Equity Implications of Atlanta Vehicle Inspection & Maintenance (I/M) Program

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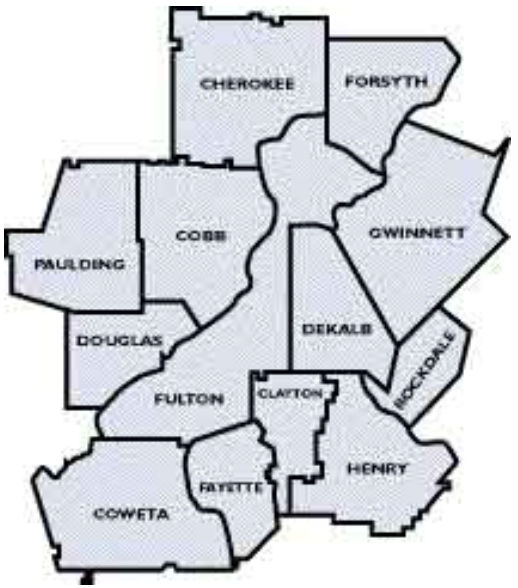
Outlines

- Background of I/M program
- I/M program: Costs of motorists
- Research question
- Data sources
- Hypotheses & models
- Samples & methods
- Results
- Conclusion
- Policy Implication

Background of I/M Program

- Severe air pollution problem in Atlanta
  - Violation of 1-hr national standard for **ozone**
  - Main source of ozone precursors is **vehicles**
  - Clean Air Act Amendment 1990 mandate state to set up vehicle **I/M program**
- Atlanta vehicle I/M program
  - 3 years or older
  - Registered in 13 counties
  - Gasoline engine
  - Few exemptions



I/M Program: Costs of Motorist

- Expectations
  - Vehicles kept clean
    - Optimal operating condition
    - Regular maintenance (at least once a year)
  - Air getting cleaner
- Benefit
  - Unharmed human health
- Short-run Costs
  - Inspection fee
  - Travel time & cost
  - Waiting time
  - Repair costs
    - Pre-inspection
    - Post-inspection (if failing 1st test)
- Long-run Costs
  - Total cost of ownership (TCO)

Research Question

- Focus on Short-run costs
  - Data limitation (1 yr cross-section)
- Focus on Repair costs
  - Other costs assumed similar across income groups
- Use Proxy of Repair costs: Fail the 1st inspection
  - Data limitation
    - Unobserved pre-test repair costs
    - Measurement error of post-test repair costs

Are vehicles owned by low-income households likely to *fail the first inspections* more than those owned by high-income?

Hypotheses & Models

Dependent Variable:

Probability of a vehicle failing the 1st inspection (p)

p = Proxy of POST-inspection repair costs

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_I \text{Income} + \varepsilon; H_A : \beta_I < 0$$

Vehicle owned by LOW-income household is MORE likely to fail

↓

LOW-income household bears MORE of (POST-test) repair costs

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_I \text{Income} + \beta_j \text{Motorist} + \beta_k \text{Vehicle} + \varepsilon; H_A : \beta_I < 0$$

Income = Proxy of PRE-inspection repair costs (maintenance)

Vehicle owned by LOW-income household is MORE likely to fail

↓

HIGH-income household bears MORE of (PRE-test) repair costs

Data sources

I/M Inspection Records 2000

Vehicle

Characteristics

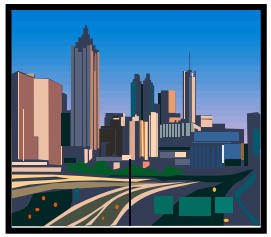
Make, Model Year

Type, Cylinder, etc.

