ISE 754: Logistics Engineering

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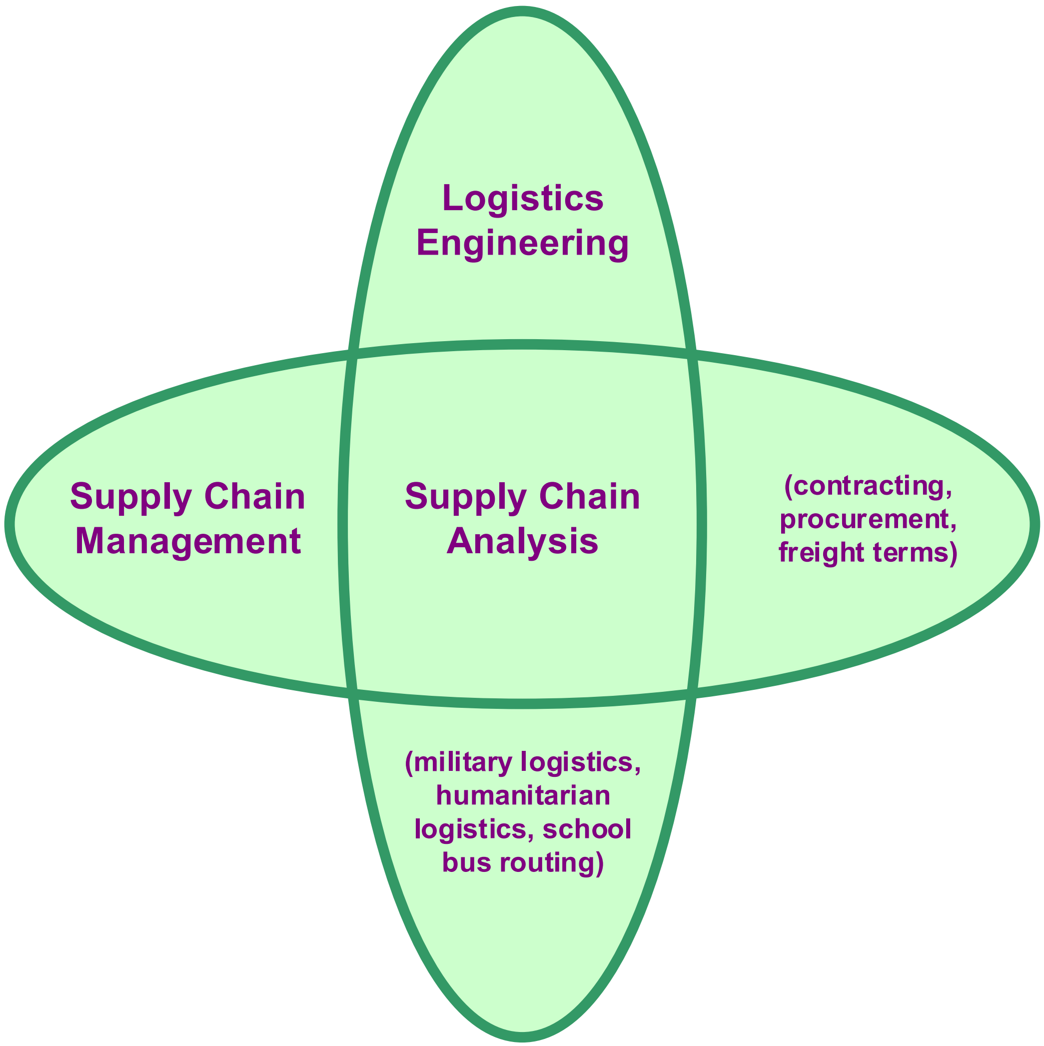
Topics

1. Introduction
2. Facility location
3. Freight transport
   – Exam 1 (take home)
4. Network models
5. Routing
   – Exam 2 (take home)
6. Warehousing
   – Final exam (in class)

