The Diffusion of Wal-Mart and Economies of Density

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Wal-Mart

- Has Revolutionized the process of getting goods from the factory into people's homes.

- McKinsey: "In general merchansise,... we found that Wal-Mart directly and indirectly caused the bulk of the productivity accelaration."

- Hausman and Leibtag: Supercenter food prices 15-25% lower than supermarkets

- Today look at one aspect of Wal-Mart's formula: *Economies of Density*.

Economies of Density: Cost savings achieved by having a dense network of stores.

- Sources:
  - Logistics of deliveries
  - Management
- In the United States Wal-Mart has always maintained density

How quantify benefits from density?

- In principle could do standard productivity analysis if data existed (but standard Census data wouldn't do even if available).

- Try a different approach that uses revealed preference to infer benefits of density.

Idea: Tradeoff between benefits of density and costs of cannibalization of sales

- Will show that in the course of this rollout, Wal-Mart has paid the price of cannibalization of sales to get density. So infer density benefits must be there.

What I do:

- Estimate a demand model for Wal-Mart stores

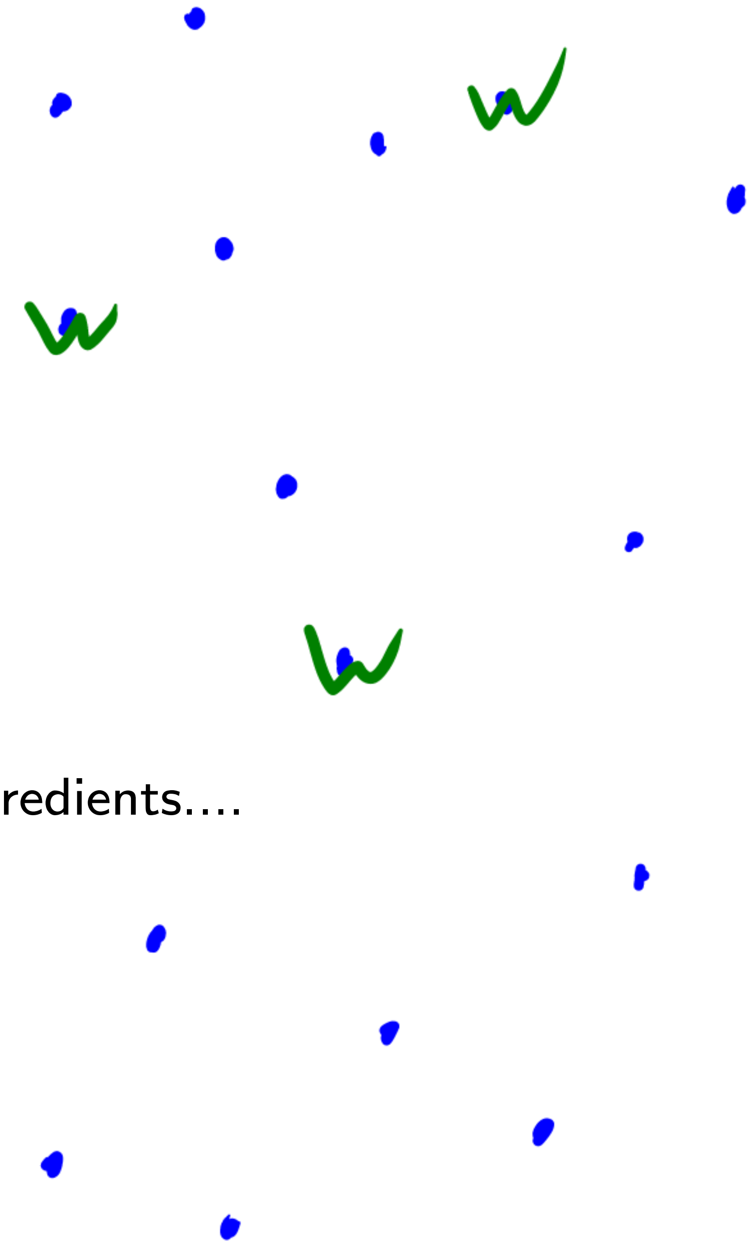
- Provide evidence of significant diminishing returns from cannibalization

- Put forth a dynamic model of Wal-Mart's site selection problem and use perturbation techiques to put a lower bound on a measure of density economies.

