

ECO 2901

EMPIRICAL INDUSTRIAL ORGANIZATION

Lecture 8: Entry, Exit, Preemption, and Cannibalization in Retail Industries

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Lecture 8: Entry, Exit, Preemption, and Cannibalization in Retail Industries

1. Holmes (ECMA, 2011):
The diffusion of Walmart and economies of density
2. Igami and Yang (QE, 2016):
Cannibalization and preemptive entry of hamburger chains in Canada

1. Holmes (2011): The Diffusion of Walmart and Economies of Density

Motivation

- For a retail chain, what is the optimal location of its new stores?
- Tradeoff between **cannibalization** and **economies of density**.
- **Cannibalization**: A proportion of customers for the new stores may come from the chain's pre-existing stores.
 - This increases with proximity to pre-existing stores.
- **Economies of density**: Given a number of stores, there are costs savings with the density (proximity) between stores.
 - Logistics of deliveries and inventories: — Save on trucking costs; Facilitates just-in-time inventory approach
 - Management: Single regional manager; Flexibility in labor relocation
 - ...

Motivation [2]

- The main purpose of this paper is to **identify the magnitude of economies of density for Walmart**.
- Why is this an important economic question?
 - ◇ Understand the patterns of **geographic diffusion of a new business format** [using the largest retail chain in US].
 - ◇ **Antitrust**: To measure some costs of **divesting Walmart**.
 - ◇ Understand the (increasing) **agglomeration of economic activity**.

Empirical Strategy

- First, measure cannibalization effects from the estimation of a **consumer demand system** for the choice of department store.
- Second, measure Walmart's costs (variable, fixed, and entry costs) and the impact of economies of density in these costs from the estimation of a **dynamic structural model of market entry and store location decisions**.
- Revealed preference approach.

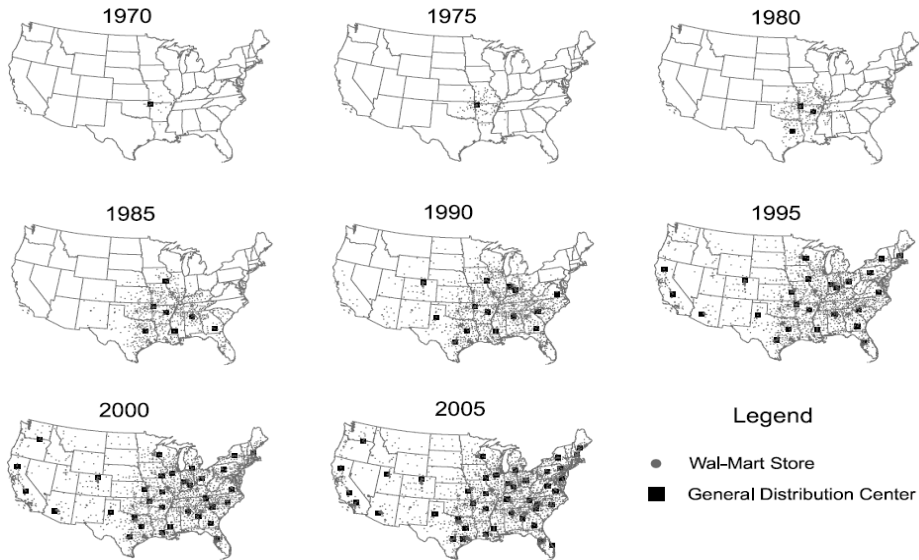
Data

- Geographic **location and opening date** of every Walmart store and every Walmart distribution center: 1962-2005.
- **Store-level data** from year 2005 (Source: AC Nielsen): Annual Sales; Employment; Store Size.
- **Firm-level data.** Annual Reports. Annual sales.
- **Population census demographics** at the census block level: Population density; Per capita income; Age distribution; Ethnic composition.
- **Wages** (at the county level) **and rents.**

Data [2]

- The 2006 annual report also provides a Walmart's own estimate of cannibalization effects

