

Measuring Mobility in the 21st Century: What Can We Learn From Mobile Device Location Data?

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Travel Survey



- Historically, personal travel behavior has been tracked through **national and local travel surveys**
- Typically collect information from a sample of households about:
 - Their **socio-demographic characteristics**, including work status and work commute
 - The **vehicles** available to them
 - A diary of all **travel** undertaken by each member of the household in the last 24 hours
 - ...

REGIONAL TRAVEL SURVEY TRAVEL LOG

Planning Our Future Together

Name Travel Date Password

		Place	Address, Intersection, or Business Name	When did you start your trip?	When did you get there?	Traveled with?	What activities did you do there?
Example	Began the day at: (place at 3AM)	Home					1
Example	Then went to:	Child's School	Luther Jackson Middle School, Falls Church, VA	7:20AM	7:25AM	Chris, Sandy	6
Example	Then went to:	Primary Workplace	ICMA, 777 North Capitol St NE, Washington, DC	7:30AM	8:25AM	Sandy	3, 6
Trip 1	Began the day at: (place at 3AM)						
Trip 2	Then went to:						
Trip 3	Then went to:						
Trip 4	Then went to:						
Trip 5	Then went to:						
Trip 6	Then went to:						
Trip 7	Then went to:						
Trip 8	Then went to:						
Trip 9	Then went to:						
Trip 10	Then went to:						
Trip 11	Then went to:						
Trip 12	Then went to:						

- ### ACTIVITY CODES
- | | | |
|---|--|--|
| 1 - At home activity (typical household responsibilities/relax/sleep) | 9 - Receive childcare or preschool services | 17 - Entertainment (e.g., movies, plays, concerts) |
| 2 - Work at home or telework (for pay) | 10 - Receive adult care services | 18 - Socialize (e.g., visit friends/relatives) |
| 3 - Work at regular workplace or other work location | 11 - Shop in store (for groceries, clothing, other goods) | 19 - Recreation (e.g., sporting event, visit parks or museums, vacation) |
| 4 - Work-related activity (e.g., meeting, conference, sales call) | 12 - Eat a meal/have coffee or drink (outside of home or work) | 20 - Exercise (e.g., gym, jog/run, bike ride, walk dog) |
| 5 - Volunteer activity | 13 - Quick stop to pick up food or coffee | 21 - Governmental, civic, or religious activity |
| 6 - Drop off/pick up someone | 14 - Fuel vehicle/get gas | 22 - Mail package/letter or other postal activity |
| 7 - Attend school/class as a student | 15 - Receive healthcare services (e.g., medical, dental, etc.) | 23 - Change travel mode (e.g., wait for plane, inter-city train, or bus) |
| 8 - Attend other school-related activity | 16 - Receive personal services (e.g., banking, dry cleaning, grooming, pet care, automotive service) | 24 - Other _____ |

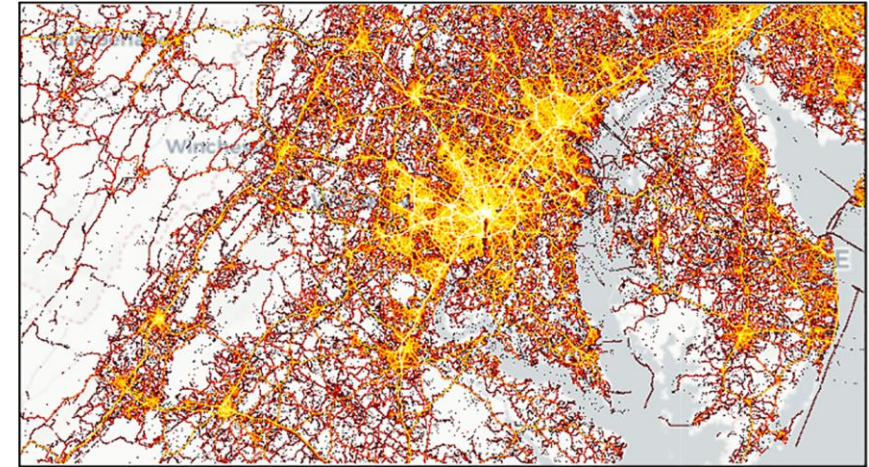
Mobile Device Location Data (MDLD)

- From cellphone tower, Global Positioning System (GPS), and location-based services (LBS), etc.
- Typically, one location sighting includes an
 - Anonymized device identifier (ID)
 - Latitude and longitude coordinates
 - Time stamps
 - Positioning accuracy
 - ...

