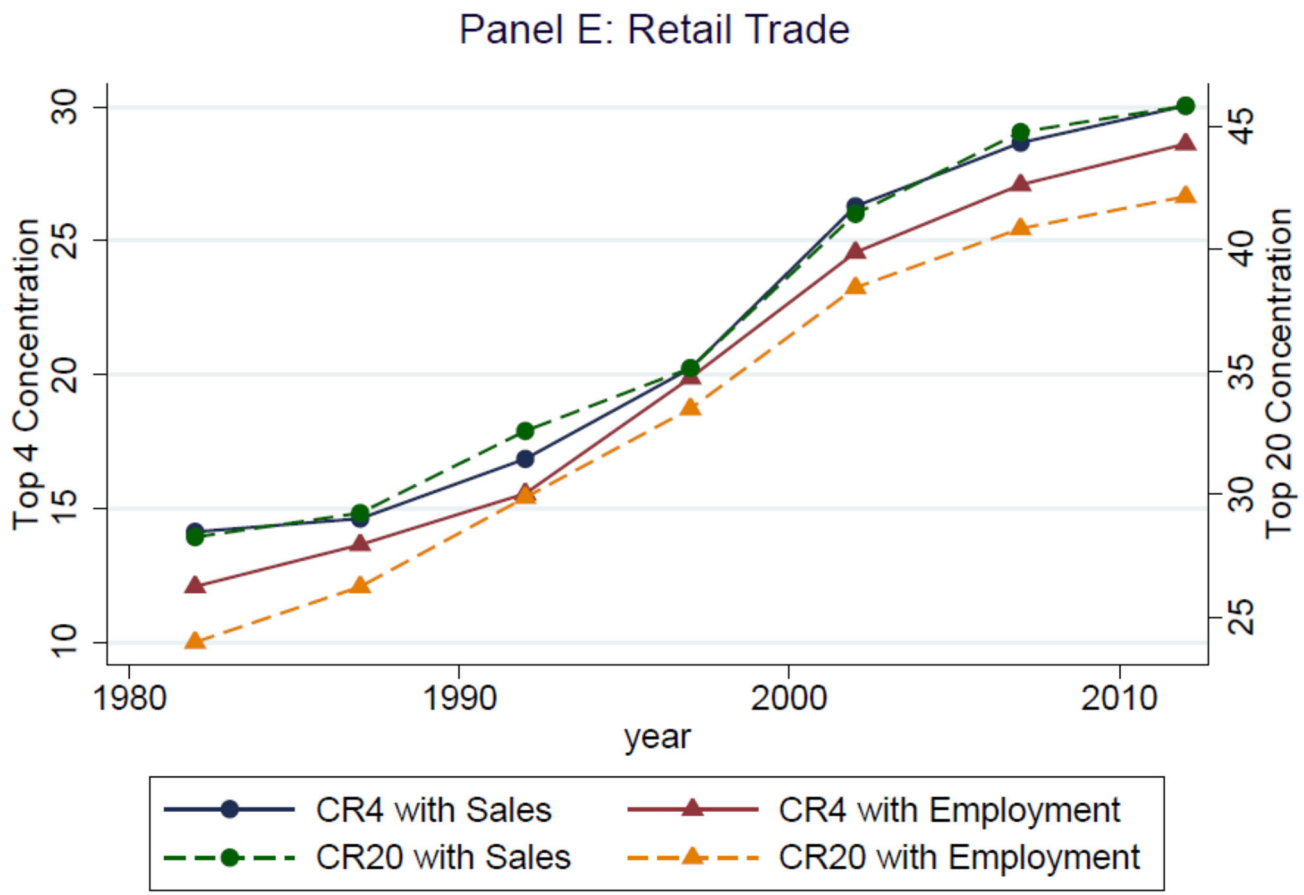


From Autor, Dorn, Katz, and Van Reenen (2017):

("…and the Rise of Superstar Firms")

- Holmes (Rand, 2001), "Barcodes Lead to Frequent Deliveries and Superstores
  - Technology complements scale, or"",
  - Walmart is a solution to an **indivisibility** problem
  - begs question of why intermediaries are not doing this...

This paper: "Indivisibilities in Distribution," (with Ethan Singer)

- Quantifies the gains from scale
- Use micro trade data to examine indivisibilities starting at front-end in Shenzhen
  - In many ways a mirror image of indivisibilities of last step getting to the store
- We will look at boxes, and how full they are
  - and if partially empty, that's a cost
  - but also going after distortions incurred to fill the boxes (a bigger deal than the empty space)

From Walmart to Amazon

- Confession: I expected the advent of online sales would neutralize Walmart's scale advantage in logistics
  - Focus on website, send goods UPS, Fedex, USPS...
- Got that wrong! Amazon is increasingly dominant as it vertically integrates in distribution
- New trend: small online firms using Amazon for fullfilment
  - small retailers getting pulled into Amazon's integrated operation (e.g. standardized product codes)
  - I think it is more than Uber pool for shipping, more 'integrated" than DHL "less than container load" shipping.