*"As we continue to add new stores in the United States, we do so with an understanding that additional stores may take sales away from existing units. We estimate that in fiscal years 2004, 2003, 2002 sales of pre-existing stores were negatively impacted by the opening of new stores by **approximately 1%**"*



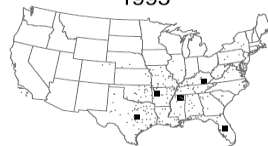
1990



1992



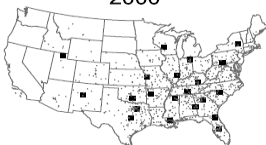
1995



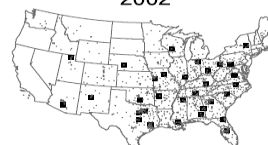
1997



2000



2002



2005



Legend

- Supercenter
- Food Distribution Center

Model: Consumer Demand

- Consumers are distributed geographically in L locations (census blocks) indexed by ℓ .
- $H_{\ell t} = \#$ consumers living in location ℓ at period t . Located at the *centroid* of the block.
- Consumers by two types of product categories: groceries (*gro*), and general merchandises (*gen*).
- Each consumer expends (in \$) λ^{gro} and λ^{gen} in these product categories.
- A consumer chooses where to purchase these two products.
- This discrete choice is modeled as a Nested Logit demand model.

Model: Nested Logit Demand Model

- The set of choice alternative for consumers in (ℓ, t) are:
 - All Walmarts within 25 miles of block ℓ . (indexed by j)
 - An outside composite choice that represents all the other retail alternatives ($j = 0$).

- Utility for consumer i if choosing the outside alternative:

$$u_{i0\ell t} = \gamma_0 + \gamma_1 \ln(m_{\ell t}) + \gamma'_z z_{\ell t} + \varepsilon_{i0\ell t}^{(1)}$$

- Utility for consumer i if choosing the Walmart store j :

$$u_{ij\ell t} = \gamma_d \text{ distance}(\ell, j) + \gamma'_x x_j + \varepsilon_{ij\ell t}^{(1)} + (1 - \sigma) \varepsilon_{ij\ell t}^{(2)}$$

- $m_{\ell t}$ represents population density within 5 mile radius. The utility from the outside alternative increases with density.

- Note: no prices.

Model: Aggregate demand and revenue

- Walmart stores can be regular (only general merchandise) or supercenters (also groceries).
- Aggregate revenue Walmart **regular store** if located in :

$$R_{jt} = R_{jt}^{gen} = \sum_{\ell \in B(j)} H_{\ell t} \lambda^{gen} s_{j\ell t}^{gen}$$

- Aggregate revenue for Walmart **supercenter store** j :

$$R_{jt} = R_{jt}^{gen} + R_{jt}^{gro} = \sum_{\ell \in B(j)} H_{\ell t} \left[\lambda^{gen} s_{j\ell t}^{gen} + \lambda^{gro} s_{j\ell t}^{gro} \right]$$

$s_{j\ell t}^{gen}$ and $s_{j\ell t}^{gro}$ are the market shares of store j for consumers living in ℓ .

- These market shares capture the cannibalization effect: they decline with the density of Walmart stores in the region.

Model: Variable Profit

- Variable profit of a store if located in ℓ :

$$VP_{\ell t} = (\mu - v_{Labor} w_{\ell t} - v_{Land} r_{\ell t}) R_{\ell t}^{gen}$$

μ , v_{Labor} , and v_{Land} are parameters.

$w_{\ell t}$ = average retail wage in the county.

$r_{\ell t}$ = average commercial rent in the county.

- The term $\mu - v_{Labor} w_{\ell t} - v_{Land} r_{\ell t}$ the price-cost margin. It is based on two assumptions:
 - Constant proportions (Leontief) technology in Labor and Land: v_{Labor} and v_{Land} are the intensities of these inputs.
 - Walmart's average price is the same in every market.
- Note: No economies of density in variables costs.

