Peer Effects in Product Adoption

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Introduction

- Peer interactions important driver of product adoption decisions
- Specific nature of peer effects central to implications
    - Extra demand or retiming of future demand?
    - Characteristics of influential individuals? Correlation with price sensitity?
    - Peer effects concentrated on product purchased by friends, or positive or negative spill-overs to competing products?
- **This project:** Explores these and other questions about peer effects in the market for phone purchases

Approach in this paper

- **Measurement Challenge:** Need to observe both peers and consumption or product adoption decisions in the same data set.
  - Anonymized data from Facebook to measure peers as well as product adoption from log-ins of mobile users.
- **Identification Challenge:** Homophily $\rightarrow$ common shocks & preferences $\rightarrow$ Correlated Behavior $\neq$ peer effects.
  - Exploiting quasi-random variation in peers purchasing phones induced by (i) breaking/losing phones, (ii) contract renewals.

Data Description

- Anonymized network data from Facebook
- Information on phones from mobile-active users
  - Phone model & carrier registered when logging into mobile app
  - Identify switches to new phones
- Unit of observation: Person-week
- Pool across weeks 2016-19, 2016-20, 2016-21, and 2016-22
  - Not close to major device release dates or shopping holidays

Research Design - Phone Purchase

- **Baseline Research Questions:** Are people more likely to buy **any** new phone if their friends recently bought a new phone?

$$\mathbb{1}(BuysPhone)_{i,t} = \beta FriendsBuyPhone_{i,t-1} + \gamma X_{i,t} + \varepsilon_{i,t}$$

- **Identification challenges** (result of homophily):
  - Correlated preferences
  - Correlated shocks

- **Our Approach:** Find instruments for *FriendsBuyPhone* that
  1. "Quasi-randomly" shifts probability of friends buying
  2. Does not affect own probability of buying, except though peer effects.

Instrument 1: “Random Phone Loss”

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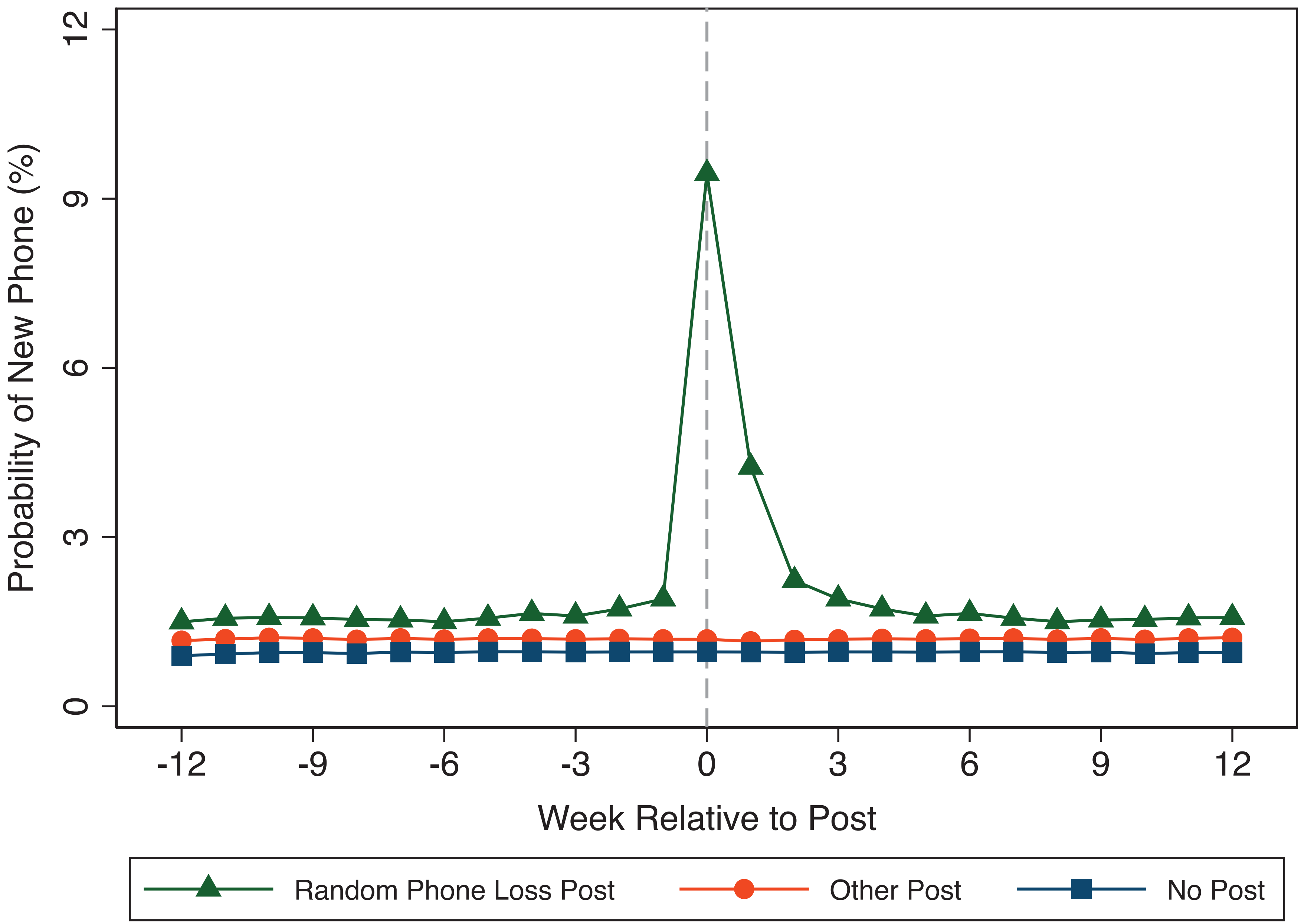
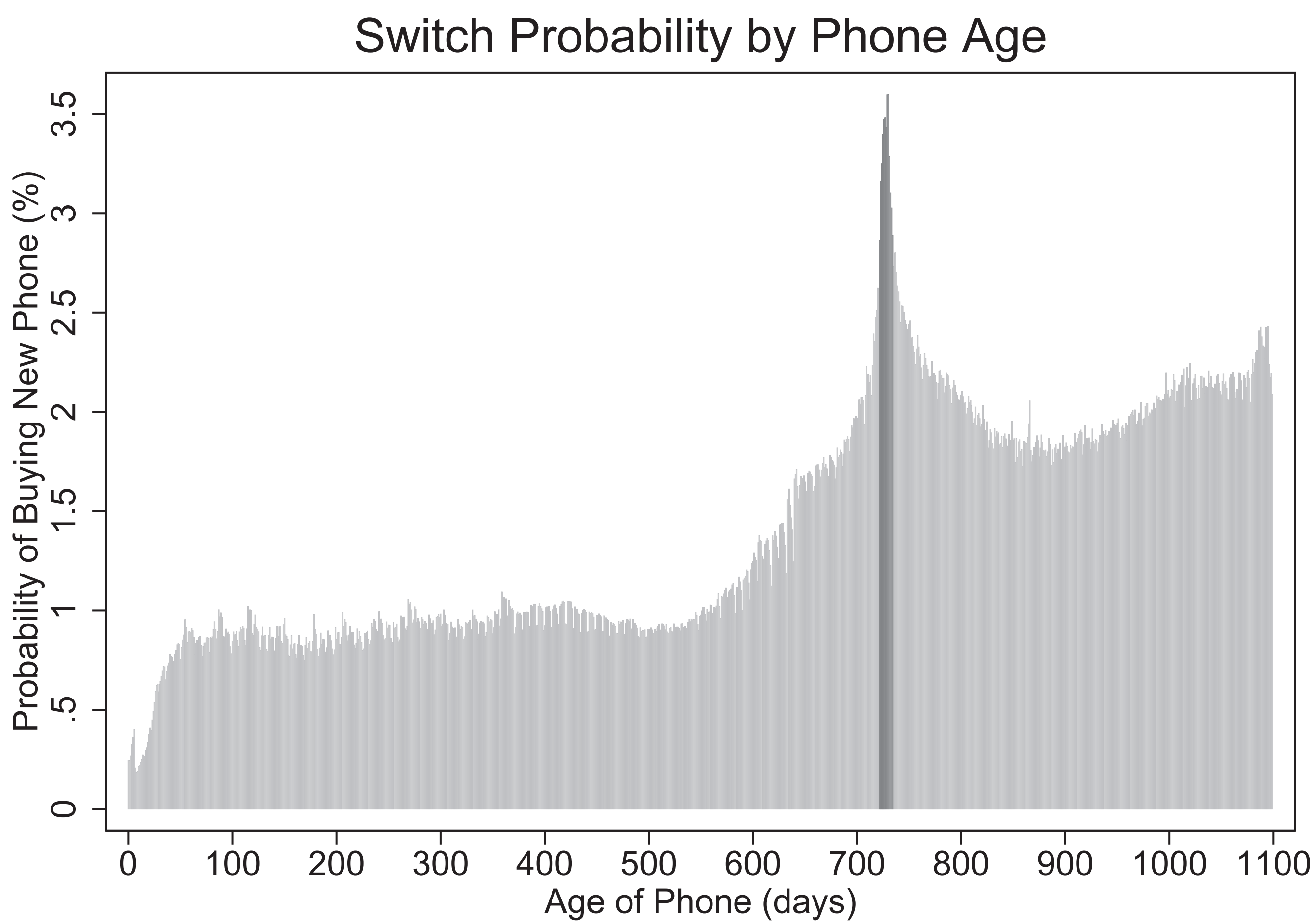
- **Approach:** Word Embeddings & Convolutional Neural Networks
  - Neural network trained on about 15k hand-classified posts.
  - Advantages relative to regular expression search
    - Remove some **false positives**:
      – *"So...I dropped my phone in the toilet yesterday...!! Still works tho!!"*
    - Discover some **false negatives**:
      – *“R.I.P phone. You will be missed.”*
      – *“uggh... water + phone = new phone time.*
      – *“Long story short, my phone tried to light my house on fire last night and you’ll have to reach me on here for a while.”*
  - Identify ∼330,000 posts about “random phone loss”

