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THE NEW PASSENGER CAR FLEET IN CHINA, 2014: TECHNOLOGY ASSESSMENT AND COMPARISON, 2014 VERSUS 2010

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ABBREVIATIONS

AMT	Automatic manual transmission
CVT	Continuously variable transmission
CAFC	Corporate average fuel consumption
DOHC	Dual overhead camshaft
GDI	Gasoline direct injection
MPI	Multi-point injection
PV	Passenger vehicle
SPI	Single-point injection
SOHC	Single overhead camshaft
VVL	Variable valve lift
VVT	Variable valve timing

EXECUTIVE SUMMARY

China, the world's largest passenger car market since 2009, accounted for almost 20.7 million car sales in 2014, up more than 50% in four years. To develop oil independence and mitigate climate change, China has adopted a series of fuel-consumption regulations since 2004. The Phase III fuel consumption limits (MIIT, 2011) were established in 2011 and implemented starting in 2012. The Phase IV fuel consumption standards (MIIT, 2014 were released in December 2014 and took effect beginning in 2016. If all manufacturers meet their corporate-average fuel consumption (CAFC) targets, the new passenger fleet average in 2020 will decline by 31% to 5.0 L/100km from 7.2 L/100km in 2014.

This paper updates a previous report by the International Council on Clean Transportation, *The New Passenger Car Fleet in China, 2010* (He and Tu, 2012). Based on the most recent year for which detailed data are available, the study observes the passenger car fleet's characteristics and technology changes by 2014 in response to the Phase III standards. The findings document the development speed of major efficiency technologies, providing the foundation for projecting the potential of future measures in support of policy-making for 2021-2025 fuel consumption standards.

Table ES 1 summarizes sales-weighted parameters and technology penetration for passenger vehicles (PVs) sold in 2010 and 2014, by domestic and imported fleet. The domestic fleet includes sales by independent automakers and joint ventures.

Table ES 1 Overview of parameters and technologies of passenger vehicles

		Chinese PV Fleet		Import Fleet		Domestic Fleet		Independent Automaker		Joint Venture	
		2010	2014	2010	2014	2010	2014	2010	2014	2010	2014
Basic Information	Sales (millions of vehicles)	13.76	20.66	0.58	1.11	13.18	19.55	4.38	5.60	8.80	13.95
	Price (USD)	21,008	23,456	92,553	87,620	17,859	19,807	11,010	12,451	20,874	22,759
Parameters	Engine Displacement (cc)	1,700	1,689	2,700	2,463	1,600	1,645	1,471	1,577	1,672	1,672
	Curb Weight (kg)	1,280	1,360	1,819	1,796	1,256	1,335	1,191	1,316	1,288	1,341
	Footprint (m^2)	3.79	4.1	4.4	4.4	3.8	4	3.5	3.9	3.9	4.1
	Horsepower (kW)	86	98	160	167	83	94	71	87	88	97
	Max Speed (km/h)	170	180	210	211	168	178	147	165	176	184
	Power/Weight (W/kg)	65	71	87	90	64	70	59	66	67	72
	Fuel Consumption (L/100km)	7.8	7.3	10.2	8.9	7.7	7.2	7.5	7.2	7.8	7.2
Fuel Type	Gasoline	99%	98%	95%	93%	99%	98%	98%	94%	100%	99%
	Diesel	1%	2%	1%	4%	1%	2%	2%	5%	0%	0%
Fuel Supply	GDI	6%	24%	22%	61%	5%	22%	0%	3%	8%	30%
Intake	Turbocharger	7%	21%	30%	56%	6%	19%	2%	17%	8%	20%
Valve System	VVT (Inlet+Inlet & Outlet)	44%	64%	90%	93%	42%	63%	7%	40%	60%	72%
Valve Lift	VVL (Continuous+Discrete)	19%	64%	49%	93%	18%	63%	4%	40%	26%	72%
Transmission	Automatic+CVT+Multi-Clutch	40%	51%	92%	98%	37%	49%	14%	24%	49%	59%
No. of Gears	≥ Six	17%	42%	63%	85%	15%	40%	2%	22%	22%	47%

KEY PARAMETERS

As in 2010, the characteristics of the 2014 domestic and imported fleets remained significantly different. Imported cars were 35% heavier, 10% larger, and 77% more powerful than domestic cars. At the same time, the fuel efficiency of the imported fleet improved faster than that of the domestic fleet as imports' engines shrank and domestic cars' expanded.

