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MARKET-WEIGHTED TRENDS IN THE DESIGN ATTRIBUTES OF HEADLAMPS IN THE U.S.

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16. Abstract

This report provides updated information regarding the market-weighted prevalence of various headlamp design attributes in the U.S. and a summary of recent trends for these design attributes. The main findings were as follows: (1) there was a general transition from dual-filament light sources in 1997 to single-filament sources in 2007; (2) the preferred optics changed from lens-based in 1997 to mostly reflector-based optics in 2007; and (3) while mechanical aim was the most frequently specified aiming method in 1997, the 2007 sample made nearly exclusive use of visual/optical aiming (with visual/optical right side as the most common specific type).

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Introduction

Driven by improvements in automotive lighting technology and regulatory changes over several recent decades, headlamp designers now enjoy a considerable range of flexibility in determining the ultimate design and implementation of headlamps for new vehicle models. The attributes accounting for the majority of this increased flexibility include the light source, optics, and aiming method specified for each headlamp. Over the past decade, significant changes to these attributes, and thus the design choices exercised by lighting designers and vehicle manufacturers, have occurred for headlamps on vehicles sold in the U.S.

Starting with the 1997 model year, we have periodically documented the various technical and photometric attributes of headlamps in the U.S. for the top-selling vehicles (Sivak, Flannagan, Kojima, & Traube, 1997; Schoettle, Sivak, & Flannagan, 2001; Schoettle, Sivak, Flannagan, & Kosmatka, 2004). To update this cumulative database of headlamp attributes, a new survey was conducted to document the state of headlamps in the U.S. for the 2007 model year.

This report provides updated information regarding the market-weighted prevalence of various headlamp attributes in the U.S. and a summary of recent trends in the U.S. for these attributes.

Approach

Samples

Table 1 describes the four samples used in these analyses. The information that was collected was market-weighted by the respective sales figures for each individual vehicle (Automotive News, 2001, 2004, 2007; Ward's Automotive Reports, 1997).

Table 1
Summary of the lamp samples used in these analyses.

Model year	Number of unique lamps	Market-weighted percentage of all vehicles sold	Study
1997	23	45.2	Sivak et al. (1997)
2000	20	39.3	Schoettle et al. (2001)
2004	20	38.8	Schoettle et al. (2004)
2007	50	58.6	present study

All lamps in these analyses were either directly purchased from vehicle dealerships in Ann Arbor, Michigan (1997, 2000, and 2004 samples), or inspected while on the lot at the same local dealerships (2007 sample). When more than one headlamp option was offered for a vehicle, the base-model lamp was documented. For a complete listing of vehicles included in each sample, see Appendices A through D.

Lamp surveys

A visual and physical inspection was made of each headlamp. The following information was documented:

- Light source (low and high beam)
- Optics (low and high beam)
- Aiming method
- Lens material

Results

Light source trends

The light sources for the sampled low beams are summarized in Table 2. The corresponding information for high beams is shown in Table 3. The information in these tables is analogously presented in graphical form in Figures 1 and 2.

The main trend for the low-beam sample involves a transition from HB5 (44% in 1997, 15% in 2007) to H11 (0% in 1997, 32% in 2007). HB4 remains the second most common light source for all years except 2004 (when it was the most common light source). Over this period, the usage of HB2 has decreased substantially (from 12% in 1997 to 4% in 2007), and HB1 was no longer present in the two most recent samples.

The main trend for the high-beam sample involves a transition from HB5 (44% in 1997, 15% in 2007) to HB3 (34% in 1997, 47% in 2007). The newer H13 is the second most common light source for the current model year. As with the low-beam samples, usage of HB2 has decreased substantially, and HB1 was no longer present in the two most recent samples.

These shifts from the dual-filament HB5 in both the low- and high-beam samples to the single-filament H11 (low beam) and HB3 (high beam) also indicate a gradual shift from two-lamp systems to four-lamp systems. (For an analysis of the relative merits of two- and four-lamp systems, see Rumar [2000].)

