Assessing the Gains from E-Commerce

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June 2019

Technology Diffusion and Productivity Workshop
Federal Reserve Bank of Richmond

What we do

- Document the rise of e-commerce using Visa data
- Estimate resulting consumer surplus $> 1\%$ of consumption
- Find gains are increasing in county population density
- Find gains are twice as big for incomes above $50k

Related literature

Gains from e-commerce and the internet

- Brynjolffson and collaborators (2003, 2012, 2017)
- Goolsbee and Klenow (2006, 2018)
- Syverson (2016)
- Couture, Faber, Gu and Liu (2018)
- Allcott, Braghieri, Eichmeyer and Gentzkow (2019)

Consumer surplus from new products more generally

- Feenstra (1994)
- Hausman (1997, 1999)
- Weinstein and collaborators (2006, 2010, 2018, 2019)

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 in recent years)
- January 2007 through December 2017

Merged with *Experian* data the last few years:

- Card income
- Card location

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 or from recent months – which is why the analysis sample ends in December 2017.

Visa data caveats

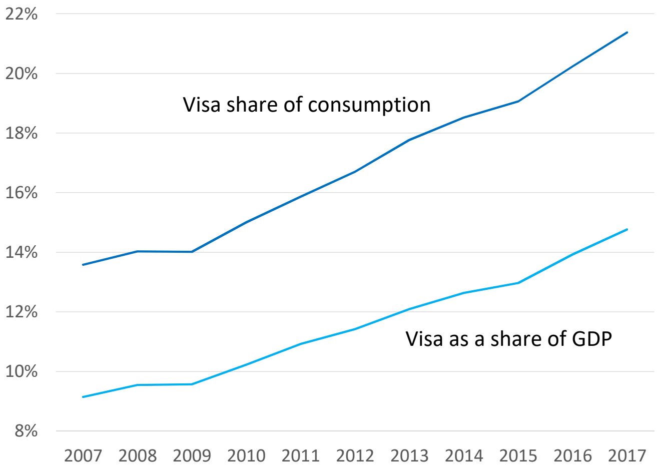
- No details on items bought or prices
- Cannot tie multiple cards to households
- Tremendous card turnover
- Will rely heavily on monetized distance to get at WTP

Visa summary statistics

U.S. annual averages from 2007 through 2017

- 380 million cards
- 35.9 billion transactions
- $1.93 trillion in sales
    - 55% credit, 45% debit

Flowing through Visa



Sources: Visa and BEA

Experian data

- Consumer credit reporting agency
- Merged with Visa cards (only in recent years)
- Can match roughly 50% of Visa credit cards 2016–2017
- Cardholder demographics (e.g. income and education)

E-commerce in the Visa data

Visa transaction flags:

- CP $\equiv$ Card Present (brick-and-mortar)
- CNP $\equiv$ Card Not Present
  - phone or mail order
  - recurring bill payments
  - ECI $\equiv$ e-commerce indicator
  - missing values

For missing values we allocate within 3-digit NAICS years:

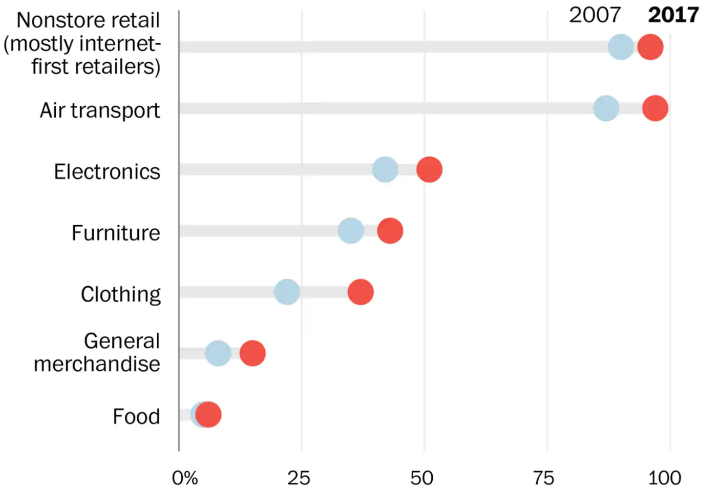
$$\text{e-commerce} = \frac{\text{ECI}}{\text{ECI + phone/mail/recurring}} \times \text{CNP}$$