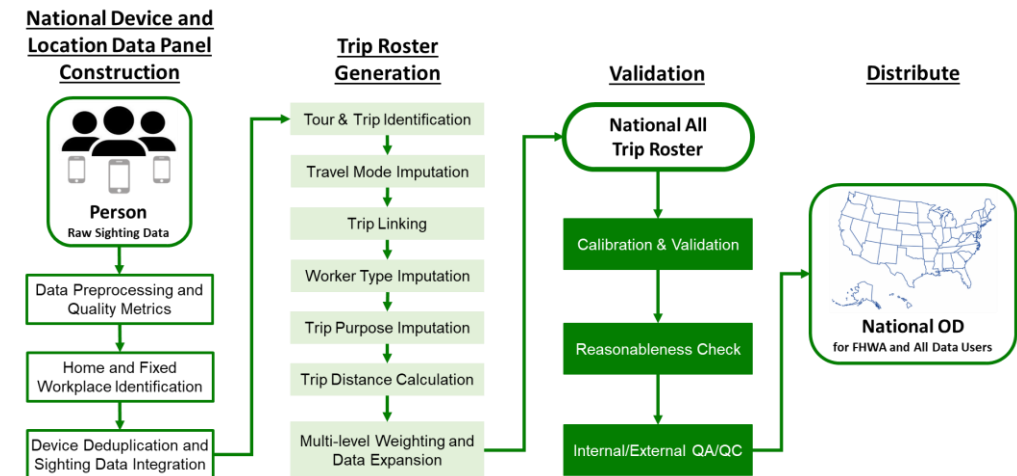


Travel Survey vs. MDLD

	Travel Survey	MDLD
Pros	<ul style="list-style-type: none"> Detailed Information Directly Reported Customization ... 	<ul style="list-style-type: none"> Continuous Monitoring Large-Scale Spatial Accuracy ...
Cons	<ul style="list-style-type: none"> Conducted infrequently (every 5-8 years) Covers different households in each wave One-day diaries ... 	<ul style="list-style-type: none"> Limited Behavioral Context Inferential Challenges Computationally expensive ...



Mobile device location data around the State of Maryland



Passenger OD data production flow chart for the Next Generation National Household Travel Survey (NextGen NHTS) OD Data Program

