Welfare analysis of equilibria with and without early termination fees in the U.S. wireless industry

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Introduction

Consumer Switching Costs

- Important in many contexts
  - Health Care, Energy, TV, Cell phone.
  - Can be endogenous and exogenous.
- Fixed and Exogenous
  - Fixed characteristic of consumers or market.
  - "Hassle" costs.
  - What can be done?
- Endogenous
  - Imposed by one of the parties.
  - A choice as opposed to a fixed characteristic.
  - Strategic.

Introduction

- We empirically investigate endogenous switching costs
- Firm Imposed Termination Fees
  - cable / satellite TV,
  - home security,
  - gym membership.
- Who likes termination fees?
  - Restricts consumer choice.
  - Creates barrier to switching providers.
  - Anti-competitive?

Introduction

- A world without switching costs
  - Who would benefit if termination fees were banned?
  - Could this be an equilibrium without regulation?
- Context: U.S. wireless industry
  - Long term contracts,
  - Early Termination Fees (ETFs), and
  - Potential multiplicity of equilibria in the market.
- Empirical evidence:
  1. Major US carriers (simultaneously) eliminated their long term contracts.
  2. Cross-country comparison (2013)
     - In the U.S.: non-contract 25% vs contract 75%.
     - In the world: non-contract 77% vs contract 23%.

Introduction

- Theory
  - Investigate possibility of multiple equilibria.
- Empirics
  - Quantify welfare implications of these equilibria.
  - Dynamic model of consumer behavior with
    - switching costs (ETFs)
    - handset durability
    - persistent heterogeneity in consumer preferences.
  - Evaluate the effect of
    - switching costs (ETF)
    - handset durability

    on the equilibrium service fees, consumer and producer welfare.

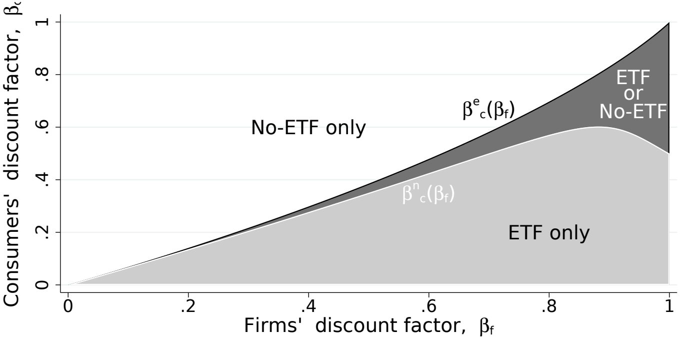
Theory: setup

- Two firms (Hotelling model).
- Discrete time, infinite horizon.
- Continuum of consumers.
- Utility flow of $\begin{cases} \delta - Cx_{it} - p_{1t}, & \text{if consume 1,} \\ \delta - C(1 - x_{it}) - p_{2t}, & \text{if consume 2.} \end{cases}$ where
  - $\delta > 0$ is a constant quality parameter,
  - $C > 0$ is the transport cost parameter,
  - p_{1t} is the price set by firm 1 in period t, and
  - $x_{it} \in [0, 1]$ is consumer i's type in period t (iid Uniform)
- Consumers' outside option is normalized to 0.
- Consumers discount future at rate $\beta_c \in [0, 1)$.
- We assume δ is sufficiently high, so the market is always covered.

Theory: setup

- Firms are symmetric, operate with a CRS technology, discount future at rate $\beta_f \in [0, 1)$, and choose
  - service fees
  - whether to use ETFs.
- If a firm uses ETF, any consumer buying from it will do so in all subsequent periods.
- At $t = -1$ firms simultaneously decide (once and for all) whether to use ETFs.

Theory: predictions



Proposition 1. Let $(\beta_c, \beta_f) \in [0,1)^2$. Then:

- (n, n) is an equilibrium if and only if $\beta_c \geq \beta_c^n(\beta_f)$ (white line).
- (e, e) is an equilibrium if and only if $\beta_c \leq \beta_c^e(\beta_f)$ (black line).
- (n, e) and (e, n) are equilibria if and only if $\beta_f = \beta_c = 0$.