Location

Pass-Fail results

United States Census 2000 **&**



Atlanta Household Travel Survey 2001-2002

Income

Block group

CENSUS 2000

Vehicle group

AHTS 2001-2002

Samples & Methods

- Aggregate-income sample (685,714)
  - No individual income for each vehicle
  - Possible bias results
- Logistic models
  - Simple regression
    - **Median imputation of income**
  - Monte-Carlo methods
    - Simulate artificial individual income
  - Heterogeneous vs. Homogeneous grouping

- Individual-income sample (465)
  - Individual income for each vehicle available
  - Small sample size
- Logistic models
  - Simple regression
  - Bootstrap methods

Results: Bootstrap & Monte Carlo

Dependent Variable: Ln (Odds of Failing 1st Inspection)

H_0: Odds of Failing 1st Inspection are the same across income groups

→ Same level of POST test repair

Restricted Model

Table 7, 8 (A)

Main Independent Variables: Ln(Annual Household Income)		Observed Individual AHI		Simulated Individual AHI		Group AHI	
Estimation Methods	Income Data	Coef.	z	Coef.	z	Coef.	z
Bootstrap Logit	AHTS	-0.619	-1.53	-	-	-	-
Logit	AHTS	-0.619	-1.72	-	-	-	-
Monte Carlo Logit	CENSUS	-	-	-0.12	-22.4	-	-
Monte Carlo Logit	AHTS	-	-	-0.18	-23.3	-	-
Logit	CENSUS	-	-	-	-	-0.572	-49.6
Logit	AHTS	-	-	-	-	-0.98	-58.0
Observations		465		685,714		685,714	

Results: Bootstrap & Monte Carlo

Dependent Variable: Ln (Odds of Failing 1st Inspection)

H_0: Odds of Failing 1st Inspection are the same across income groups, given same vehicles

→ Same level of PRE test repair

Unrestricted Model

Table 7, 8 (B)

Main Independent Variables: Ln(Annual Household Income)		Observed Individual AHI		Simulated Individual AHI		Group AHI	
Estimation Methods	Income Data	Coef.	z	Coef.	z	Coef.	z
Bootstrap Logit	AHTS	-0.282	-0.57	-	-	-	-
Logit	AHTS	-0.282	-0.75	-	-	-	-
Monte Carlo Logit	CENSUS	-	-	-0.031	-5.25	-	-
Monte Carlo Logit	AHTS	-	-	-0.020	-2.57	-	-
Logit	CENSUS	-	-	-	-	-0.261	-16.83
Logit	AHTS	-	-	-	-	-0.152	-8.05
Observations		465		685,714		685,714	

Results: Homogeneous vs. Heterogeneous Grouping

Dependent Variable: Ln (Odds of Failing 1st Inspection)

Restricted Model
Unrestricted Model

Table10 (A), (B) 6 Samples

Main Independent Variable	Highly Homogeneous Income Group			Highly Heterogeneous Income Group		
Ln(Annual Household Income)	Gini	SD	CV	Gini	SD	CV
Block Group Median AHI	-0.462	-0.381	-0.385	-0.524	-0.591	-0.638
(z statistics)	(7.20)	(5.01)	(5.15)	(8.09)	(8.79)	(11.0)
Block Group Median AHI	-0.093	-0.144	-0.157	-0.302	-0.239	-0.308
(z statistics)	(0.65)	(1.02)	(1.17)	(2.88)	(2.28)	(3.23)
Observations	13,907	13,975	14,120	13,721	14,016	13,716

Results: Summary

Income Variables	Model Specifications		
	Restricted	Unrestricted	
Observed income			
Individual income	-0.62*	-0.28	Unbiased estimates
Group income	-1.31***	-1.19***	Ecological fallacy
Simulated income			
Individual from block group info	-0.12***	-0.03***	Not substantive effect
Individual from vehicle group info	-0.18***	-0.02***	Not substantive effect
Group level income			
Median group income			
Census block group	-0.57***	-0.26***	Ecological fallacy
Vehicle characteristics group	-0.98***	-0.15***	Ecological fallacy
Census block group income			
Heterogeneous group	-0.59***	-0.30***	Ecological fallacy
Homogeneous group	-0.38***	-0.14	Unbiased estimates

Conclusion

- Vehicles owned by low-income household is MORE likely to fail the 1st inspection
  - Low-income households bear more burden (POST test repair cost) in complying with I/M program
- Vehicles owned by low-income household is EQUALLY likely to fail the 1st inspection, given the same vehicles
  - Low-income households maintain (PRE test repair costs) their vehicles roughly the same level as high-income households
- Cost of I/M compliance is NOT equally distributed across income groups

Policy Implications

- Clean vehicles → Clean air?
  - Low-income owners cannot afford the costs
    - Clean-for-a-day phenomena
    - Ineffective repair last for a short-period
    - 'Wash sale' to people living outside I/M areas
    - Illegal driving without registration
- Supplemental programs may help…
  - Repair subsidy
  - Old vehicle scrapping program: Orange county, CA
  - Warning: fungibility

Comments & Suggestions ???