Research Questions

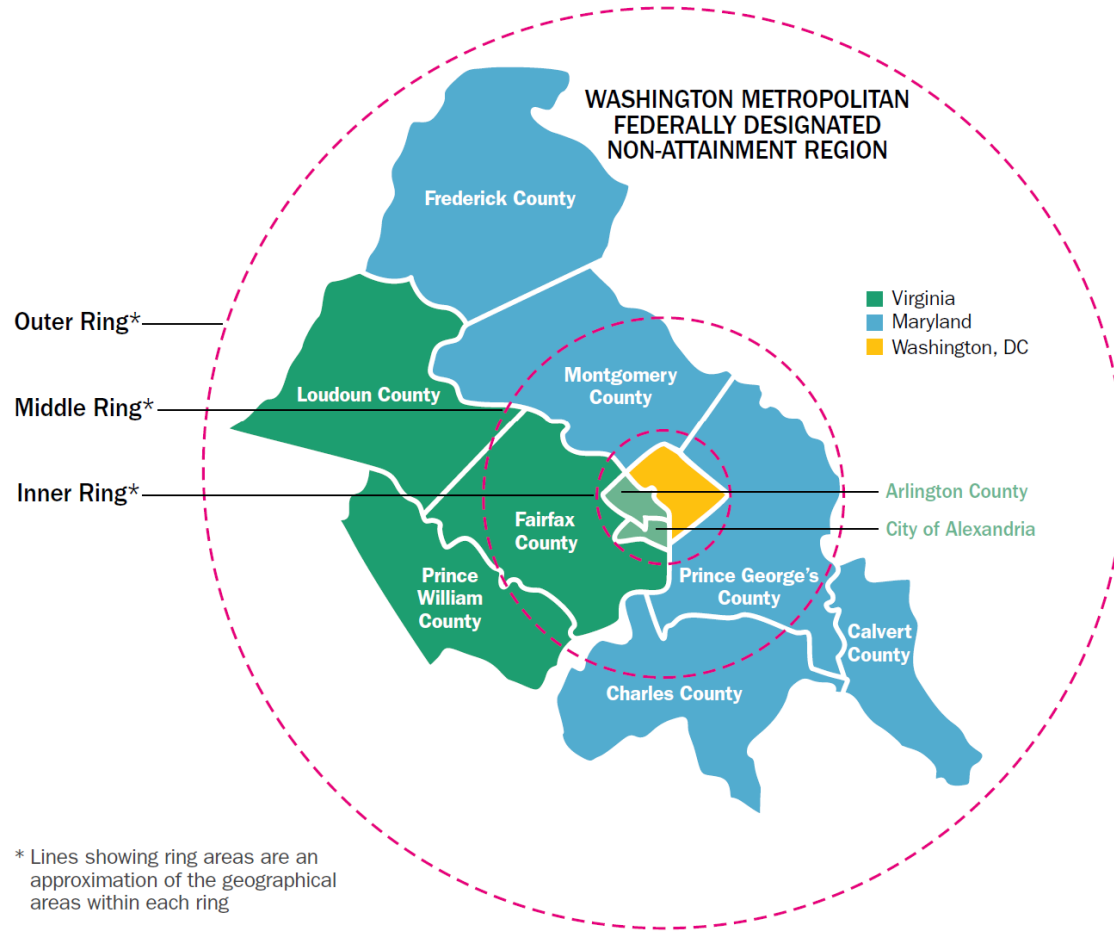


- How do MDLD Vehicle Miles Travelled (VMT) compare with VMT from high-quality, more traditional trip diaries/trip rosters?
- Can we form micro-level, longitudinal datasets using the MDLD?
- MDLD VMT...
 - Do they reflect fluctuations and local differences in gasoline prices?
 - Are they good predictors of station-level gasoline prices?

Study Area



Geographic Sub-Areas –
Core (Inner Ring), Middle Ring, Outer Ring



* Lines showing ring areas are an approximation of the geographical areas within each ring