For every $\beta_f > 0$, the set of β_c's such that equilibria (n, n) and (e, e) coexist is an interval with non-empty interior.

Theory: results

Our theory model suggests coexistence of two equilibria:

1) ETF (all firms offer long-term contracts subject to ETFs).
2) No-ETF (none of the firms charge ETFs).

Under ETFs

- equilibrium service fees are lower
- consumer surplus is higher
- producer profits are lower
- allocative efficiency is worse under ETF.

Theory: intuition

- If quality levels are sufficiently negatively correlated:
  (1) static model ⇒ set of independent Bertrand equilibria;
  (2) in dynamic model consumers buy sequences of utility flows;
  (3) products appear more similar when sold in bundles; therefore
  (4) firms ability to set higher prices is limited under ETF.
- When ETFs are eliminated, products become "more differentiated" and markups increase.
  - Size of price increase depends on the correlation in quality covariates across service providers.
  - We use empirical model to infer the level of correlation in product quality across providers over time.

Empirical model

- We use an empirical model to investigate further and quantify these predictions.
- Setup of the demand-side model
  - *Discrete time*: $t = 0, \dots, \infty$.
  - *Consumers*: $i = 1, \dots, N$, with random preferences ω_i.
  - *Products*: $j \in \mathcal{J}_t \subseteq (\mathcal{H}_t \times \mathcal{C}) \cup \{o\}$, where $\mathcal{H}_t$ and $\mathcal{C}$ are sets of hardware and carriers.
  - *Holdings*: $e = (j, \tau)$, τ time of the most recent purchase.
  - *Decisions*: $d_{it} \in \mathcal{J}_t$ or $d_{it} = \varnothing$ if no active decisions.
  - Let P_{jt} denote handset price, p_e service fee, F_{et} early termination fees, $\alpha_{ip} \in \omega_i$ price sensitivity, and define
    - $\eta_i(e, t) \equiv \mathbb{1}\left(t - \tau < \mathcal{T}\right) \alpha_{ip} F_{et}$, where $\mathcal{T}$ is contract length.

Empirical model

- Setup of the demand-side model
  - *Per-period utility function*:

$$U_i(d, e, t, X_t, \bar{\varepsilon}_t) = \begin{cases} \delta^f(x_{et}, \xi_{et}, \omega_i) + \varepsilon_{iet} - \alpha_{ip} p_e, & \text{if } d = \varnothing, \\ \delta^f(x_{dt}, \xi_{dt}, \omega_i) + \varepsilon_{idt} - \alpha_{ip} p_{(d,t)} - \eta_i(e,t) - \alpha_{ip} P_{jt}, & \text{otherwise.} \end{cases}$$

where x and ξ are observed and unobserved product attributes.

  - *Information*: perfect foresight up to idiosyncratic shocks $\bar{\varepsilon}_{it} = (\varepsilon_{iet}, \varepsilon_{i0t}, \varepsilon_{i1t}, \ldots, \varepsilon_{iJ_t t})$, i.i.d. across everything.

Empirical model

- Consumer dynamic programming problem (i is omitted):

$$V(e,t,\varepsilon) = \max \left\{ \begin{array}{c} \delta^f_{et} + \varepsilon_{et} - \alpha_{ip} p_e + \beta \mathrm{E} V(e,t'), \\ \max_j \left[\delta^f_{jt} + \varepsilon_{jt} - \alpha_{ip} p_{(d,t)} - \eta(e,t) - \alpha_{ip} P_{jt} + \beta \mathrm{E} V((j,t),t') \right] \end{array} \right\},$$

where

$$t' = \begin{cases} t+1, & \text{if } t < T, \\ T & \text{otherwise}, \end{cases}$$

and

$$\mathrm{E}V\left((j,\tau),t\right) \equiv \int \cdots \int V((j,\tau),t,\varepsilon) dF(\bar{\varepsilon}).$$

- Terminal period T: assume the market stops evolving (we provide robustness checks).
- *Note:* not a "Markovian" model (e.g., Melnikov 2013, Gowrisankaran and Rysman 2012).