Instrument 1: “Random Phone Loss” – First Stage



Instrument 2: "Contract Renewal" – First Stage



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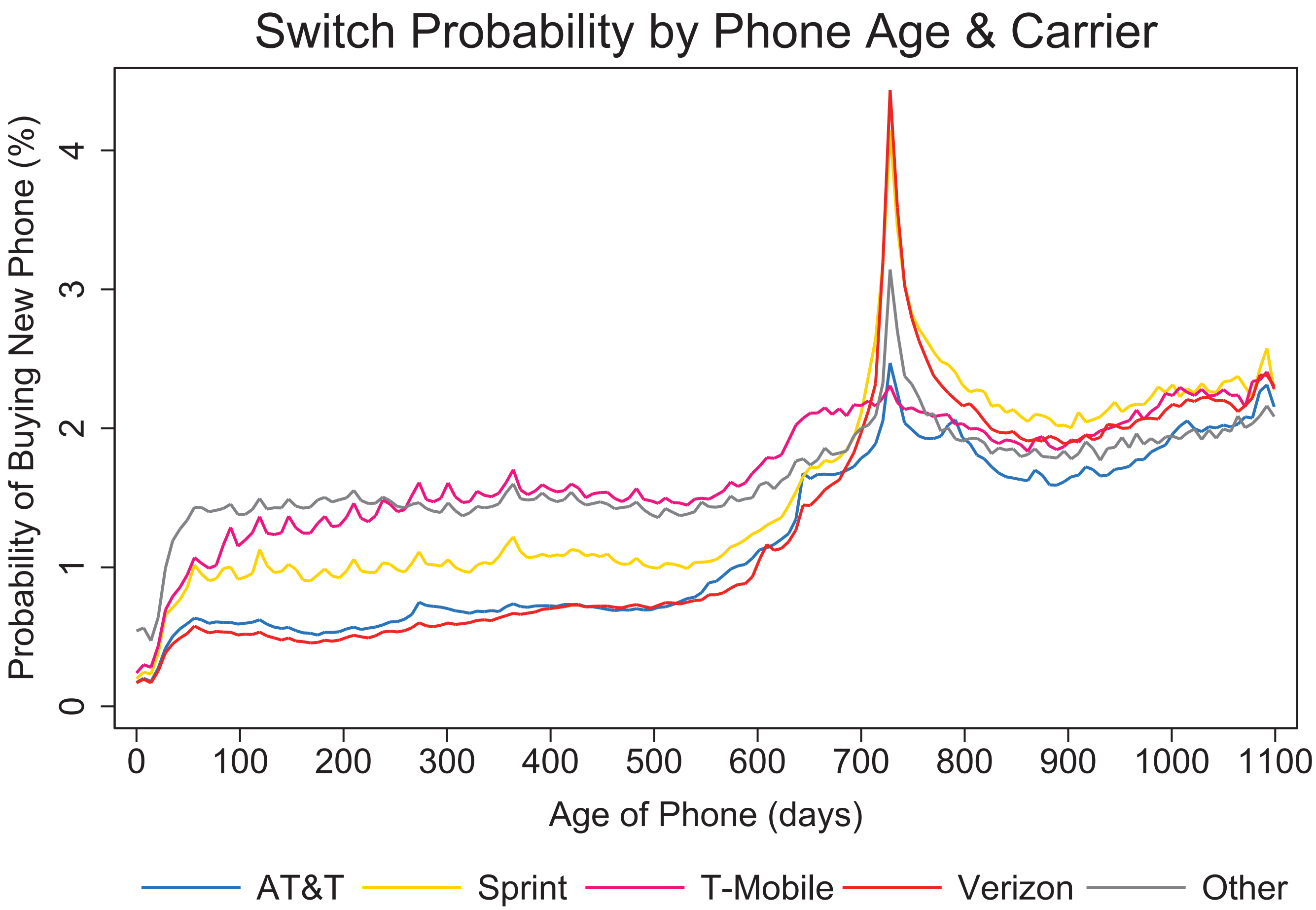