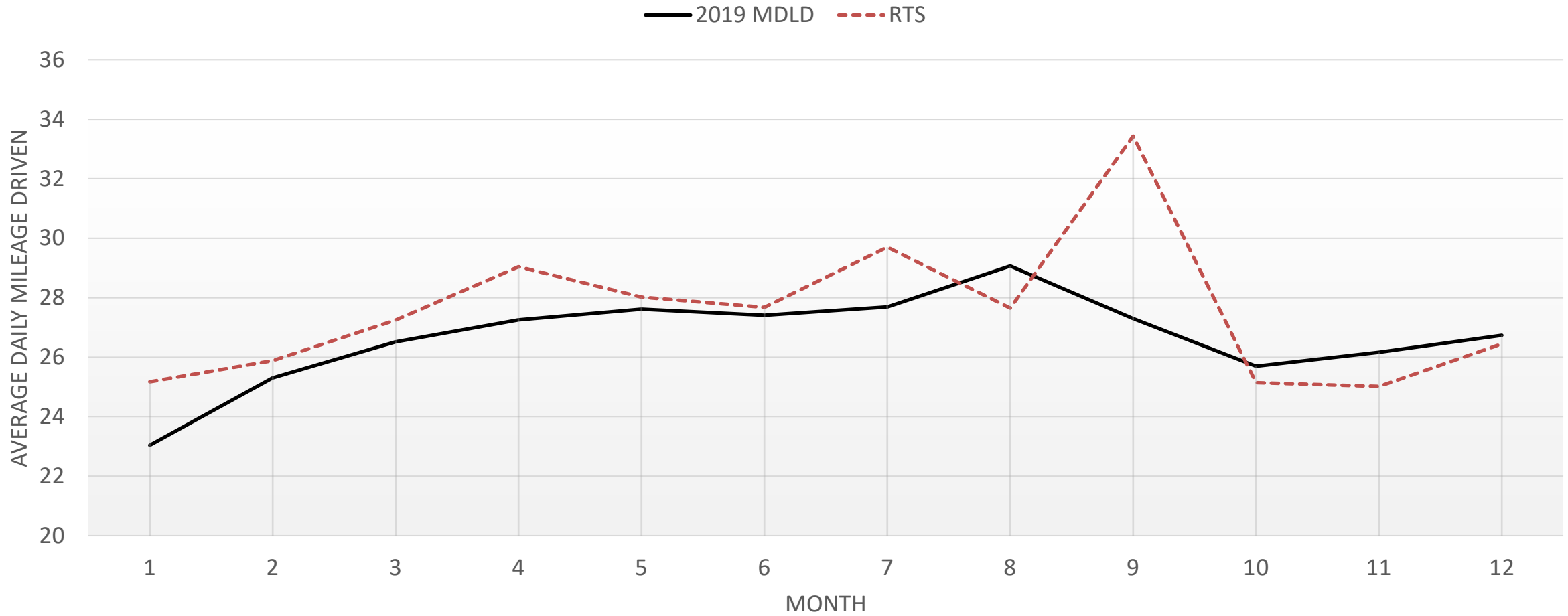
DC + the “Middle Ring” counties

Commuting Patterns:

	2019	2022
DC	35.12%	34.96%
Middle Ring	61.21%	57.71%
Elsewhere or unknown	3.66%	7.33%

From Metropolitan Washington Council of Governments' State of the Commute (2019, 2022)

MDLD 2019 vs RTS Average Daily VMT



Leap into Unknown: 2021-2022