Results

- Descriptive evidence based on container imports
  - Large firms shipping fill boxes, doing extensive consolidation.
  - Small firms often shipping boxes half full; intermediaries consolidating across firms is fairly small
- Develop and estimate structural model of indivisibility costs
  - Find indivisibility costs bite even for Walmart
  - particularly at Asia sources other than China, related to "everything travels the same way" distribution strategy

- Simulations with the model
  - Bust up Walmart in half, get tight bounds on effects of increased cost
    - 4.0 to 4.7 percent of ocean freight
    - A big deal given thin profit margins and since not counting other parts of supply chain.
  - Online retail has an advantage in flexibility over bricks-and mortar.
    - Everything doesn't travel the same way.
    - Show this flexibility has value.

Model: Planning problem for particular product (SKU)

- Exogenous annual volume Q
- Assume large number of deliveries over the course of a year
- Let n measure of deliveries, indexed by $i \in [0, n]$
- Let $s(i)$ be the share allocated to delivery i,

$$\int_0^n s(i)di = 1$$

- Waiting cost: $W = Q\phi \int_0^n s(i)^2 di$
- Order cost ψ

Simple Case with No Indivisibilities

- λ shipping cost per unit.
- Maximize profit by perfectly smoothing deliveries $s = \frac{1}{n}$
- Profit given choice n is

$$-Q\phi \int_0^n s(i)^2 di - Q\lambda - n\psi$$

$$-Q\phi n \left[\frac{1}{n}\right]^2 - Q\lambda - n\psi$$

- From FONC

$$n^* = \left[\frac{\xi Q\phi}{\psi}\right]^{\frac{1}{2}}, \; q^* = \frac{Q}{n^*}$$

Introducing Indivisibilities

- Box size normalized to one, let λ cost of unit box. Assume $q^* < 1$

- Can consolidate, but face friction η, so cost per unit is $\lambda(1+\eta)$

- For a given shipment, random factors make consolidate or unconsolidate more or less desirable
  - ε_c and ε_u drawn for each shipment
  - Type 1 extreme value, std dev: $\zeta = \frac{Q}{n}$.

- Pick consolidation quantity $q_c = x$ before realizations of ε_c and ε_u

- With probability ω can adjust unconsolidated q_u after see realizations
  - If flex, set $q_u = y$
  - No flex, set $q_u = x$

Problem: Pick n, x, y, and rules for ε_c and ε_u to yield p_c^{flex} and p_u^{flex}, p_c^{noflex} and p_u^{noflex} to maximize

$$
\begin{aligned}
&-Q\left[\omega p_c^{flex}+(1-\omega)\right] n\phi\left(\frac{x}{Q}\right)^{1+\xi}-Q\omega p_u^{flex} n\phi\left(\frac{y}{Q}\right)^{1+\xi}\\
&-n\left[\omega p_c^{flex}+(1-\omega)\, p_c^{flex}\right] x\lambda\,(1+\eta)-n\left[\omega p_u^{flex}+(1-\omega)\, p_u^{noflex}\right]\lambda\\
&-n\psi\\
&+E\left[\varepsilon|n,p_c,p_u\right]
\end{aligned}
$$

Subject to:

$$Q=n\left[\omega p_c^{flex}+(1-\omega)\right] x+n\omega p_u^{flex} y$$

Indivisibility Cost Low in this Model When:

- Friction η low
- Flexibility ω is high.
- ideal shipment size ignoring indivisibility is large, or a multiple of 1.

More Details of the Model

- Allow for cutting up deliveries over space as well as time.
  - Firm pick m, number of import distribution centers.
  - If Q° is annual volume with $m = 1$
  - $\frac{Q^{\circ}}{m}$ volume with $m > 1$.
  - Constaint: m same for all goods. Pick m first, then solve product level problems

- Scale economies in consolidation
  - Let Q_{jk}^{total} be total volume of all goods shipped origin j to destination k
  - $\eta = \beta_0 - \beta_1 \ln\left(Q_{jk}^{total}\right)$
- Counterfactuals:
  - (1) cut operation in half...
  - (2) free up constraint that m same for all products.

