Price Differences Within Retail Gasoline Markets

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Motivation:
Why do gasoline prices vary from station to station?

- Gasoline retailers within the same market sell a homogeneous good
- Retailers display prices for both consumers and the competition to see

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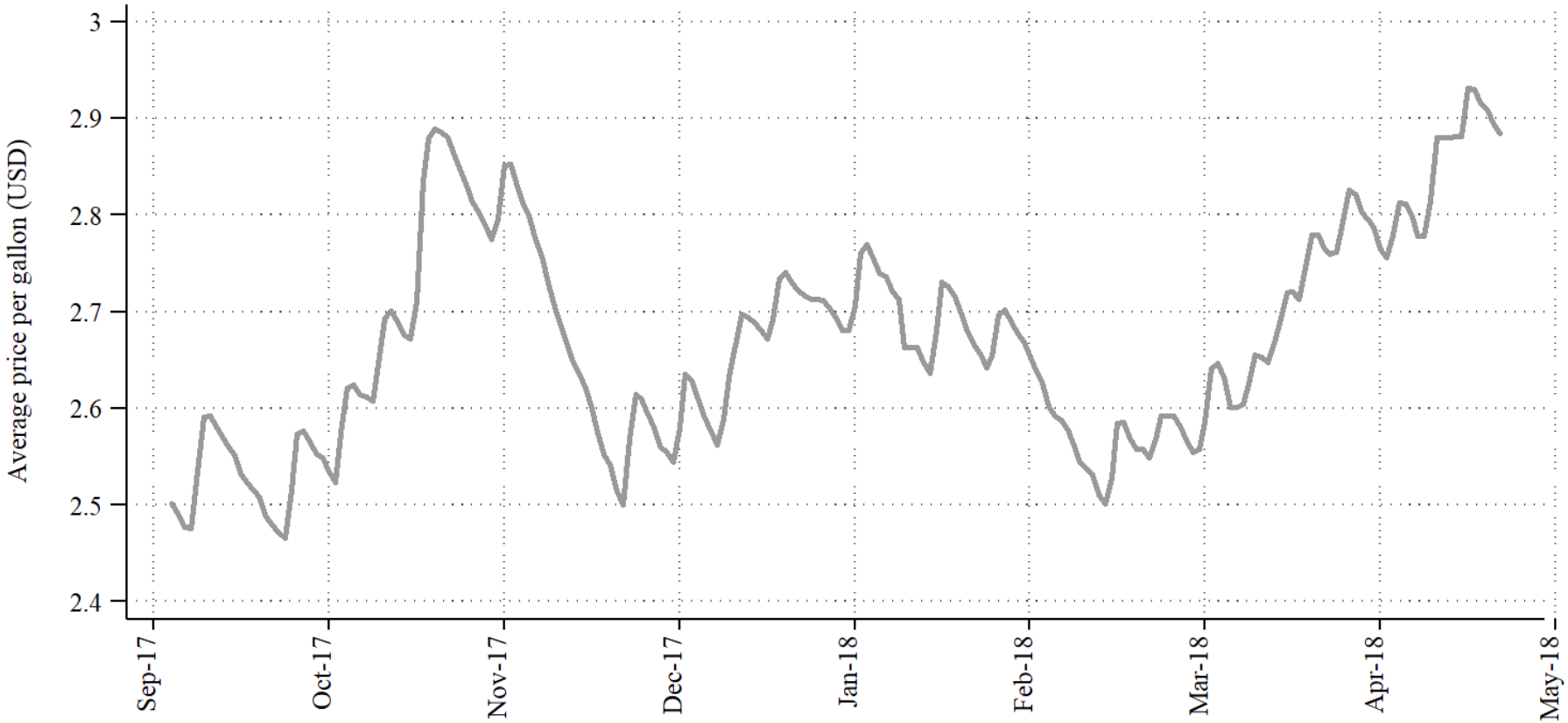
- Previous research on station-level price dispersion focuses on
  - Market structure
  - Retailer characteristics
  - Gasoline brand
  - Geographic differentiation
  - Market concentration
- However, a lot of variation remains unexplained
- GOAL: Revisit the sources of price differences by accounting for the **fueling stations' price dynamics**

Motivation: Some markets show predictable price cycles

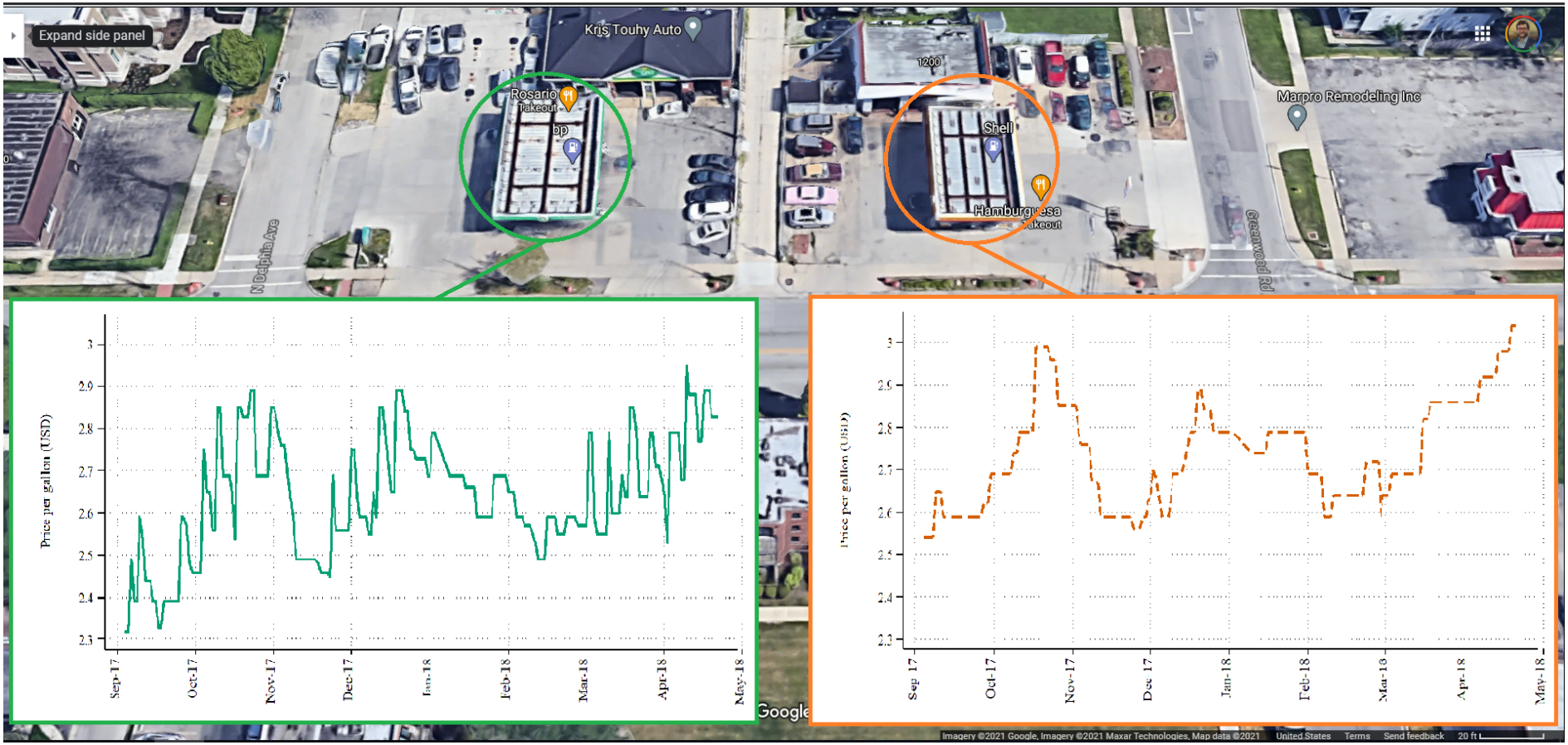
Average price dynamics in the Chicago metropolitan area between September 2017 and April 2018



Asymmetric pricing = Price cycles = 'Edgeworth cycles' = Asymmetric price cycles

Motivation:
Some stations show asymmetric pricing and others don't

A cycler (station A on the left) and a non-cycler (station B on the right) in the Chicago metropolitan area



Preview of Findings

- Unique database of U.S. gasoline retailers
  - Locations, daily prices, attributes, local characteristics
  - Analysis between September of 2017 and April of 2018
- Develop a 'Cycling Indicator' at the station level
  - Show asymmetric pricing heterogeneity within markets
- What station attributes correlate with asymmetric price cycles?
  - Cash and loyalty discounts reduce the likelihood of cycling behavior
- What explains the asymmetric pricing?
  - Conventional forms of collusion? No
    - ◇ Cyclers charge lower gasoline prices than non-cyclers stations
  - The standard 'Edgeworth cycle' model? No
    - ◇ Stations price cycles have predictable weekly patterns
  - Result of consumer search and price sensitivity? Strong evidence
    - ◇ Consumer search is higher for cycler than for non-cyclers stations