Thank You
for Your Time …

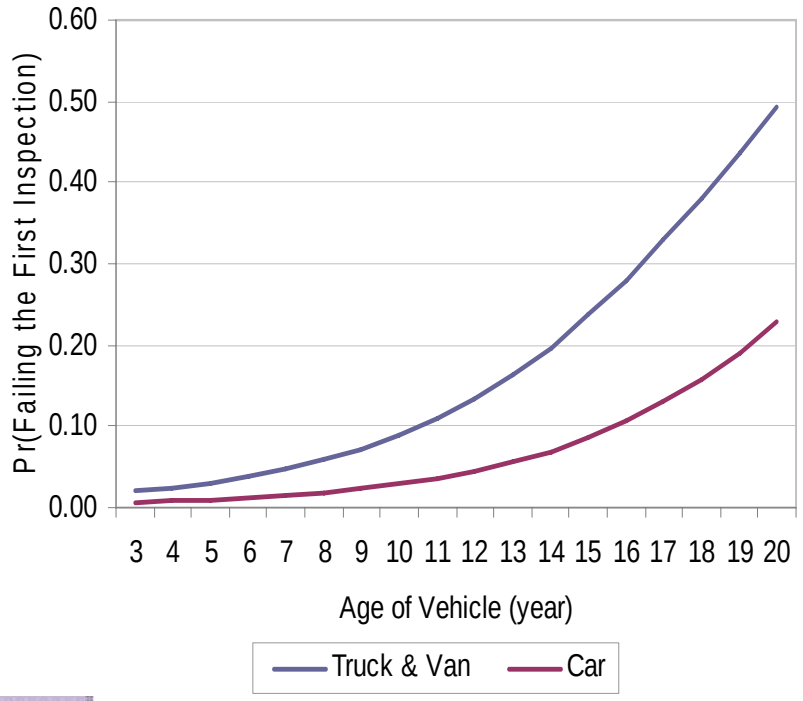
Appendix: Summary statistics of two Samples

Variables	Aggregate-Income Sample				Individual-Income Sample				Difference	
	Mean	Std. Div.	Min	Max	Mean	Std. Div.	Min	Max	t z	P(|T| > |t|) P(|Z| > |z|)
Dependent Variables										
First inspection result (Pass = 0; Fail = 1)	0.07	0.25	0	1	0.05	0.23	0	1	1.69	0.09
Independent Variables										
Household income ($US)										
Observed Ln of individual income					10.83	0.6	8.52	11.51		
Ln of *block* group median income	10.94	0.39	7.82	12.21						
Ln of *vehicle* group median income	11.01	0.26	8.52	11.51						
Owner characteristics in the block group										
Median age of population (year)	34.2	4.76	12.6	75.4						
Percent black population	0.26	0.3	0	1						
Percent other ethnic population	0.09	0.08	0	0.72						
Percent Latino population	0.07	0.1	0	0.84						
Percent male population	0.49	0.04	0.13	1						
Black					0.26	0.44	0	1		
Other					0.14	0.35	0	1		
Vehicle characteristics										
Age (year)	6.81	3.61	0.5	19.5	6.93	3.31	3	20	-0.78	0.43
Ln of mileage	9.09	3.28	0	13.82	11.41	0.56	8.21	12.91	-88.31	0
Displacement (liter)	3.03	1.17	1	7.4	2.94	1.05	1	5.9	1.85	0.07
Location of production: European	0.05	0.22	0	1	0.07	0.25	0	1	-1.98	0.05
Location of production: Asian	0.2	0.4	0	1	0.24	0.43	0	1	-2.16	0.03
Location of production: Other	0.12	0.33	0	1	0.12	0.33	0	1	0	1
Fuel Induction: EFI	0.16	0.36	0	1	0.21	0.41	0	1	-2.94	0
Fuel induction: FI	0.21	0.41	0	1	0.22	0.42	0	1	-0.53	0.6
Fuel induction: MFI	0.33	0.47	0	1	0.29	0.45	0	1	1.83	0.07
Exhaust gas recirculation (EGR)	0.78	0.41	0	1	0.76	0.43	0	1	1.04	0.3
Thermostatic air cleaner (TAC)	0.1	0.3	0	1	0.07	0.25	0	1	2.16	0.03
Type: Car	0.73	0.44	0	1	0.72	0.45	0	1	0.49	0.63
Type: Van	0.14	0.35	0	1	0.18	0.39	0	1	-2.48	0.01
Number of groups										
Census block groups		4,157				-				
Vehicle groups		1,014				-				
(Make-Model Year-Cylinder-Type)										
Observations		685,714				465				