- Instrument for $FriendsBuyPhone_{i,t-1}$ with number of friends whose phone is aged 720-735 days, and their characteristics
  - E.g., Larger effects at Verizon and Sprint

Results - Phone Purchase

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Controls in $X_{i,t}$ include:

- **User** characteristics FE:
  age bucket $\times$ gender $\times$ education $\times$ state $\times$ week
- **Device** characteristics FE:
  device $\times$ carrier $\times$ phone age bucket $\times$ week
- **Friends** characteristics FE:
  number of friends $\times$ friends switching phones in last 6 months $\times$ week
- Linear controls for
  - Individual probability of buying a new phone
  - Average purchase probability among friends
  - Individual and friend posting behavior (random phone loss instrument)
  - Number and behavior of friends at threshold (contract renewal)

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	OLS	Second Stage DV: Prob Buys New Phone (%)	
	(1)	(2) Broken Phone	(3) Contract Threshold
# of Friends Buying (t-1 and t)	0.034***	0.041***	0.026**
	(0.000)	(0.005)	(0.013)
Controls + Fixed Effects	Y	Y	Y
Mean Dependent Variable	0.95	0.95	0.95
Number of Observations	335m	335m	335m
F-Statistic Instrument		339,156	55,592

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- Effect not driven by family members
- Not caused by advertising responding to instrument