On the Agenda

1. A Cycling Indicator at the Station Level
2. Data and Sample
3. What Attributes Correlate With Asymmetric Pricing?
4. Explaining Asymmetric Pricing
   - Are Cycles Collusive?
   - Are Asymmetric Prices 'Edgeworth cycles'?
   - Can Consumer Search Explain Asymmetric Prices?
5. Conclusion

On the Agenda

A Cycling Indicator at the Station Level

- First step: classify gasoline stations according to their price dynamics
- Cycling Indicator relies on three fundamental characteristics:
  1. Price increases are more significant than price reductions
  2. Price jumps are sizable in terms of percentage changes
  3. Significant proportion of price changes during the period of analysis
- We measure a 'Cycling Ratio' and 'Price Jump' for each station
- We classify retailers as cyclers using the previous measurements

Cycling Ratio

- We use the first fundamental characteristics of price cycles:
  - Average price increases are larger than price decreases
- We categorize the subset of dates at which each station experiences
  - increasing-price and decreasing-price stages

$$CR_s = \frac{\overline{\Delta p_{s,+}}}{\overline{\Delta p_{s,-}}} = \frac{\frac{\sum_{t=1}^{T} |\Delta p_{s,t}| \times \mathbb{I}(t \in \tau_{s,+})}{\sum_{t=1}^{T} \mathbb{I}(t \in \tau_{s,+})}}{\frac{\sum_{t=1}^{T} |\Delta p_{s,t}| \times \mathbb{I}(t \in \tau_{s,-})}{\sum_{t=1}^{T} \mathbb{I}(t \in \tau_{s,-})}},$$

- Were:
  - s indicates the gasoline station
  - $\tau_{s,+}$ is the subset of dates of an increasing-price stage
  - $\tau_{s,-}$ is the subset of decreasing-price days
  - The function $\mathbb{I}(\cdot)$ takes the value of one if the condition holds
  - $p_{s,t}$ is the retail price at time t
  - $|\Delta p_{s,t}| = |p_{s,t} - p_{s,t-1}|$

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Price Jump

- We use the second fundamental characteristics of asymmetric pricing:
  - Average price jumps are sizable in terms of percentage changes
- We use the dates of increasing-price stage

$$PJ_s = 100 \times \frac{\sum_{t=1}^{T} \frac{\Delta p_{s,t}}{p_{s,t-1}} \times \mathbb{I}(t \in \tau_{s,+})}{\sum_{t=1}^{T} \mathbb{I}(t \in \tau_{s,+})},$$

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Multiple Price Changes

- We use the third fundamental characteristics of asymmetric pricing:
  - Significant proportion of price changes during the period of analysis
- We account for this attribute using a two-step procedure
  1. Assigning $CR_s = PJ_s = 0$ if station doesn't change prices frequently

     Price changes at least 10% of the days of analysis
  2. Cycling Indicator classifies stations with CR and PJ larger than zero
- We classify as 'non-cycler' stations with fewer than 10% price changes

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Our Cycle Indicator

- We define our Cycling Indicator at the station level as:

$$CI_s = \begin{cases} 1 & \text{if } (CR_s \geq 1.5) \text{ or } (\ 1.1 < CR_s < 1.5 \text{ and } PJ_s \geq 1\ ) \\ 0 & \text{otherwise} \end{cases}$$

- We classify gasoline stations as 'cyclers' if:
  - Price increases are at least fifty percent larger than the price decreases
  - For stations with Cycling Ratios between 1.1 and 1.5
    - ◇ we demand more evidence: average price jump of at least 1%

- We also consider a more stringent classifications with similar results
  - i.e., 'cyclers' if $CR_s \geq 2$ & 'non-cyclers' if $CR_s \leq 1.1$

On the Agenda

Data and Sample

- Unique dataset that includes:
  - Location of gasoline retailers: Web-scraping GasBuddy.com
  - Retail gasoline price: Daily reported price of retailers (09/17 to 04/18)
  - Station attributes: Retailers' marketing strategies and attributes
  - Population density and income per capita: CBG from the ACS*
  - Cities of analysis: Core-Based Statistical Areas
  - ZIP Code Tabulation Areas: Zip Codes defined by the Census Bureau
- Sample:
  - eligible station: more than 100 price observations and reported income
  - eligible cities:
    - at least 70% of suitable stations, or
    - cities with three hundred or more retailers

*CBG: Census Block Groups. ACS: American Community Survey

Summary Statistics: Large variability across regions

	Eligible Stations (1)	Average Price (2)	Eligible Cities (3)	Population Density♣ (4)	Neighb. Stations♦ (5)	Loyalty Discounts♥ (6)	Cash Discounts♥ (7)	Cycling Indicator♥ (8)
West	12,254	2.94	57	5.8	4	24.5	27.3	36.4
Midwest	14,847	2.50	113	2.8	3	23.6	9.5	72.0
South	23,129	2.38	87	2.8	4	23.2	8.9	45.1
Northeast	7,444	2.66	27	5.2	3	28.3	24.6	35.1
Total for U.S.	57,674	2.57	284	3.8	3	24.2	15.0	48.9

♣Population density in thousand people per square mile
♦Neighboring stations defined with a 1-mile radious
♥Percentage of stations offering discounts or classified as cyclers

- Regions and divisions specified by the Census Bureau
- We find cyclers and non-cyclers gasoline stations in every region
- Fraction offering cash discounts differs significantly across area
- Fraction of stations offering loyalty discounts is relatively constant
- High density correlates with large cities
- Areas with more States have more stations and markets
- Large variation in average retail gasoline prices by region

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A Simple Linear Probability Model

Linear model of our Cycling Indicator with city and brand size fixed-effects

$$CI_s = \underbrace{A_s}_{\substack{\text{Station}\\ \text{Attrib.}}} \beta_1 + \underbrace{C_s}_{\substack{\text{Location}\\ \text{Char.}}} \beta_2 + \underbrace{N_s}_{\substack{\text{Neighb.}\\ \text{Cycling}}} \beta_3 + X + \varepsilon_s$$

X includes constant, city fixed-effects, and brand size fixed-effects

- Station Attributes:

  marketing strategies: loyalty and cash discounts

  amenities: convenience store, restaurant, car wash, service station, truck stop

- Location Characteristics:

  Income per capita, population density, quadratic in neighbors

- Neighboring Stations' Cycling Behavior:

  Average CI of near stations, CI of and distance to closest station

Note: Brand size: small (retailers <10); small-med ($10 \leq$ retailers <100); med-big ($100 \leq$ retailers <1000); big ($1000 \leq$ retailers)

	All Brands (1)	Small (2)	Small-Med (3)	Med-Big (4)	Big (5)
Station Attributes					
Loyalty Discounts	-.043	.028	-.003	.011	-.055
	(.009)	(.028)	(.039)	(.019)	(.010)
Cash Discounts	-.102	-.021	-.017	-.083	-.113
	(.012)	(.017)	(.032)	(.030)	(.015)
Brand Size					
Small-Med	.133				
	(.013)				
Med-Big	.211				
	(.017)				
Big	.051				
	(.014)				
Adjusted-R^2	.237	.159	.186	.199	.251
Observations (Fueling Stations)	57,674	4,319	4,172	12,289	36,894
Fraction of Cycling Stations (%)	48.9	37.3	53.1	63.3	44.9
Has Loyalty Distcounts (%)	24.2	5.6	18.7	34.6	23.6
Has Cash Distcounts (%)	15.0	17.5	11.6	8.2	17.4
Number of Cities	284	272	261	282	283
City FE	Yes	Yes	Yes	Yes	Yes
Location Characteristics	Yes	Yes	Yes	Yes	Yes

Brand size: small (retailers <10); small-med ($10 \leq$ retailers <100); med-big ($100 \leq$ retailers <1000); big ($1000 \leq$ retailers)
We present in parenthesis robust standard errors clustered at the city level.

▸ Full

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Are Cycles Collusive?

