ECO 2901
EMPIRICAL INDUSTRIAL ORGANIZATION

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

Victor Aguirregabiria (University of Toronto)

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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 and 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.

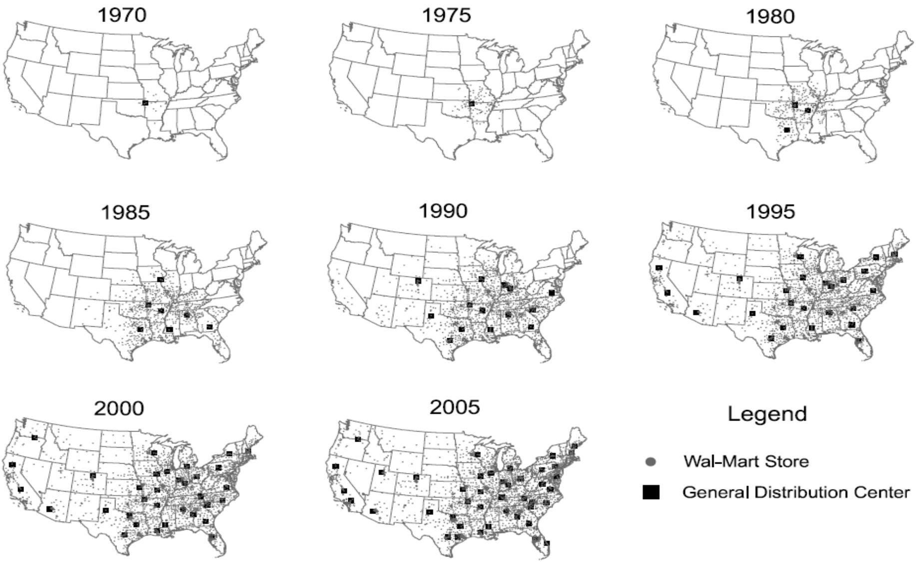
- **Population census demographics** at the census block level: Population density; Per capita income; Age distribution; Ethnic composition.

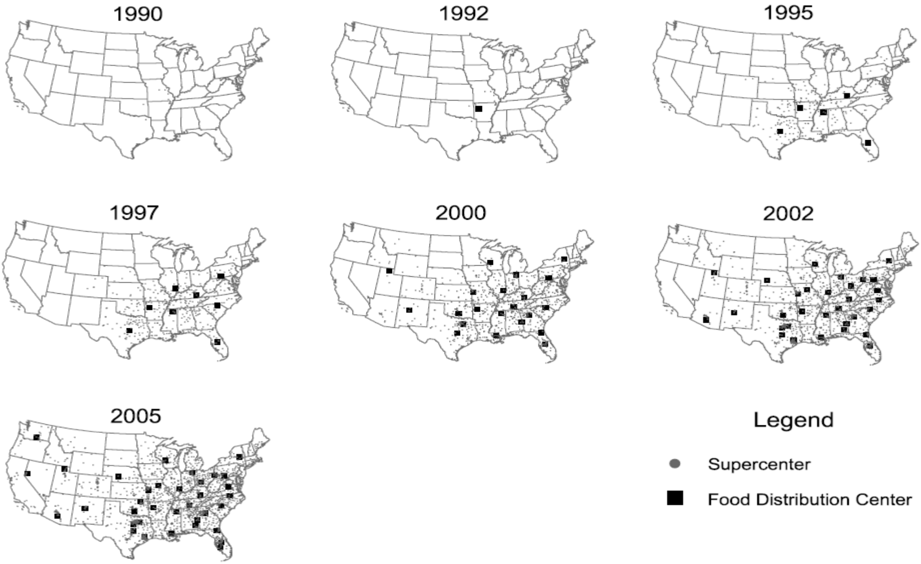
- **Wages** (at the county level) **and rents.**

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%***"*


1970
1975
1980
1985
1990
1995
2000
2005
Legend
Wal–Mart Store
General Distribution Center


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 buy 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:

$$\begin{aligned} u_{ij\ell t} &= -\xi_0 \text{ distance}\,(\ell, j) - \xi_1 \text{ distance}\,(\ell, j) * ln(m_{\ell t}) \\ &\quad +\gamma_x' \; x_j + \varepsilon_{i\ell t}^{(1)} + (1 - \sigma) \; \varepsilon_{ij\ell t}^{(2)} \end{aligned}$$

- $m_{\ell t}$ 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 :

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

• 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:

$$VP_{\ell t} = R_{\ell t} - VC_{\ell t} = R_{\ell t} - \left[CMer_{\ell t} + CLabor_{\ell t} + CLand_{\ell t} \right]$$

- $CMer_{\ell t}$ = Cost of Merchandise. Assumption:

$$\frac{R_{\ell t} - CMer_{\ell t}}{R_{\ell t}} = \frac{p - c}{p} = \mu \quad \text{(Gross margin)}$$

- $CLabor_{\ell t}$ = Cost of Labor. Assumption. The number of workers needed is proportional to the store's revenue.

$$CLabor_{\ell t} = w_{\ell t} \ L_{\ell t} = w_{\ell t} \ \upsilon_{Labor} \ R_{\ell t}$$

where υ_{Labor} is the number of workers per \$ of revenue.

- $CLandr_{\ell t}$ = Rental cost of land.

$$CLandr_{\ell t} = \upsilon_{Land} * ValueLand_{\ell t}$$

where υ_{Land} is the rental price as % of value of land.

Model: Variable Profit [2]

- Puting these pieces together, we have:

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

where $r_{\ell t} = \dfrac{ValueLand_{\ell t}}{R_{\ell t}^{gen}}$.