Data

- Bills of Lading
  - Customs and Border Protection (CBP) distributes records for water-bourne imports
  - 1 million a month

Example Bill of Lading #1

Field Name	Value of Record
Bill of Lading Number	CMDUUH2053195
Shipper	**redacted**
Consignee	**redacted**
Vessel Name	Felixstowe Bridge
Arrival Date	2015-01-07
Place of Receipt	Zhongshan,
Foreign Port	57067 - Chiwan, China
US Port	5301 - Houston, Texas
Container ID Number	CMAU5601550, CMAU4618671, …
Piece_Count	640, 640, …(each container)
Products	5120 Pcs Hb 1.1 **Cu.Ft. Digital Mwo Blk(Microwave Oven)** Purchase Order Number 0254059971 **ITEM No:550099354** This Shipment Contains No Regulated Wood Packaging Materials Freight Collect Load Type:Cy **GLN: 0078742000008** Department No.: 00014 **HTS:8516500060** …
Marks	To:**Walmart** Case Identification Number Us Dept 00014 (5 Digits-Counting Leading Zeros) Po 0254059971

- Microwave example
  - max volume import 2015, 828 containers (2× month to 5 IDCs, averaging 7 containers per shipment
  - $ figures:
    * $2500 cost to ship container (640 microwaves, so $4 a piece)
    * wholesale cost (delivered to US port): $42 piece ($27,000 per container)
    * ocean freight around 10 percent in this case (8 percent typical)

Sample Statistics
(All statistics in millions)

	Count of Shipments (millions)			Count of Containers (millions)		
	All Sources	From China	From Shenzhen	All Sources	From China	From Shenzhen
9−Year Walmart Sample	2.0	1.7	1.0	1.8	1.6	0.8
18−Month Sample	14.0	6.3	1.6	17.0	7.4	2.0
Beneficial Cargo Owners (BCO)	6.7	2.7	0.9	10.5	3.9	1.2
FF Intermediated (HOUSE)	7.3	3.6	0.7	6.5	3.4	0.8

- *Consolidated Shipment:* any container on the shipment record referenced by other shipment

- Link shipments with shared containers into *consolidated shipment group*

List of Facts

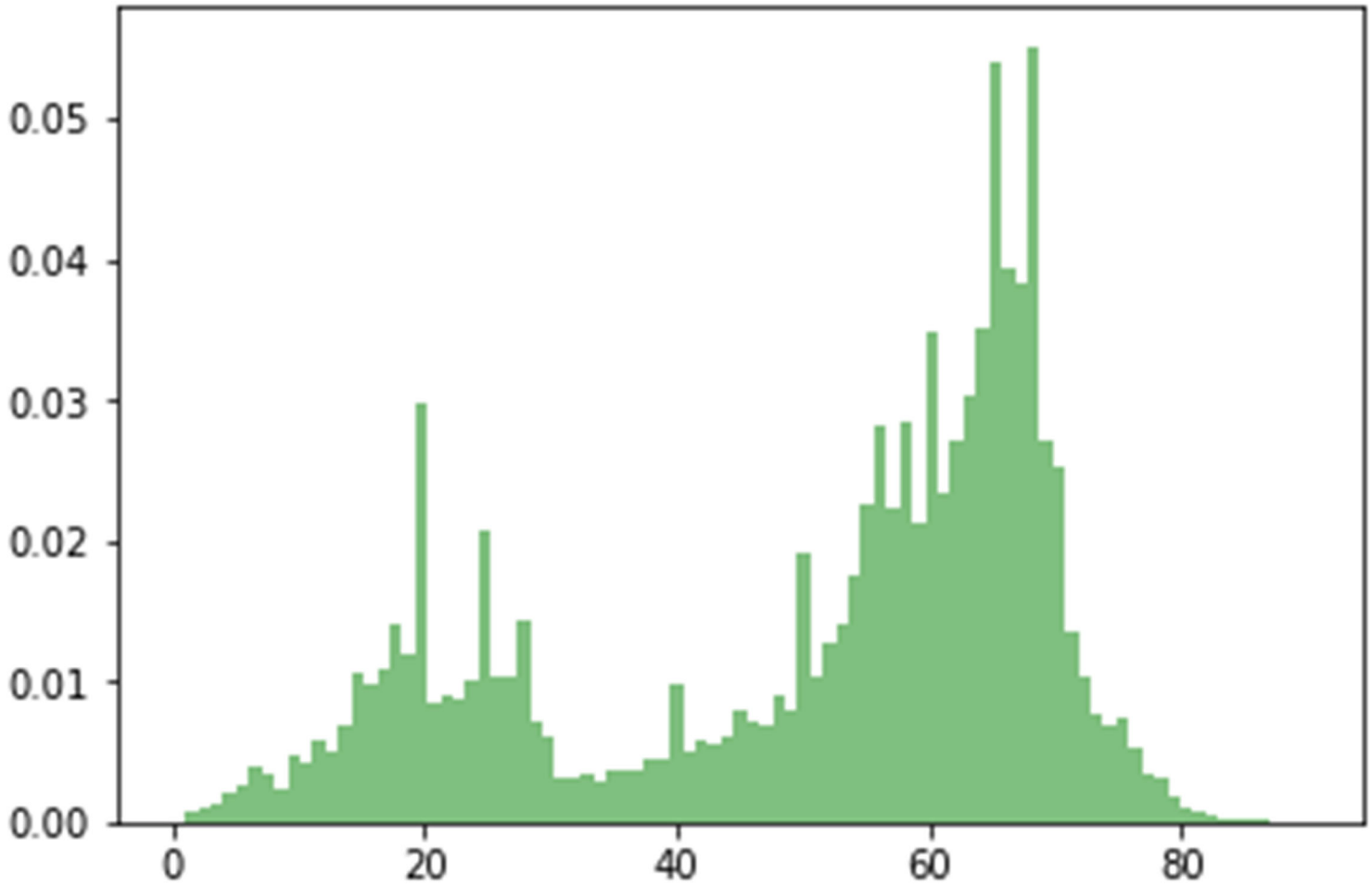
1. Consolidation by mass discounters significant; small firms, not so much