Estimation algorithm

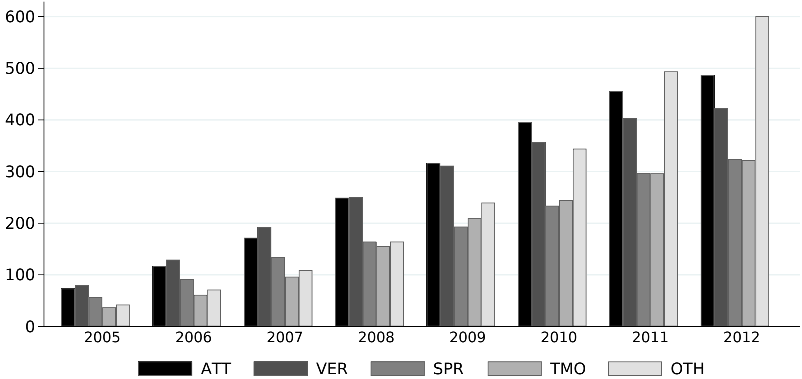
- Fix parameter values.
- Solve consumer dynamic programming problem.
- Invert ξ_{jt} by matching model predictions to observed data.
- Form moment conditions for GMM based on $\mathrm{E}[\xi_{jt}|Z_{jt}] = 0$.
- To identify type-specific preference parameters (e.g., type-specific price sensitivity) we include "micro-moments"
- Evaluate GMM criterion function, repeat to minimize it.

Data

- Survey by *comScore Inc.* from Q1 2005 to Q3 2012.
  - random sample of about 36,000 cell phone users per quarter;
  - questions about h-set price, current carrier calling plan, demographic characteristics of the individual, previous carrier, etc.
  - The sample of consumers is weighted and balanced to match national number of subscribers and demographic characteristics.
- Extensive database of handset characteristics.
- Data on ETFs from carriers

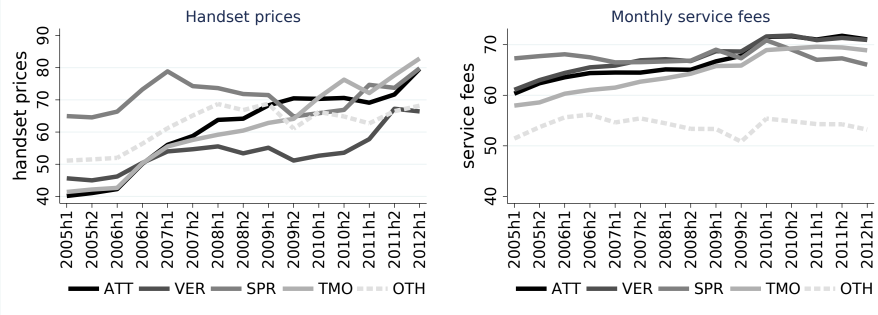
Data

Figure: Number of handsets by carrier-year, 2005-2012



Data

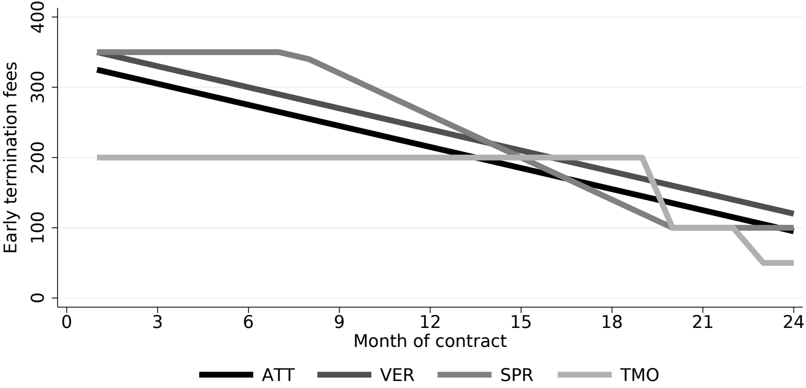
Figure: Average handset prices (left) and service fees (right) by carrier-year, 2005-2012