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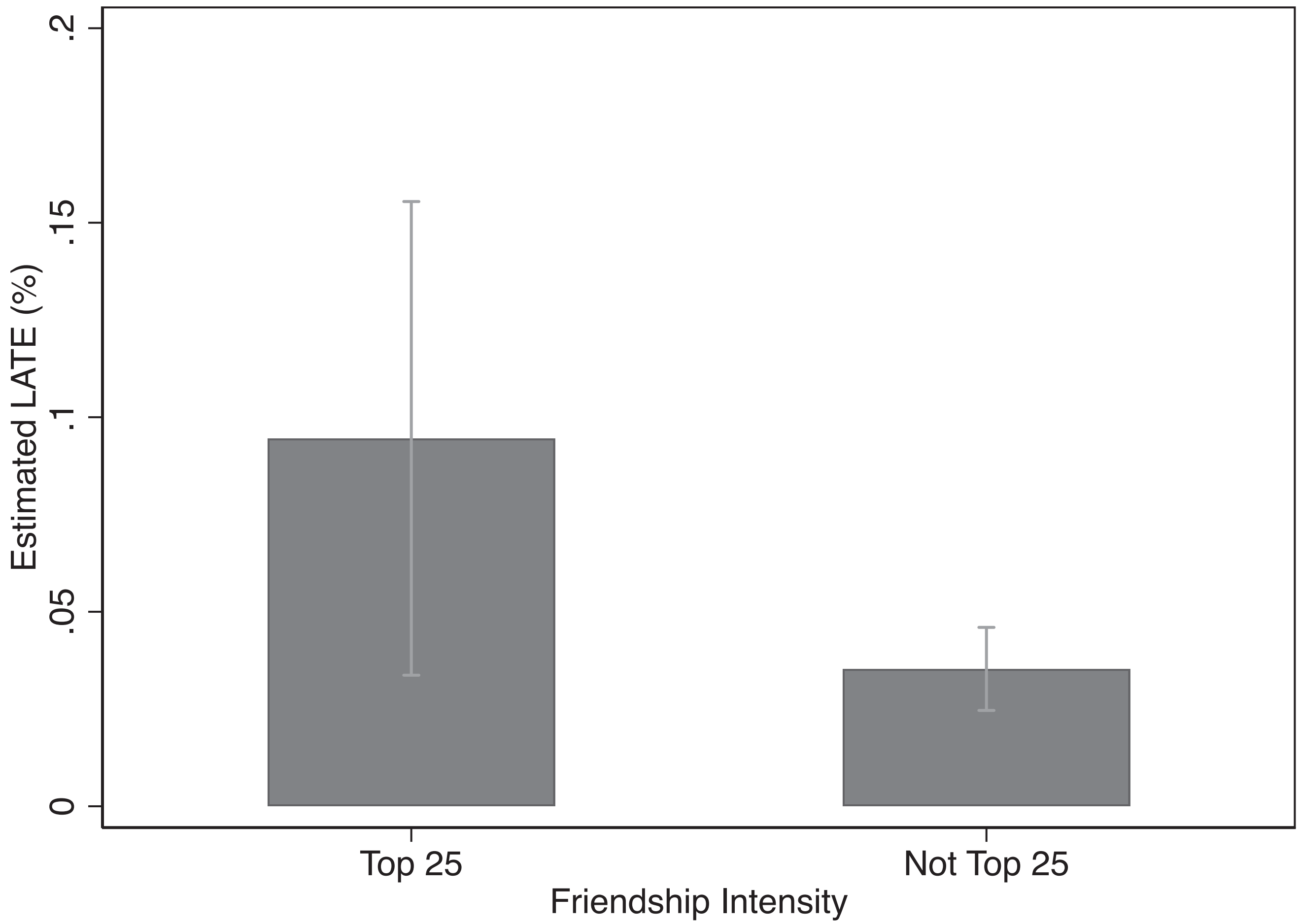
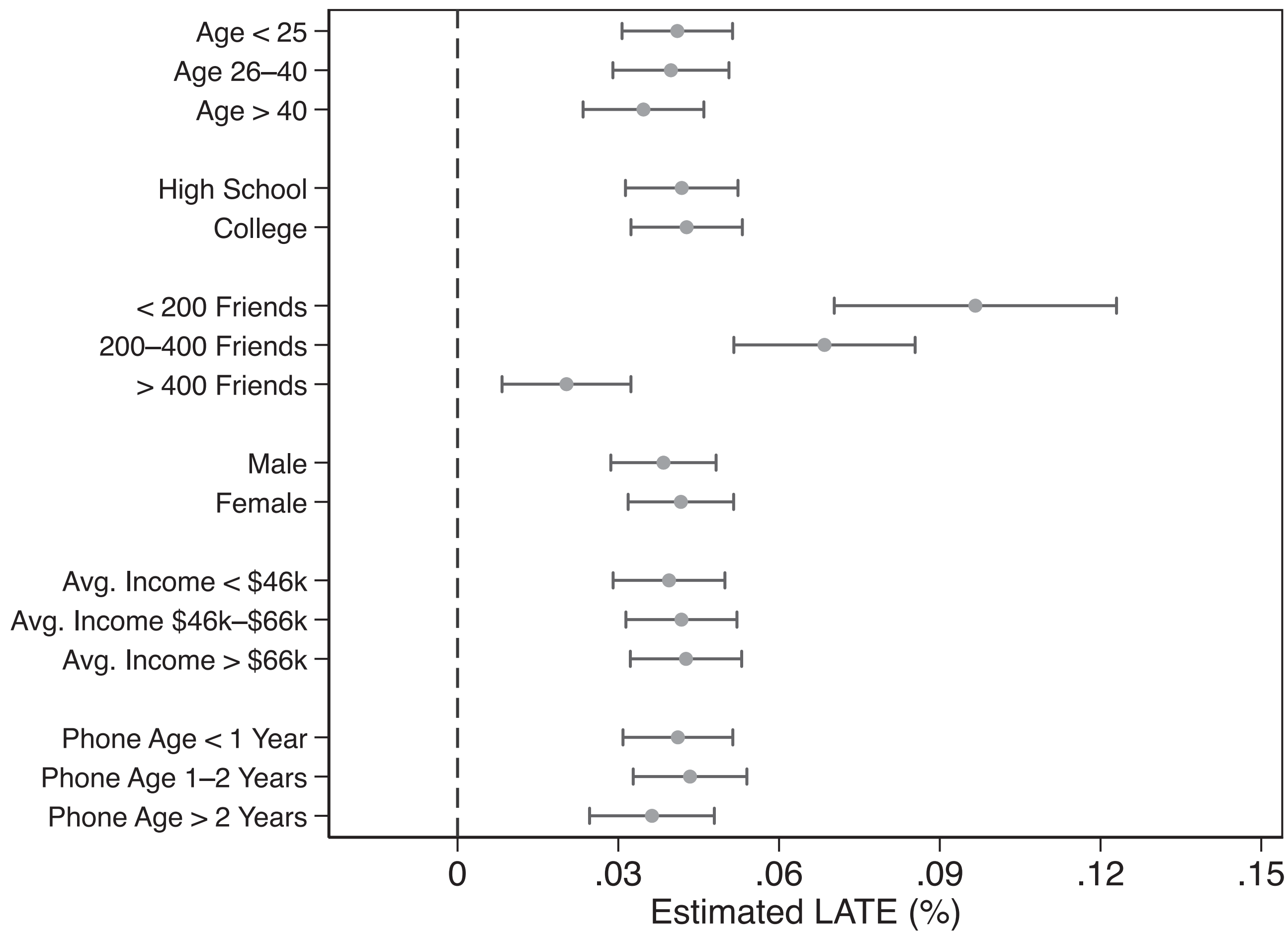
- $\uparrow$ 1 Friend Buys Phone $\rightarrow \uparrow$ P(Buy Phone Next Week) by 0.04ppt
- OLS $\approx$ IV: Common shocks/preferences less problematic at short horizon (conditional on controls)?
- Different instruments identified off of different individuals