- Existence and predictability of asymmetric prices raise the question
- Collusive behavior in some Canadian and Australian gasoline markets
- Yet, evidence that average prices are lower in U.S. 'cyclers' cities
- Difficult interpretation with aggregate markets
  - Asymmetric pricing is related the market's competitive nature
  - Competition has an effect on prices
- Model:

$$p_{s,t} = \underbrace{CI_s}_{\substack{\text{Cycling} \\ \text{Indicator}}} \beta_1 + \underbrace{A_s}_{\substack{\text{Station} \\ \text{Attrib.}}} \beta_2 + \underbrace{C_s}_{\substack{\text{Location} \\ \text{Char.}}} \beta_3 + X + \eta_t + \varepsilon_{s,t}$$

X includes constant, local markets and gasoline markets fixed-effects

Are Cycles Collusive? No in the traditional way

	Time Adjusted (1)	Local Markets (2)	Gasoline Markets (3)	Intensity Effect (4)
Cycling Indicator	-10.9	-6.0	-4.3	-2.8
	(2.082)	(.554)	(.323)	(.330)
Cycling Intensity				-.65
				(.088)
Adjusted-R^2	.258	.923	.951	.952
Observations (Stations × Dates)	9,962,432	9,567,984	9,567,984	9,567,984
Stations	57,674	55,883	55,883	55,883
Average Price (cents)	256.1	256.0	256.0	256.0
Date FE	Yes	No	No	No
Date-Zip-Code FE	No	Yes	Yes	Yes
Number of Cities	284	284	284	284
City-Brand FE	No	No	Yes	Yes

We present in parenthesis robust standard errors clustered at the city level.

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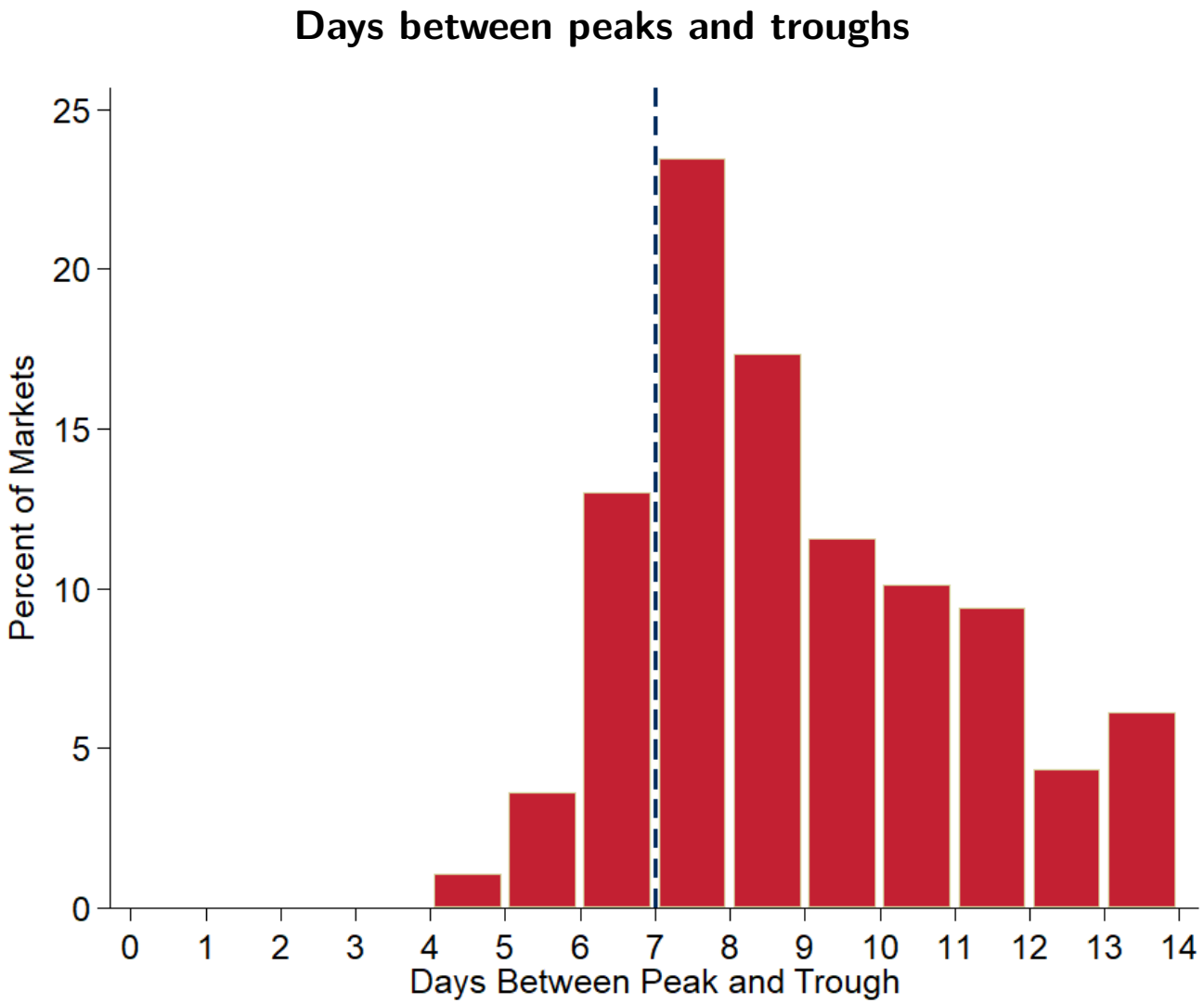
Are Asymmetric Prices 'Edgeworth cycles'?

- The theoretical foundation of asymmetric price cycles:
  - seminal paper by Maskin and Tirole (1988)
  - cycles are the outcomes of a dynamic oligopoly game
- In the 'Edgeworth cycle' equilibrium:
  - decreasing phase: firms undercutting each other until marginal cost
  - war of attrition: firms randomize between restoring or not prices
  - increasing phase: one firm increases prices the other follows
- The end of the cycle should be random under 'Edgeworth cycles'

Are Asymmetric Prices 'Edgeworth cycles'? No

Strong Weekly Patterns for Cycler Stations



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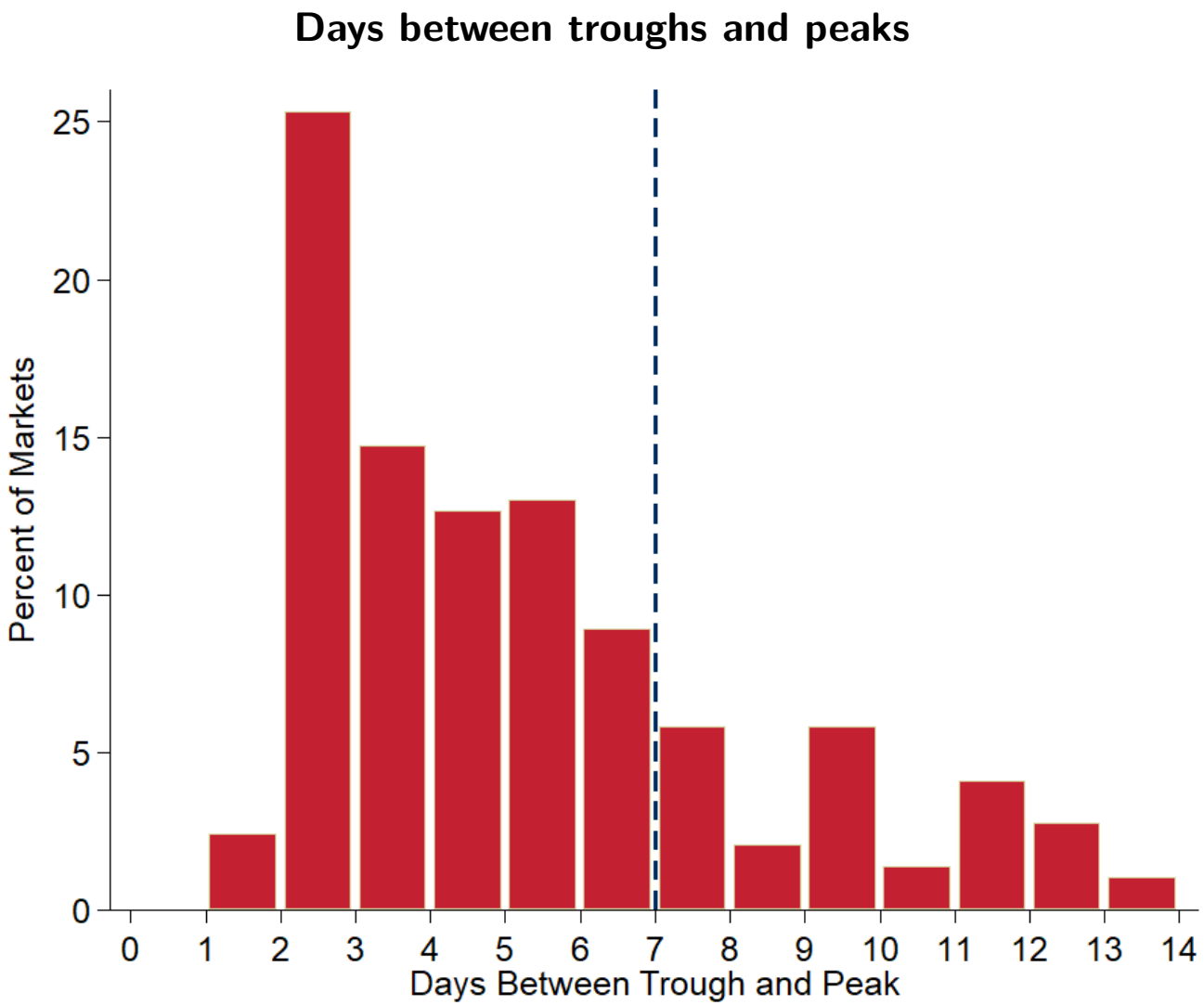