E-Commerce industries

Retail	Example
Nonstore Retail	Amazon
Clothing	Nordstrom
Misc Retail	Staples
General Merchandise	Walmart
Electronics	Best Buy
Building Material, Garden Supplies	Home Depot
Furniture	Bed Bath & Beyond
Sporting Goods, Hobby	Nike
Health, Personal Care	CVS
Food	Safeway
Ground Transportation	Uber

Non-Retail	Example
Admin, Support Services	Expedia Travel
Air Transportation	American Airlines
Accommodation	Marriott
Car Parts	AutoZone
Rental Services	Hertz Rent-A-Car

Share of visa spending online, select industries

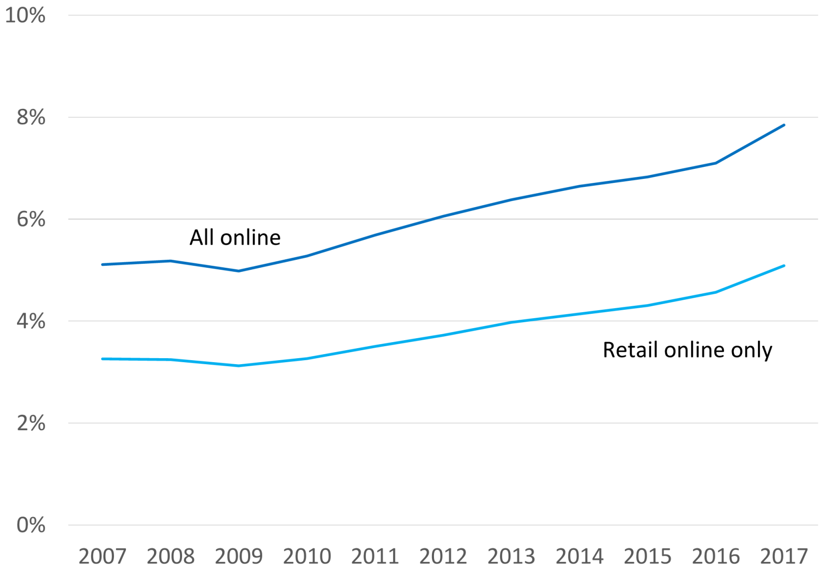


Estimating e-commerce in the U.S. overall

$$\text{U.S. Online Share} = \frac{\text{Total Card Spending}}{\text{Consumption}} \cdot \text{Visa Online Share}$$

- Calculate e-commerce share in Visa as described above
- Assume Visa representative of all card transactions
- Assume non-card transactions are all offline

Share of U.S. consumption online



Estimating e-commerce by county-income group

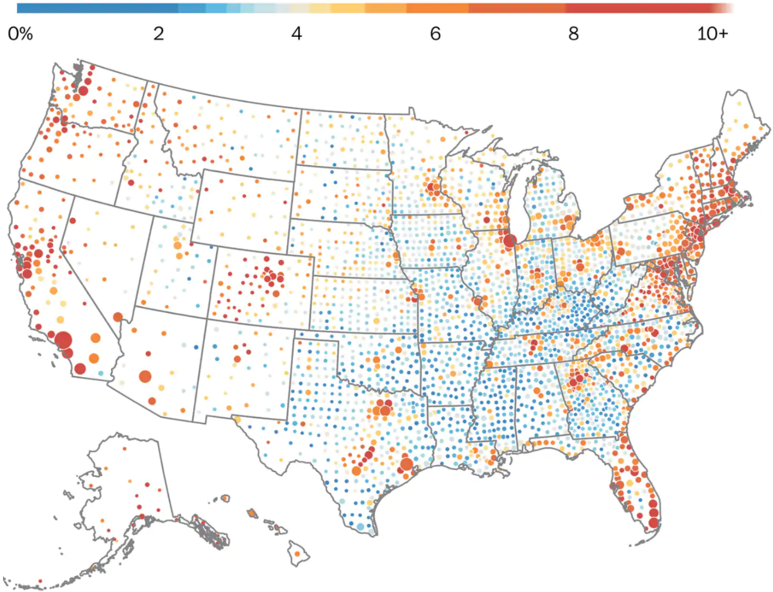
Fraction of households with cards:

$$\widehat{\alpha}_{cy} \propto \frac{\text{\# of Visa Cards}_{cy}}{\text{Tax Filers}_{cy}}$$

Fraction of *all* consumption on e-commerce for each county-income:

$$\widehat{\text{s}}_{cy} \propto \frac{\text{Visa online spending}_{cy}}{\text{Total Visa spending}_{cy}} \cdot \widehat{\alpha}_{cy}$$

Online commerce as a share of consumer spending



E-commerce share by population density and income

Online share of all consumer spending:

Below-median density counties	6.4%
Above-median density counties	9.1%
Cardholder income $\leq$ \$50k	3.4%
Cardholder income $>$ \$50k	9.7%

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Consumer problem

$$\max\ U = \left[\sum_{m=1}^{M} (q_m \cdot x_m)^{1-\frac{1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

subject to

$$M_b^{\phi} F_b + M_o^{\phi} F_o + \sum_{m=1}^{M} p_m \cdot x_m \leq w$$

- q_m = “quality” of merchant m
- x_m = quantity purchased from merchant m
- p_m = price per unit at merchant m
- $M = M_b + M_o =$ total merchants bought from
- 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

- Merchants are either online or offline (not both)
  - Broadly consistent with low merchant overlap within cards
- $\sigma > 1$ 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

Producer problem

$$\max_{p_m} \quad \pi_m \;=\; p_m\, y_m - wL_m - wK_j$$

subject to

$$y_m = \frac{M_j}{M_{j,market}}\, L\, x_m \quad \text{and} \quad y_m = Z_m L_m$$

- $j = o$ or b
- $M_j \leq M_{j,market}$
- Brick-and-mortar (online) sellers split their market evenly
- K_j = overhead labor needed to operate

Free entry and market clearing

For each market j:

$$E_j[\pi_m] = 0$$

Labor market clearing:

$$L \;=\; \sum_m L_m \;+\; L_b \;+\; L_o + \; M_{b,market} K_b \;+\; M_{o,market} K_o$$

Shopping technology

$$L \cdot M_b^{\phi} \;=\; Y_b \;=\; A_b \, L_b$$

$$L \cdot M_o^{\phi} = \; Y_o \;=\; A_o \, L_o$$

Perfectly competitive so marginal cost pricing:

$$F_b \;=\; \frac{w}{A_b}$$

$$F_o \;=\; \frac{w}{A_o}$$

Symmetric technologies

Process efficiency:

$$Z_m = Z$$

Quality offline:

$$q_m = q_b \text{ for } m \in M_{b,market}$$

Quality online:

$$q_m = q_o \text{ for } m \in M_{o,market}$$

Symmetric outcomes

Pricing:

$$p_m = p = \frac{\sigma}{\sigma - 1} \cdot \frac{w}{Z}$$

Spending per merchant online (o) and offline (b):

$$\frac{o}{b} = \left(\frac{q_o}{q_b}\right)^{\sigma-1}$$

Profits:

$$\pi_o = \frac{M_o}{M_{o,market}} L \cdot \frac{o}{\sigma} - wK_o$$

$$\pi_b = \frac{M_b}{M_{b,market}} L \cdot \frac{b}{\sigma} - wK_b$$

Merchants in GE

$$\text{Define } \; k \equiv \left(\frac{q_o}{q_b}\right)^{\frac{\phi}{\phi-1}(\sigma-1)} \left(\frac{A_o}{A_b}\right)^{\frac{1}{\phi-1}}$$