Heterogeneity by Relationship Characteristics



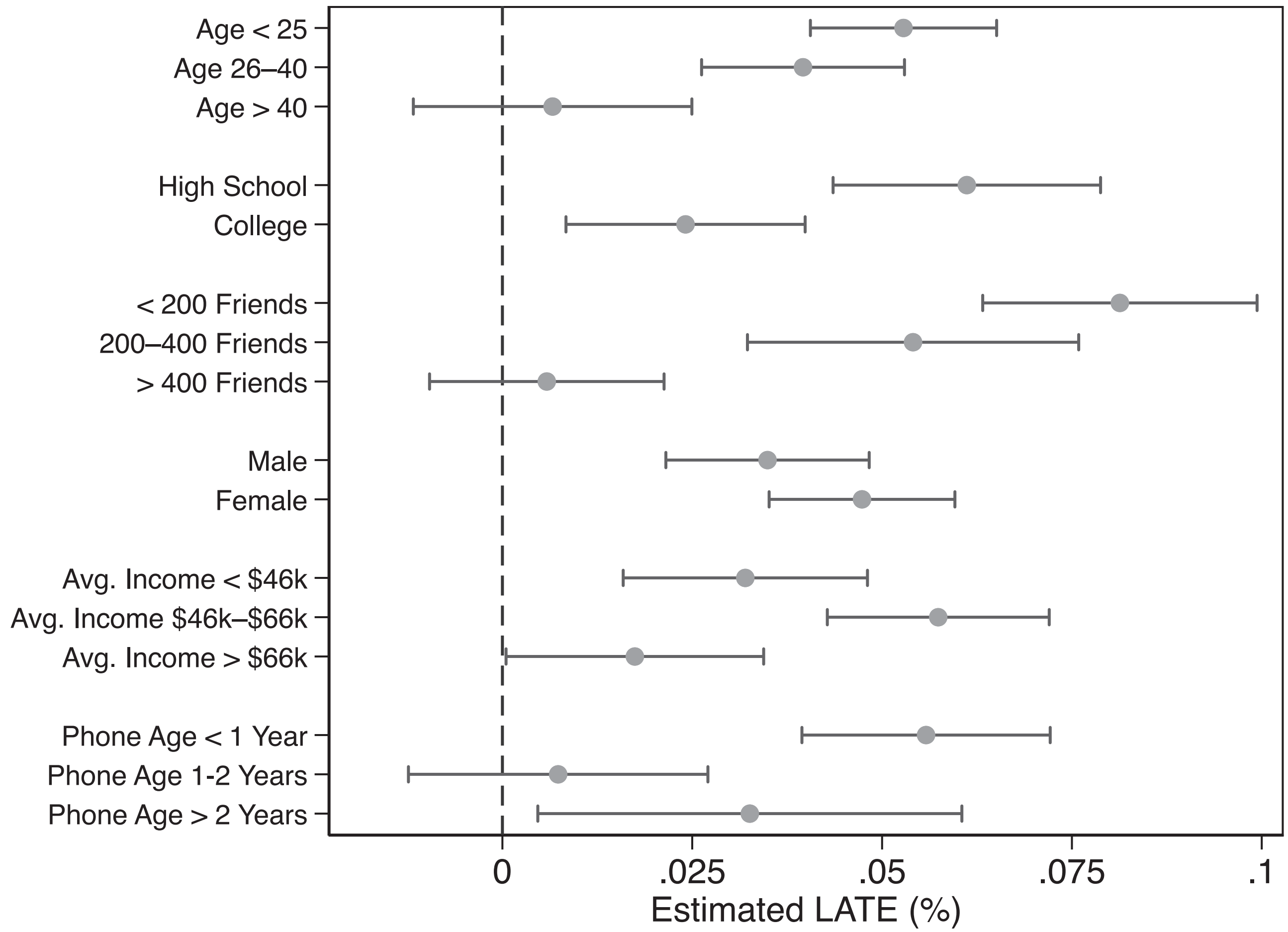
- Closer friends are more influential

Heterogeneity by Own Characteristics



- Not much heterogeneity in influencability
- Having more friends: Each friends less close on average

Heterogeneity by Friend Characteristics



- Younger and less educated friends are more influential

Heterogeneity: Implications for Demand

- Peer effects $\rightarrow$ Aggregate demand more elastic than individual demand
- Key: Correlation between individual price elasticity and peer influence
- Estimate for groups of users
  - Individual price elasticity:
    Increase in purchases following price cut of iPhone 6 in September 2016
  - Peer influence

  $\rightarrow$ Correlation between price elasticity and peer influence: 0.45
- Implications
  - Deviation of aggregate and individual price elasticity large
  - Peer effects lead to lower prices ceteris paribus
  - Rationale for queuing

Timing of Peer Effect: New Demand or Pulling Forward?

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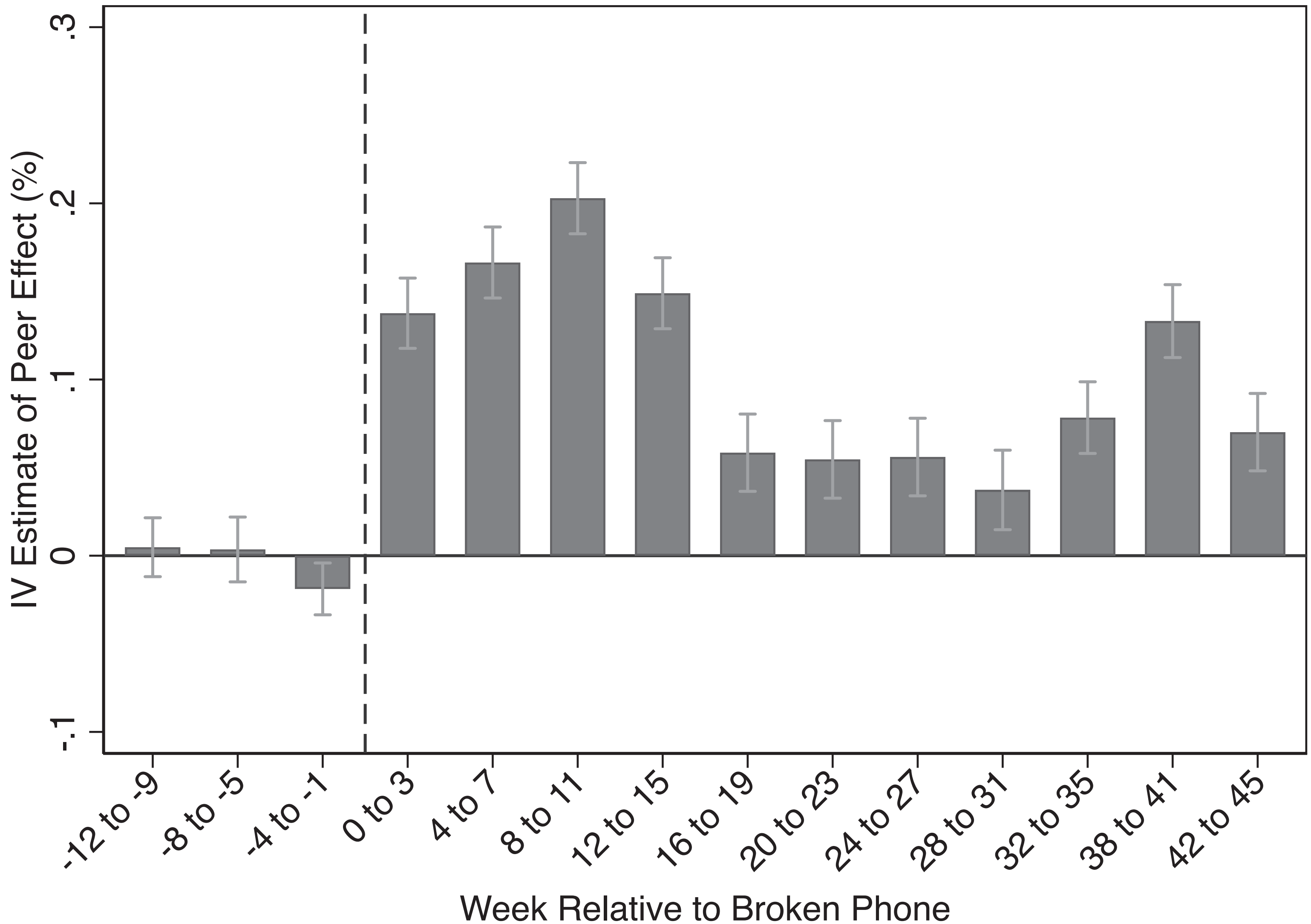