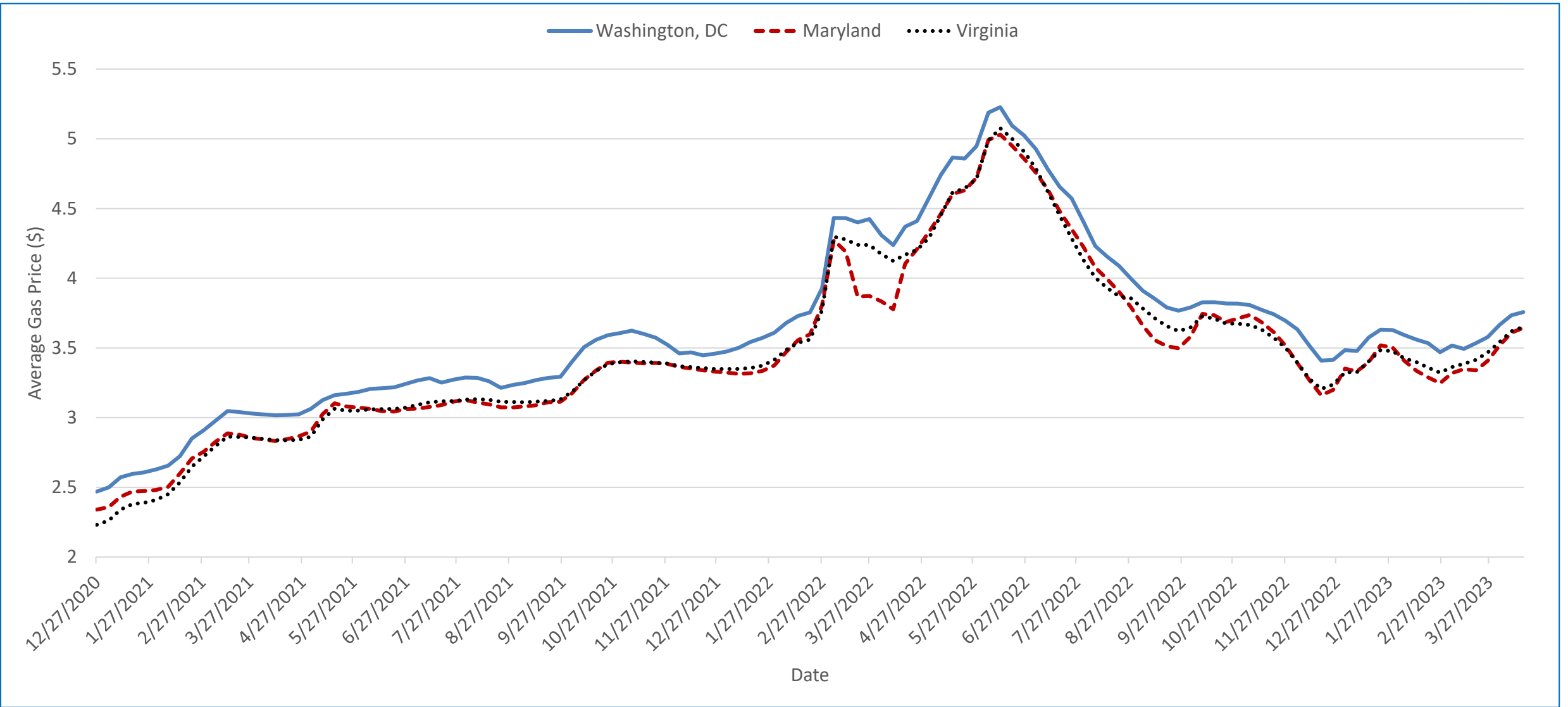
- **No government-run travel surveys were conducted at that time**
- **With 2021-2022 MDLD:**
 - **Can we form micro-level, longitudinal datasets using the MDLD?**
 - **MDLD VMT...**
 - **Do they reflect fluctuations and local differences in gasoline prices?**
 - **Are they good predictors of station-level gasoline prices?**