Model: Fixed Costs & Economies of Density

- The fixed cost of store has two components:

$$FC_{\ell t} = f_{\ell t} + \tau d_{\ell t}^{DC}$$

- $f_{\ell t}$: exogenous fixed and does not depend on economies of scope:

$$f_{\ell t} = \omega_0 + \omega_1 \ln(m_{\ell t}) + \omega_2 \ln(m_{\ell t})^2$$

- $\tau d_{\ell t}^{DC}$ is the distribution cost and it depends on $d_{\ell t}^{DC}$ = Distance to the nearest distribution center.

Model: Fixed Costs & Economies of Scale

- We should expect a component of the fixed cost to depend on the number of stores.
- This component is implicit in all the analysis of this paper. However, the paper does not study, specifies, or estimate economies of scale.
- We will see later how the estimation approach avoids dealing with (dis)economies of scale in the total number of stores.
paper avoids

Model: Entry and Store Location Decisions

- Let $a_{\ell t}^g \in \{0, 1\}$ = indicator "Walmart has store type g in block ℓ at t ". Every period t , Walmart decides $\mathbf{a}_t$ to maximize its expected intertemporal value:

$$\mathbb{E}_t \left(\sum_{s=0}^T \beta^s \left[\sum_{\ell=0}^L a_{\ell t}^{gen} \Pi_{\ell t}^{gen} + a_{\ell t}^{gro} \Pi_{\ell t}^{gro} \right] \right)$$

- Store opening decisions are irreversible** (very large exit cost). This is the only source of dynamics in this model. Therefore, a key restriction is:

$$\mathbf{a}_t \geq \mathbf{a}_{t-1}$$

- Walmart's strategy is a function σ such that ($\mathbf{z}_t$ is the vector with exogenous location characteristics):

$$\mathbf{a}_t = \sigma(\mathbf{a}_{t-1}, \mathbf{z}_t)$$

such that σ maximizes the Walmart's value at any state $(\mathbf{a}_{t-1}, \mathbf{z}_t)$.

Model: Dimensionality of the Problem

- The dimension of the set of $\mathbf{a}_{t-1}$ – both the state space and the action space – is 2^L , where $L \simeq 11$ million is the number of census blocks in US: $2^L \simeq 10^{1,000,000}$.
- Solving exactly this DP problem is impractical.
- The irreversibility of the entry decisions implies that we cannot use "finite dependence properties" of some DP problems that generate optimality conditions involving profits at a small number of period (e.g., two consecutive periods).
- Holmes uses Monte Carlo simulation methods to approximate the Value of Walmart, V_σ , under the actual σ observed in the data (σ_{obs}) and under some hypothetical / counterfactual σ 's (σ^*). Then, he uses the inequalities:

$$V_{\sigma,obs} \geq V_{\sigma^*}$$

to estimate the structural parameters in costs.

Estimated Demand Parameters

PARAMETER ESTIMATES FOR DEMAND MODEL

Parameter	Definition	Unconstrained	Constrained (Fits Reported Cannibalization)
λ^g	General merchandise spending per person (annual in \$1,000)	1.686 (.056)	1.938 (.043)
λ^f	Food spending per person (annual in \$1,000)	1.649 (.061)	1.912 (.050)
ξ_0	Distance disutility (constant term)	.642 (.036)	.703 (.039)
ξ_1	Distance disutility (coefficient on $\ln(\text{Popden})$)	-.046 (.007)	-.056 (.008)
α	Outside alternative valuation parameters		
	Constant	-8.271 (.508)	-7.834 (.530)
	$\ln(\text{Popden})$	1.968 (.138)	1.861 (.144)
	$\ln(\text{Popden})^2$	-.070 (.012)	-.059 (.013)
	Per capita income	.015 (.003)	.013 (.003)
	Share of block group black	.341 (.082)	.297 (.076)
	Share of block group young	1.105 (.464)	1.132 (.440)
	Share of block group old	.563 (.380)	.465 (.359)
γ	Store-specific parameters		
	Store age 2+ dummy	.183 (.024)	.207 (.023)
σ^2	Measurement error	.065 (.002)	.065 (.002)
N		3,176	3,176
Sum of squared error		205.117	206.845
R^2 (Likelihood)		.755 -155.749	.753 -169.072

Estimated Demand: Parameter estimates

- Outside good is better in more dense areas.
- Utility decreases in distance traveled to a Walmart.
- See Table in next slide for the magnitude of the effects of Distance and Pop density.
- Non-linearity of the effect of distance: from 5 to 10 miles.
- Estimates of λ^{gen} and λ^{gen} can be compared to aggregate statistics from national consumer surveys.
 - In 2005, \$1,800 per capita in general merchandise stores (NAICS 452)
 - In 2005, \$1,800 per capita in food & beverages stores (NAICS 445).