Note: reported handset prices are weighted by the number of respondents

Data

Figure: ETF Schedule by Carrier, 2012



Data

Table: Selected handset characteristics

variable name	variable name
Smartphone (y/n)	GPS (y/n)
Built-in storage (y/n)	Email (y/n)
JAVA version (MIDP 2.0, Dalvik, etc.)	Full-keyboard (y/n)
Bluetooth (y/n)	GPRS (y/n)
Infrared (y/n)	IM (y/n)
Display width	MMS (y/n)
Display height	MPEG-4 (y/n)
Display color (65,536; B&W, etc.)	Formfactor (Candybar, Slider, etc.)
Audio type (Realtones, Monophonic, etc.)	Release date (year/q)
GSM (y/n)	OS type (Microsoft, Symbian, etc.)
CDMA (y/n)	Camera resolution (mgp)

Instrumental variables

- It is likely that firms observe ξ_{jt}, $\implies$
  - handset prices, and
  - service fees

  are likely to be endogenous.

- We worry much less about the ETFs because they
  - change very infrequently,
  - chosen for large sets of products.

- Use observed handset characteristics to define "similar"
  - IV1 = number of similar products offered by other carriers,
  - IV2 = avg age of similar products,
  - IV3 = avg consumer satisfaction by similar products, and
  - IV4 = total number of devices by the same OEM.

Results

Table: Static vs dynamic estimates and elasticity predictions

parameter	parameter estimates	
	(1) Static	(2) Dynamic
price coefficient, α_p	-9.574	-8.163
(s.e.)	(2.846)	(3.014)
carrier-time fixed effects	yes	yes
handset fixed effects	yes	yes
service fee elasticity		
average	-3.477	-2.967
median	-3.558	-3.033
standard deviation	0.981	0.838
handset price elasticity		
average	-0.618	-0.524
median	-0.484	-0.410
standard deviation	0.478	0.404
Sargan stat/Hansen's J-stat	2.475	0.841
(p-value)	(0.480)	(0.359)

Results

Table: Monthly churn rates and revenues from ETFs by carrier

carrier	churn rates			ETF-revenues/subscriber		
	mean	median	st.dev.	mean	median	st.dev.
ATT	0.03	0.03	0.00	3.76	3.71	0.63
OTH	0.01	0.01	0.00	1.28	1.29	0.40
SPR	0.02	0.02	0.00	2.73	2.77	0.28
TMO	0.01	0.01	0.00	1.87	1.92	0.29
VER	0.03	0.04	0.01	4.70	4.62	0.94
Average	0.02	0.02	0.01	2.87	2.77	1.36

Notes: Revenues from ETFs are provided at monthly level assuming market size of one.