- No evidence of a pre-trend, no evidence of reversal over 10 months.
- Implication for firm: Value of customer > Direct effect on profit

Specific Phone Purchase - Motivation

- So far: Effect of friends purchasing **any phone** on own probability of purchasing any phone.

- Next: Effect of friends purchasing **a specific brand of phone** (e.g., iPhone) on own probability of purchasing

  1. That specific brand of phone
  2. A different phone by a competing manufacturer (e.g., Samsung Galaxy)

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- Conceptually two effects:
  1. Among those who are newly encouraged to buy, how many buy that specific phone vs. another phone (potential for positive demand spillover)
  2. Among those who would have bought anyways, what is the effect on the probability of buying that specific phone vs. another phone (potential for negative demand spillover)

Specific Phone Purchase - Research Design

$$\mathbb{1}(BuysX)_{i,t} = \beta_1 FrBuysX_{i,t-1} + \beta_2 FrBuysY_{i,t-1} + \gamma X_{i,t} + \varepsilon_{i,t}$$

- **Common shocks + homophily:** You are more likely to buy the same phone as your friends, even in the absence of peer effects.
- **Observation:** Individuals differ in their (conditional) propensity to buy particular phones, *PropX*
  - Current iPhone users more likely to buy another iPhone
- **Identification Idea:**
  - IV: *PropX* among all people who post about randomly losing their phone
  - Control for average of *PropX* among all friends

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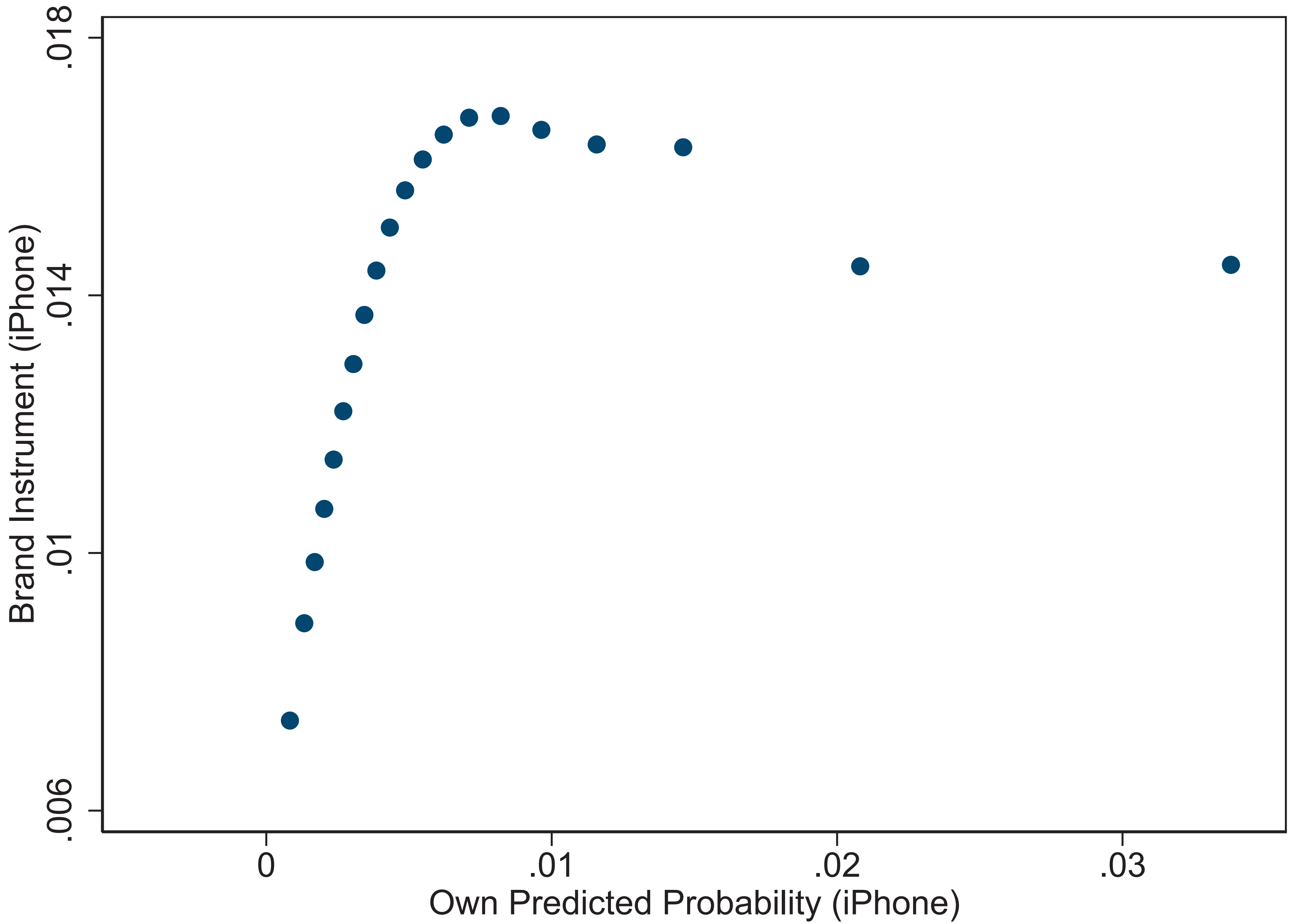