As shown in **Table ES 2**, the lower medium segment still dominated the Chinese domestic fleet in 2014. However, the market shares of the mini, small, and minivan segments shrank significantly from 2010 as the medium, MPV, and SUV segments expanded. SUVs became the second-largest subdivision with larger and more powerful models. Reflecting the market shift to larger cars, the 2014 domestic vehicle fleet was 6% heavier than the 2010 fleet. Mini-cars showed the greatest decline in fuel consumption at 15.6%, followed by MPVs, 15.4%, and medium, 14.1%. Minivans had the smallest reduction, 5%.

Table ES 2 Average of the key parameters by segment

	Mini		Small		Lower Medium		Medium		MPV		SUV		Minivan	
	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014
Market Share (%)	6%	2%	15%	6%	32%	33%	10%	18%	2%	10%	10%	20%	16%	7%
Engine Displacement (cc)	1,100	1,048	1,397	1,385	1,620	1,559	2,016	1,776	2,034	1,570	2,091	1,898	1,071	1,223
Curb Weight (kg)	918	904	1,080	1,069	1,258	1,231	1,464	1,417	1,526	1,393	1,567	1,538	998	1,100
Footprint (m^2)	3.1	3.2	3.6	3.6	3.9	4	4.2	4.2	4.2	4.1	4	4.1	3	3.6
Horsepower (kW)	50	53	71	73	84	86	112	107	103	84	110	114	45	60
Max Speed (km/h)	142	145	169	170	181	183	198	194	165	157	171	182	110	125
Power/Weight (W/kg)	55	58	66	69	67	70	77	75	67	60	70	74	45	54
Fuel Consumption (L/100km)	6.4	5.4	6.7	6.1	7.4	6.6	8.5	7.3	9.1	7.7	9	8.1	7.6	7.2

Note: For each parameter, value decrease from dark green to light yellow

TECHNOLOGY ADOPTIONS

From 2010 to 2014, the domestic and imported fleets dramatically increased adoption of advanced technologies. Both fleets tripled employment of gasoline direct injection (GDI), doubled the penetration of turbochargers and superchargers, and increased the use of variable valve timing (VVT), variable valve lift (VVL), continuously variable transmissions (CVT), and multi-clutch technologies.

Figure ES 1 compares technology adoption rates of 16 of the 18 biggest vehicle manufacturers. Joint ventures (JV) still had higher adoption rates for most technologies than independent automakers (IA).