While several bulbs have decreased in usage (or disappeared from our samples altogether), there is a clear trend toward an increased diversity of light sources. Both low- and high-beam samples employed only four bulb types in the 1997 and 2000 samples, increasing to seven (low beam) and eight (high beam) for the current model year. This trend is not an effect of the increased sample size for the 2007 model year, as all of the light sources documented in this report are present in both the 20 best-selling vehicles (a sample size similar to the previous studies), as well as the 50 best-selling vehicles that were included in this analysis. This increased diversity is a result of more frequent usage of newer tungsten-halogen bulb technology (H9, H11, and H13) and the recent appearance of HID (D4R) as standard equipment on a top-selling vehicle.

Table 2
Light sources used in the sampled low-beam headlamps. The entries in each cell are sales-weighted percentages. The most frequently installed equipment for each year is shown in bold. (H11, H13, and D4R became legal equipment in 1999, 2002, and 2005, respectively [NHTSA, 1999b, 2002, 2005].)

Light sources		Model year			
Designation	Number of filaments	1997	2000	2004	2007
HB1 (9004)	2	9.3	5.6		
HB2 (9003)	2	12.5	12.3	3.6	3.6
HB4 (9006)	1	34.3	35.0	**57.8**	27.1
HB5 (9007)	2	**43.9**	**47.1**	22.4	14.8
H1	1			3.1	
H7	1				3.8
H11	1				**31.8**
H13	2			13.1	17.8
D4R	n/a				1.1

Table 3
Light sources used in the sampled high-beam headlamps. The entries in each cell are sales-weighted percentages. The most frequently installed equipment for each year is shown in bold. (H9, H13, and D4R became legal equipment in 1999, 2002, and 2005, respectively [NHTSA, 1999a, 2002, 2005].)

Light sources		Model year			
Designation	Number of filaments	1997	2000	2004	2007
HB1 (9004)	2	9.3	5.6		
HB2 (9003)	2	12.5	12.3	3.6	3.6
HB3 (9005)	1	34.3	35.0	**60.9**	**47.1**
HB5 (9007)	2	**43.9**	**47.1**	22.4	14.8
H1	1				1.5
H7	1				5.4
H9	1				8.7
H13	2			13.1	17.8
D4R	n/a				1.1