Effect of "Distance to Closest Walmart" & "Pop Dens"

* Benchmark (Distance = 0 and Density = 1): Rural household besides a Walmart store.

COMPARATIVE STATICS WITH DEMAND MODEL^a

Distance (Miles)	Population Density (Thousands of People Within a 5-Mile Radius)						
	1	5	10	20	50	100	250
0	.999	.989	.966	.906	.717	.496	.236
1	.999	.979	.941	.849	.610	.387	.172
2	.997	.962	.899	.767	.490	.288	.123
3	.995	.933	.834	.659	.372	.206	.086
4	.989	.883	.739	.531	.268	.142	.060
5	.978	.803	.615	.398	.184	.096	.041
10	.570	.160	.083	.044	.020	.011	.006

Estimated Demand: Implied Cannibalization

- Calculate what sales would be in a particular year for preexisting stores if no new stores were opened in the year: $\widehat{Sales}_t(\text{without new stores})$.
- Calculate predicted sales to preexisting stores when the new store openings for the particular year take place: $\widehat{Sales}_t(\text{with actual new stores})$.
- Define:

$$Cannibalization\ Rate_t = 100 * \frac{\widehat{Sales}_t(\text{without new stores})}{\widehat{Sales}_t(\text{with actual new stores})}$$

- The estimate demand model (unrestricted) does a good job in generating cannibalization rates close to Walmart's self-reported 1%.
- By Revealed Preference, the larger the Cann. rate Walmart is willing to tolerate, the larger the estimated Econ of Density. To get a lower bound on Econ. Dens., Holmes restricts Cann. Rate = 1% in 2005.

Cannibalization from Estimated Demand

CANNIBALIZATION RATES, FROM ANNUAL REPORTS AND IN MODEL^a

Year	From Annual Reports	Demand Model (Unconstrained)	Demand Model (Constrained)
1998	n.a.	.62	.48
1999	n.a.	.87	.67
2000	n.a.	.55	.40
2001	1	.67	.53
2002	1	1.28	1.02
2003	1	1.38	1.10
2004	1	1.43	1.14
2005	1	1.27	1.00 ^b

^aSource: Estimates from the model and Wal-Mart Stores, Inc. (1971–2006) (Annual Reports 2004, 2006).

Incremental sales of each new store

- Given the estimated demand, we can measure the (counterfactual) **incremental revenue generated by each new store j** (opened at period t), ΔR_{jt}^* :

$$\Delta R_{jt}^* \equiv [\text{Total annual revenue of Walmart at } t \text{ with opening of } j] \\ - [\text{Total annual revenue of Walmart at } t \text{ if } j \text{ had not been opened}]$$

- We can also obtain the (counterfactual) **incremental sales if the new store were a stand-alone operation** (no other Walmart stores in the vicinity): ΔR_{jt}^{alone} .
- Cannibalization implies that $\Delta R_{jt}^{alone} \geq \Delta R_{jt}^*$. The difference:

$$\Delta R_{jt}^{alone} - \Delta R_{jt}^* = \$41.4M - \$36.3M \simeq \$5.1M$$

informs about the magnitude of economies of density.

- Note: $\$5.1/\$41.4 = 12\%$. This is not inconsistent with the 1% Cann rate (see paragraph on page 275).

