Assessing the Gains from E-Commerce

Liran Einav, Stanford and NBER
Pete Klenow, Stanford and NBER
Ben Klopack, Stanford
Jonathan Levin, Stanford and NBER
Larry Levin, Visa
Wayne Best, Visa

September 18, 2017

Minneapolis Fed Lunch Talk

Motivation

- E-commerce is a rapidly growing share of U.S. retail spending
- How big is the consumer surplus from e-commerce?
- How are the gains distributed by geography and affluence?

Related literature

Gains from e-commerce and the internet

- Brynjolffson and collaborators (2003, 2012, 2017)
- Syverson (2016)
- Varian (2013)
- Goolsbee and Klenow (2006)

Consumer surplus from new products

- Redding and Weinstein (2016)
- Broda and Weinstein (2006, 2010)
- Hausman (1997, 1999)
- Feenstra (1994)

Outline

1. **Visa data and basic facts**
2. Estimating the *pure convenience* gains from shopping online
3. Estimating the *variety* gains from e-commerce

Visa data

Raw data is similar to line items in monthly statements:

- Transaction amount and day
- Unique card identifiers (credit and debit)
- Store name, NAICS, ZIP (longitude-latitude down the road)
- January 2007 through December 2014

Two data constructs:

- Card location (based on card purchases)
- Card affluence (based on card spending)

Visa data confidentiality

All results have been reviewed to ensure that no confidential information about Visa merchants or cardholders is disclosed.

Cards are anonymized, and we report no data on individual cards. Cardholder information is based solely on the card's transactions.

We report no data on specific merchants, and observe a 2-year blackout – which is why the analysis sample ends in December 2014.

Visa data caveats

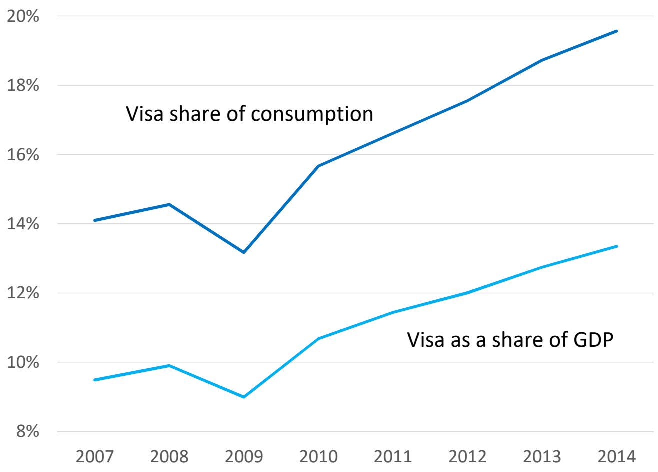
- No details on items bought or prices
- Cannot tie multiple cards to households
- Cannot see card-holder demographics
- Tremendous card turnover
- Will rely heavily on monetized distance to get at WTP

Visa summary statistics

U.S. annual averages from 2007 through 2014

- 373 million cards
- 31.9 billion transactions
- \$1.7 trillion in sales
  - 48% credit, 52% debit

Flowing through Visa



Sources: Visa and BEA

Online vs. offline Visa spending

Visa transaction flags

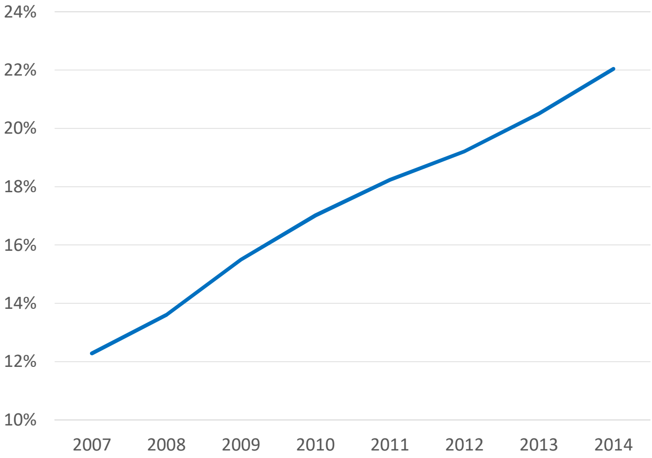
- CP $\equiv$ Card Present
- CNP $\equiv$ Card Not Present