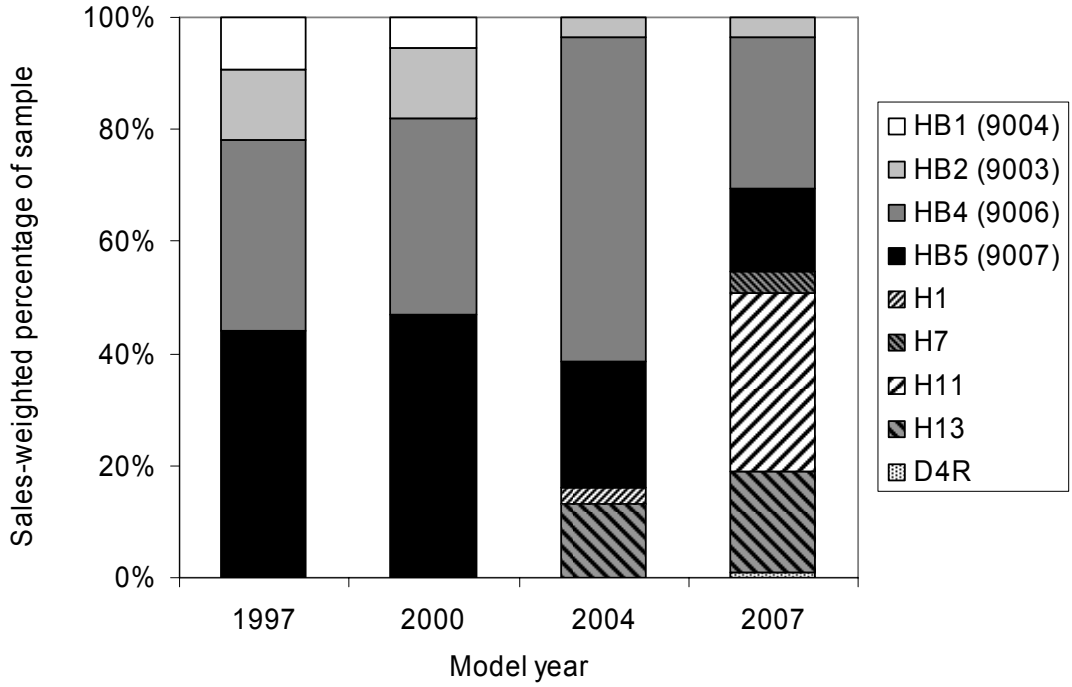

Figure 1. Sales-weighted distribution of low-beam light sources within each sample.

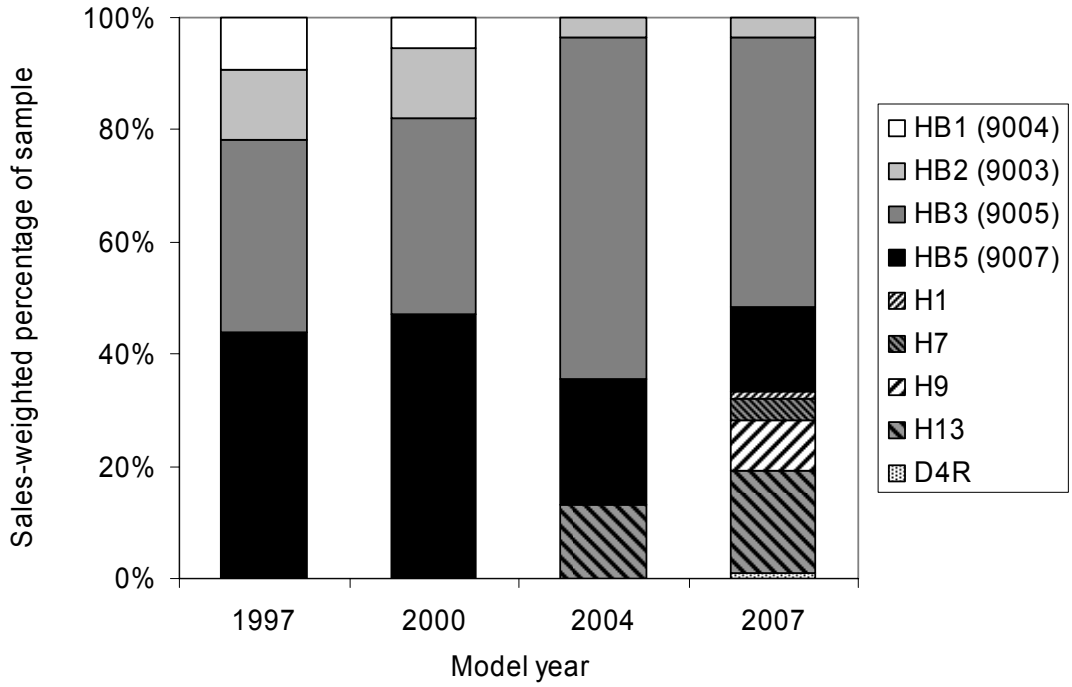

Figure 2. Sales-weighted distribution of high-beam light sources within each sample.

Optics trends

The optics employed in the low-beam headlamps is summarized in Table 4, while the corresponding information for high beams is listed in Table 5. The information in these tables is analogously presented in graphical form in Figures 3 and 4.

The trends for both the low- and high-beam samples show a relatively abrupt transition from mainly lens-based optics in 1997 (67%) to reflector-based optics in 2007 (90%). Additionally, for the first time in these analyses, projector-based optics appear in 2007 as standard equipment on top-selling vehicles within the current sample.

Table 4
Optics of the sampled low-beam headlamps. The entries in each cell are sales-weighted percentages. The most frequently installed equipment for each year is shown in bold.