INCREMENTAL AND STAND-ALONE VALUES OF NEW STORE OPENINGS^a

	<i>N</i>	Incremental Sales	Operating Profit	Incremental Distribution Center Distance (Miles)	Stand-Alone Sales	Stand-Alone Operating Profit
Part A: General Merchandise (New Wal-Marts Including Supercenters)						
All	3,176	36.3	3.1	168.9	41.4	3.6
By state's Wal-Mart age at opening						
1-2	288	38.0	3.5	343.3	38.7	3.6
3-5	614	39.5	3.5	202.0	41.5	3.7
6-10	939	37.6	3.3	160.7	40.9	3.6
11-15	642	36.1	2.9	142.1	42.2	3.4
16-20	383	32.9	2.8	113.7	41.2	3.5
21 and above	310	29.5	2.4	90.2	44.4	3.6
Part B: Food (New Supercenters)						
All	1,980	40.2	3.6	137.0	44.8	4.0
By state's Wal-Mart age at opening						
1-2	202	42.4	3.9	252.9	43.9	3.9
3-5	484	42.7	4.0	171.2	44.7	4.1
6-10	775	41.0	3.6	113.5	45.3	4.0
11-15	452	36.7	3.2	95.3	45.3	3.9
16-20	67	30.1	2.8	94.0	38.6	3.5

^aAll evaluated at 2005 demand equivalents in millions of 2005 dollars.

Estimation of Fixed Cost Parameters from Dyn. Model

- The remaining parameters to estimate are the fixed cost parameters: ω_0 , ω_1 , and τ .
- Holmes uses a **moment inequality approach**.
- Let $\theta = (1, \omega_0, \omega_1, \tau)'$. The intertemporal value of Walmart at period t (under the observed actions σ_{obs}) is:

$$\mathbf{x}_t^{\sigma_{obs}} \theta + \eta_t^{\sigma_{obs}}$$

where $\mathbf{x}_t^\sigma$ is a vector of present values.

- We can construct this present values under alternative actions (policies) different to the observed ones. Let σ be this alternative policy, with value $\mathbf{x}_t^\sigma \theta + \eta_t^\sigma$.

Estimation of Fixed Cost Parameters [2]

- Optimality implies that for any σ :

$$[\mathbf{x}_t^{\sigma_{obs}} - \mathbf{x}_t^{\sigma}] \theta + \eta_t^{\sigma_{obs}} - \eta_t^{\sigma} \geq 0$$

- And the following moment inequalities. For any vector of function of the state variables $h(\mathbf{a}_{t-1}, \mathbf{z}_t)$ that is positive valued:

$$\mathbb{E} \left(h(\mathbf{a}_{t-1}, \mathbf{z}_t) [\mathbf{x}_t^{\sigma_{obs}} - \mathbf{x}_t^{\sigma}] \theta \right) \geq 0$$

- Given K of these instruments and S alternative policies σ , the estimator is:

$$\hat{\theta} = \arg \min_{\theta} \sum_{k=1}^K \sum_{s=1}^S \min \{0 ; h_k(\mathbf{a}_{t-1}, \mathbf{z}_t) [\mathbf{x}_t^{\sigma_{obs}} - \mathbf{x}_t^{\sigma_s}] \theta\}^2$$

Selection of Deviation Policies σ

- For this model, approximating the present values $\mathbf{x}_t^{\sigma_s}$ is computationally very costly.
- It is feasible to implement only very few alternative policies σ_s . Therefore, it is important to "design" these alternative policies in a way that they can be as informative as possible about the structural parameters ω_0 , ω_1 , and τ .
- Holmes considers the following deviation σ_s .
- Restrict attention to **pairwise resequeing**: opening dates of pairs of stores are reordered.
 - * If store number 1 actually opened in 1962 and number 2 opened in 1964, a pairwise resequeing would be to open store number 2 in 1962, store number 1 in 1964, leaving everything else the same.

Selection of Deviation Policies σ [2]

- Holmes consider 12 deviations σ^s that belong to three different "groups"
 - according to the intuition for the target identification

Store density decreasing; Store density increasing; Population density changing

- **“Store density decreasing” deviations.**

- Actual choice: at some early time period (t) there was a new store (j) near the pre-existing stores; at a later period (t') there was a store opening (j') that at period t would have been far away from the cluster of preexisting store.