We define offline to include:

- CP (brick-and-mortar)
- CNP phone + mail + recurring

Visa defines the rest of the CNP categories as *e-commerce*

Share of Visa spending online



Online spending shares, selected NAICS (in %)

	2007	2014
Electronics	27.9	35.7
Air Transport	10.3	33.4
Clothing	9.6	20.6
Furniture	6.6	14.8
General Merchandise	4.0	8.6
Food	1.9	3.1

Decomposing the growth of online spending

	2007	2014	$\frac{2014}{2007}$	Share*
Online card share	0.61	0.74	1.22	31%
Online spending per merchant ($)	214	264	1.24	35%
Online merchants per card	4.3	5.5	1.27	34%
Offline spending per merchant ($)	174	168	0.97	
Offline merchants per card	23	23	1.00	

* Contribution to growth in (spending online)/(spending offline)

Growth in # of offline stores vs. e-commerce growth

- Across $\sim$ 3,000 counties from 2007–2014:

$$\Delta \ln N_{cn} = \alpha_n + \beta_n \, \Delta s_{cn} + \epsilon_{cn}$$

- c = county
- n = NAICS (12 total)
- N = number of merchants
- s = share of spending on e-commerce

Growth in # of offline stores vs. e-commerce growth

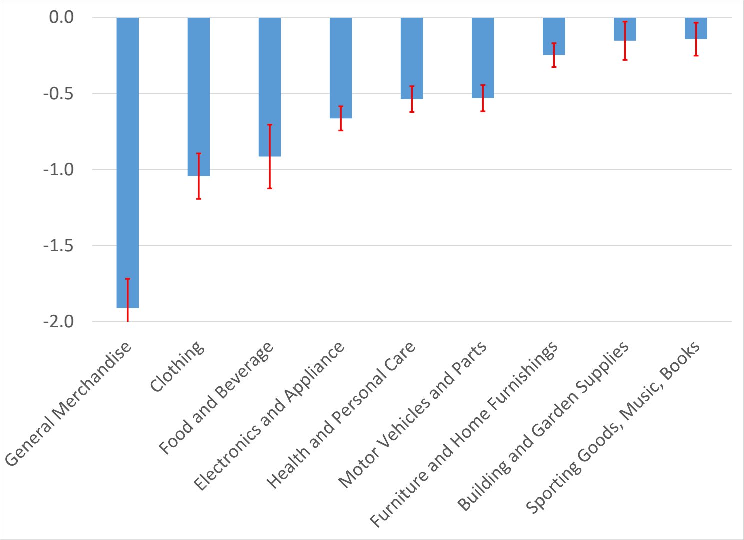
Coefficient from regressing the % change in offline stores on the change in online spending share from 2007 to 2014:

All stores	-1.42
Chains	-1.75
Independents	-1.13

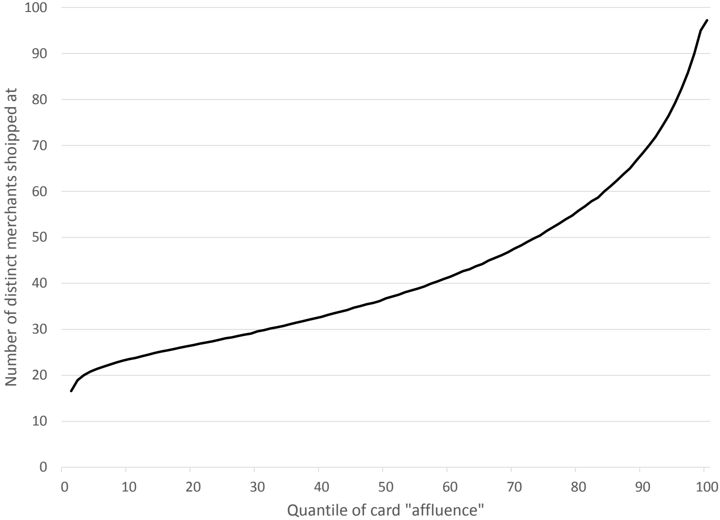
Across counties, pooled over NAICS.