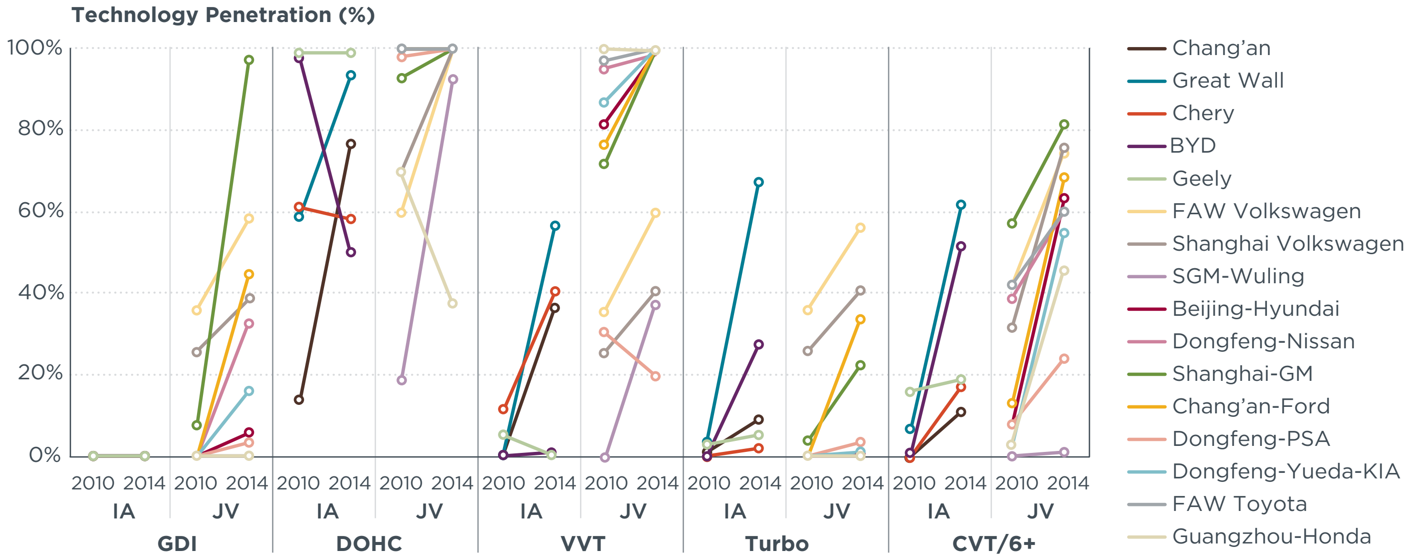

Figure ES 1 Advanced technology adoption rates by top-selling independent automakers (IA) and joint ventures (JV), 2010 versus 2014

FUEL CONSUMPTION

The Phase III fuel consumption standards successfully encouraged the introduction of advanced engine and transmission technologies. The sales-weighted average fuel consumption of the domestic fleet decreased by 6.5% from 2010 to 2014, or an average of 1.7% annually. Most manufacturers met the 2015 fuel consumption targets in 2014.

However, market shifts to larger vehicles counteracted the effects of advanced technology deployment. The increase in curb weight was faster than the increase in footprint across major manufacturers (**Figures ES 2 and ES 3**).

Individual joint venture cases showed that with proper adoption of advanced technologies, fuel consumption can be reduced even as the fleet gets heavier and larger (**Figure ES 3**). Therefore, it is suggested that independent automakers should change their strategies and adopt more advanced technologies to further reduce fleet fuel consumption.

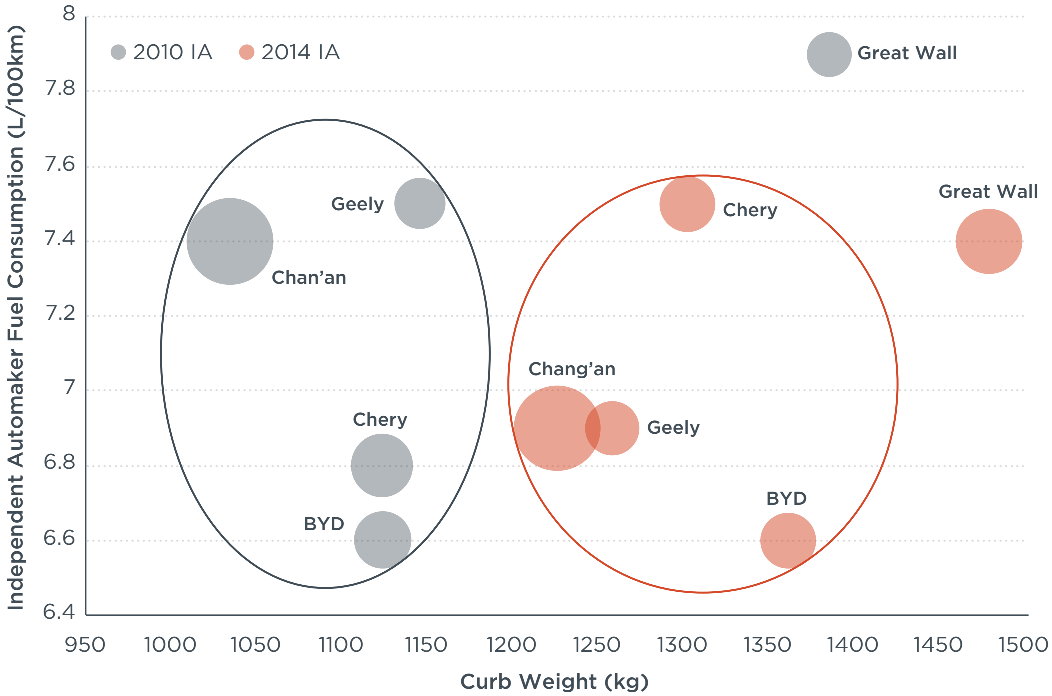

Figure ES 2 Fuel consumption, curb weight/footprint, and market size trend by independent automaker in 2010 and 2014