Optics	1997	2000	2004	2007
Reflector	33.4	**51.2**	**93.9**	**89.7**
Lens	**66.6**	48.8	6.1	1.5
Projector				8.8

Table 5
Optics of the sampled high-beam headlamps. The entries in each cell are sales-weighted percentages. The most frequently installed equipment for each year is shown in bold.

Optics	1997	2000	2004	2007
Reflector	33.4	**60.6**	**100.0**	**89.7**
Lens	**66.6**	39.4		1.5
Projector				8.8

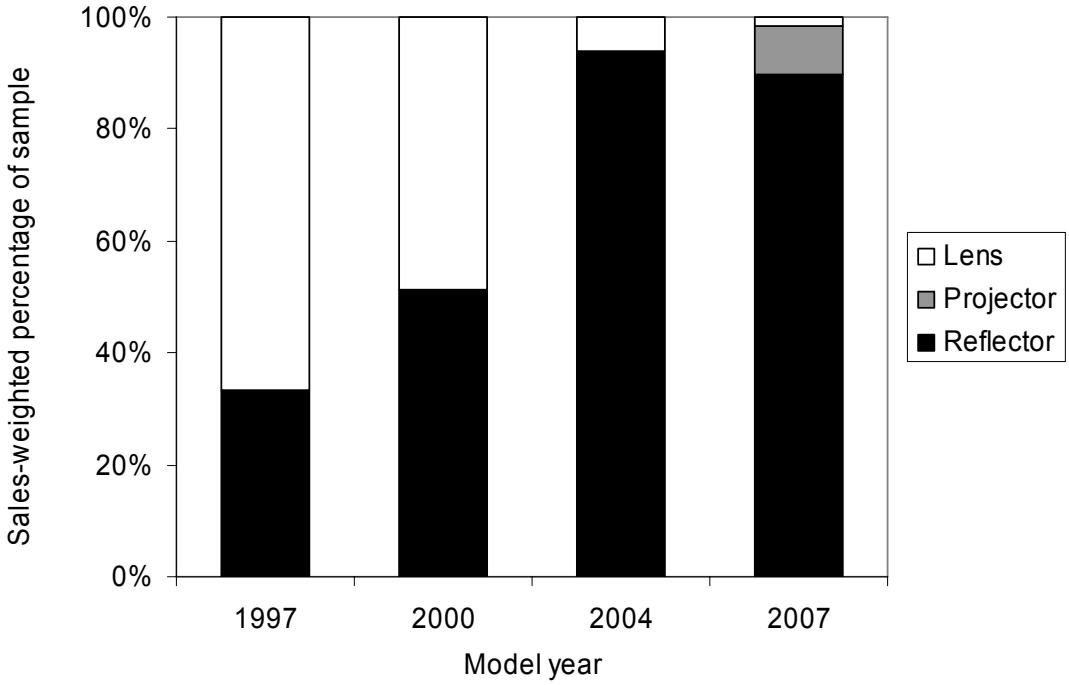

Figure 3. Sales-weighted distribution of low-beam optics within each sample.