Each standard error is about 0.03.

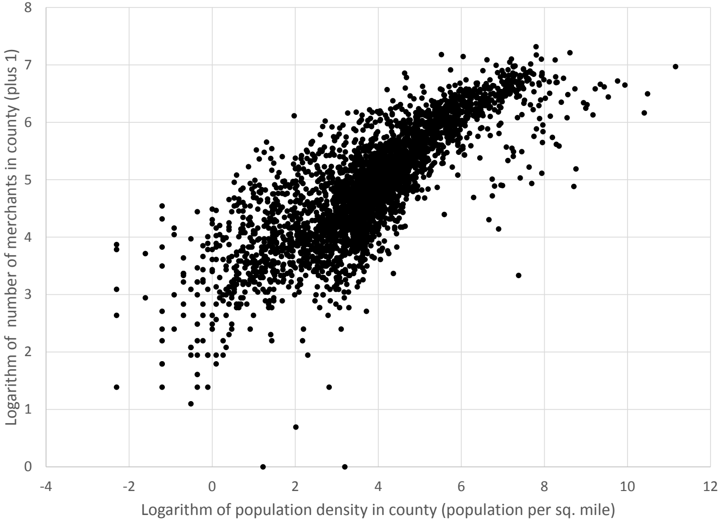
Growth in # of stores vs. e-commerce growth (by NAICS)



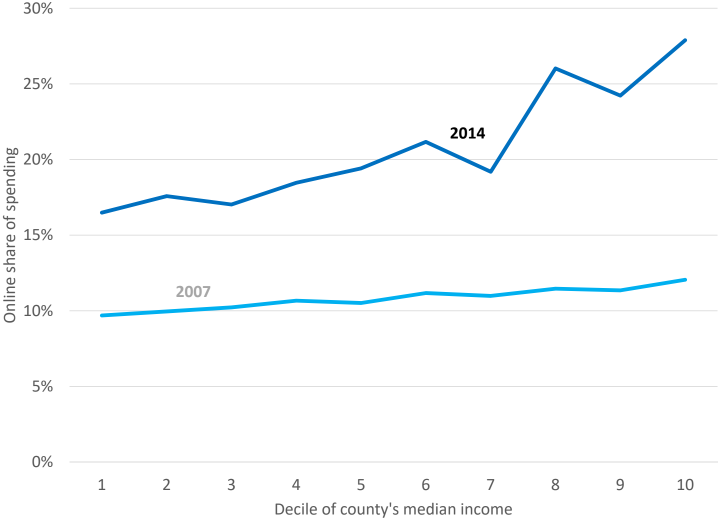
of merchants shopped at by card affluence in 2014



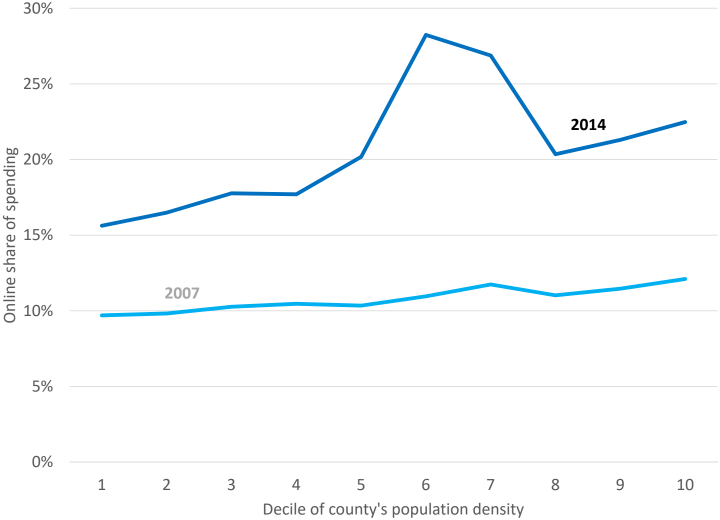
Merchants vs. population density across counties in 2014



Online share by county income



Online share by county density



Outline

1. Visa data and basic facts
2. **Estimating the *pure convenience* gains from shopping online**
3. Estimating the *variety* gains from e-commerce