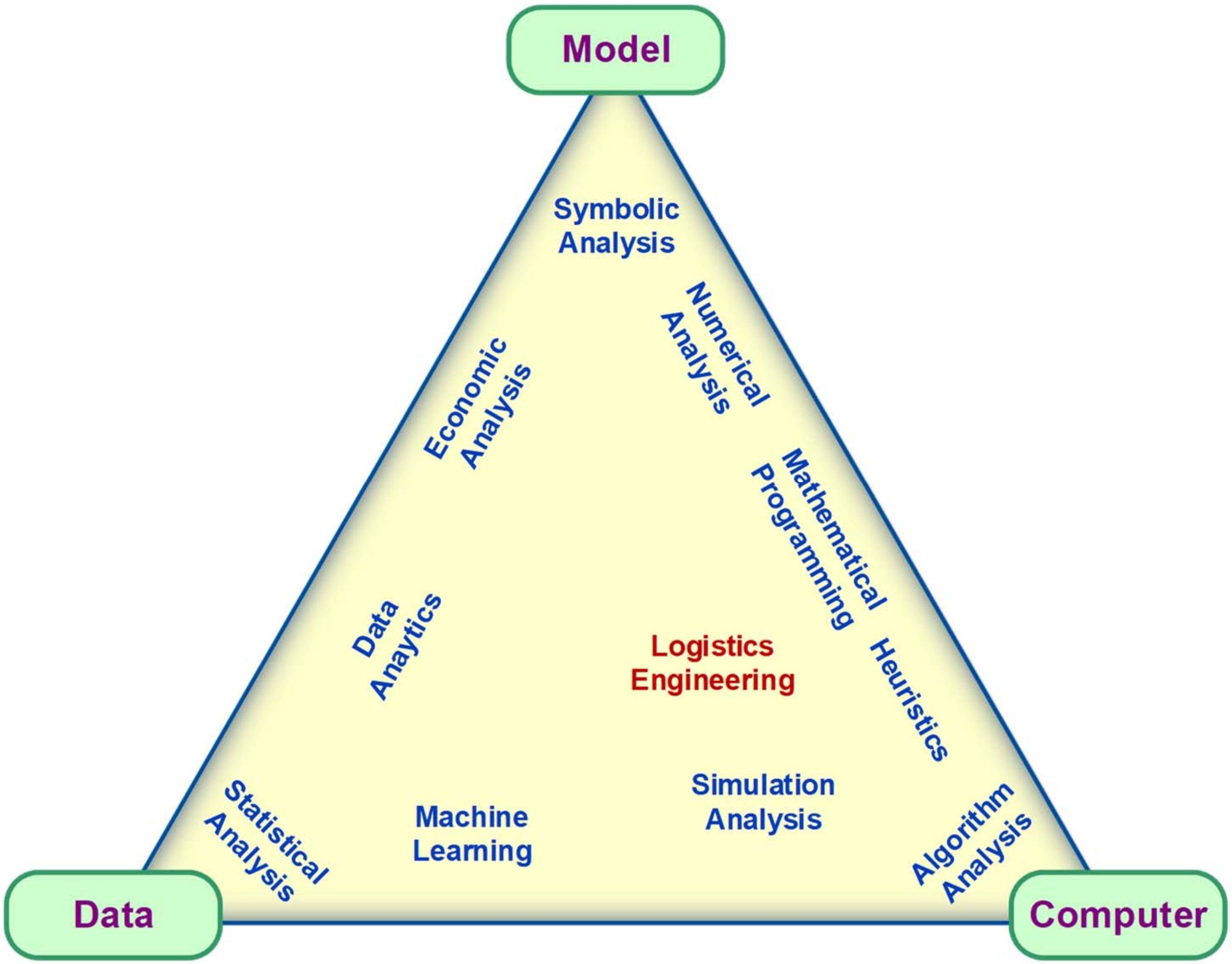
Outside the box

Inside the box

SCM vs Logistics Engineering



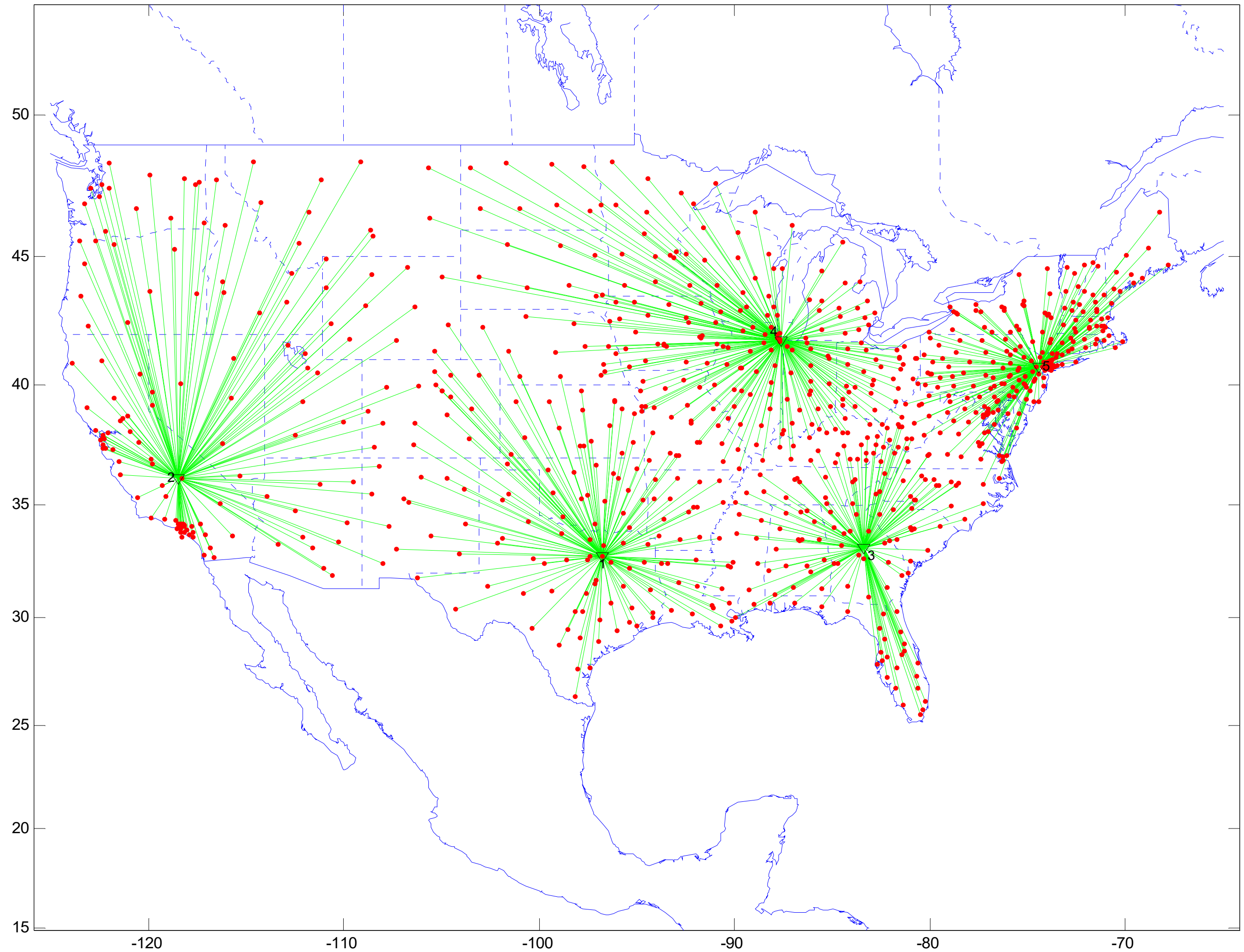
Analysis Triangle