Device Panel & Pseudo Panels

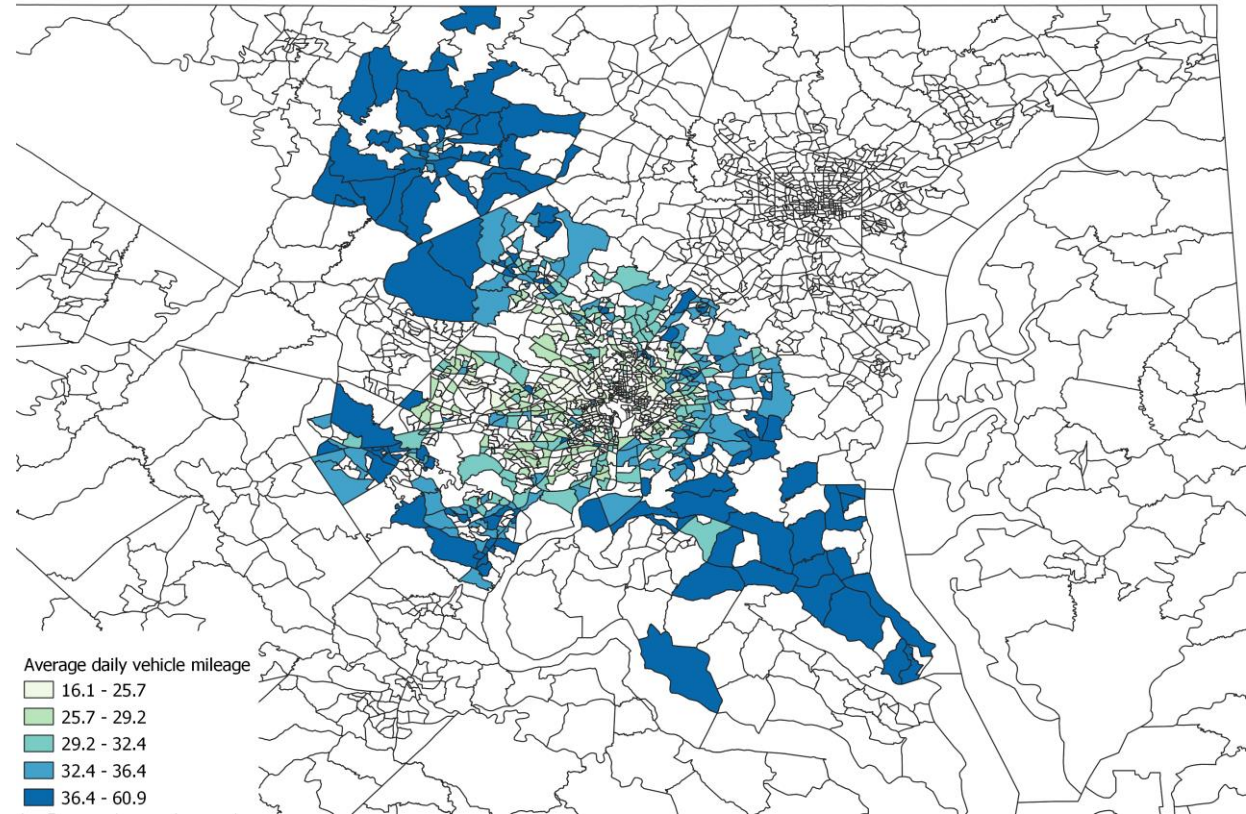
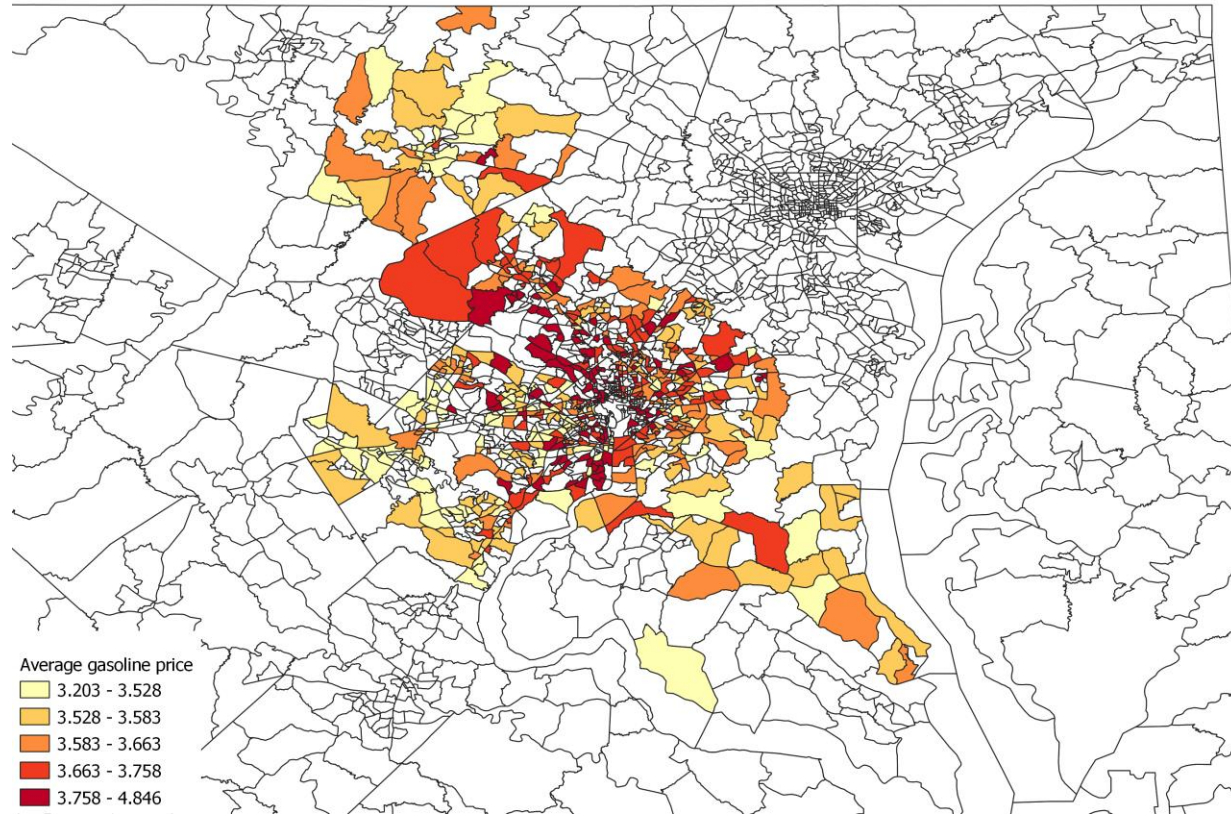


