How Does Shared Mobility Affect Personal Vehicle Ownership, Use, and Emissions?

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Introduction: Transportation in transition

Potential paradigm change:

- Transportation sector emits most CO_2 in the U.S.
- New shared mobility services (e.g., Uber and Lyft) have already changed how many urban travelers move.

Energy and emissions implications: U.S. DOE national laboratories estimate **60% lower or 200% higher** (for shared autonomous vehicles)

Limited research to-date suggests vehicle ownership declines given access to automated or shared mobility options:

	Vehicle Ownership	Vehicle Usage
Simulated shared, autonomous vehicles [1]	1–11 vehicles replaced per SAV	6–16% decline
Survey of Car2Go users [2]	9 vehicles replaced per Car2Go vehicle	8% increase

This research applies an econometric approach to analyzing next-generation mobility.

Background: Shared mobility market entry timing

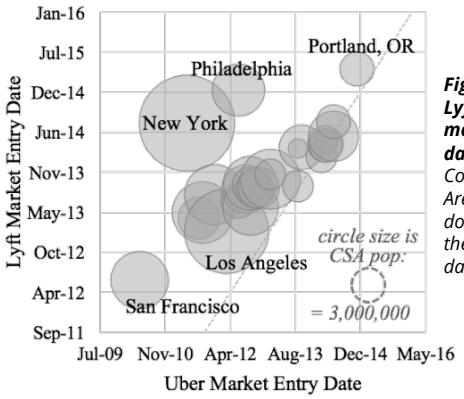

Figure 1. Uber and Lyft comparative market launch dates differ *by Combined Statistical Area (CSA), The dotted line reflects the coincidence of dates on both axes.*

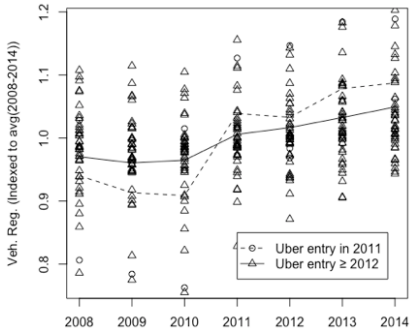

Figure 2. *Comparison of vehicle registrations (indexed to 2008) in 48 states* and DC, grouped by "early" Uber entry (in 2011) and "late" Uber entry (≥ 2012).*

**DOT's State Statistical Abstracts do not include NY, and CA is excluded here because Uber "enters" prominently twice there (San Francisco in 2010 and Los Angeles and San Diego in 2012)*

Approach: Econometric modeling

A difference-in-difference model with fixed effects examines vehicle ownership using state-level data from 2008–2014:

- Uber and Lyft market launch data
- Annual light-duty vehicle registrations and state populations (DOT's Office of Highway Policy Information's State Statistical Abstracts),
- Real personal income data (Bureau of Economic Analysis), and
- Average gas price by state (Energy Information Administration)

$$y_{st} = \beta x_{st} + \gamma v_s + \delta w_t + \varepsilon_{st}$$

- y_{st}: change in vehicle ownership (from year 2008), in state s and year t (after 2008);
- βx_{st}: state-time covariates, including controls for population, gas price, real personal income, **and an indicator variable (or set of indicator variables) indicating access to shared mobility**
- γv_s: vectors of unobserved state fixed effects, v_s
- δw_t: unobserved annual time fixed effects, w_t
- ε_{st}: unexplained error

Four structural approaches are used:

- **(I) baseline**
- **(II) baseline + discrete annual indicators** (*"SmdiscX" for an Uber presence of "X" years in Table 1*)
- **(III) baseline + linear indicator** (*"SMlinear", years since Uber entry*)
- **(IV) baseline + lagged binary indicator** (*"SMbinary", >2 years of Uber or not*)

Illustrative Regression Results

Table 1. *Regression results with change vehicle ownership since 2008 as dependent variable.*

	(I)	(II)	(III)	(IV)
(Intercept)	−8.394e7+	−10.239e8*	−9.143e7*	−10.083e8*
	(4.460e7)	(4.457e7)	(4.41276)	(4.421e7)
log(Population)	8.130e6*	8.911e6**	8.553e6*	8.887e6**
	(9.110e−1)	(3.359e7)	(3.346e6)	(3.340e6)
GasPrice	−2.776e5**	−2.667e5**	−2.606e5**	−2.644e5**
	(9.143e4)	(8.633e4)	(8.642e4)	(8.603e4)
log(Income)	−1.829e6	−1.517e6	−1.806e6	−1.584e6
	(1.730e6)	(1.714e−3)	(1.709e6)	(1.705e6)
SMdisc1	—	5.169e4	—	—
		(1.342e5)		
SMdisc2	—	−1.310e5	—	—
		(1.790e5)		
SMdisc3	—	−4.833e5*	—	—
		(2.281e5)		
SMdisc3+	—	−8.078e5*	—	—
		(3.204e5)		
SMlinear	—	—	−1.921e5**	—
			(6.579e4)	
SMbinary	—	—	—	−6.165e5**
				(1.894e5)

*Note: '***' p<0.001, '**' p<0.01, '*' p<0.05, '+' p<0.10; n=300*

Shared mobility indicators: *(II) discrete annual, (III) linear, and (IV) binary*

Discussion: Shared mobility implications for vehicle numbers

Shared mobility indicators are statistically significant and negative in specifications (II), (III), and (IV). The implications are depicted in Figure 3 for a synthetic "average" state, where shared mobility is associated with a reduction in vehicle registrations of ~100,000–500,000, or 2–10% of the state vehicle population.

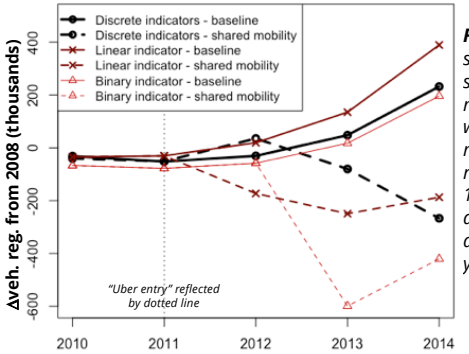

Figure 3 *shows a synthetic "average" state of just over 6 million residents, where roughly 5 million vehicles are registered and 15,000 net additional vehicles are registered each year.*

The implied change in net vehicle registrations is a large one. For context, **consider illustrative reductions in Pennsylvania vehicle registrations:**

- ~2–10% statewide
- ~3–15% in Philadelphia *and* Pittsburgh metro areas, or
- ~13–60% in the cities themselves.

Summary and Conclusions

- The growth of shared mobility services and the rapid advance of vehicle automation technology make increasingly important an improved understanding of effects on private vehicle ownership, use, and emissions.
- **State-level models suggest access to shared mobility corresponds to reductions in additional vehicle registrations.**
- **Future research will refine these preliminary specifications using individual vehicle data, which are more suited for identifying localized effects.**

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References

[1] Fagnant, D., K. Kockelman, and P. Bansal (2015). "Operations of a Shared Autonomous Fleet for the Austin, Texas Market." *Transportation Research Board.*

[2] Martin, E. and S. Shaheen (2016). "The Impacts of Car2go on Vehicle Ownership, Modal Shift,Vehicle Miles Traveled, and Greenhouse Gas Emissions: An Analysis of Five North American Cities". UC-Berkeley Working Paper.