Estimates of convenience surplus

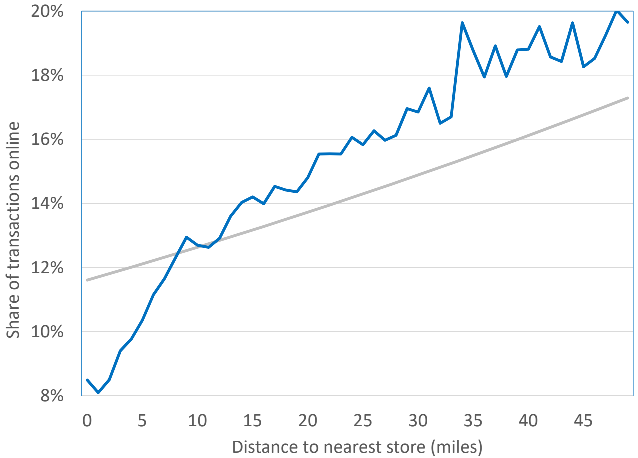
- Assume basket is fixed and, for a given merchant, identical prices online and offline (Cavallo, 2017)
- Focus on the binary decision when both options are available:

$$u_{ij}^{o} = \gamma_j^{o} + \epsilon_{ij}^{o}$$
$$u_{ij}^{b} = \gamma_j^{b} - \beta \cdot dist_{ij} + \epsilon_{ij}^{b}$$

i is the individual, j is the merchant, and the distance is between the individual i and the nearest store of merchant j

If iid Type I extreme value distribution of idiosyncratic preferences, logit online/offline indicator on distance and merchant fixed effects

Pr(shop online) vs. distance to merchant store



- An observation is an individual transaction
- Sample = transactions in 5 "mixed online/offline" retail categories (1% sample of cards) in 2014

Converting distance into WTP

- A straight-line mile requires 1.5 miles of driving on average (Einav et al, 2016)
- 1.4 minutes per mile of driving (Einav at al, 2016)
- 2017–2014 average hourly wage = \$31 per hour (BLS)
- 2007–2014 average fuel + depreciation per mile \$0.54 (IRS)
- Each mile counts for two miles of round trip
- Each mile costs \$0.80 in direct costs and \$1.05 in time costs, for a total of \$3.71 per roundtrip mile

Consumer surplus from convenience

$$CS_{ij} = \frac{\ln[exp(-\beta \cdot dist_{ij}) + exp(\gamma_j)] - \ln[exp(-\beta \cdot dist_{ij})]}{\beta}$$

- 16.6 mile-equivalents per transaction
- 4.2 off the data, rest from "online lovers" in the logit fat tail
- "Direct" savings per online transaction = \$15.5 ($4.2 \cdot 2 \cdot \$1.85$)
- Typical transaction is \$62 and 14 miles away, so convenience value is $\approx 14\%$ (= \$16/\$114)
- In 2014, share of all Visa spending at "mixed" merchants with distance < 50 miles in our 5 "mixed" NAICSs was 7%, so overall convenience gains are $\approx 1.0\%$ (7% of 14%)

Interpreting the pure convenience gains

- Convenience gains are driven by substitution from offline to online for the *same* merchant
- However, 88% of spending online is at merchants at which the same card has never transacted offline
- So much of the gains may be due to accessing new merchants rather substitution within merchants' offline/online arms
- To quantify this, we next write down a stylized model in which consumers can add merchants, and calibrate it using the Visa data

Outline

1. Visa data and basic facts
2. Estimating the *pure convenience* gains from shopping online
3. **Estimating the *variety* gains from e-commerce**

Consumer problem

$$\max\ U = \left[\sum_{m=1}^{M} (b_m + q \cdot o_m)^{1-\frac{1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

subject to

$$M_b^{\phi} F_b + M_o^{\phi} F_o + \sum_{m=1}^{M} (b_m + o_m) \leq y$$

- b_m (o_m) = brick-and-mortar (online) spending on merchant m
- q = relative "quality" of the online channel
- M_b (M_o) = # of merchants shopped at in-store (online)
- F_b (F_o) = scale of fixed costs for shopping in-store (online)