$$M_{b,market} = \frac{1}{1+k} \cdot \frac{1}{\sigma} \cdot \frac{(\sigma-1)\phi}{1+(\sigma-1)\phi} \cdot \frac{L}{K_b}$$

$$M_{o,market} = \frac{k}{1+k} \cdot \frac{1}{\sigma} \cdot \frac{(\sigma-1)\phi}{1+(\sigma-1)\phi} \cdot \frac{L}{K_o}$$

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

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

GE comparative statics

	$\frac{M_{o,market}}{M_{b,market}}$	$\frac{M_o}{M_b}$	$\frac{o}{b}$
$\frac{A_o}{A_b}$	+	+	0
$\frac{q_o}{q_b}$	+	+	+

Online spending share

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 $k \equiv \left(\frac{q_o}{q_b}\right)^{\frac{\phi}{\phi-1}(\sigma-1)} \left(\frac{A_o}{A_b}\right)^{\frac{1}{\phi-1}}$

- s_o rises with q_o/q_b and A_o/A_b
- Consumers gain from rising s_o if it is due to a combination of better (rising q_o) and easier to access (rising A_o) online options

Welfare

Consumption-equivalent welfare is proportional to

$$Z \cdot M^{1/(\sigma-1)} \cdot \bar{q}$$

where average quality is

$$\bar{q} \equiv \left[\frac{{q_b}^{\sigma-1} \cdot M_b + {q_o}^{\sigma-1} \cdot M_o}{M} \right]^{1/(\sigma-1)}$$

Welfare gain from e-commerce

In terms of exogenous variables, welfare is proportional to

$$Z \cdot \left(q_b{}^{\frac{\phi}{\phi-1}(\sigma-1)} A_b^{\frac{1}{\phi-1}} + q_o{}^{\frac{\phi}{\phi-1}(\sigma-1)} A_o^{\frac{1}{\phi-1}} \right)^{\frac{\phi-1}{\phi}\frac{1}{\sigma-1}}$$

For given Z, q_b, and A_b, welfare is increasing in s_o :

$$Z \cdot q_b \cdot A_b^{\frac{1}{\phi(\sigma-1)}} \left(\frac{1}{1-s_o} \right)^{\frac{\phi-1}{\phi(\sigma-1)}}$$

Quantitative strategy

Calibrate:

- ϕ = convexity of fixed shopping costs
- σ = elasticity of substitution across merchants

Then infer the welfare gain from the path of s_o

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 idiosyncratic fixed costs are uncorrelated with a card's total expenditures

Estimates of ϕ (convexity of fixed shopping costs)

	2007	2017
$\widehat{\phi}$	1.73	1.75
# of cards	283M	462M
R^2	0.67	0.67

Standard errors are tiny ...

Estimating σ

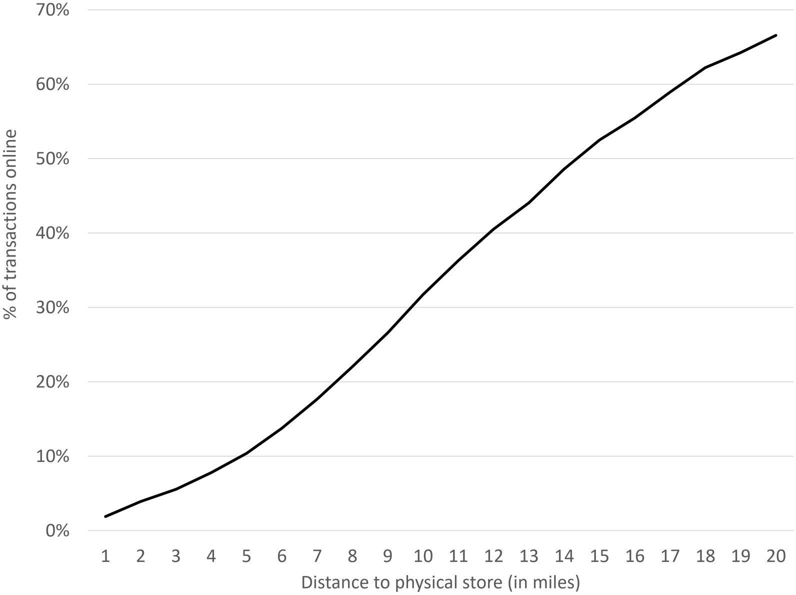
- Assuming distance is uncorrelated with preferences (controlling for merchant fixed effects), we can use how visits change with distance to estimate σ

