Assessing the Gains from E-Commerce

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What we do

- Document the rise of e-commerce using Visa data
- Estimate 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)
- Jo, Matsumura, and Weinstein (2019)
- Allcott, Braghieri, Eichmeyer and Gentzkow (2020)
- Couture, Faber, Gu and Liu (2021)

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 —
the sample currently ends in December 2017.

Visa data caveats

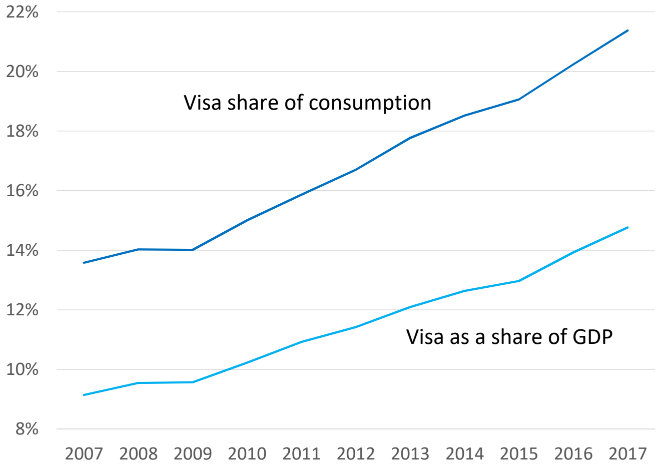
- No details on items bought or prices
- Cannot tie multiple cards to households
- Cards last 1-2 years on average
- Will rely heavily on monetized distance to get at WTP

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 in 2016 and 2017
- Can match roughly 50% of Visa credit cards
- 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:

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

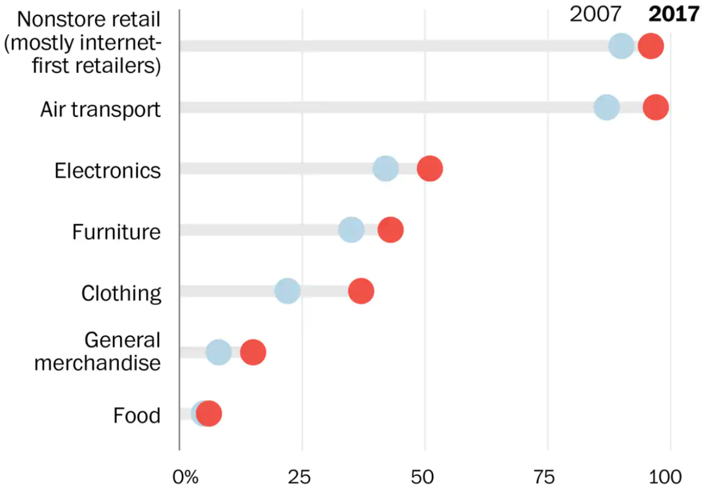
Retail e-commerce

Retail industry	Example
Nonstore Retail	Amazon
Clothing	Nordstrom
Miscellaneous Retail	Staples
General Merchandise	Walmart
Electronics and Appliance Stores	Best Buy
Building Material and Garden Supply Stores	Home Depot
Furniture and Home Furnishings Stores	Bed Bath & Beyond
Sporting Goods, Hobby, Music and Book Stores	Nike
Health and Personal Care Stores	CVS
Food and Beverage Stores	Safeway
Ground Transportation	Uber

Non-retail e-commerce

Non-Retail industry	Example
Administrative and 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

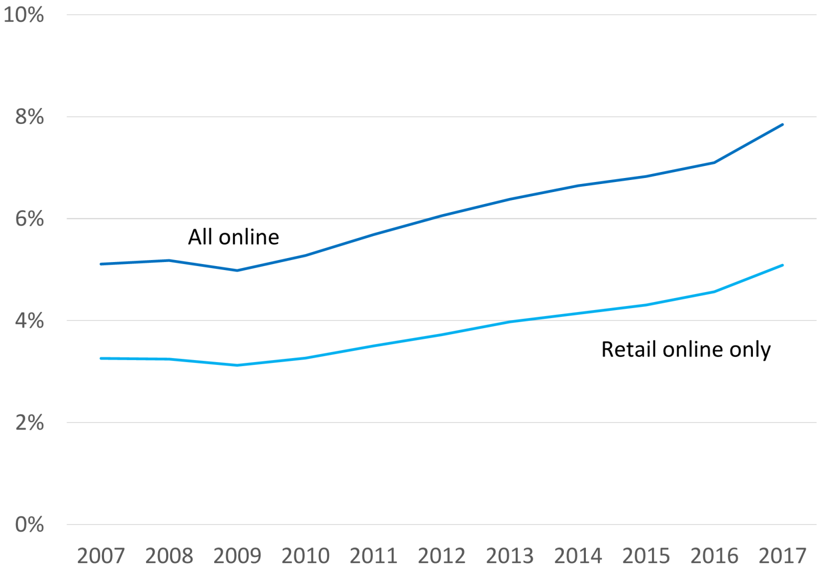


Estimating e-commerce in the U.S. overall

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

- 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 in each county-income group:

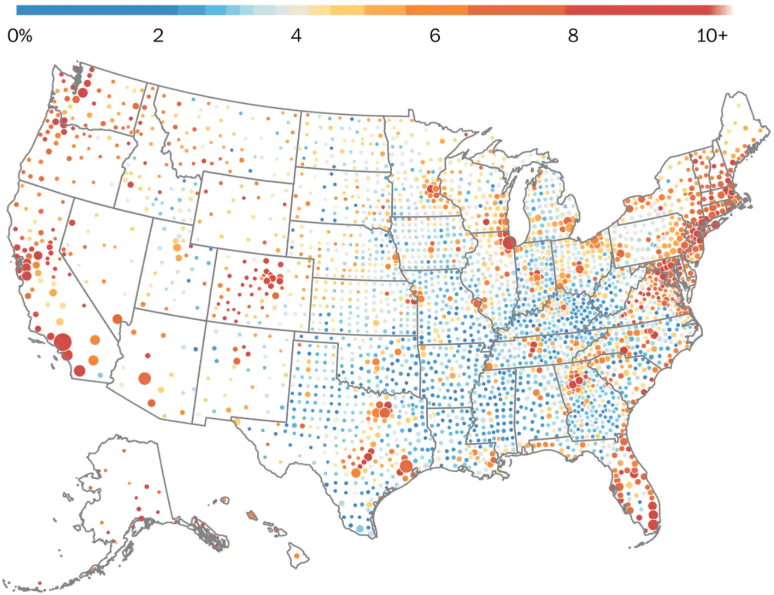
$$\widehat{\alpha}_{cy} \propto \frac{\text{\# of Visa Cards}_{cy}}{\text{Tax Filers}_{cy}}$$

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

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

Scaled to match the national e-commerce ratio in each year

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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2. Estimating the *pure convenience* gains from shopping online
3. **Estimating the *variety* gains from e-commerce**

Consumer problem

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

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 and variety of products at merchant m
- x_m = quantity purchased from merchant m
- p_m = price per unit at merchant m
- M_b (M_o) = # of merchants shopped at in-store (online)
- $M = M_b + M_o$ = total merchants bought from
- 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

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

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 customers 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:

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

L_b and L_o are labor used in the shopping sectors

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 within each sector

Process efficiency and quality offline

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

Process efficiency and quality online

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

Symmetric outcomes

Pricing

$$p_b = \frac{\sigma}{\sigma - 1} \cdot \frac{w}{Z_b} \text{ and } p_o = \frac{\sigma}{\sigma - 1} \cdot \frac{w}{Z_o}$$

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

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

Profits

$$\pi_o = \frac{M_o}{M_{o,market}} L \cdot \frac{o}{\sigma} - wK_o \text{ and } \pi_b = \frac{M_b}{M_{b,market}} L \cdot \frac{b}{\sigma} - wK_b$$

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

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

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

GE comparative statics

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

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

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

Welfare

Consumption-equivalent welfare is proportional to

$$M^{\frac{1}{\sigma-1}} \cdot \overline{qZ}$$

where the generalized mean of quality times process efficiency is

$$\overline{qZ} \equiv \left[\frac{1}{M} \sum_m (q_m \cdot Z_m)^{\sigma-1} \right]^{\frac{1}{\sigma-1}}$$

Welfare gain from e-commerce

In terms of exogenous variables, welfare is proportional to

$$\left(\left[A_o^{\frac{1}{\phi}}\left(Z_o q_o\right)^{\sigma-1}\right]^{\frac{\phi}{\phi-1}}+\left[A_b^{\frac{1}{\phi}}\left(Z_b q_b\right)^{\sigma-1}\right]^{\frac{\phi}{\phi-1}}\right)^{\frac{1}{\sigma-1}\frac{\phi-1}{\phi}}$$

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

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

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: 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

Note: Standard errors are tiny

Estimating σ

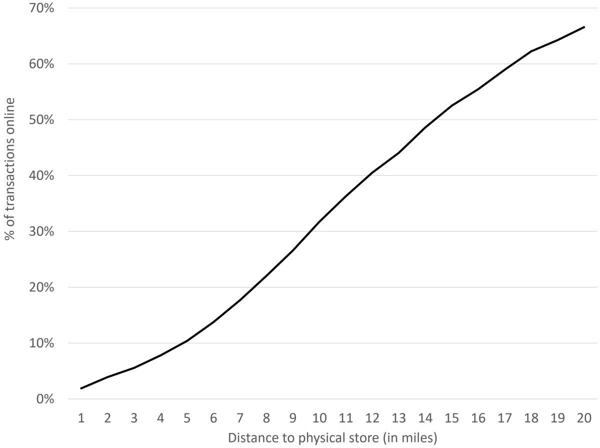
- Assuming distance is uncorrelated with preferences (controlling for merchant fixed effects), we can use how visits change with distance to estimate σ

- 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 and price 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, Finkelstein, and Williams, 2016)
- 1.4 minutes per mile of driving on average (Einav at al, 2016)
- 2007–2017 average wage = \$23 per hour (BLS)
- 2007–2017 average IRS fuel + depreciation per mile = \$0.535
- Each mile of distance counts as two miles of round-trip travel
- Thus each mile of distance involves \$0.80 in direct costs and \$0.79 in time costs, for a total of \$3.18 per round-trip 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

Note: 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: 10 mixed offline/online 3-digit NAICS

Consumption-equivalent gains by 2017

1 big CES nest (baseline)	1.06%
16 CES nests*	1.62%

* For the 16 CES nests:

- 10 mixed, 5 mostly online, and 1 offline
- We use the average $\sigma = 4.3$ for 6 of these
- We allocate nonstore retail to the 10 mixed nests
- Cobb-Douglas aggregation of the 16 nests

Retail Apocalypse

	Due to rising q_o, Z_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