	Device Panel	Pseudo Panels	
		#1	#2
Unit	Device	Census Block Group	Census Tract
Average daily VMT in each week	By device	By all devices residing in the CBG	By all devices residing in the CT
N. units	82,866 (10% sample)	817	623
Avg N. observations (weeks) per unit	7	62	68
% of Obs with 0 VMT	5%	0.2%	0.02%

Gasoline Price Variation in Different States



Spatial Distribution at the Census Tract Level



- People may choose to live where housing is more affordable, gas prices tend to be lower, and they drive more

Regression of Average Daily VMT from MDLD



- Equation

$$VMT_{it} = \alpha_i + \gamma_t + \beta_1 \cdot GasPrice_{it} + \varepsilon_{it}$$

VMT_{it} - the average daily vehicle miles travelled (VMT) by individual or residents in zone i at week t

α_i - the fixed effect of individual or zone i

γ_t - time fixed effects

β_1 - the coefficient of $GasPrice_{it}$

$GasPrice_{it}$ - the average gasoline price near individual i or inside zone i at week t

ε_{it} - the error term

Regression of Average Daily Miles Driven from MDLD



- With local gasoline prices

	Device-level panel, Weekly	Device-level panel, incl. zeros, weekly	Block group averages, weekly	Census tract averages, weekly
Coeff. on gasoline price	-0.6009 *** (0.1647)	-0.3255 * (0.1148)	-2.3679 *** (0.5727)	-2.4099 *** (0.6321)
Price Elasticity of daily VMT	-0.0790 (0.0217)	-0.0451 (0.0159)	-0.2679 (0.0649)	-0.2789 (0.0732)
Fixed effects	Device	Device	Block group	Census tract
Time fixed effects	Month, year	Month, year	Month, year	Month, year
R square	0.03	0.03	0.24	0.41
N. Observations	560,779	590,572	50,435	42,257

Regression of Gasoline Price at the Station Level



- Equation

$$GasPrice_{it} = \alpha_i + \gamma_t + \beta_1 \cdot VMT_{i,t-1} + \varepsilon_{it}$$

$GasPrice_{it}$ - the average gasoline price of gasoline station i at week t

α_i - the fixed effect of gasoline station i

γ_t - time fixed effects

β_1 - the coefficient of $VMT_{i,t-1}$

$VMT_{i,t-1}$ - the total vehicle miles travelled (VMT) at the previous week $t - 1$ by individuals residing in the zone where the gasoline station i is located

ε_{it} - the error term

Gas station specific gasoline prices



	#1	#2
Coeff. on total mileage driven in the previous week at Census tract-level, Weekly	-3.12E-08 (2.08E-08)	1.28E-07 *** (3.37E-08)
Coeff. on number of gas stations within 0.25 miles	-0.0172 *** (0.0011)	NA
Other independent variables that are statistically significant	Population density, Income distribution, Age distribution, Education-level distribution, Road-network density, ...	NA
Fixed effects	Brand, State	Station , Brand, State
Time fixed effects	Month, Year	Month, Year
R square	0.65	0.67
N. Observations	20,021	20,021

Conclusion



- Average Daily VMT from 2019 MDLD shows a similar monthly trend as VMT from RTS
- Different ways of forming longitudinal datasets with MDLD
 - Device-level panel, with shorter tracking period, and more units
 - Pseudo Panels, aggregated, with longer series, fewer units, and more stable
- MDLD VMT...
 - Average daily VMT negatively correlated with the price of gasoline, reflecting fluctuations and local differences in gasoline prices.
 - Total VMT help explain the price of gasoline in the area and thus serve as a good proxy for demand pressure on fuel prices.

Thank you!

Comments? Questions?

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