Scope

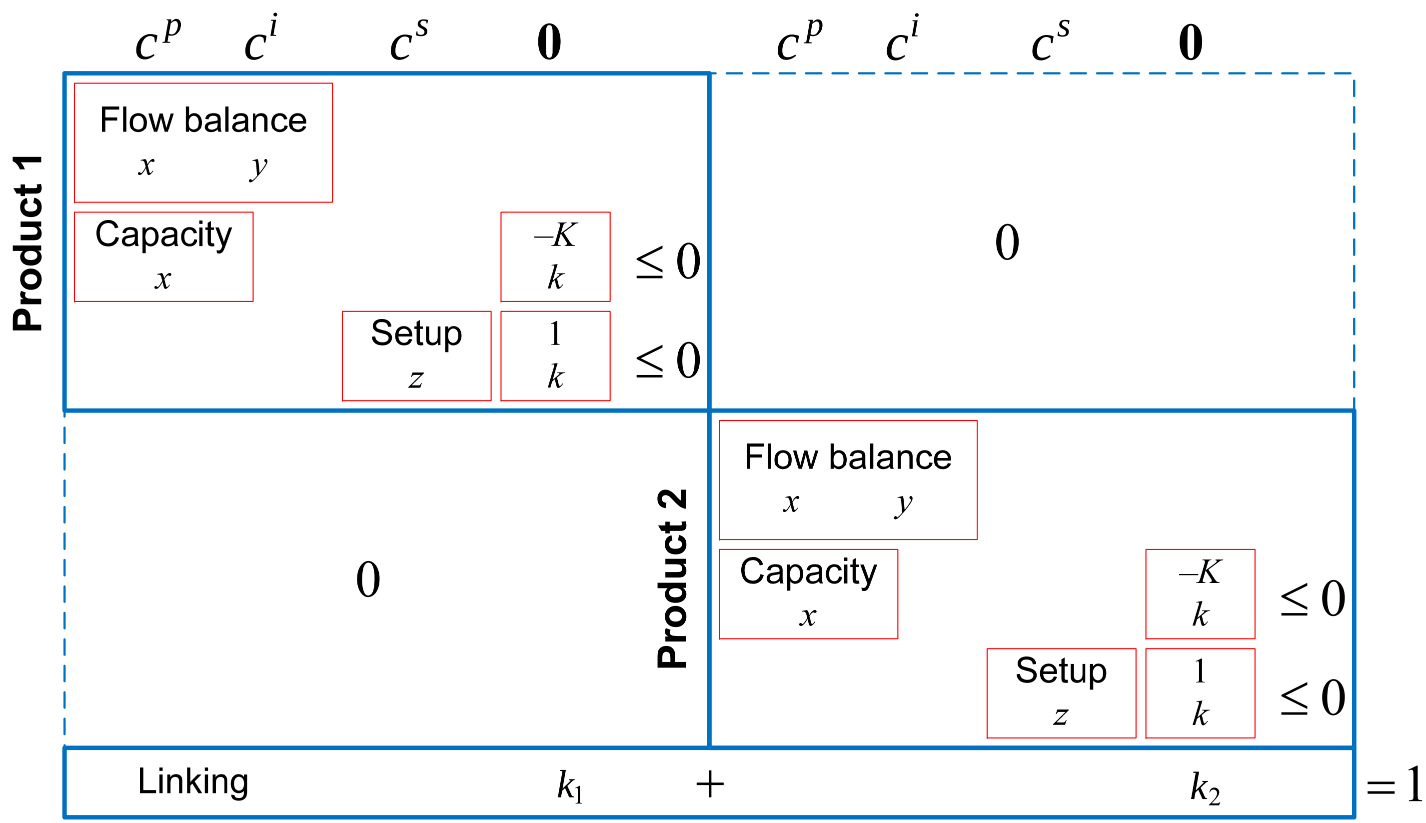
- Strategic (years)
  - Network design
- Tactical (weeks-year)
  - Multi-echelon, multi-period, multi-product production and inventory models
- Operational (minutes-week)
  - Vehicle routing

Strategic: Network Design



Optimal locations for five DCs serving 877 customers throughout the U.S.