- Back it out as a residual.

- Other interpretations?

Model



- Discrete set of points B on a plain

- B^{wal} are locations with a Wal-Mart

Besides geography, model has four key ingredients....

Ingredient 1: A Model of Sales

- Store-level revenue $\mathit{Rev}_j(B^{wal})$

Ingredient 2: Density Economies

- Store density
  - Proportioniate decay $\alpha = .02$
  - Store Density at location ℓ is

$$Density_{\ell}^{store} = \exp(\alpha \times \text{distance to store 1}) + \exp(\alpha \times \text{distance to store 2}) + \ldots$$

  - Density indexes d_{ℓ}^{store}

$$d_{\ell}^{store} = 1 - \frac{1}{Density_{\ell}^{store}}$$

  - Equals 0 for singleton store. Equals 1 for infinitely dense network.

← 20 miles →

W W

$Density = 1 + e^{-.02 \times 20} = 1.67$

$1 - \frac{1}{1.67} = .4$

- Distribution Center

$$d_\ell^{distribution} = -\text{distance to closest distribution center}$$

$$\text{Density Benefit} = \phi^{store} d_\ell^{store} + \phi^{distribution} d_\ell^{distribution}$$

Ingredient 3: Fixed coefficient Inputs for Variable Inputs

Ingredient 4: Fixed cost that varies by population density

Wal-Mart's Problem

1. How many new Wal-Marts and how many new supercenters to open?

2. Where to put the new Wal-Marts and supercenters? (locatons are permanent, no exit)

3. How many new distribution centers to open?

4. Where to put the new distribution centers?

My approach: Solve 2, conditioned upon 1,3,4.

Wal-Mart's Problem

$$\max_{a} \sum_{t=1}^{T} (\rho_t \beta)^{t-1} \left[\sum_{j \in B_t^{wal}} \left[\pi_{jt} - f_{jt} + \phi^{store} d_{jt}^{store} + \phi^{dist} d_{jt}^{dist} \right] \right].$$

for operating profit defined by

$$\pi_{jt} = \left(\mu - wages_{jt} - rent_{jt} \right) \textit{Rev}_{jt}(\theta)$$

Approach: Assume measurement error on $\tilde{R}_{ij}$, $\tilde{w}ages_{jt}$, $\tilde{r}ent_{jt}$

Strategy: (1) Estimate demand parameters θ (and technology)

(2) Bound ϕ^{store}, $\phi^{distribution}$, and parameters of fixed cost using a perturbation approach (moment inequalities)

Data Element 1: Store-Level Data for 2005
Source: TradeDimensions (ACNeilsen)

Store Type	N	Mean Sales ($Millions/Year	Employment	Bldg Size (1,000 sq ft.)
All	3,176	70.5	254.9	143.1
Regular	1,196	47.0	123.5	98.6
SuperCenter	1,980	84.7	333.8	186.9

Data Element 2: Facility opening states
Various sources, including Wal-Mart

Decade Open	Wal-Marts	Supercenters	Regional Distribution Centers	Food Disribution Centers
1960s	15	0	1	0
1970s	243	0	1	0
1980s	1,082	4	8	0
1990s	1,130	679	18	9
2000s	706	1,297	14	25

Data Element 3: Demographic Information by Block Group
Source: Census 1980, 1990, 2000

	1980	1990	2000
N	269,738	222,764	206,960
Mean population (1,000)	0.83	1.11	1.35
Mean Density (1,000 in 5 mile radius)	165.3	198.44	219.48
Mean Per Capita Income (Thousands of 2000 dollars)	14.73	18.56	21.27
Share old (65 and up)	0.12	0.14	0.13
Share yound (21 and below)	0.35	0.31	0.31
Share Black	0.13	0.13	0.13

