media and Library Mail
14	Penalty, Franked and Free Mail
15	Domestic Mail Services ex Evps & Box Rents

Price (P) and Properties of Mail (X-vector)

P	FWI	Fixed-Weight Index, or
	RPP	Revenue per Piece
X	Std. Wgt/Pc	Weight per Piece in 2011, or
	Wgt/Pc	Weight per Piece
	Letters	Proportion of Letters
	Cards	Proportion of Cards
	Flats	Proportion of Flats
	Parcels	Proportion of Parcels (large and small)
	Presort	Number of USPS Machine Passes to Sort
	Distance	Log of Number of Miles to Destination
	Service	Dummy for Domestic Mail Services

Demographic Variables (D-vector)

hhadults	Adults per Household (22+ years of age)
gdp per hh	Real Gross Domestic Product per Household (Chained 2005 Dollars)
chg gdp per hh	Annual Change in Real GDP per Household (Chained 2005 Dollars)
net worth per hh	Real net Worth per Household (Chained 2005 Dollars)
broadband	Proportion of Households with Broadband Access
unemployment rate	Unemployment Rate
linear trend	Linear Trend from 1970 to 2012

Selected Results – Mean Indirect Utility

Table 1a

	FWI	Weight/ Piece	Letters	Cards	Flats	Parcels	Presort	Distance	Service
	Alpha	Beta (X1)	Beta (X2)	Beta (X3)	Beta (X4)	Beta (X5)	Beta(X6)	Beta(X7)	Beta(X8)
Coefficient	-2.51	1.50	5.21	7.92	3.86	7.95	-1.27	0.08	2.31
T-Value	-24.6	13.3	65.1	76.7	34.2	69.1	-41.3	4.5	32.5

- Households place a higher value on services that permit heavier mailings

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- Cards and Parcels are the most highly valued shape
- Flats are the least valued shape

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- Reflects a preference for mail that may be workshared
- Presortation allows for a more efficient division of mail preparation
- Is also associated with many other advantages
  - Bulk entry, simplified weight-based payment, faster service, etc.

Selected Results – Elasticity Estimates

		(1)	(2)	(7)	(9)	(10)	SUM	Thress (USPS 2012)
(1)	First-Class Single-Piece Letters Flats and Cards	-0.846	0.147	0.001	0.134	0.050	-0.285	-0.189 (L) -0.063 (C)
(2)	First-Class PreSort Letters Flats and Cards	0.137	-0.878	0.001	0.152	0.057	-0.268	-0.436 (L) -0.292 (C)
(7)	Periodicals (In County)	0.29	0.367	-2.92	0.356	0.162	-0.871	-0.122
(9)	Standard Non Carrier Route Letters Flats and Cards	0.178	0.212	0.002	-1.131	0.083	-0.251	-0.335 0.265 (NP)
(10)	Standard Carrier Route Letters, Flats and Cards	0.193	0.232	0.003	0.217	-1.441	-0.338	-0.789 -0.542 (NP)

Preliminary Conclusions

- We have found a model and methodology for estimating elasticities across all postal products
  - Statistical properties of the model are quite good
  - Signs of coefficients conform to expectations
- U.S. postal products are much more sensitive to demand than conventional models estimate
  - Conventional models yield estimates that combine the effects of own and all cross-price elasticities
- Results should be regarded as the early results of an initial exploration

Future Work

- Our application of the Random-Coefficient Discrete-Choice Normal mode leaves room for improvement
  - Could fit the model using quarterly data with post PAEA definitions of mail classes
  - Could include a broader set of demographic variables
  - Could include a broader set of hedonic properties
  - Efficiency of the estimation methodology could be improved through generalized least squares