Tactical: Production-Inventory Model



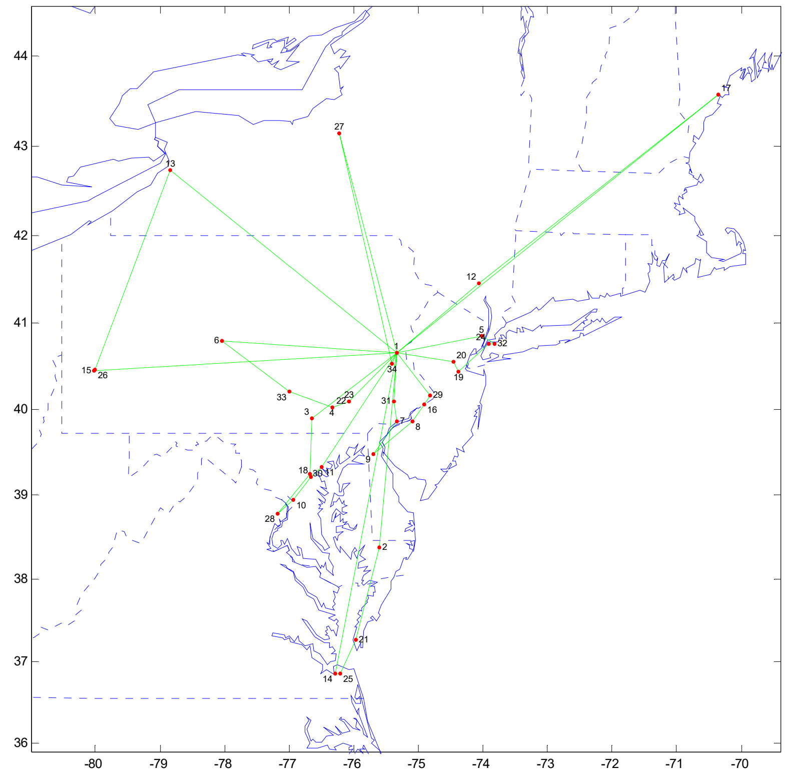
Constraint matrix for a 2-product, multi-period model with setups

Vehicle Routing

Eight routes served from DC in Harrisburg, PA

Route Summary Information

Route	Load Weight	Route Time	Customers in Route	Layover Required
1	12,122	18.36	4	1
2	4,833	16.05	2	1
3	9,642	17.26	3	1
4	25,957	13.77	6	0
5	12,512	9.90	2	0
6	15,156	13.70	5	0
7	29,565	11.30	6	0
8	32,496	8.84	5	0
		109.18		3



Detailed Route Information

						Start	L/D (hr)	Depart	Total Time (hr)	Zip Code
Route		1								
	1					23:29	0	23:29	0	18020
	14	2,328	7.51	7:00	399	7:00	0.59	7:35	8.1	23510
	25	4,697	0.19	7:46	6	7:46	0.68	8:27	0.87	23502
	21	3,682	1.12	9:34	37	9:34	0.64	10:13	1.76	23310
	2	1,415	2.51	12:43	93	12:43	0.56	13:17	3.07	21801
	1	0	4.57	17:51	196	17:51	0	17:51	4.57	18020
Total		12,122	15.89		731		2.47		18.36	

Geometric Mean

- How many people can be crammed into a car?
  - Certainly more than one and less than 100: the average (50) seems to be too high, but the geometric mean (10) is reasonable

$$\text{Geometric Mean:} \quad X = \sqrt{LB \times UB} = \sqrt{1 \times 100} = 10$$

- Often it is difficult to directly estimate input parameter *X*, but is easy to estimate reasonable lower and upper bounds (LB and UB) for the parameter
  - Since the guessed LB and UB are usually orders of magnitude apart, use of the arithmetic mean would give too much weight to UB
  - Geometric mean gives a more reasonable estimate because it is a logarithmic average of LB and UB

Fermi Problems

- Involves "reasonable" (i.e., +/– 10%) *guesstimation* of input parameters needed and back-of-the-envelope type approximations
  - Goal is to have an answer that is within an order of magnitude of the correct answer (or what is termed a *zeroth-order approximation*)
  - Works because over- and under-estimations of each parameter tend to cancel each other out as long as there is no consistent bias
- How many McDonald's restaurants in U.S.? (actual 2013: 14,267)

Parameter	LB		UB	Estimate	
Annual per capita demand	1	1 order/person-day x 350 day/yr =	350	18.71	(order/person-yr)
U.S. population				300,000,000	(person)
Operating hours per day				16	(hr/day)
Orders per store per minute (in-store + drive-thru)				1	(order/store-min)
Analysis					
Annual U.S. demand		(person) x (order/person-yr) =		5,612,486,080	(order/yr)
Daily U.S. demand		(order/yr)/365 day/yr =		15,376,674	(order/day)
Daily demand per store		(hrs/day) x 60 min/hr x (order/store-min) =		960	(order/store-day)
Est. number of U.S. stores		(order/day) / (order/store-day) =		16,017	(store)