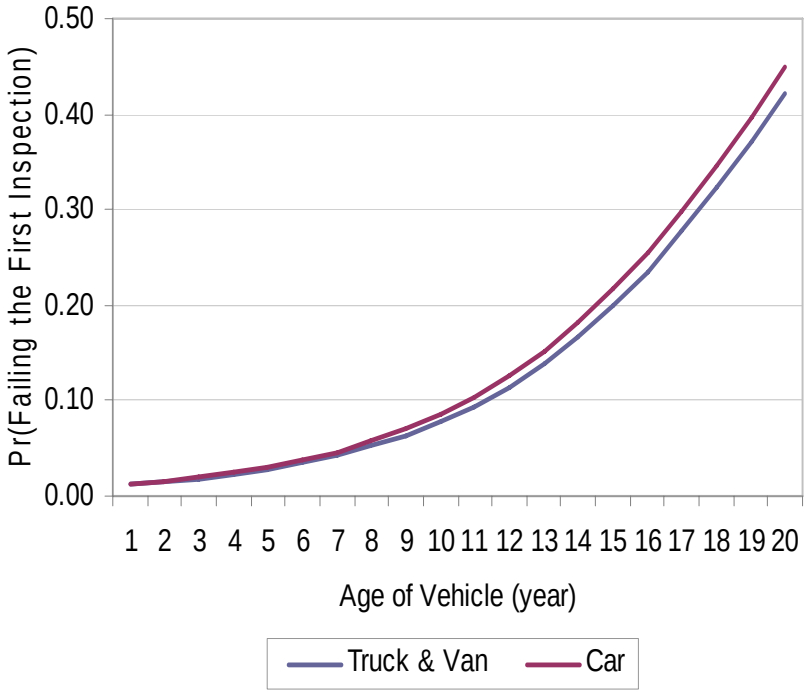
Appendix: Summary statistics of simulated income

Descriptive Statistics	Empirical Distribution		Log-Normal Distribution	
	AHTS 2001	CENSUS 2000	AHTS 2001	CENSUS 2000
Mean	10.915	10.837	10.915	10.837
Standard deviation	0.583	0.887	0.615	0.887
Minimum	8.517	8.517	3.998	5.625
Maximum	11.513	12.612	15.950	15.678
1st Percentile	8.517	8.517	9.178	8.624
5th Percentile	9.616	8.517	9.856	9.349
10th Percentile	10.127	9.741	10.142	9.707
25th Percentile	10.714	10.373	10.559	10.269
50th Percentile	11.120	10.906	10.967	10.857
75th Percentile	11.379	11.374	11.326	11.425
90th Percentile	11.513	11.828	11.599	11.940
95th Percentile	11.513	12.070	11.801	12.256
99th Percentile	11.513	12.612	12.257	12.880
Skewness	-1.478	-0.667	-0.597	-0.136
Kurtosis	5.784	3.704	5.018	3.346
Total sampling dist.	1000	1000	1000	1000