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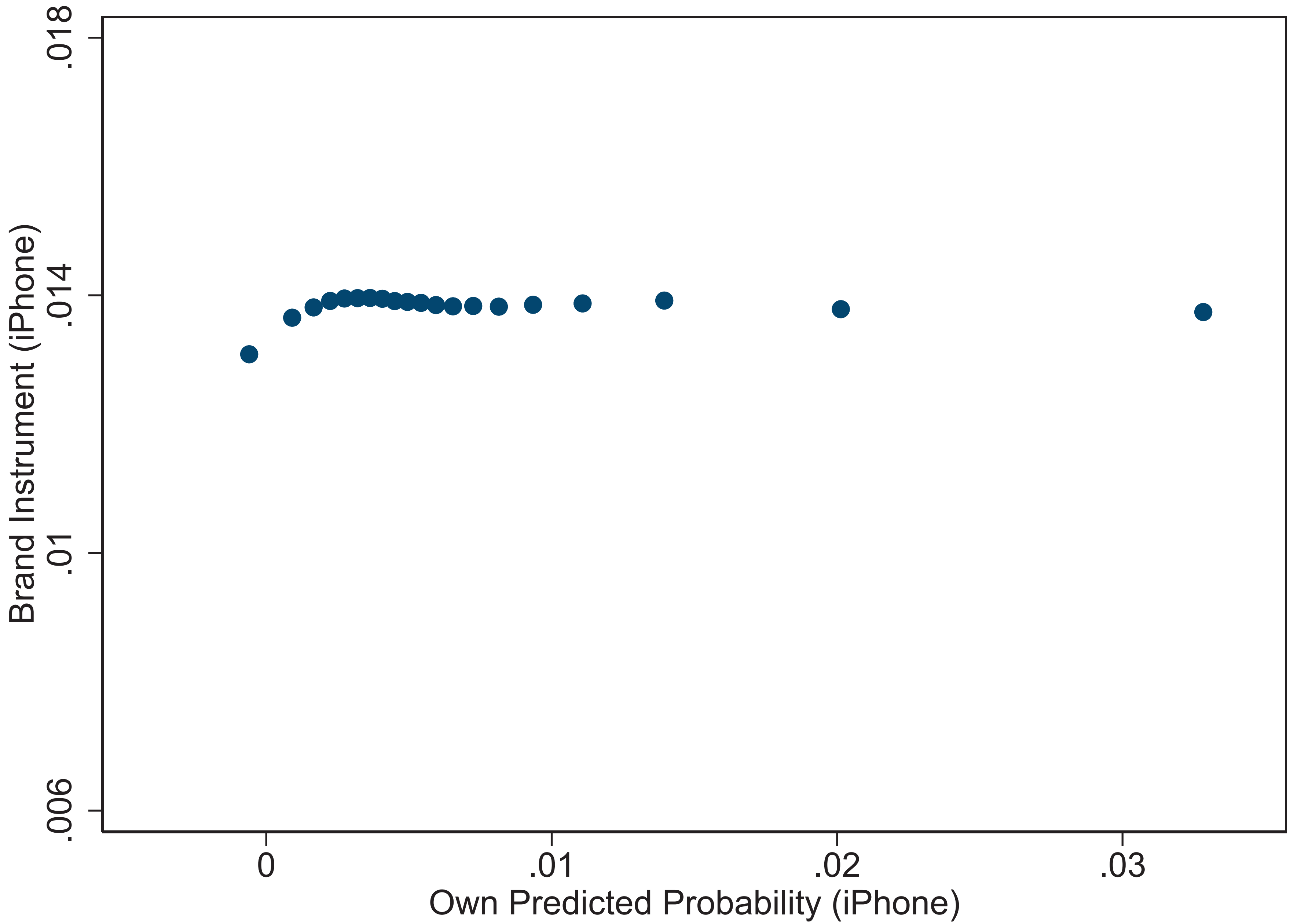

Within and Across Brand Peer Effects

Cumulative Effects over 24 Weeks

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Cumulative Effects over 24 Weeks

	Dependent Variable: Buys between t and t+24 (%)			
	iPhone	Galaxy	Other	Any Phone
Friends buy iPhone	0.331***	-0.003	-0.121***	0.207***
	(0.024)	(0.018)	(0.017)	(0.033)
Friends Buy Galaxy	-0.196***	0.670***	0.403***	0.877***
	(0.043)	(0.037)	(0.036)	(0.063)
Friends buy Other	-0.470***	0.081***	1.438***	1.049***
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Mean Dependent Variable	11.74	6.58	5.91	24.23
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- Largest positive peer effects for same brand
- Same brand effect smallest for iPhone (social learning?)

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- Negative across-OS spillover

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- Losing customers to a rival firm hurts me due to
  - Loss of future sales through positive peer effects from this person
  - Loss of customers this person will bring to competitor who would have otherwise bought my product