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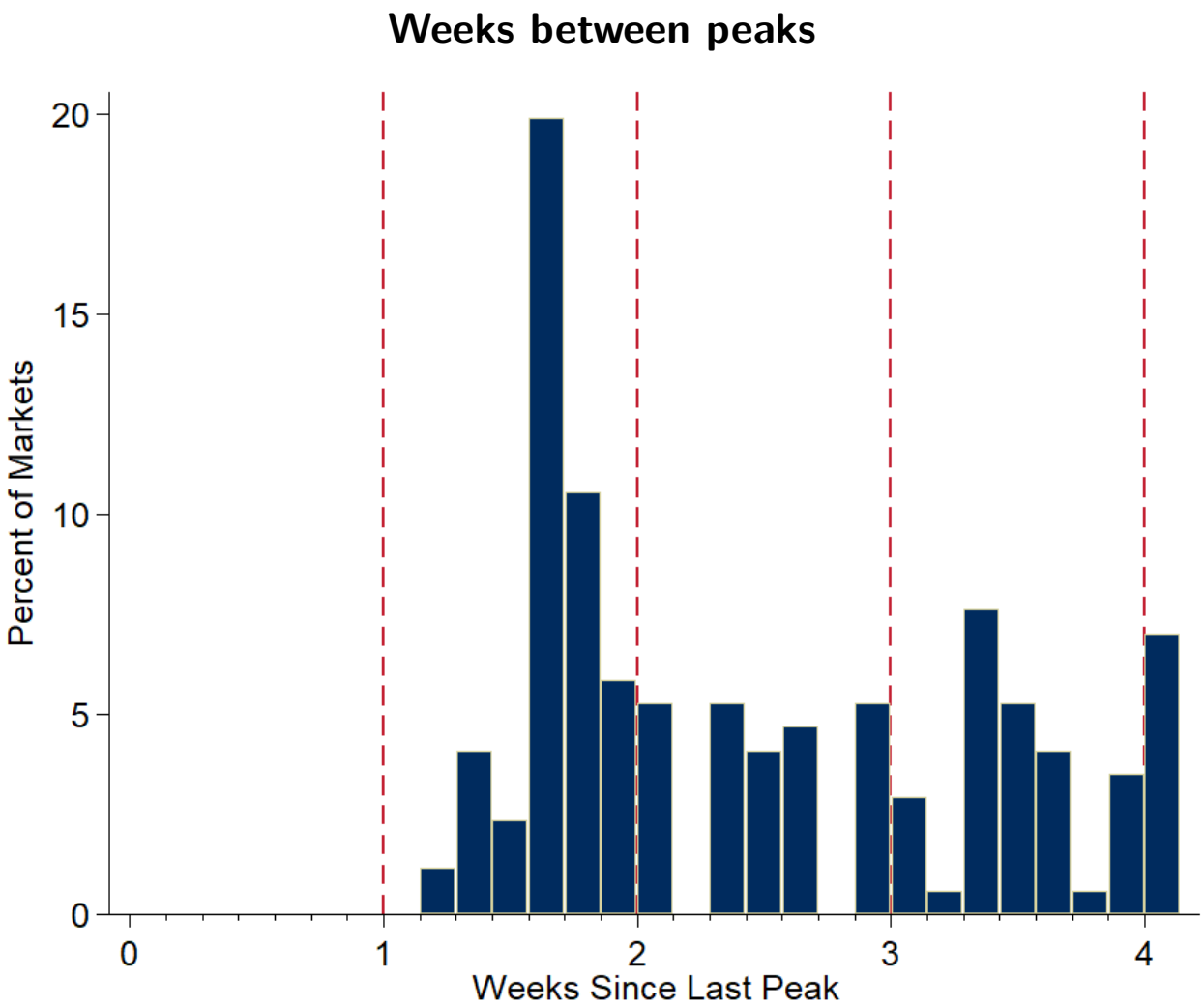

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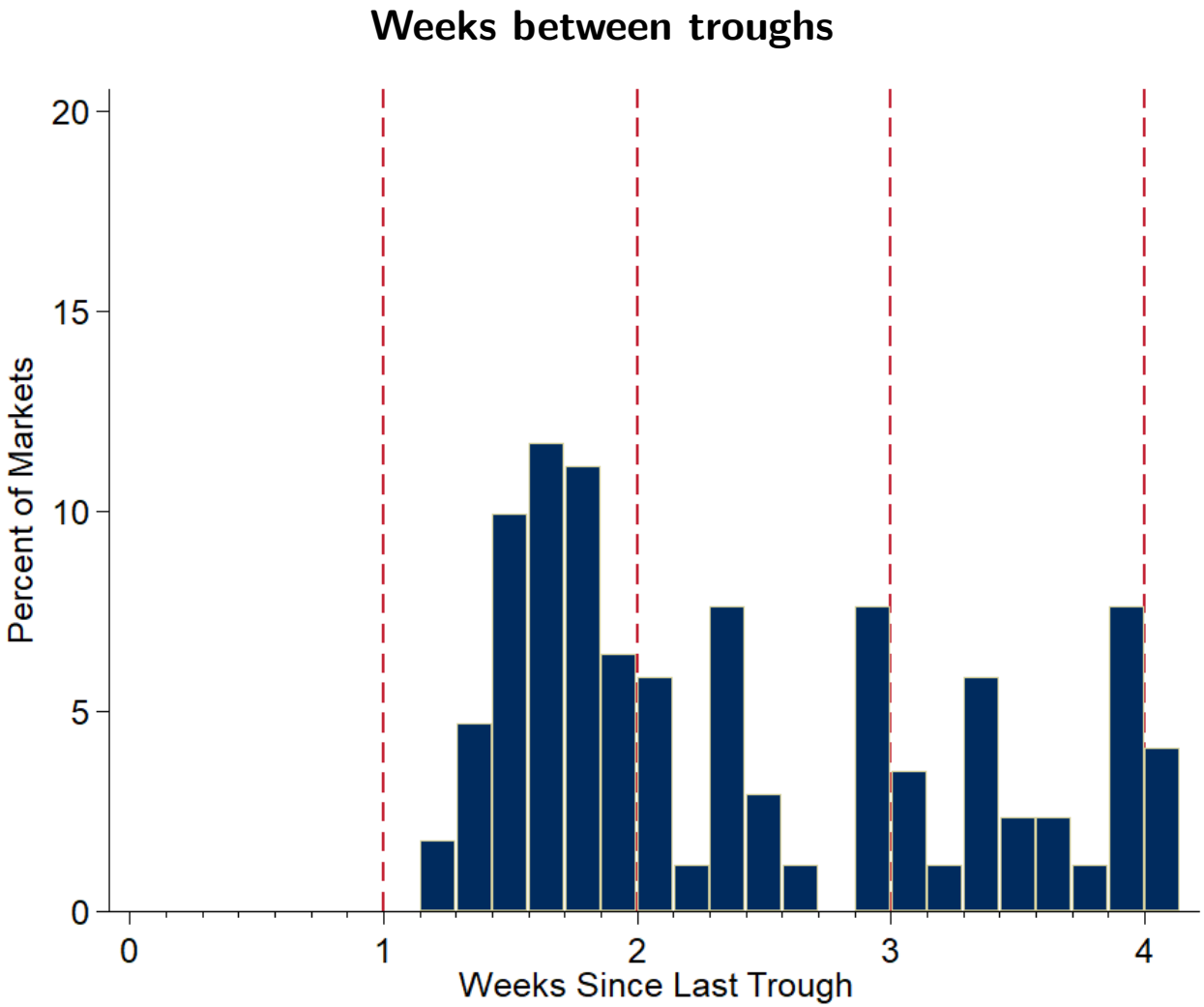