- Holmes has data on $w_{\ell t}$ and $r_{\ell t}$ at the store level, and he calibrates parameters μ, υ_{Labor}, and υ_{Land} using data from WalMart's annual reports.

$$\begin{cases} \mu = & \text{Gross margin} = & 24\% \\ \upsilon_{Labor} = & \#\text{ workers per million \$ sales} = & 3.61 \\ \upsilon_{Land} = & \text{Rental cost as \% of property value} = & 20\% \end{cases}$$

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:

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

- $\tau \ d_{\ell t}^{DC}$ 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 intertemporal value:

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

• **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):

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

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

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 Cannibalizatio
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($\underline{\text{Popden}}$))	−.046 (.007)	−.056 (.008)
α	Outside alternative valuation parameters		
	Constant	−8.271 (.508)	−7.834 (.530)
	ln($\underline{\text{Popden}}$)	1.968 (.138)	1.861 (.144)
	ln($\underline{\text{Popden}}$)^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		.755	.753
(Likelihood)		−155.749	−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: $\widehat{Sales}_t(without\ \ new\ \ stores)$.

- Calculate predicted sales to preexisting stores when the new store openings for the particular year take place: $\widehat{Sales}_t(with\ actual\ new\ stores)$.

- Define:

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

- 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 Mode (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]

[a]Source: Estimates from the model and Wal-Mart Stores, Inc. (1971–2006) (Annual Reports 2004, 2006).

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**.

• Holmes represents a strategy σ as the sequence of store opening choices from $t = 1$:

$$\sigma = \{\mathbf{a}_t : t = 1, 2, ..., \infty\}$$

• σ^{obs} represents the actual observed strategy (evolution), and σ is any other alternative strategy.

• If $V_t(\sigma)$ is the value of Walmart at period t, optimal behavior implies that for any $\sigma \neq \sigma^{obs}$:

$$V_t(\sigma^{obs}) - V_t(\sigma) \geq 0$$

Estimation of Fixed Cost Parameters [2]

- We can use the inequalities $V_t(\sigma^{obs}) - V_t(\sigma) \geq 0$ to form moment inequalities that provide partial (set) identification of structural parameters.

- In this model:

$$V_t(\sigma^{obs}) - V_t(\sigma) = y_t(\sigma) - \mathbf{x}_t(\sigma)\ \boldsymbol{\theta}$$

with $y_t(\sigma) = V_t^{\pi}(\sigma^{obs}) - V_t^{\pi}(\sigma)$:

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

Estimation of Fixed Cost Parameters [3]

- $\boldsymbol{\theta} = (\tau, \omega_0, \omega_1)$ and $\mathbf{x}_t(\sigma) = \left[V_t^d(\sigma^{obs}) - V_t^d(\sigma), \; V_t^{c1}(\sigma^{obs}) - V_t^{c1}(\sigma), \; V_t^{c2}(\sigma^{obs}) - V_t^{c2}(\sigma)) \right]$, with:

$$
\begin{array}{rcl}
V_t^d(\sigma) & = & \sum_{s=0}^{T} \beta^s \left[\sum_{\ell=0}^{L} a_{\ell t}(\sigma) \; d_{\ell t}^{DC}(\sigma) \right] \\
V_t^{c1}(\sigma) & = & \sum_{s=0}^{T} \beta^s \left[\sum_{\ell=0}^{L} a_{\ell t}(\sigma) \; \ln(m_{\ell t}) \right] \\
V_t^{c2}(\sigma) & = & \sum_{s=0}^{T} \beta^s \left[\sum_{\ell=0}^{L} a_{\ell t}(\sigma) \; \ln(m_{\ell t})^2 \right]
\end{array}
$$

Estimation of Fixed Cost Parameters [3]

- Let $\{z_{kt} : k = 1, 2, ..., K\}$ be K instruments with $z_{kt} \geq 0$ (e.g., predetermined state variables). For any (k, σ), at the true $\boldsymbol{\theta} = \boldsymbol{\theta}^0$:

$$m_{k,\sigma}(\boldsymbol{\theta}) = \mathbb{E}\left(z_{kt}\left[y_t(\sigma) - \mathbf{x}_t(\sigma)\ \boldsymbol{\theta}\right]\right) \geq 0$$

- Let $\widehat{m}_{k,\sigma}(\boldsymbol{\theta})$ be the sample counterpart of $m_{k,\sigma}(\boldsymbol{\theta})$:

$$\widehat{m}_{k,\sigma}(\boldsymbol{\theta}) = \left[\frac{1}{T}\sum_{t=1}^{T} z_{kt}\ y_t(\sigma)\right] - \left[\frac{1}{T}\sum_{t=1}^{T} z_{kt}\ \mathbf{x}_t(\sigma)\right]\boldsymbol{\theta}$$

- The estimation of the identified set Θ_I is:

$$\widehat{\Theta}_I = \text{set of } \arg\min_{\boldsymbol{\theta}} \sum_{k,\sigma} \min\left\{0\ ;\ \widehat{m}_{k,\sigma}(\boldsymbol{\theta})\right\}^2$$

Selection of Deviation Policies sigma

• How to choose the policies σ that deviate from σ^{obs}?

• 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 resequencing**: opening dates of pairs of stores are reordered.

* If store number 1 actually opened in 1962 and number 2 opened in 1964, a pairwise resequencing would be to open store number 2 in 1962, store number 1 in 1964, leaving everything else the same.

Selection of Deviation Policies sigma [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: $\Delta\tilde{\Pi}$ (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

TABLE VI

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

[a] Units 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