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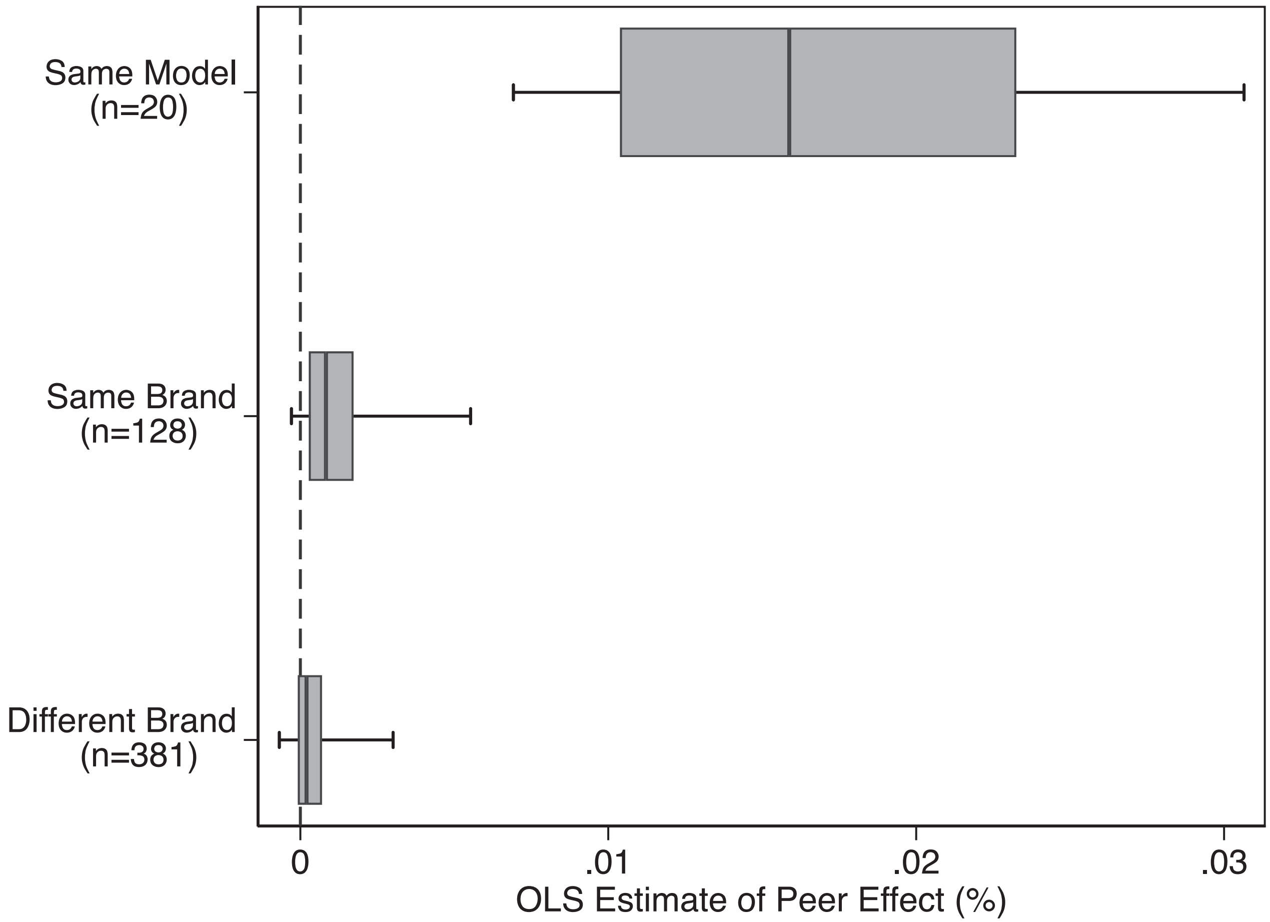
- Positive across-brand spillovers for Android phones (social learning?)

Specific Phone Purchase - Model vs. Brand

- Next: Can we split up effect further? Effect of friends purchasing **a specific model of phone** (e.g., iPhone 6s) on own probability of purchasing
  1. That specific model of phone (e.g., iPhone 6s)
  2. A different phone by the same manufacturer (e.g., iPhone 6)
  3. A different phone by a competing manufacturer (e.g., Samsung Galaxy)
- Empirical Challenge:
  - Predicted propensities for iPhone and iPhone 6s are highly correlated

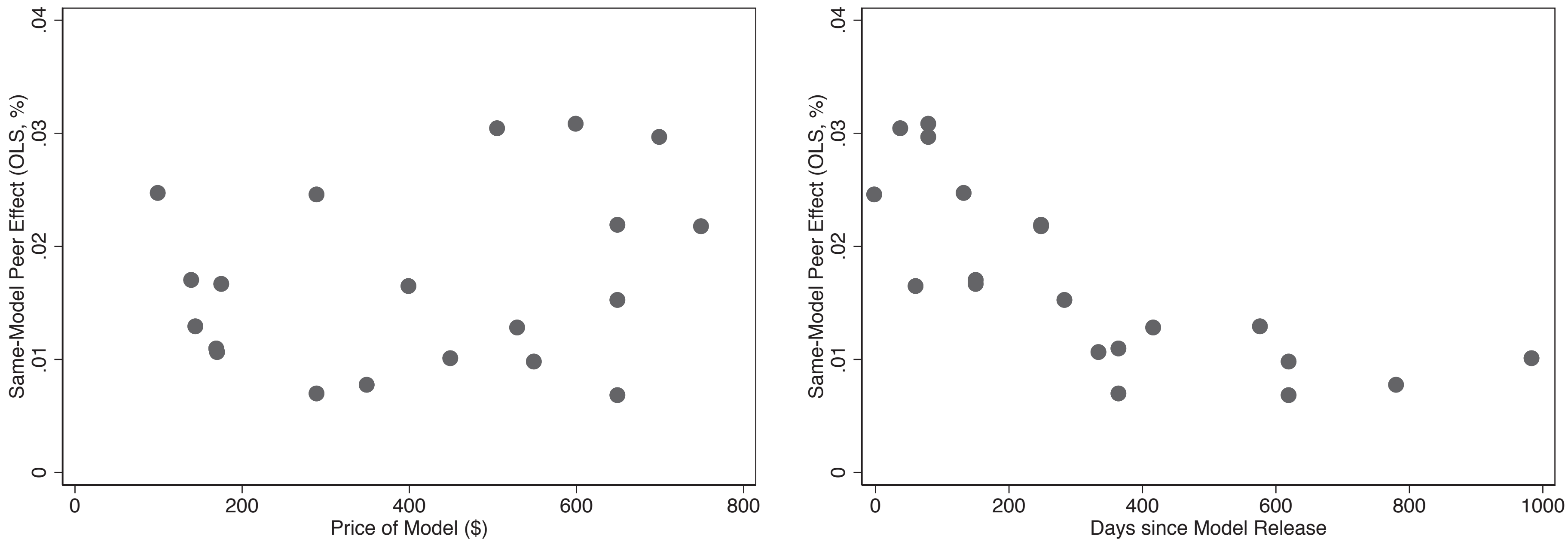
  → No separate shifter for "friend buys iPhone 6s" and "friend buys iPhone"
  - Can still study the OLS (with all appropriate caveats)

Within and Across Model Peer Effects



- Concentrated on same model, some positive same-brand spillovers

Within Model Peer Effects



- Same model peer effects independent of price
- Same model peer effects larger for newer phones

→ Social learning plays important role

Conclusion

- More likely to buy any new phone if friends recently bought new phone
- Largest effect on specific device, some positive within-brand spillovers
- Negative across-brand spillovers, but substantial new overall demand
- Most price elastic individuals are most influential

→ Value of customers; competitive implications; price setting

→ Understanding precise nature of peer effects important for implications

- Follow-on project to explore similarities across products