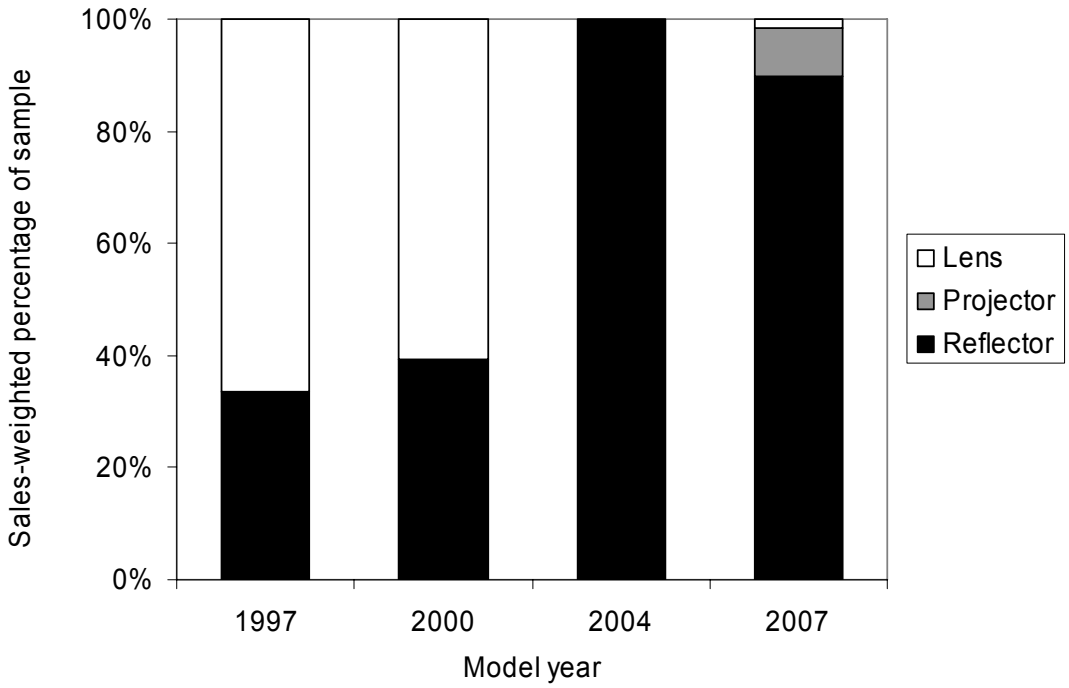

Figure 4. Sales-weighted distribution of high-beam optics within each sample.

Aiming trends

The aiming methods specified for the headlamps are summarized in Table 6, and presented graphically in Figure 5.

A clear trend is evident, as headlamp designs transitioned from predominantly mechanical aiming in 1997 (75%) to nearly exclusive use of visual/optical aiming methods in 2007 (98%). Within the visual/optical aiming category, visual/optical right side (VOR) aiming leads visual/optical left side (VOL) aiming in prevalence (73% and 25% of the most recent sample, respectively). However, the usage of VOL has increased since first appearing in our analyses in 2004 (13% in 2004, 25% in 2007). Additionally, VHAD (vehicle headlamp aiming device), which comprised the remainder of the first sample (25%) following mechanical aiming, has not been present in the two most recent samples.

Table 6
Specified aiming methods of the sampled lamps. The entries in each cell are sales-weighted percentages. The most frequently specified aiming method for each year is shown in bold.

Aiming method	1997	2000	2004	2007
Mechanical	**74.8**	**61.8**	9.4	1.5
VHAD	25.2	9.2		
VOL			13.3	25.4
VOR		29.0	**77.3**	**73.1**