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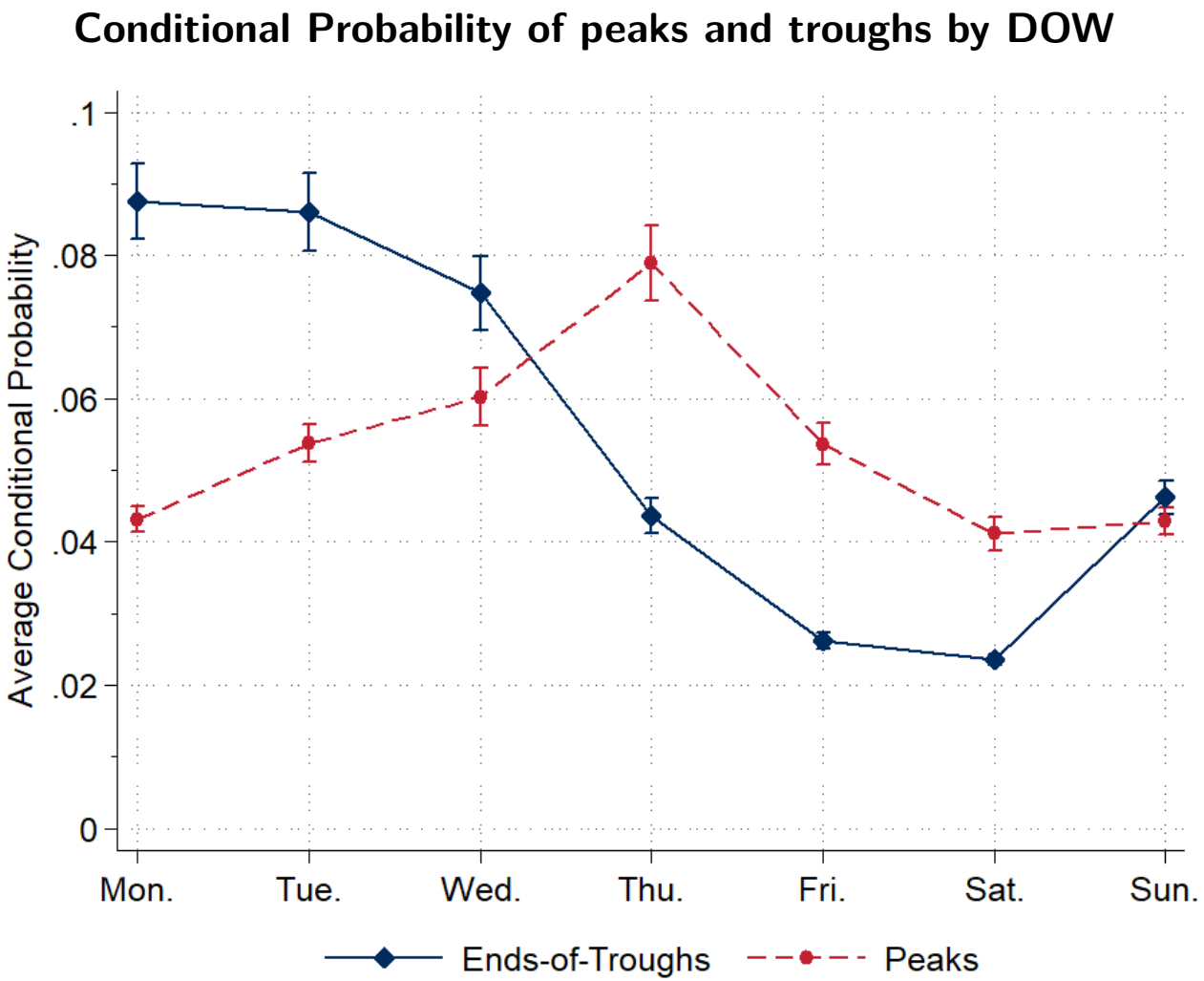
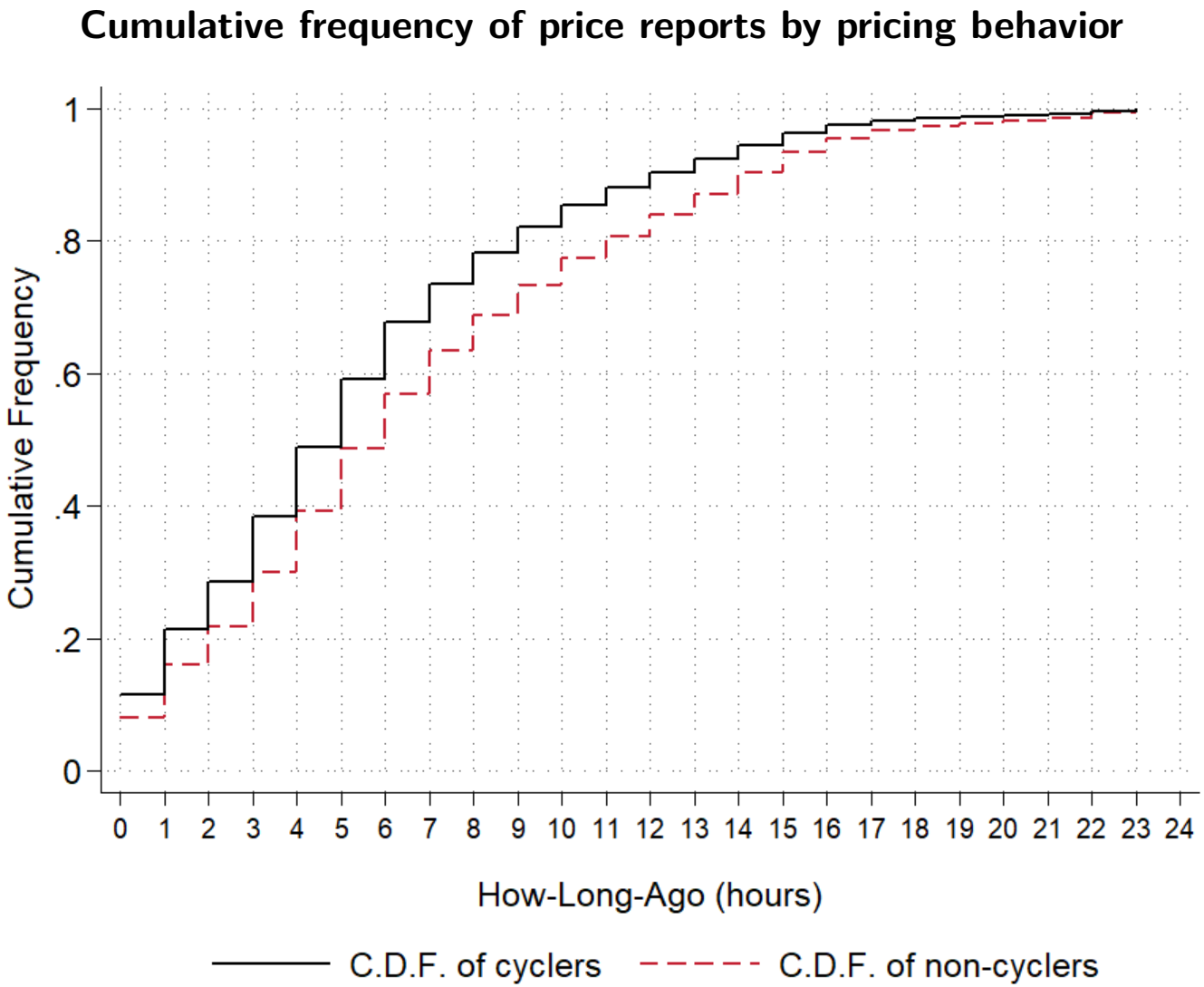


Can Consumer Search Explain Asymmetric Prices?

- Cycler and non-cycler stations coexist in equilibrium
- Do they divide the market to serve different types of consumers?
  - Cycler stations: attract price-sensitive, search-prone consumers
    - charge lower prices
    - lower prices concentrated in few days
    - many price changes
  - Non-cycler stations: attract less elastic consumers
    - price discounts
    - fewer and milder changes in price
- Test: measure of report frequency $\sim$ search activity
  - Use self-report nature of our data
    - Each price has a timestamp of 'how long ago' the price was reported