2. Mass discounters stuff containers full; small firms, not so much

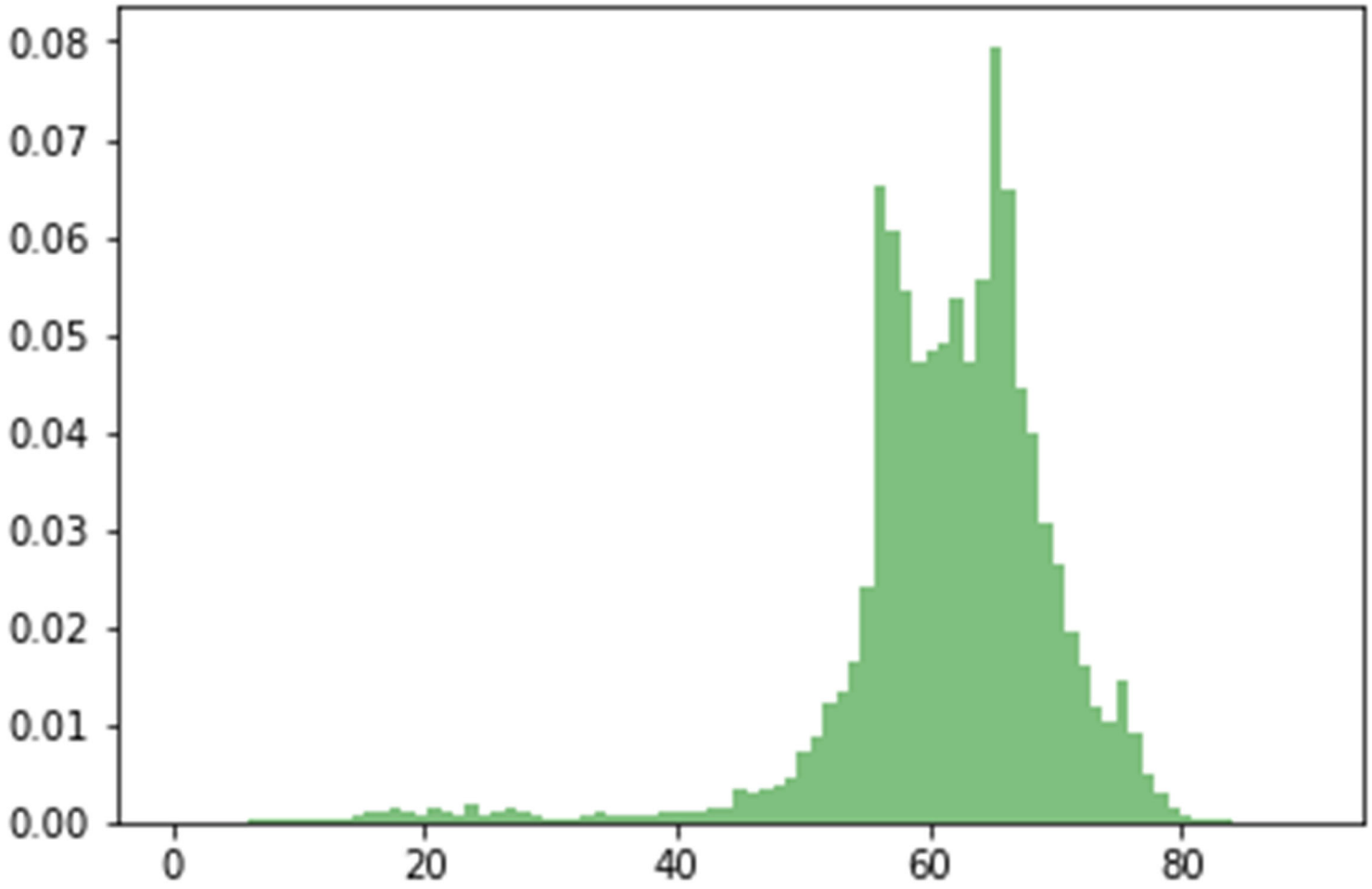
3. Increasing division of deliveries over space, as well as time.