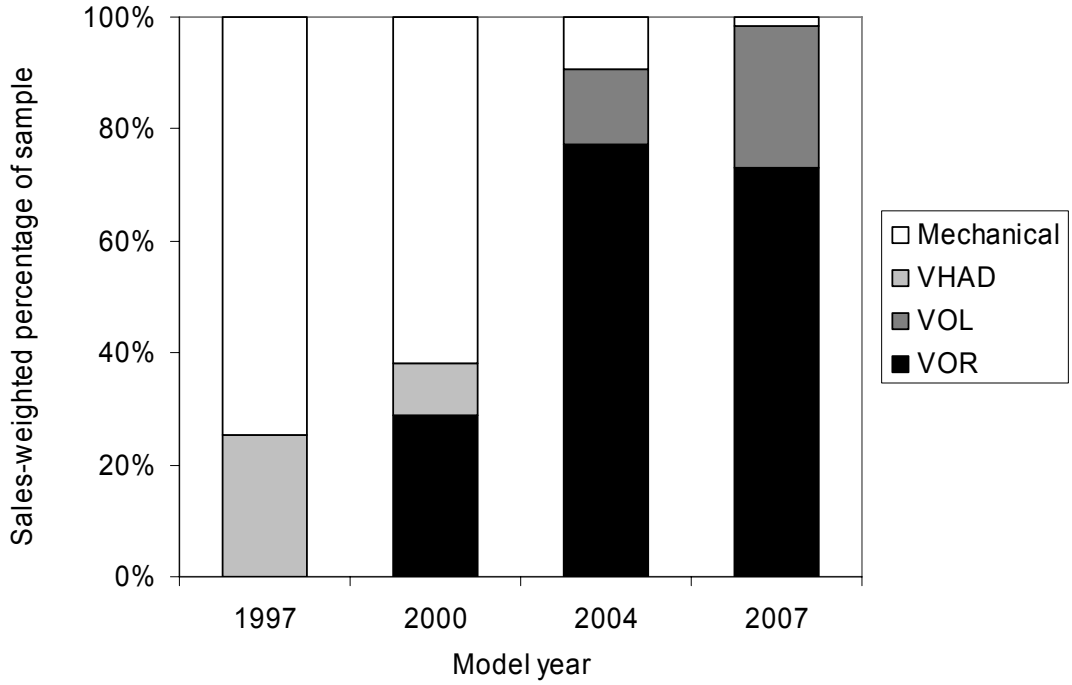

Figure 5. Sales-weighted distribution of the specified aiming methods within each sample.

Lens material trends

As has been the case since these analyses began in 1997, all U.S. headlamps surveyed for these reports were constructed with plastic outer lenses.

Conclusions

This report provided (1) updated information regarding the current market-weighted prevalence of various headlamp design attributes in the U.S. and (2) a summary of recent trends for these design attributes.

There were several main findings. There was a general transition from dual-filament light sources (HB5) in 1997 to single-filament sources (H11 and HB3) in 2007. This trend also indicates a gradual shift from two-lamp systems to four-lamp systems. The preferred optics changed from lens-based (67%) in 1997 to mostly reflector-based optics (90%) in 2007. The specified aiming methods exhibited the strongest trend. While mechanical aim was typically used in 1997 (75%), the 2007 sample made nearly exclusive use of visual/optical aiming (98%), with VOR as the most common specific type (73%). Table 7 presents summaries of the most common headlamp attributes in the earliest and most recent samples.

Table 7
Summaries of the most common headlamp attributes in the earliest (1997) and most recent (2007) samples.

Attribute	1997	2007
Low beam light source	HB5 (9007)	H11
High beam light source	HB5 (9007)	HB3 (9005)
Low beam optics	Lens	Reflector
High beam optics	Lens	Reflector
Aiming method	Mechanical	VOR

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Appendix A: Vehicles included in the 1997 sample.

Model	Maker	Sample share %	Market share %
F-series	Ford	10.88	4.92
C/K pickup	Chevrolet	7.78	3.52
Explorer	Ford	5.81	2.63
Camry	Toyota	5.77	2.61
Taurus	Ford	5.62	2.54
Ram pickup	Dodge	5.30	2.40
Accord	Honda	5.13	2.32
Civic	Honda	4.62	2.09
Cavalier	Chevrolet	4.52	2.05
Caravan/Grand Caravan	Dodge	4.38	1.98
Ranger	Ford	4.24	1.92
Escort	Ford	4.08	1.84
Grand Cherokee	Jeep	3.98	1.80
SL	Saturn	3.77	1.70
Lumina	Chevrolet	3.43	1.55
Blazer	Chevrolet	3.36	1.52
Corolla	Toyota	3.25	1.47
Grand Am	Pontiac	3.02	1.36
Contour	Ford	2.33	1.05
Grand Prix	Pontiac	2.25	1.02
Intrepid	Dodge	2.22	1.00
Altima	Nissan	2.16	0.98
LeSabre	Buick	2.10	0.95
	Total:	100.00	45.22

Appendix B: Vehicles included in the 2000 sample.