- Aggregating merchant pairs $\{j, k\}$ with the same $\{dist_{ij}, dist_{ik}\}$:

$$\ln\left(\frac{Trips_j}{Trips_k}\right) = \ln\left(\frac{q_j}{q_k}\right) - \sigma \cdot \ln\left(\frac{p_{jk} + \tau_{ij}}{p_{jk} + \tau_{ik}}\right)$$

  - p_{jk} = average ticket size at merchants j, k
  - τ = transportation costs for i to j or k
  - τ = 0 for online transactions
  - Capture relative quality with cross fixed effects
  - Regress on both online-offline and offline-offline samples

Transactions online vs. distance to a physical store



Converting distance into WTP (willingness to pay)

- A straight-line mile requires 1.5 miles of driving on average (Einav et al, 2016)
- 1.4 minutes per mile of driving on average (Einav at al, 2016)
- 2017–2017 average hourly wage = $23 per hour (BLS)
- 2007–2017 average fuel + depreciation per mile = $0.535 (IRS)
- Each mile counts as two miles of round trip travel
- Each mile costs $0.80 in direct costs and $0.79 in time costs, for a total of $3.18 per roundtrip mile

Estimates of σ

	online-offline	offline-offline
$\widehat{\sigma}$	4.3	6.1
# of obs	3.6M	14.0M
R^2	0.97	0.94

Standard errors are tiny (on the order of 0.001)

Consumption-equivalent gains from e-commerce

	ϕ	σ	Gains
Baseline	1.74	4.3	**1.06%**
Offline ϕ	*1.58*	4.3	0.91%
Offline σ	1.74	*6.1*	0.68%

Consumption-equivalent gains by income and density

Card income $\leq$ \$50k	0.45%
Card income $>$ \$50k	1.32%
Below-median density counties	0.85%
Above-median density counties	1.24%

Substitutability by NAICS

	$\widehat{\sigma}$
Building Material, Garden Supplies	7.7
Motor Vehicle and Parts Dealers	7.5
Furniture and Home Furnishings Stores	7.4
General Merchandise Stores	5.8
Health and Personal Care Stores	5.5
Clothing and Clothing Accessories Stores	5.2
Miscellaneous Store Retailers	5.2
Sporting Goods, Hobby, Music, Book Stores	4.2
Food and Beverage Stores	3.6
Electronics and Appliance Stores	3.4

Note: These are the 10 mixed offline/online 3-digit NAICS

Consumption-equivalent gains by 2017

1 big CES nest (baseline)	1.06%
16 CES nests (allocating nonstore retail)	1.62%

Note: assumes Cobb-Douglas aggregation of nests

Retail Apocalypse

	Due to rising q_o and A_o	2007–2017 Change
b	spending per offline merchant	–1.6%
M_b	# of offline merchants bought from	–2.1%
$M_{b,market}$	# of offline merchants in the market	–3.7%
Π	profits of offline merchants	0%

Conclusions

1. Allowing for *variety* gains, surplus $\approx 1\%$ of consumption
2. Consumer surplus from e-commerce is:
   - smaller for incomes below $50k (less likely to have cards)
   - larger in more densely populated counties
3. Modest implications for growth and inequality trends