Appendix: Effects of vehicle age and type

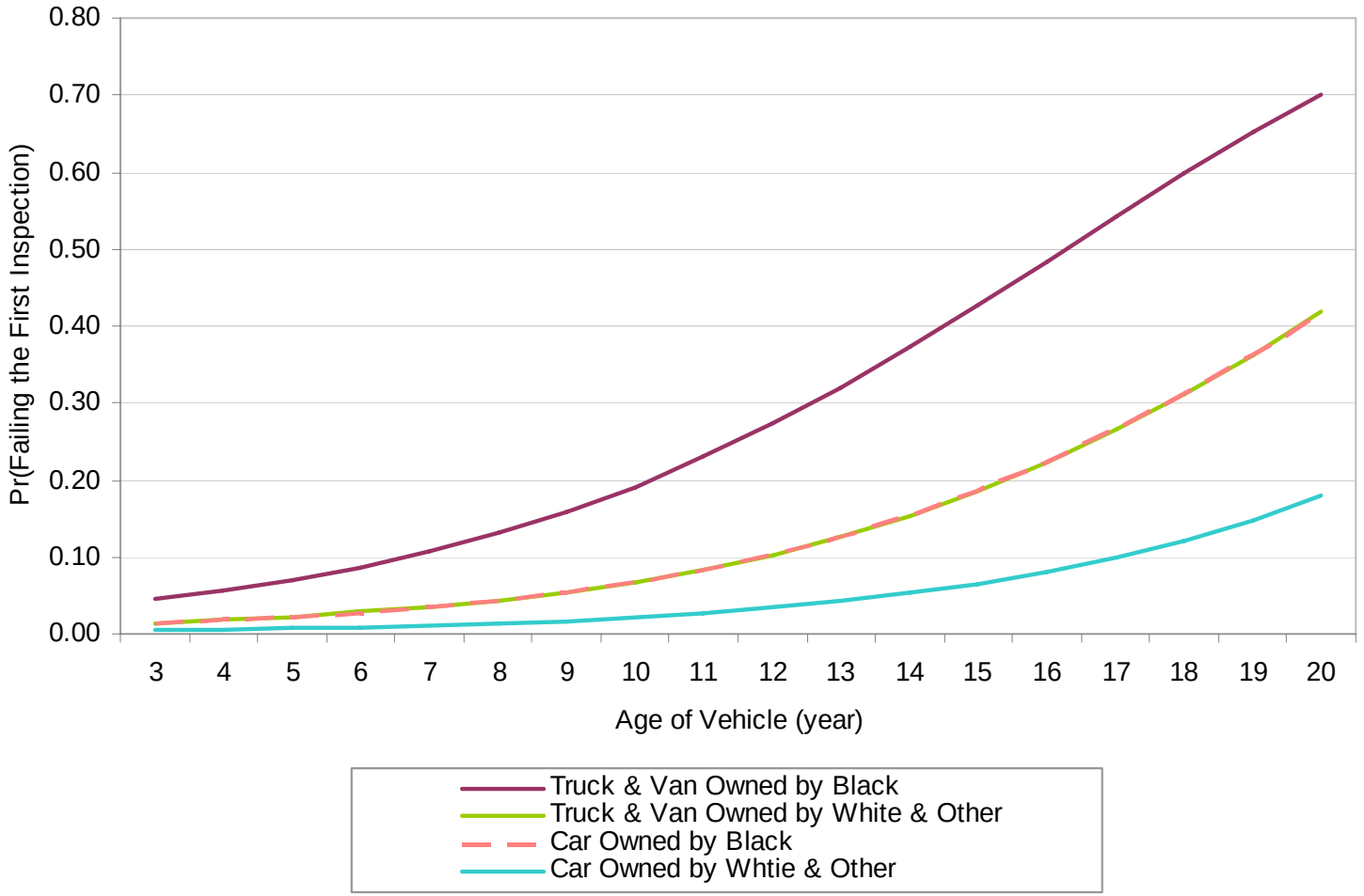


Individual Income Sample
(465)