Model	Maker	Sample share %	Market share %
F-series	Ford	12.86	5.05
Silverado	Chevrolet	9.42	3.70
Explorer	Ford	6.53	2.57
Camry	Toyota	6.21	2.44
Accord	Honda	5.94	2.33
Taurus	Ford	5.61	2.20
Ram pickup	Dodge	5.59	2.20
Ranger	Ford	4.84	1.90
Civic	Honda	4.76	1.87
Focus	Ford	4.20	1.65
Caravan/Grand Caravan	Dodge	4.19	1.65
Grand Cherokee	Jeep	3.99	1.57
Cavalier	Chevrolet	3.48	1.36
Corolla	Toyota	3.38	1.33
Blazer	Chevrolet	3.32	1.30
Windstar	Ford	3.26	1.28
Grand Am	Pontiac	3.15	1.24
Expedition	Ford	3.13	1.23
S10	Chevrolet	3.10	1.22
Malibu	Chevrolet	3.04	1.19
	Total:	100.00	39.28

Appendix C: Vehicles included in the 2004 sample.

Model	Maker	Sample share %	Market share %
F-series	Ford	13.08	5.07
Silverado	Chevrolet	10.58	4.10
Ram pickup	Dodge	6.95	2.69
Camry	Toyota	6.39	2.48
Accord	Honda	6.15	2.39
Explorer	Ford	5.77	2.24
Taurus	Ford	4.65	1.80
Civic	Honda	4.64	1.80
Impala	Chevrolet	4.14	1.61
TrailBlazer	Chevrolet	4.04	1.57
Corolla	Toyota	3.99	1.55
Cavalier	Chevrolet	3.97	1.54
Caravan/Grand Caravan	Dodge	3.61	1.40
Focus	Ford	3.55	1.38
Ranger	Ford	3.24	1.25
Grand Cherokee	Jeep	3.21	1.24
Altima	Nissan	3.11	1.21
Tahoe	Chevrolet	3.08	1.19
Sierra	GMC	3.04	1.18
Expedition	Ford	2.81	1.09
	Total:	100.00	38.78

Appendix D: Vehicles included in the 2007 sample.

Model	Maker	Sample share %	Market share %
F-series	Ford	8.21	4.81
Silverado	Chevrolet	6.56	3.84
Camry	Toyota	4.62	2.71
Ram pickup	Dodge	3.76	2.20
Accord	Honda	3.66	2.14
Civic	Honda	3.26	1.91
Impala	Chevrolet	2.99	1.75
Corolla	Toyota	2.81	1.64
Altima	Nissan	2.40	1.40
Cobalt	Chevrolet	2.18	1.28
Caravan/Grand Caravan	Dodge	2.18	1.28
Sierra	GMC	2.17	1.27
Explorer	Ford	1.85	1.08
Tacoma	Toyota	1.84	1.08
Odyssey	Honda	1.83	1.07
Focus	Ford	1.83	1.07
Taurus	Ford	1.80	1.06
TrailBlazer	Chevrolet	1.80	1.06
CR-V	Honda	1.75	1.03
Mustang	Ford	1.72	1.01
Malibu	Chevrolet	1.69	0.99
Sienna	Toyota	1.68	0.99
Tahoe	Chevrolet	1.67	0.98
Town & Country	Chrysler	1.64	0.96
G6	Pontiac	1.63	0.95
Escape	Ford	1.62	0.95
Pilot	Honda	1.57	0.92
RAV4	Toyota	1.57	0.92
Sonata	Hyundai	1.54	0.90
E-series van	Ford	1.53	0.89
300	Chrysler	1.48	0.87
Fusion	Ford	1.47	0.86
Grand Cherokee	Jeep	1.43	0.84
PT Cruiser	Chrysler	1.43	0.84
Liberty	Jeep	1.38	0.81
Highlander	Toyota	1.34	0.78
Tundra	Toyota	1.28	0.75
Express/G van	Chevrolet	1.27	0.74
3-series	BMW	1.24	0.73
Sentra	Nissan	1.22	0.71
Matrix	Toyota	1.19	0.69
Charger	Dodge	1.18	0.69
Equinox	Chevrolet	1.17	0.69
Grand Prix	Pontiac	1.12	0.66
RX 330/350/400h	Lexus	1.12	0.65
Prius	Toyota	1.10	0.65
Jetta	VW	1.07	0.62
4Runner	Toyota	1.06	0.62
Ion	Saturn	1.05	0.62
HHR	Chevrolet	1.04	0.61
	Total:	100.00	58.57