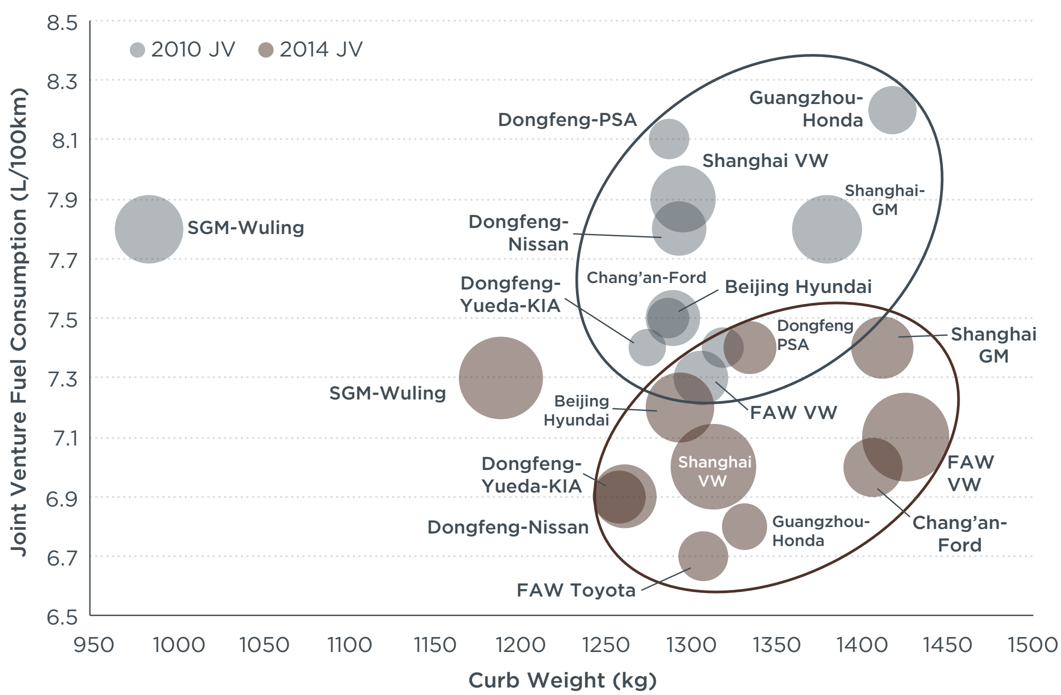

Figure ES 3 Fuel consumption, curb weight/footprint, and market size trend by joint venture in 2010 and 2014

Based on our analysis comparing the 2010 and 2014 fleets, we recommend the following to regulators for further reductions in passenger car fuel consumption:

- Impose more-stringent fuel consumption standards with long-term goals to continue encouraging deployment of advanced technologies.
- Encourage faster uptake of advanced technologies by independent automakers.
- Switch to footprint-based fuel-efficiency standards to slow the increase in fleet weight and set neutral standards that provide incentives for all technologies, including light-weighting.
- Set special policies to encourage production and sale of smaller vehicles.
- Create special incentives to improve efficiency of MPVs.

1. INTRODUCTION

1.1 BACKGROUND

China has been the world's largest passenger car market since 2009. Almost 20.7 million new cars were sold in 2014, up more than 50% from 2010. Consequently, passenger cars are a large and expanding contributor to fuel consumption and emissions.

To develop oil independence and mitigate climate change, China has imposed a series of regulations on vehicle fuel consumption (**Figure 1.1.1**). The nation first set fuel-consumption standards for passenger vehicles in 2004 (MIIT, 2004). This established Phase I and Phase II regulations, imposing fuel-consumption standards for each model before it entered the market.

Under Phase III (MIIT, 2011), established in 2011 with implementation beginning in 2012, manufacturers were required to meet corporate-average fuel consumption (CAFC) targets in addition to complying with specific per-vehicle limits by weight class. The Phase IV standards (MIIT, 2014) were released in December 2014 and took effect beginning in 2016. Fleet fuel consumption by new PVs will decline by 31% to 5.0 L/100km in 2020 from 7.2 L/100km in 2014 if all manufacturers meet their specific CAFC targets.