Comments on the consumer problem

- The implicit assumption is that all merchants charge the same price (across merchants and online vs. offline)
  - as a result, optimal spending is the same across different offline (online) merchants visited: $o_m = o$ and $b_m = b$
- Offline and online are perfect substitutes, so a consumer spends online or offline (or neither) for a given merchant
  - Broadly consistent with low within-card merchant overlap
- $\sigma > 1$ is the elasticity of substitution across *merchants*
  - $\sigma < \infty \Rightarrow$ "love of variety"
- ϕ governs how fast fixed shopping costs rise with the # of online and brick-and-mortar merchants shopped at
  - $\phi > 1$ so we get an interior solution despite love of variety

Consumer intensive and extensive margins

The utility-maximizing choices are

$$o = (\sigma - 1)\,\phi F_o^{\frac{1}{\phi}} \left[\left(\frac{k}{k+1} \right) \left(\frac{1}{1 + (\sigma - 1)\,\phi} \right) y \right]^{\frac{\phi - 1}{\phi}},$$

$$b = (\sigma - 1)\,\phi F_b^{\frac{1}{\phi}} \left[\left(\frac{1}{k+1} \right) \left(\frac{1}{1 + (\sigma - 1)\,\phi} \right) y \right]^{\frac{\phi - 1}{\phi}}$$

$$M_o = \left[\left(\frac{k}{k+1} \right) \left(\frac{1}{1 + (\sigma - 1)\,\phi} \right) \frac{1}{F_o} y \right]^{\frac{1}{\phi}}$$

$$M_b = \left[\left(\frac{1}{k+1} \right) \left(\frac{1}{1 + (\sigma - 1)\,\phi} \right) \frac{1}{F_b} y \right]^{\frac{1}{\phi}}$$

where $k \equiv q^{\frac{\phi}{\phi - 1}(\sigma - 1)} \left(\frac{F_b}{F_o} \right)^{\frac{1}{\phi - 1}}$

Online spending share and gains from e-commerce

Let s_o denote the share of card spending online:

$$s_o \equiv \frac{oM_o}{oM_o + bM_b} = \frac{k}{k+1}$$

where $k \equiv q^{\frac{\phi}{\phi-1}(\sigma-1)} \left(\frac{F_b}{F_o}\right)^{\frac{1}{\phi-1}}$

- s_o rises with q and F_b/F_o; trends in o, b, M_o, and M_b tell us how much s_o has risen because of rising q vs. falling F_o (for given F_b)

Estimating ϕ (convexity of fixed shopping costs)

According to the model, we can estimate ϕ using one of two regressions that yield the same answer by construction:

$$\ln M = \alpha + \frac{1}{\phi} \cdot \ln\left(oM_o + bM_b\right)$$

$$\ln\left(\frac{oM_o + bM_b}{M}\right) = \eta + \frac{\phi - 1}{\phi} \cdot \ln\left(oM_o + bM_b\right)$$

Extensive and intensive margin Engel Curve slopes should reflect ϕ

Caveat: This assumes no idiosyncratic fixed costs or online/offline preferences correlated with a card's total expenditures

Estimates of ϕ (convexity of fixed shopping costs)

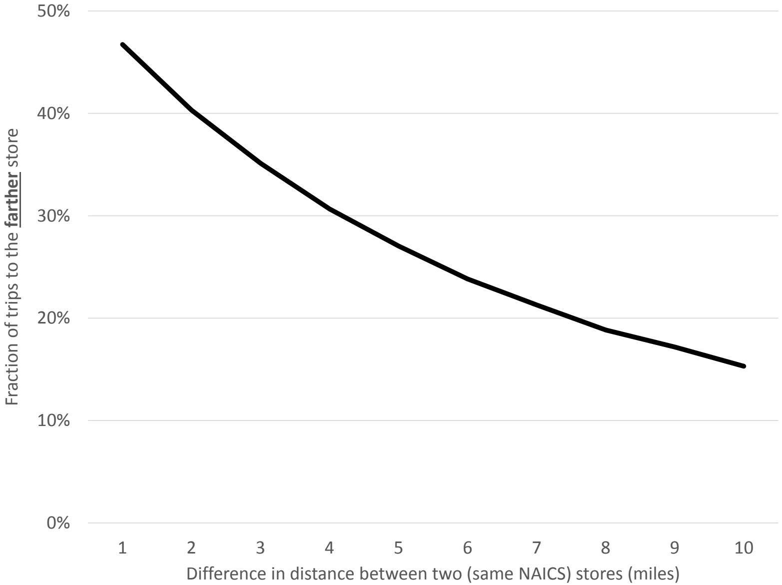
	2007	2014
$\widehat{\phi}$	1.78	1.82
# of cards	287M	453M
R^2	0.66	0.67