Can Consumer Search Explain Asymmetric Prices? Strong evidence



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	Frequency
Cycling Indicator	**0.092*****
	(0.010)
Price	-0.012***
	(0.000)
$\Delta p = 0$	-4.389***
	(0.024)
R^2	0.2027
Obs	9,968,687
Day-of-the-week FE	Yes
Week-zip FE	Yes
City-Brand FE	Yes

p-values in parenthesis

X includes constant, indicators for peak and through and interactions with CI

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questions, comments, suggestion:
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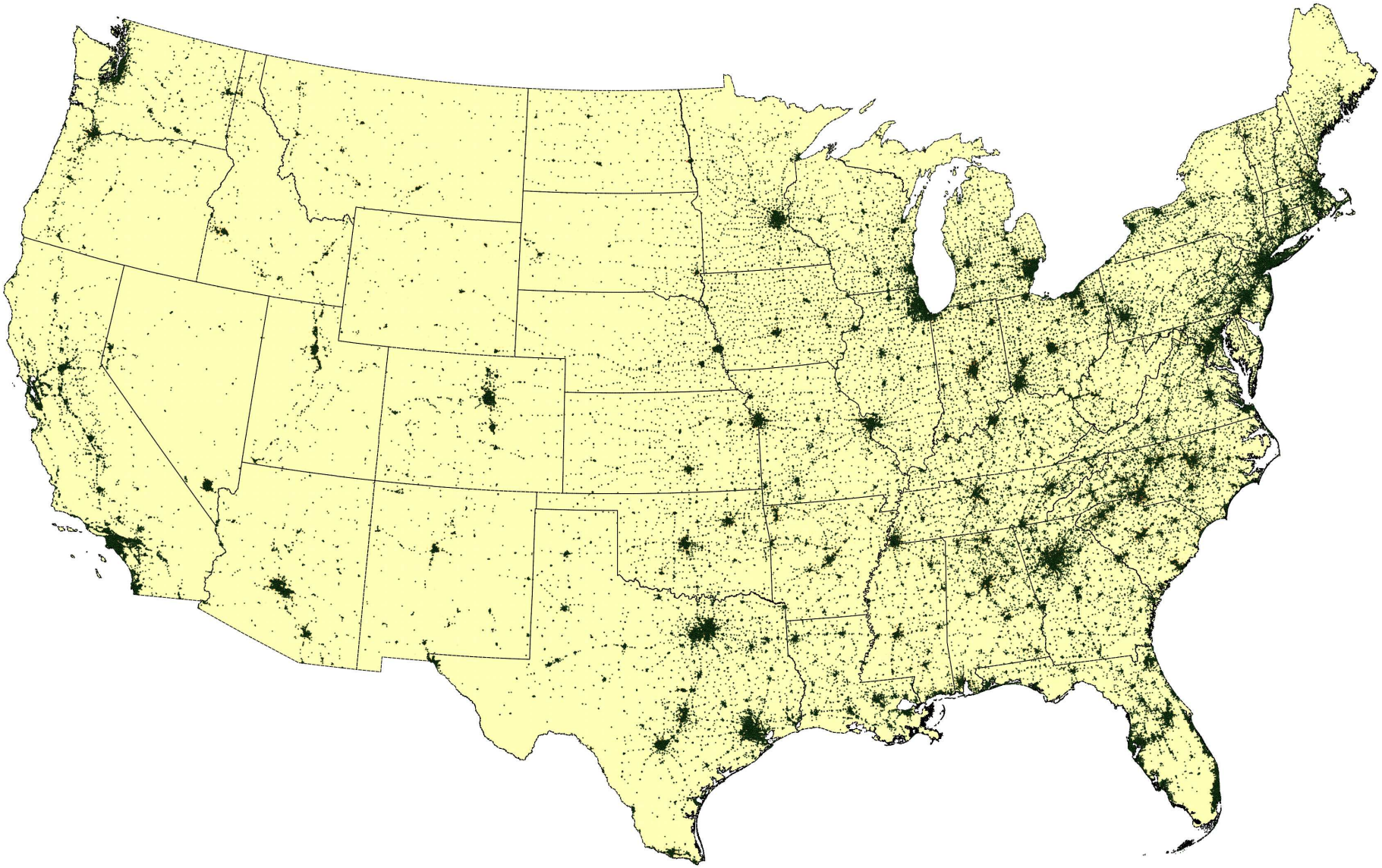
Location of Gasoline Retailers



Source: Authors' calculation

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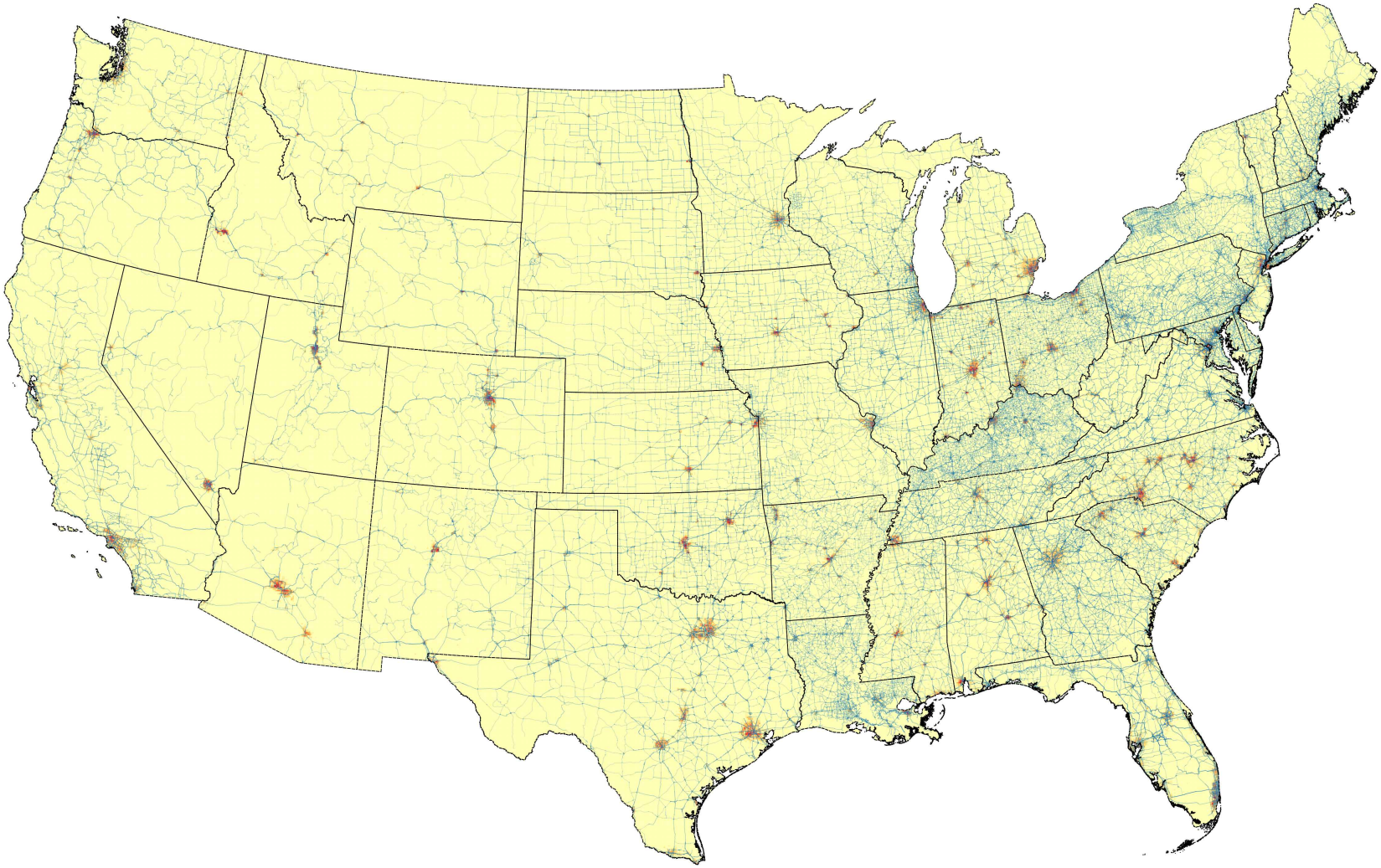
Population and Roads