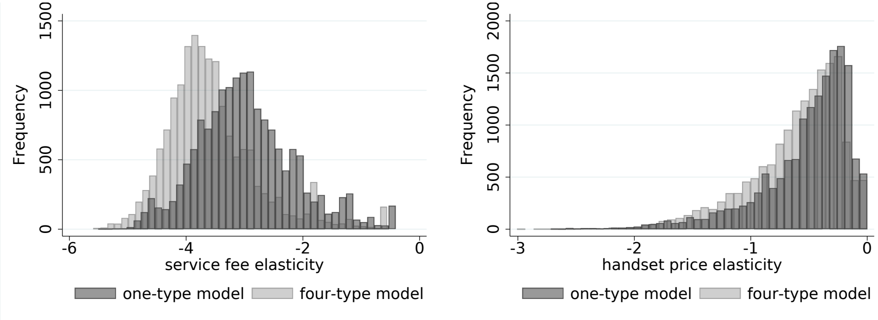
Results

Table: Estimation results for heterogeneous consumers

type	(1) income	(2) age	(3) age < 45	age ≥ 45
income, $< 50K$	-8.777		-10.483	-12.953
(s.e.)	(2.103)		(2.246)	(2.239)
income, $\geq 50K$	-7.805		-5.283	-11.152
(s.e.)	(2.102)		(2.043)	(2.248)
age, < 45		-7.068		
(s.e.)		(2.151)		
age, ≥ 45		-9.759		
(s.e.)		(2.165)		
carrier-time dummy	yes	yes	yes	
handset dummy	yes	yes	yes	
Hansen J-stat	1.419	1.357	2.526	
(p-value)	(0.492)	(0.507)	(0.283)	

Results

Figure: Own service fee elasticity for one- and four-type models



Partial equilibrium analysis

- To address our research question within a partial equilibrium we fix service fees at observed level.
- We simulated three counterfactual scenarios based on whether a handset is purchased or "rented" and whether there are ETFs:
  - Purchase a handset, No-ETFs (only durability);
  - Rent a handset, ETFs (only switching costs);
  - Rent a handset, No-ETFs (no dynamics).

... and evaluated them against observed (Purchase, ETFs).

- Rental prices are obtained assuming handset value depreciation rate of 0.28 per period.

Partial equilibrium analysis

Table: Consumer welfare and market shares relative to the observed outcomes, one-type model.

ETFs	handset	mean	p50	min	max	sd
counterfactual scenario						
		change in value functions				
No	purchased at obs. prices	0.76	0.73	0.67	0.98	0.05
No	purchased at new prices	0.48	0.47	0.38	0.68	0.04
No	rented	1.16	1.13	1.02	1.43	0.06
Yes	rented	0.19	0.19	0.16	0.21	0.01
ETFs	handset	change in market shares				
No	purchased at obs. prices	0.48	0.45	-0.76	2.25	0.35
No	purchased at new prices	0.63	0.63	-0.89	3.97	0.59
No	rented	0.70	0.41	-0.87	18.50	1.08
Yes	rented	0.31	0.12	-0.60	8.01	0.68

Partial equilibrium analysis

Table: Change in service fees offsetting consumer gains from ETF elimination, %

type of compensating change	one-type	four-type
$\uparrow$ in service fees at obs. h-set prices	42.59	41.21
$\uparrow$ in service fees at new h-set prices	31.70	29.60

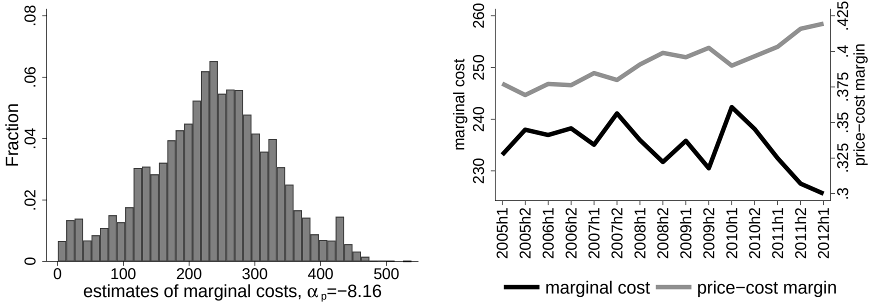
Notes: offsetting price increases are computed such that the differences between consumer value functions before the ETF elimination and consumer value functions after the ETF elimination with corresponding proportional change in service fees are zero on average.

Full Equilibrium: supply side

- We recover supply side cost structure assuming open-loop equilibrium where firms
  - can predict future values of their marginal costs,
  - set all prices simultaneously at the beginning of the game,
  - all prices are observed by the consumers.
- Four major service providers maximize joint profits from all of their products in all time periods.
- Small carriers (group "Other") also maximize joint profit.
- The firms must take into account the fact that a change in price at t affects the demand in all periods (both before and after t).