Deviation: swap the opening of j and j' : that is, j' is opened at period t , and j is opened at period t' .

- This deviation reduces the density of Walmart stores between periods t and t' .

Estimation Dynamic Model: Alternative Policies

SUMMARY STATISTICS OF DEVIATIONS BY DEVIATION GROUP

Deviation Group	Brief Description of Group	Number of Deviations	Mean Values			
			$\Delta \tilde{I}$ (Millions of 2005 Dollars)	ΔD (Thousands of Miles)	ΔC_1 (log Popden)	ΔC_2 (log Popden ²)
Store density decreasing						
1	$-.75 \leq \Delta D < 0$	64,920	-2.7	-.4	-.6	-3.0
2	$-1.50 \leq \Delta D < -.75$	61,898	-3.6	-1.1	-1.5	-9.0
3	$\Delta D < -1.50$	114,588	-4.7	-3.0	-3.4	-22.2
Store density increasing						
4	$0 < \Delta D \leq .75$	158,208	3.0	.3	-1.9	-17.2
5	$.75 < \Delta D \leq 1.50$	34,153	3.7	1.0	-3.6	-28.9
6	$1.50 < \Delta D$	16,180	5.9	2.1	-4.8	-37.7
Population density changing						
7	Class 4 to class 3	7,048	1.2	.0	3.2	31.1
8	Class 3 to class 2	10,435	3.7	.0	3.4	25.7
9	Class 2 to class 1	14,399	5.3	-.1	3.5	19.3
10	Class 1 to class 2	12,053	-2.4	.0	-3.4	-19.3
11	Class 2 to class 3	14,208	.6	-.1	-3.9	-29.4
12	Class 3 to class 4	14,877	2.5	.0	-4.6	-44.9
All	Weighted mean	522,967	-.2	-.6	-2.1	-15.6

Estimation Dynamic: Distribution Costs

BASELINE ESTIMATED BOUNDS ON DISTRIBUTION COST τ^a

	Specification 1 Basic Moments (12 Inequalities)		Specification 2 Basic and Level 1 (84 Inequalities)		Specification 3 Basic and Levels 1, 2 (336 Inequalities)	
	Lower	Upper	Lower	Upper	Lower	Upper
Point estimate	3.33	4.92	3.41	4.35	3.50	3.67
Confidence thresholds						
With stage 1 error correction						
PPHI inner (95%)	2.69	6.37	2.89	5.40	3.01	4.72
PPHI outer (95%)	2.69	6.41	2.86	5.45	2.97	5.04
No stage 1 correction						
PPHI inner (95%)	2.84	5.74	2.94	5.11	3.00	4.62
PPHI outer (95%)	2.84	5.77	2.93	5.13	2.99	4.97

^aUnits are in thousands of 2005 dollars per mile year; number of deviations $M = 522,967$; number of store locations $N = 3,176$.

Estimation Dynamic: Distribution Costs [2]

- Baseline estimate of $\tau = \$3,500$ per mile, store, and year.
- If all 5,000 Walmart stores were each **100 miles farther** from their distribution centers, Walmart's costs would increase by almost **\$2 billion per year**.
- Based on information on trucking costs (and back of the envelope calculation), Holmes estimate that this $\tau = \$3,500$ is approximately four times as large as the savings in trucking costs alone.
- Holmes interprets the additional component of τ as coming from the value of just-in-time inventory management (flexibility to respond to demand shocks), and managerial economies of density.

Summary & Conclusions

- Estimates of this paper show that public policies that would substantially constrain Walmart's store density would result in significant cost increases.
- The analysis does not take explicit account of the location of competitors but it is very implausible that competition explains Walmart's geographic pattern of expansion: Kmart, the leader in the 1970s and 80s ...
- More interestingly, the analysis ignores Walmart's preemption motive. This may play a role in Walmart's pattern of geographic expansion.

2. Igami and Yang (2016): Cannibalization and Preemptive Entry of Hamburger Chains in Canada