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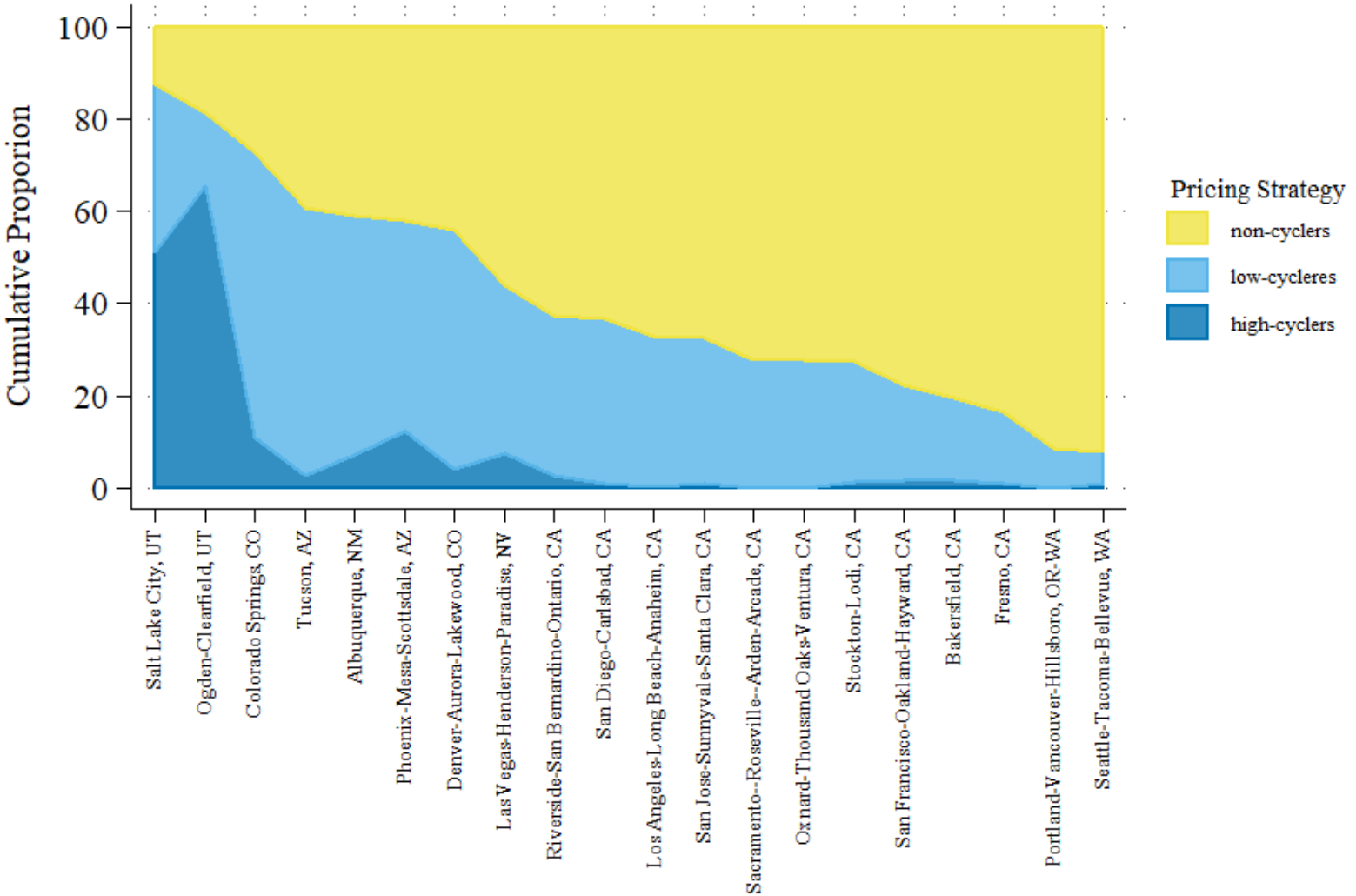
Source: American Community Survey

West region



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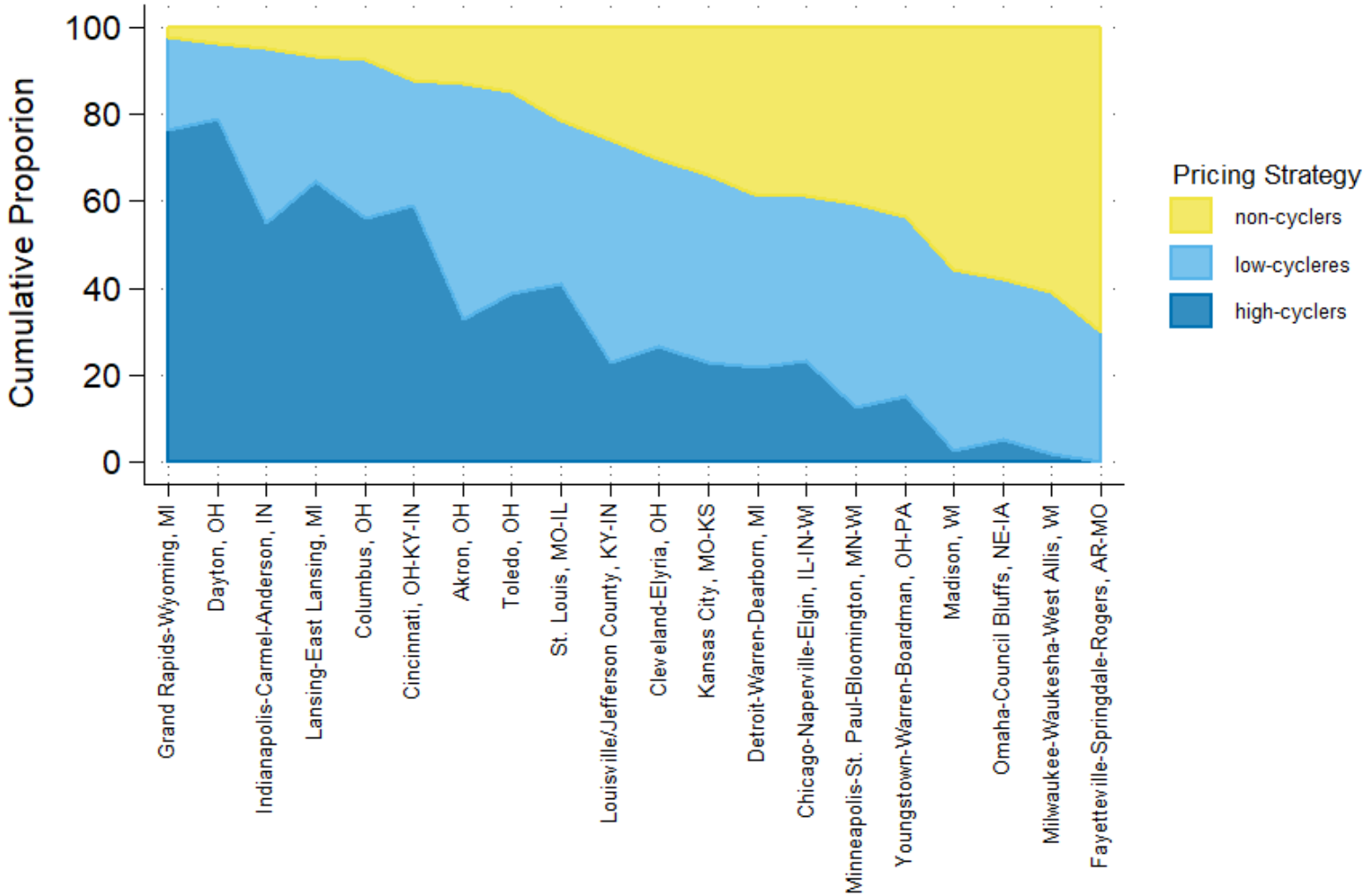
Midwest region



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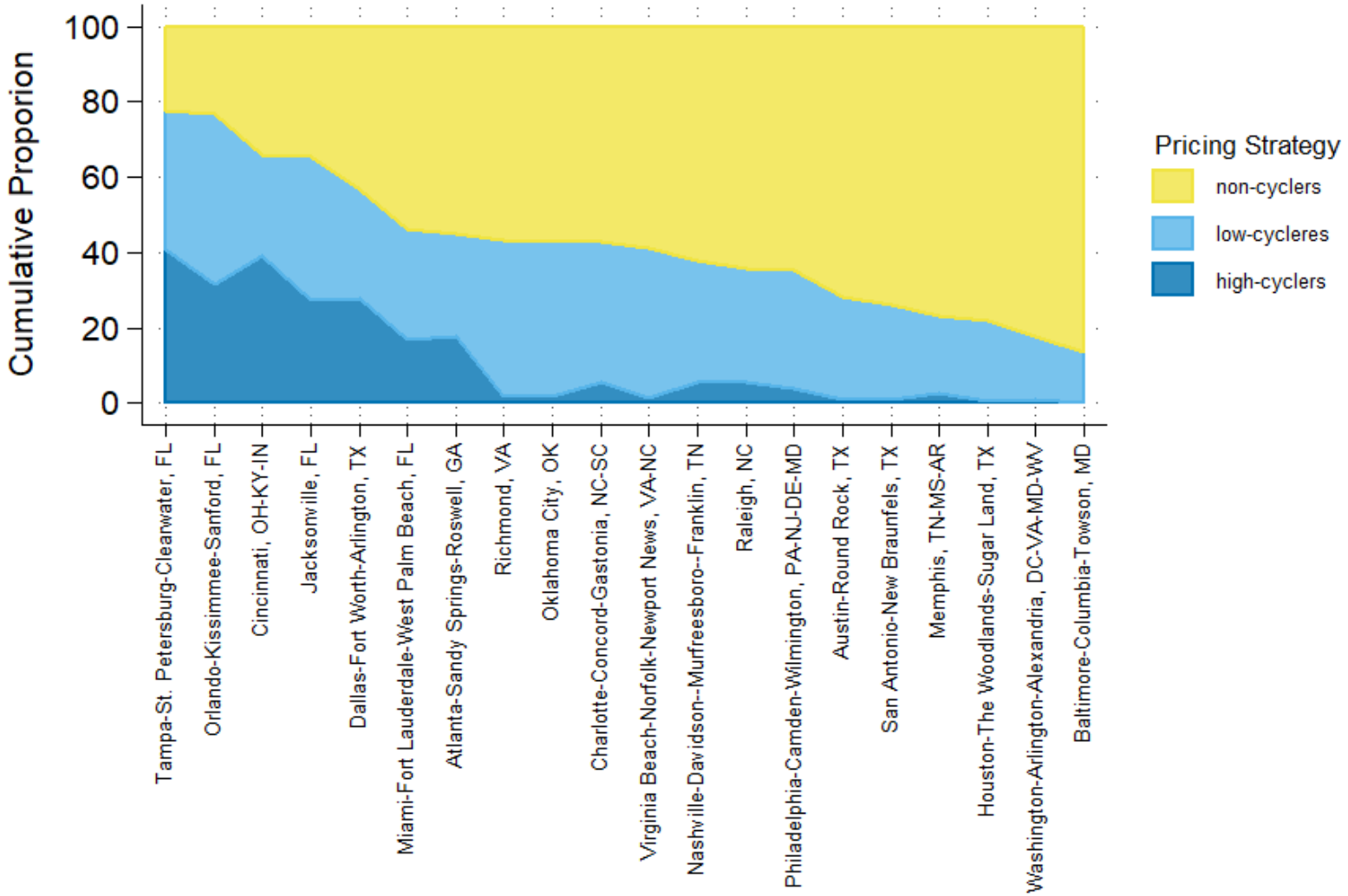
South region