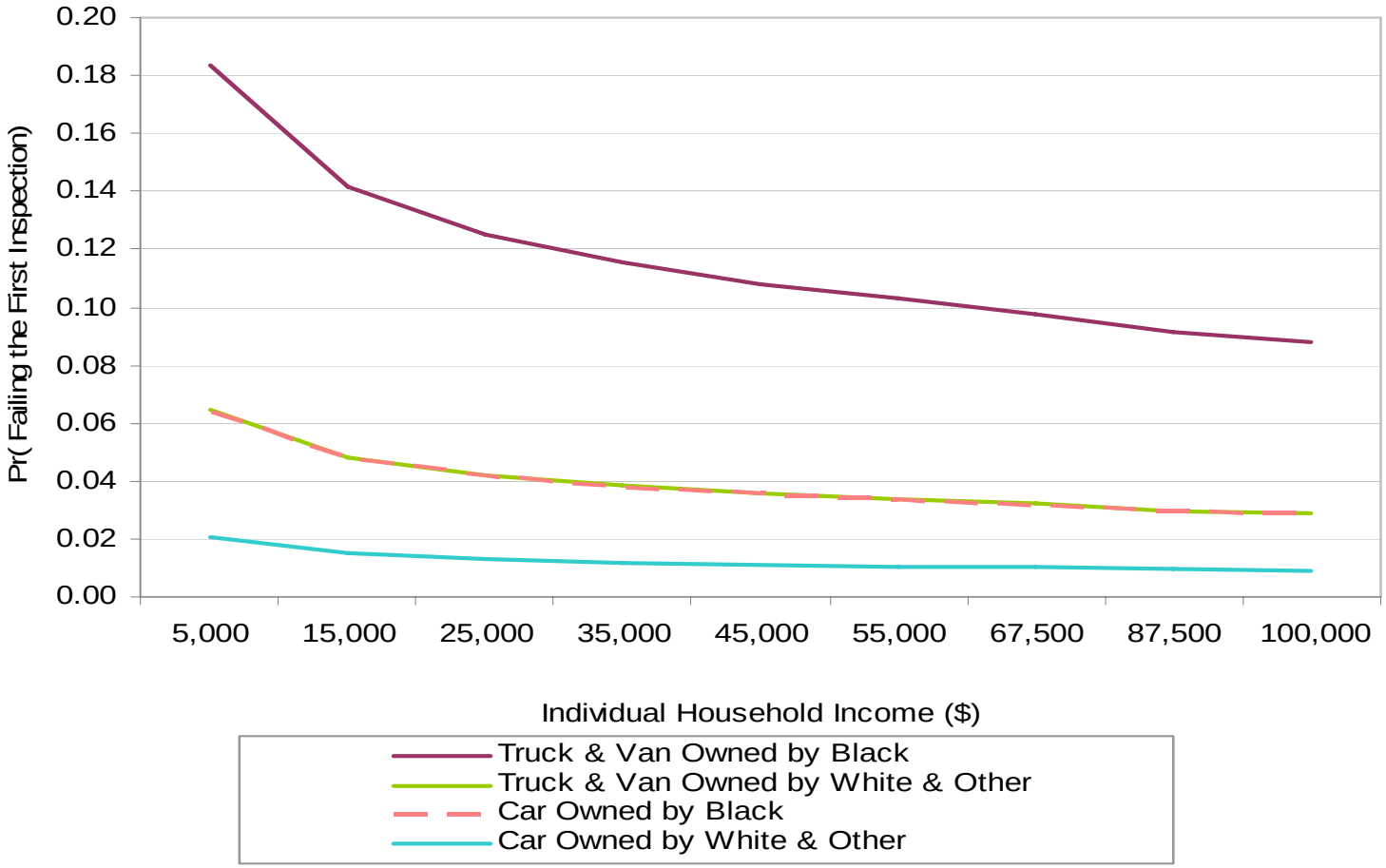


Aggregate Income Sample
(685,714)

Appendix: Effect of vehicle age, type and owner's ethnicity



Appendix: Effects of owner's income & ethnicity and vehicle type



Appendix: Effects of share of black population in block group and vehicle age