Standard errors are tiny ...

Estimating σ (elasticity of substitution across merchants)

- We use a 1% sample of cards that transacted in 2014
- For each card i, we look at offline purchases made within 10 miles of i's location
- construct all pairs of stores j and k for each NAICS and, for each individual i who buys in one of these stores, compute $|dist_{ij} - dist_{ik}|$
- calculate the share of combined trips to each pair made to the farther store at each absolute distance

Relative trips vs. distance



Estimating σ (continued)

- Assuming distance is uncorrelated with preferences (controlling for merchant fixed effects), we can use how visits change with distance to estimate σ
- Moving from 6 to 16 miles away implies an effective price change of \$37 (round trip); given an average ticket size of \$42, this is a price increase of 57%
- The trip *share* drops by about 68%, implying a σ of approximately 3.6

Welfare gain from e-commerce

Maximized utility can be written as

$$W = \left(\frac{1}{1-s_o}\right)^{\frac{\phi-1}{\phi}\frac{1}{\sigma-1}} \left(\frac{1}{F_b}\right)^{\frac{1}{\phi}\frac{1}{\sigma-1}} \frac{(\sigma-1)\,\phi\, y^{\frac{1}{\sigma-1}\left(\sigma-\frac{\phi-1}{\phi}\right)}}{[1+(\sigma-1)\,\phi]^{\frac{1}{\sigma-1}\left(\sigma-\frac{\phi-1}{\phi}\right)}}$$

For given expenditures y and fixed costs for offline stores F_b, welfare rises with the share of spending online s_o

Consumers gain from rising s_o due to a combination of:

- online options becoming better (rising q)
- easier access to online merchants (falling F_o)

Consumption-equivalent welfare gains from e-commerce

	ϕ	σ	s_o^{2014} vs. s_o^{2007}	s_o^{2014} vs. $s_o = 0$
Baseline	1.8	3.6	1.7%	**3.6%**
Sensitivity checks:				
High ϕ	2	3.6	1.9%	4.1%
High σ	1.8	4	1.5%	3.2%

Welfare gains by county affluence

	s_o^{2014} vs. s_o^{2007}	s_o^{2014} vs. $s_o = 0$
Quartile 1 (poorest)	1.2%	2.7%
Quartile 2	1.3%	2.9%
Quartile 3	1.5%	3.2%
Quartile 4 (richest)	2.8%	4.6%

Note: Quartiles based on cards; 25% of cards in each quartile

Welfare gains by county density

	s_o^{2014} vs. s_o^{2007}	s_o^{2014} vs. $s_o = 0$
Quartile 1 (sparse)	1.1%	2.6%
Quartile 2	1.4%	3.0%
Quartile 3	2.6%	4.3%
Quartile 4 (dense)	1.7%	3.5%

Note: Quartiles based on cards; 25% of cards in each quartile

Conclusions

1. *Convenience* gains $\approx$ 1.0% of Visa spending

2. Allowing for *variety* gains, consumer surplus from online spending $\approx$ 3.6% of Visa spending

3. Consumer surplus from e-commerce is:
   - Greater for consumers in richer counties
   - Greater for consumers in more densely populated counties

Gains relative to overall consumption and GDP

Gains as a share of all Visa spending	3.6%
Credit + Debit share of all consumer spending	36.2%
Gains as a share of all consumer spending	1.3%
Gains as a share of GDP	0.9%

Next

1. Business stealing and loss of brick & mortar stores
2. Customer acquisition
   - 75 to 90% of sales variation across merchants, outlets, time
3. Store entry: too little, too much, or just right?