Data Element 4: Wages and Rents

- Wages: County Business Patterns, 1977-2004
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- Rents: Use Census data on residential property values to create index

Data Element 5: Annual Reports

Information about cannibalization from management's report

"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 comparative store sales in fiscal year 2004, 2003, 2002 were negatively impacted by the opening of new stores by approximately 1%

Particulars of Demand:

- Consumers distributed across discrete locations (blockgroups)
- Total spending λ_t^{gen} and λ_t^{groc}.
- Logit model to allocate spending across..
  - outside good is composite of retail alternatives (that gets better with higher population density)
  - inside goods are all Wal-Marts within 25 miles. Keep track of distance between blockgroup and the Wal-Mart (as crow flies)

- Fit parameters so model fits *store-level* sales.

- Obtain a good fit with sensible comparative statics of distance and population density.

Cannibalization Rates
(Percent Existing Firms Sales Lost to New Stores)

	Cannibalization Percent		
Fiscal Year	Wal-Mart's Report	Unconstrained Model	Constrained Model
1999	no report	.69	.44
2000	no report	.95	.65
2001	no report	.61	.37
2002	1.00	.73	.49
2003	1.00	1.41	.93
2004	1.00	1.48	1.06
2005	1.00	1.55	1.10
2006	1.00	1.35	1.00*

Evidence on Diminishing Returns
Incremental Operating Profits on General Merchandise

Within-State Age	N	Incremental Sales ($million)	Incremental Operating Profit ($million)	Stand-alone Operating Profit ($million)	Incremental Store Density Index	Incremental Distribution Center Density (miles)
1-2	288	38.35	3.55	3.62	0.82	343.26
3-5	614	39.98	3.55	3.70	0.96	202.04
6-10	939	38.04	3.39	3.64	0.98	160.68
11-15	642	36.75	2.95	3.36	0.99	142.10
16-20	383	33.48	2.86	3.47	1.00	113.66
21 and above	310	29.95	2.44	3.56	1.00	90.19

Incremental Profits on Groceries

Within-State Age	N	Incremental Sales ($million)	Incremental Operating Profit ($million)	Stand-alone Operating Profit ($million)	Incremental Supercenter Density Index	Incremental Distribution Center Distance (miles)
1-2	202	42.30	3.86	3.93	0.73	252.90
3-5	484	42.71	3.97	4.13	0.93	171.17
6-10	775	41.00	3.63	3.97	0.99	113.52
11-15	452	36.70	3.19	3.84	1.00	95.32
16-20	67	29.69	2.71	3.42	1.00	93.95

Estimating Bounds on Parameters

- Use pairwise deviations like Bajari and Fox
- Use moment inequalities like Pakes, Porter, Ho, and Ishii
- Get lower bound of $\phi^{store} \geq .85$.

A Sense of Magnitudes

- What happens if we change density, but keep sales the same

- E.g., suppose we split Wal-Mart into two separate companies and eliminate density benefits across companies. But consumers still doing same things, so sales at each store the same.

- Use bounds to get an estimates in the change in density economies.

- Take ratio to 1.3 percent of sales (Walmart's distribution costs as a percent of sales)

Lower Bound on Savings from Increased Density
(Expressed as a percentage of .013*sales)

General Merchandise

Location	Number of Stores	Mean Store Density Index	Bound: To current density from half density	Bound: To Most Dense State (NJ)
U.S.	3,176	.948	6.4	4.9
ND	8	.505	25.3	78.9
CA	159	.945	5.4	4.0
NJ	41	.980	2.4	0.0

Lower Bound on Savings from Increased Density
(Expressed as a percentage of .013*sales)

Groceries

Location	Number of Stores	Mean Store Density Index	Bound: To current density from half density	Bound: To Most Dense State (GA)
U.S.	1,980	.923	9.1	6.2
ND	1	.525	19.9	51.7
CA	13	.665	19.6	36.6
GA	101	.963	5.3	0.0