System Performance Estimation

- Often easy to estimate performance of a new system if can assume either perfect or no control
- Example: estimate waiting time for a bus
  - 8 min. avg. time (aka "headway") between buses
  - Customers arrive at random
    - assuming no web-based bus tracking
  - Perfect control (LB): wait time = half of headway
  - No control (*practical* UB): wait time = headway
    - assuming buses arrive at random (Poisson process)

$$\text{Estimated wait time} = \sqrt{LB \times UB} = \sqrt{\frac{8}{2} \times 8} = 5.67 \text{ min}$$

  - Bad control can result in higher values than no control

http://www.nextbuzz.gatech.edu/

SELF-COORDINATING BUSES
REDUCE BUNCHING

HOME THE IDEA PROOF OF CONCEPT HOW IT WORKS CONTRIBUTORS

A BUS-HEADWAY CONTROLLER

A software system to coördinate buses on a route, based on an idea by John J. Bartholdi III and Donald D. Eisenstein. The current version of the software was designed and largely written by Loren K. Platzman. Implementation has been led by Russ Clark, Jin Lee, and David Williamson.

THE IDEA

Delaying buses briefly at certain checkpoints equalizes headways

Read more

PROOF OF CONCEPT

Coordinating trolleys on Georgia Tech's busiest route

Read more

HOW IT WORKS

Tablets, GPS, cellular networks, and web-based control

Read more

Levels of Modeling

0. Guesstimation (order of magnitude)
1. Mean value analysis (linear, ±20%)
2. Nonlinear models (incl. variance, ±5%)
3. Simulation models (complex interactions)
4. Prototypes/pilot studies
5. Build/do and then tweak it

Crowdsourcing

- Obtain otherwise hard to get information from a large group of online workers
- Amazon's Mechanical Turk is best known
  - Jobs posted as HITs (Human Information Tasks) that typically pay $1-2 per hour
  - Main use has been in machine learning to create tagged data sets for training purposes
  - Has been used in logistics engineering to estimate the percentage homes in U.S. that have sidewalks (sidewalk deliveries by Starship robots)

Starship Technologies

- Started by Skype co-founders
- 99% autonomous
- Goal: “deliver ‘two grocery bags’ worth of goods (weighing up to 20lbs) in 5-30 minutes for ‘10-15 times less than the cost of current last-mile delivery alternatives.’”

Ex 1: Geometric Mean

- If, during the morning rush, there are three buses operating on Wolfline Route 13 and it takes them 45 minutes, on average, to complete one circuit of the route, what is the estimated waiting time for a student who does not use TransLoc for real-time bus tracking?

Answer :

$$\text{Frequency (TH)} = \frac{WIP}{CT} = \frac{\text{3 bus/circuit}}{\text{45 min/circuit}} = \frac{1}{15} \text{ bus/min}, \quad \text{Headway} = \frac{1}{\text{Freq.}} = 15 \text{ min/bus}$$

$$\text{Estimated wait time} = \sqrt{LB \times UB} = \sqrt{\frac{15}{2} \times 15} = 10.61 \text{ min}$$

Ex 2: Fermi Problem

- Estimate the average amount spent per trip to a grocery store. Total U.S. supermarket sales were recently determined to be $649,087,000,000, but it is not clear whether this number refers to annual sales, or monthly, or weekly sales.

$$\textbf{Answer:}\quad \frac{\$6.5e11}{3e8} \approx \$2,000 / \text{person-yr}, \quad LB = 1 \text{ trips/wk}, UB = 7 \text{ trips/wk}$$

$$\Rightarrow \sqrt{1(7)} \times 52 \approx 2 \times 52 \approx 100 \text{ trips/yr} \Rightarrow \frac{\$2,000}{100} = \$20 / \text{person-trip}$$

Supermarket / Grocery Store Statistics	Data
Total number of grocery store employees	3,400,000
Total supermarket sales in 2015	$649,087,000,000
Total supermarket sales in 2012	$602,609,000,000
Total number of grocery stores / supermarkets	37,053
Median weekly sales per supermarket store	$384,911
Average grocery store transaction amount	$27.30
Average number of grocery store trips per week a consumers makes	2.2
Average number of items carried in a supermarket	38,718