Figure 3. Histograms of Container Fill Levels (Cubic Meters) for Three Samples

a) Sample 1: All Containers Originating in China



(b) Sample 2: Walmart Containers Originating in China



(c) Sample 3: Walmart Containers Originating in India

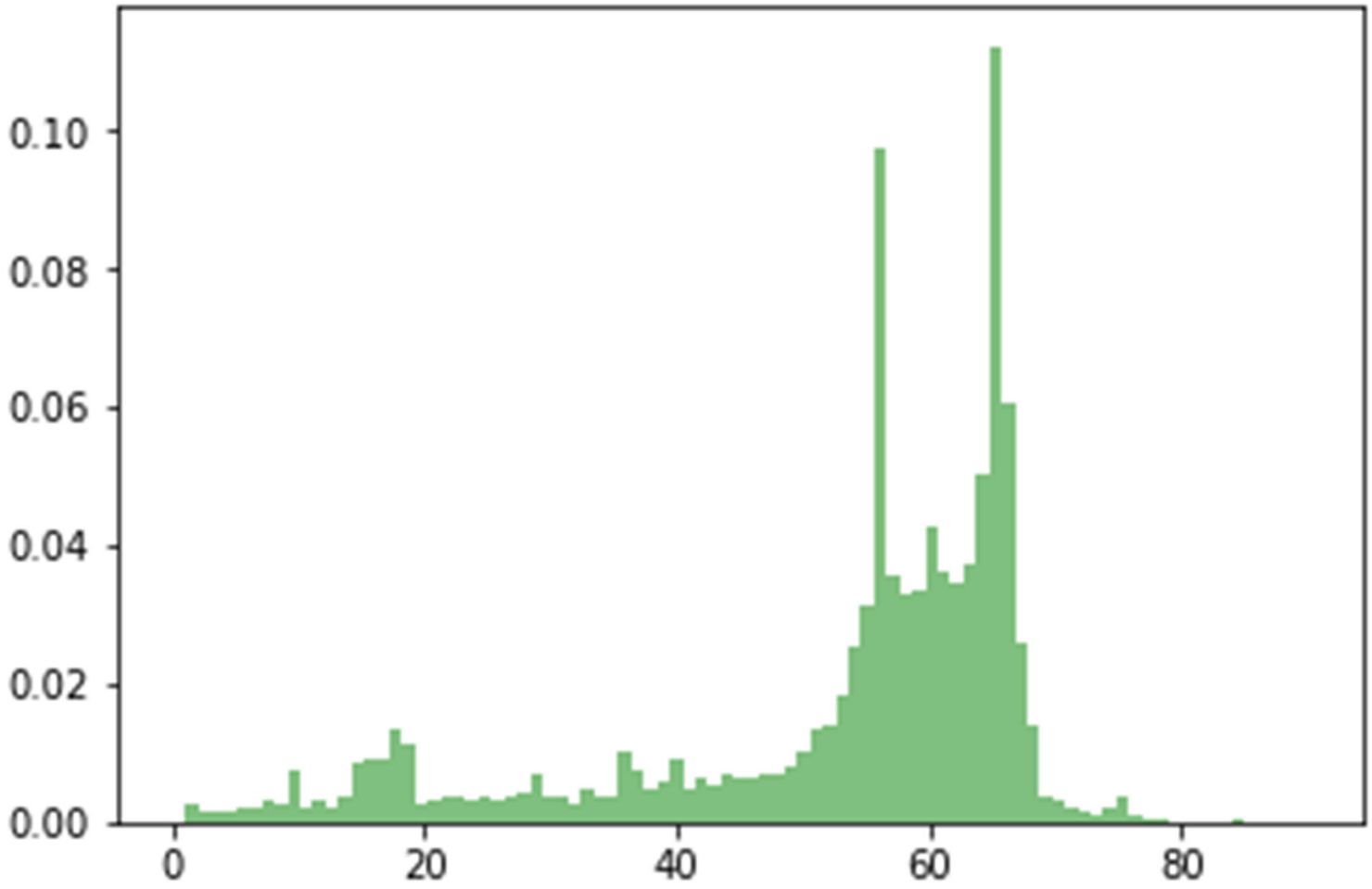


Table 4

Distribution of Shipments by Consolidated, Single, or Multi for Various Samples

Panel A :Walmart 9-Year Sample for Selected Source Countries

Source Country	Container Imports (millions)	Consolidated Shipment (Percent)	Single Container Shipment (percent)	Multi-Container Shipment (percent)
China	1.57	42.0	8.1	49.9
Bangladesh	0.03	75.3	5.5	19.2
India	0.03	38.2	18.9	42.9
Thailand	0.03	15.5	26.0	58.5
Vietnam	0.03	39.8	13.2	47.0
Rest of World	0.14	30.5	23.7	45.8

Panel C: FF Intermediated Imports with China Source
by Importing Firm Size Category
(Consolidation Defined as Across Firm)

Size Category	Container Imports (millions)	Consolidated Shipment (Percent)
All Sizes	2,435.7	4.8
By Count of Linked Shipments		
1	103.6	9.0
2-4	196.5	7.0
5-20	570.1	5.9
21-100	927.6	4.7
101-250	398.5	2.9
251 and above	239.4	1.4