Full Equilibrium: cost structure

Figure: Marginal costs and price-cost margins



Note: averaged across products, negative values of marginal costs excluded.

Full Equilibrium: consumer welfare

Table: Changes in consumer value functions after ETF elimination

	factual $\mathrm{E}[V_i]$		No ETF, old prices			No ETF, new prices		
carrier	level	$ value	level	$ value	% dif.	level	$ value	% dif.
ATT	19.2	2,349	33.7	4,133	75.9	32.1	3,935	67.5
OTH	19.0	2,329	33.6	4,110	76.5	32.0	3,914	68.1
SPR	19.2	2,358	33.8	4,142	75.7	32.2	3,944	67.2
TMO	19.1	2,342	33.7	4,125	76.1	32.1	3,928	67.7
VER	19.2	2,358	33.8	4,141	75.7	32.2	3,943	67.2
Average	19.16	2,347	33.7	4,130	76.0	32.1	3,932.3	67.5

Full Equilibrium: carrier welfare

Table: Wireless carriers' profits under alternative scenarios

Profit sources and comparison	ATT	OTH	SPR	TMO	VER
	Factual				
Profits from service fees	15.30	4.06	9.22	5.97	20.23
Revenues from ETF payments	14.19	4.71	10.72	7.11	17.59
	No ETF, old prices				
Profits from service fees	20.97	6.55	15.56	10.05	27.19
Revenues from ETF payments	0.00	0.00	0.00	0.00	0.00
	No ETF, new prices				
Profits from service fees	22.98	7.32	17.13	11.16	29.43
Revenues from ETF payments	0.00	0.00	0.00	0.00	0.00
% of factual without ETF payments	149.90	183.38	183.96	188.83	146.13
% of factual with ETF payments	77.92	83.47	85.91	85.32	77.82
% of No ETF, old prices	109.59	111.76	110.09	111.04	108.24
ETF costs if "No-ETF" profitable	6.51	1.45	2.81	1.92	8.39

Notes: profits are computed for market of size one.

Full Equilibrium: profit max assumption for Other

Table: Service fees under individual vs joint maximization for OTH

carrier	average service fees			% change in service fees		
	(1) factual	(2) joint	(3) individual	(1) vs (2)	(1) vs (3)	(2) vs (3)
ATT	375.88	390.70	390.37	4.25	4.16	-0.09
OTH	311.85	318.54	307.19	2.32	-1.58	-3.78
SPR	363.89	376.90	376.70	3.76	3.70	-0.06
TMO	380.41	390.18	390.02	2.75	2.70	-0.05
VER	384.86	404.39	403.99	5.44	5.33	-0.10
Avg.	363.38	376.14	373.66	3.70	2.86	-0.82

Conclusions/Discussion

- Theoretical possibility that ETF and No-ETF equilibria coexist
  - ETF are not necessarily harmful to consumers.
  - No-ETF equilibrium can be more profitable for the firms.
  - Correlations in competitors' quality over time is important.
- Partial equilibrium counterfactuals
  - consumer welfare ↑ by 76% (old P_{jt}) and 48% (new P_{jt})
  - consumers better off if service fees increase by less than 32%
- Full equilibrium counterfactuals
  - Service fees increase by 2 to 5% on average.
  - Consumers are 68% better off than under ETFs.
  - Firms' profits from service fees increase by 50 to 89%.
  - Accounting for ETF payments, costs of processing these payments should be $1.45 (small providers) to $8.39 (Verizon) for carriers to be better off without ETFs.

Gowrisankaran, G. and Rysman, M. (2012). Dynamics of consumer demand for new durable goods. *Journal of Political Economy*, 120(6):1173–1219.

Melnikov, O. (2013). Demand for differentiated durable products: the case of the U.S. computer printer market. *Economic Inquiry*, 51(2):1277–1298.