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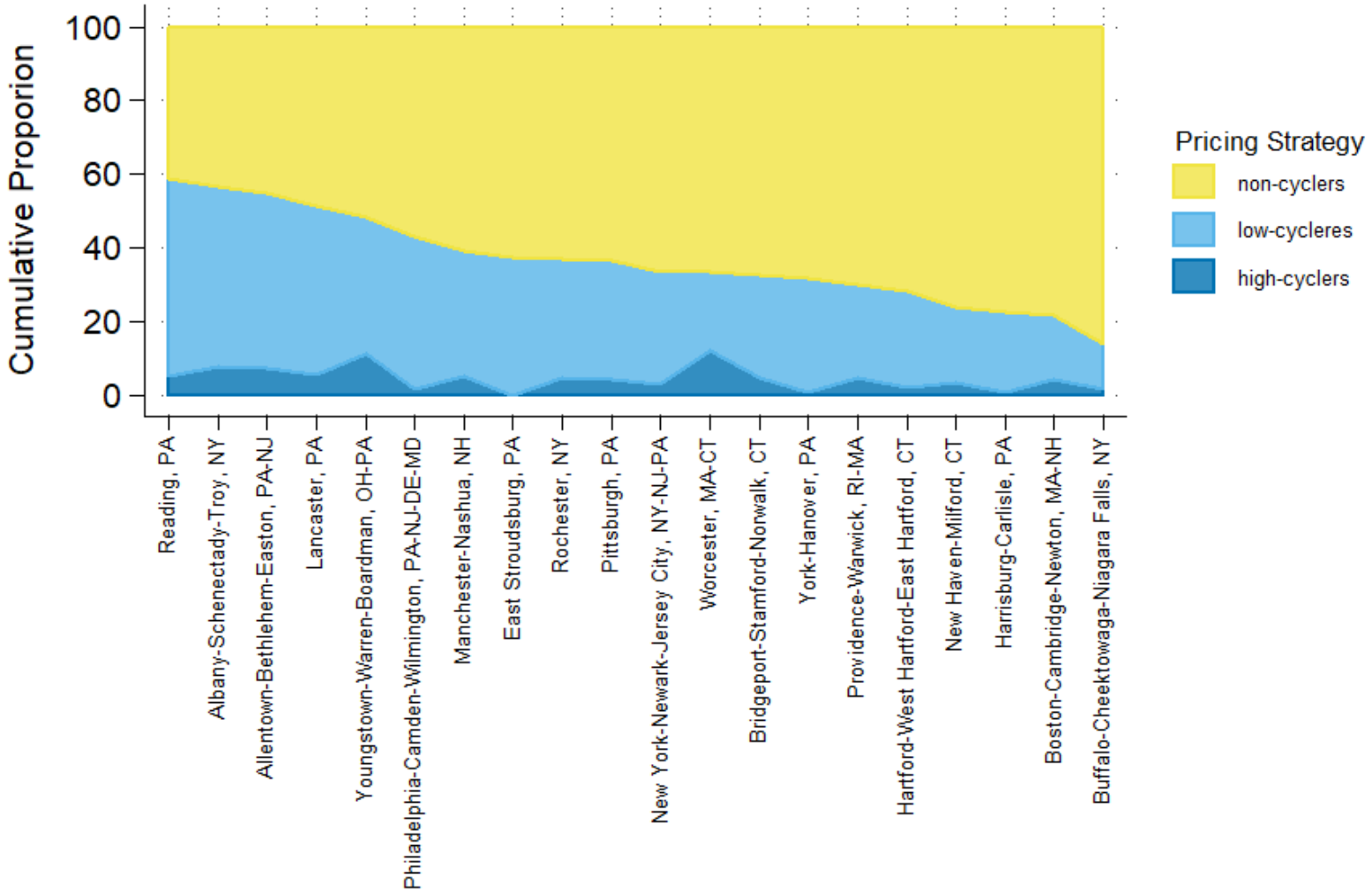
Northeast region



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Station Attributes					
Loyalty Discounts	-.043	.028	-.003	.011	-.055
	(.009)	(.028)	(.039)	(.019)	(.010)
Cash Discounts	-.102	-.021	-.017	-.083	-.113
	(.012)	(.017)	(.032)	(.030)	(.015)
Convenience Store	.056	.068	.050	.068	.058
	(.008)	(.020)	(.030)	(.015)	(.010)
Restaurant	-.028	.002	.007	-.010	-.045
	(.009)	(.027)	(.023)	(.021)	(.011)
Car Wash	-.004	-.019	.009	-.011	-.002
	(.009)	(.027)	(.026)	(.017)	(.010)
Service Station	-.101	-.102	-.062	-.186	-.092
	(.011)	(.024)	(.032)	(.030)	(.013)
Truck Stop	.014	-.032	-.030	.027	.008
	(.012)	(.037)	(.039)	(.027)	(.016)
Adjusted-R^2	.237	.159	.186	.199	.251
Observations (Fueling Stations)	57,674	4,319	4,172	12,289	36,894
Fraction of Cycling Stations (%)	48.9	37.3	53.1	63.3	44.9
Has Loyalty Distcounts (%)	24.2	5.6	18.7	34.6	23.6
Has Cash Distcounts (%)	15.0	17.5	11.6	8.2	17.4
Number of Cities	284	272	261	282	283
City FE	Yes	Yes	Yes	Yes	Yes
Location Characteristics	Yes	Yes	Yes	Yes	Yes

Brand size: small (retailers <10); small-med ($10 \leq$ retailers <100); med-big ($100 \leq$ retailers <1000); big ($1000 \leq$ retailers)
We present in parenthesis robust standard errors clustered at the city level.

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	Full (1)	Restricted (2)
Pricing Strategy		
Cycling Indicator	-4.3	-6.7
	(.323)	(.465)
Location Characteristics		
Income (log)	.18	.23
	(.090)	(.144)
Population Density	-.37	-.51
	(.125)	(.202)
No. of Neighboring Stations	-.23	-.24
	(.046)	(.063)
Sqr. No. of Neighb. Stations	.01	.01
	(.004)	(.006)
Station Attibutes		
Loyalty Discounts	.56	.55
	(.177)	(.178)
Cash Discounts	3.4	3.5
	(.494)	(.545)
Convenience Store	-.07	-.12
	(.221)	(.189)
Restaurant	.36	.35
	(.104)	(.134)
Car Wash	-.29	-.29
	(.132)	(.144)
Service Station	1.6	1.7
	(.349)	(.432)
Truck Stop	-.63	-.64
	(.287)	(.419)
Adjusted-R^2	.951	.948
Observations (Stations × Dates)	9,567,984	6,301,266
Stations	55,883	36,949
Average of Cycling Indicator (%)	51.9	52.0
Average Price (cents)	256.0	256.4
Sample	Preferred	Conservative
Date-Zip-Code FE	Yes	Yes
Number of Cities	284	284
City-Brand FE	Yes	Yes

Restricted: 'cyclers' if $CR_s \geq 2$ & 'non-cyclers' if $CR_s \leq 1.1$

We present in parenthesis robust standard errors clustered at the city level.

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