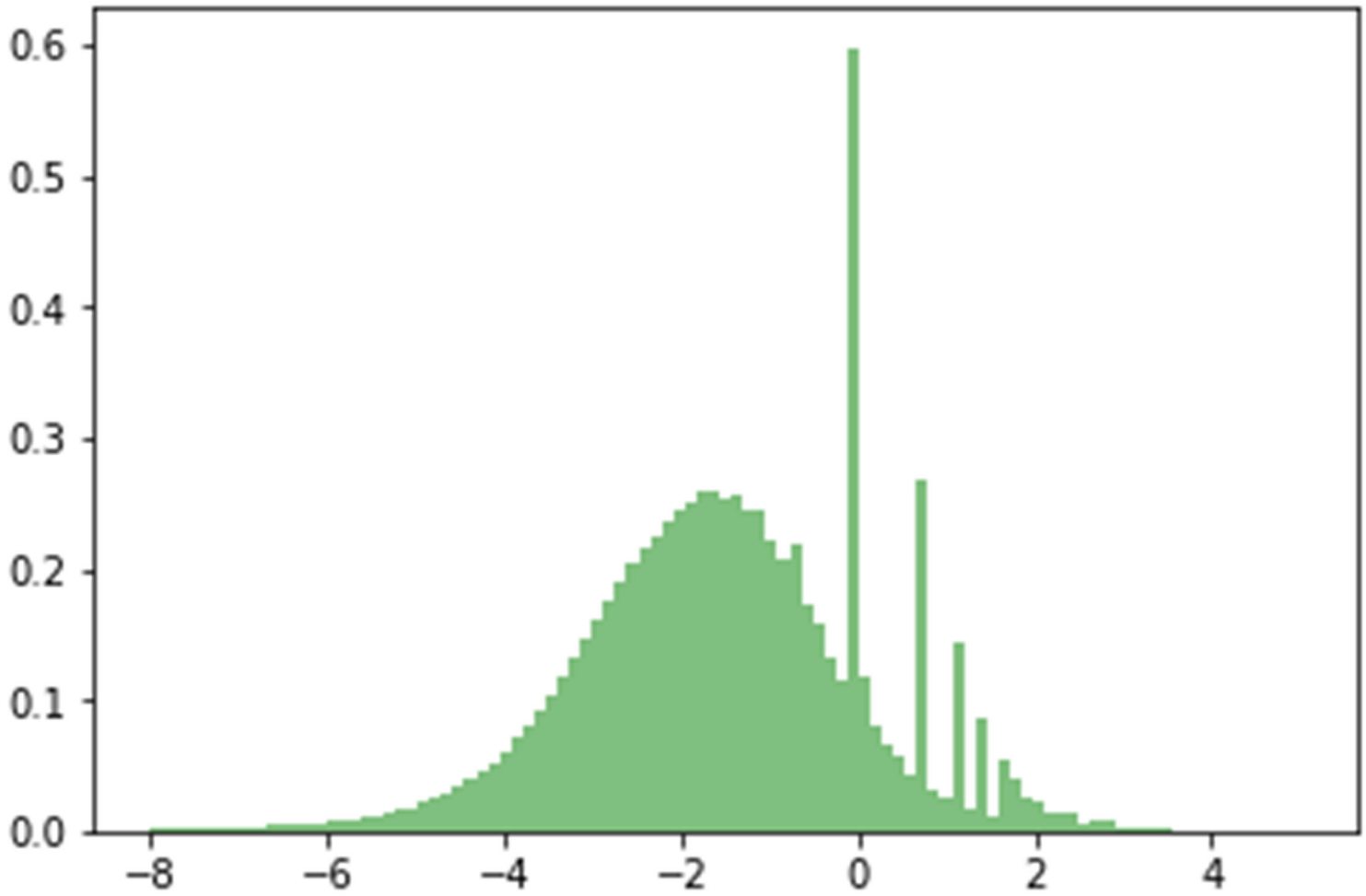
Increasing Division of Deliveries Over Space

- Walmart Import Distribution Center (IDC) history
  - Pre 2000: Savannah + Los Angles
  - 2000 Norfolk
  - 2005-2006 added Houston and Chicago
  - 2018 adding Mobile Alabama
- Target: 4 IDCs

Step 1: Estimate Parameters of Shipment-Level Problem from source j

- Take η_j fixed at location j
- Let x be log normal, parameters μ_j and σ_j
- Trade-off between high ω and low ϕ in generating flexibility, this version set ϕ is a low level and let ω do the work of governing flexibility
- ξ governs the shocks ε_u and ε_f.

Figure 6(a)
Shenzhen Histogram of Log Walmart Shipment Volumes: Data (Green)



Model Statistics used for GMM

- Size distribution of consolidated versus unconsolidated
- Share consolidated
- Share unconsolidated using half-size
- Mean empty space in unconsolidated shipments

Table 7

Estimates of Shipment-Level Model for Various Samples

Panel A: Cross Section of Walmart Source Locations, 2007-2015

Sample	Shipment Count (1,000)	eta	$omega_1$	zeta	mu	sigma	GMM criterion
Walmart Shenzhen	1,049	0.126	0.785	0.103	-0.771	1.598	0.006
Walmart-Mumbai	20	0.470	0.408	0.007	-0.828	1.328	0.102

Figure 8
Consolidation Frictions and Market Size
(Horizontal Axis Is Log Container Quantity)

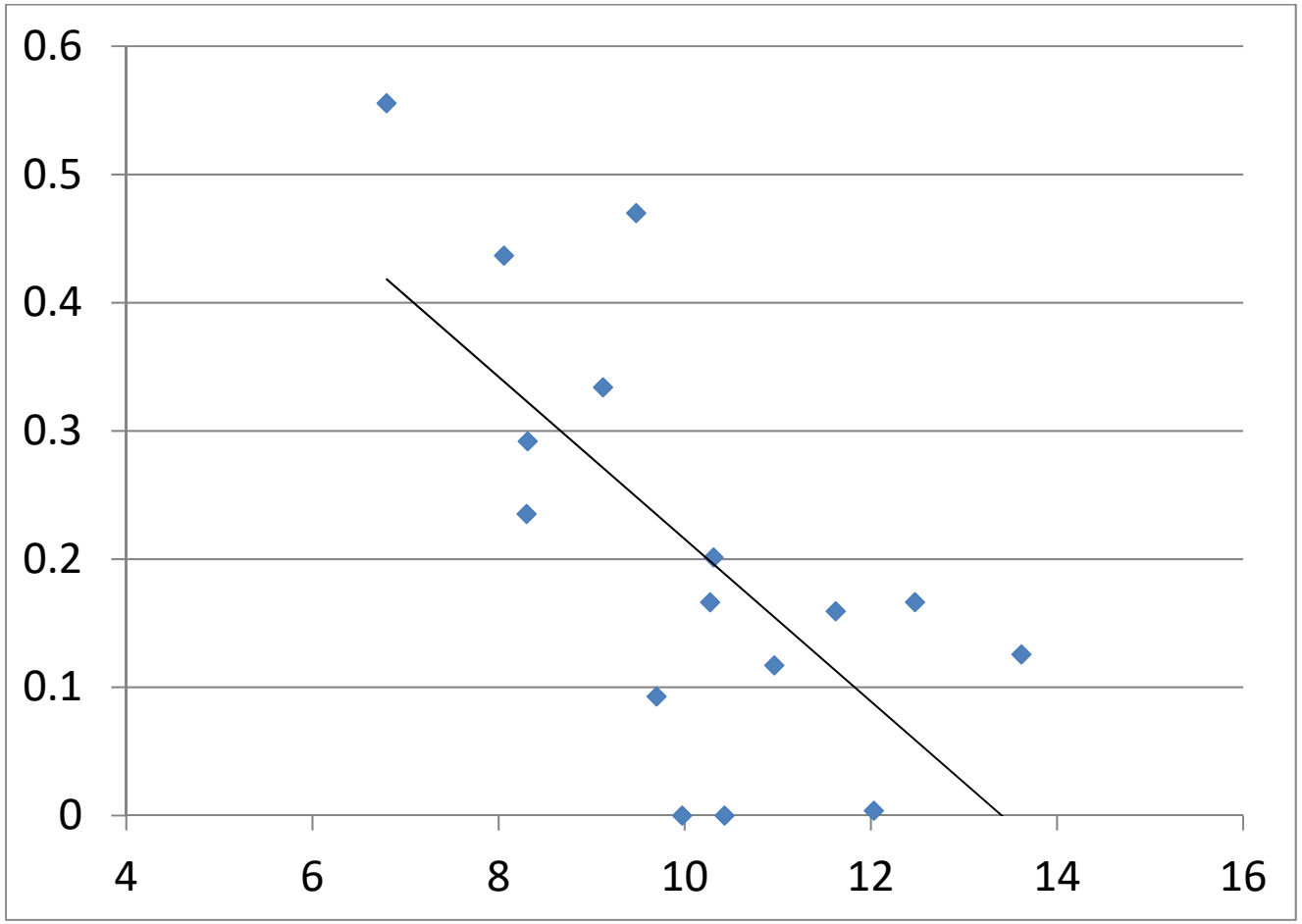


Figure 9

Walmart Seasonal Pattern out of Shenzhen and Estimated Consolidation Friction

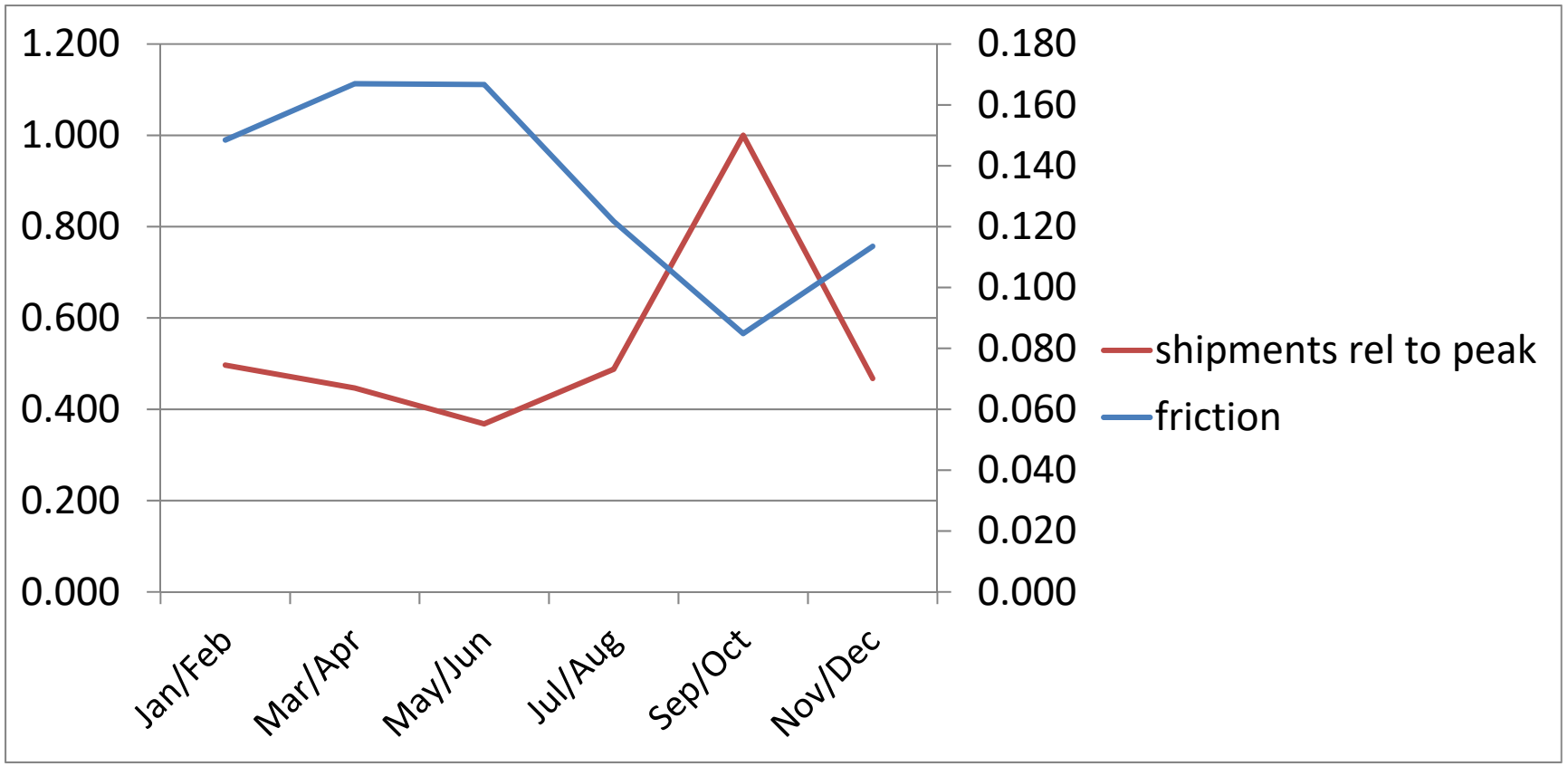


Table 8

Regression Results: Consolidation Friction for Walmart and Shipping Volume

Parameter	Sample 1 Cross Section of Locations	Sample 2 Average Seasonal (Bimonthly) Shenzhen
Constant	0.838 (0.245)	1.060 (0.318)
Log(Count of Containers)	**−0.064** **(0.024)**	**−0.079** **(0.027)**
R^2	0.337	0.679
N	16	6

Estimated Unit Indivisibility Costs
(Cost Is Percentage of Ocean Freight)

Walmart Shenzhen	
Actual m=5	10.3
Counterfactual m=1	2.7
Walmart Mumbai	
Actual m=5	25.3
Counterfactual m=1	11.5
Target Shenzhen (m=4)	12.0
Freight Forward Intermediated from China By Count of Linked Shipments	
1	40.1
21-100	18.5
251 and up	14.3

Estimated Cost Effects of Dissolution of Walmart

Type of Change	Upper Bound *m*	Effect on Total Cost (Percent of Ocean Freight)	
		Lower Bound	Upper Bound
Dissolution 2 firms	4	3.7	4.1
Dissolution 10 firms	2	14.2	16.5

T

Gains from Relaxing “Everything Travels the Same Way” Constraint

Walmart out of Shenzhen:

benefit equals 2.3 percent of ocean freight

Walmart out of Mumbai:

benefit equals 12.5 percent of ocean freight