The State Council also published a master strategy for China's future manufacturing, titled *Made in China 2025* (State Council, 2015). For new passenger cars, the Ministry of Industry and Information Technology set targets to further reduce fuel consumption to 4.0L/100km by 2025.

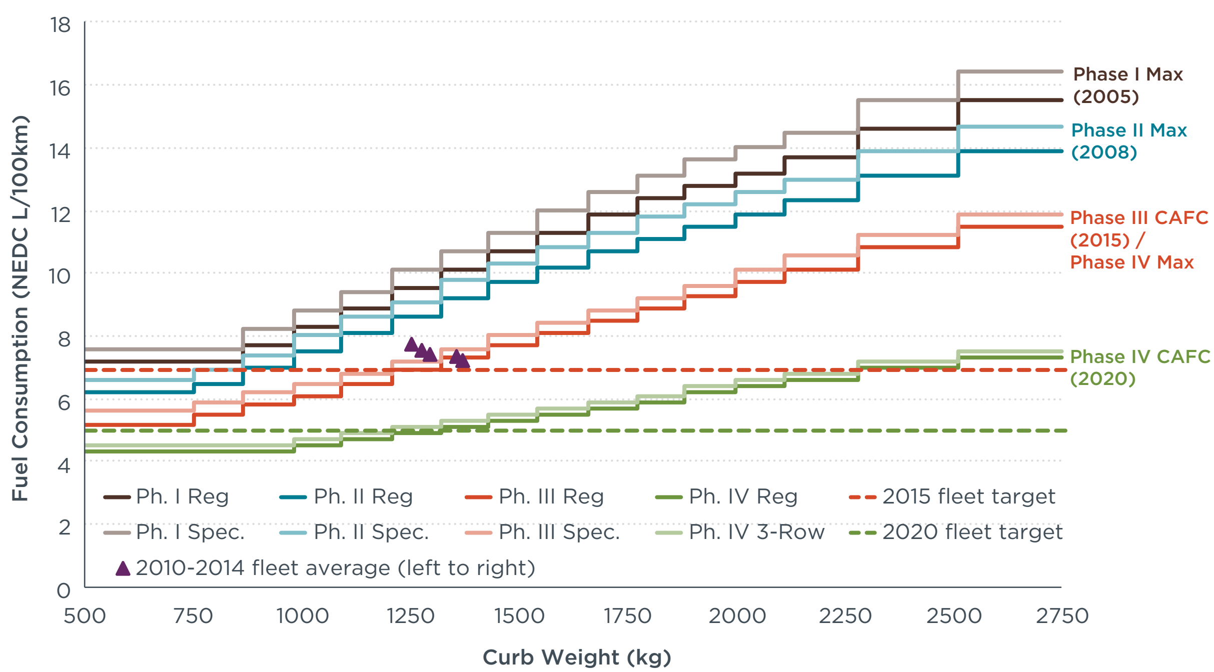

Figure 1.1.1 China fuel consumption standards phases I to IV.

1.2 OBJECTIVE

This is an update of a previous report by the International Council on Clean Transportation, *The New Passenger Car Fleet in China, 2010* (He and Tu, 2012). The objective is to observe and analyze the characteristics and technology changes of the new passenger car fleet since the adoption of Phase III fuel-efficiency standards. The paper offers an assessment of key parameters and technology adoptions for Chinese passenger cars in 2014, the most recent year for which detailed data are available, compared with 2010 autos. As in the previous edition, the analysis covers the general fleet as well as providing detailed breakdowns by segment and manufacturer.

The findings may provide insights into key questions related to the stringency and improvement of current regulations and standards as policy makers consider 2021-2025 fuel-consumption requirements

The questions include:

- Did technology adoptions for Chinese passenger cars improve after 2010 under the Phase III standards?
- Which technologies developed faster than others?
- How different were independent automakers from joint ventures in terms of technology adoptions since 2010?
- How did the characteristics of Chinese passenger cars change as a result of market preference and policy?
- What can be improved in future policy making?

1.3 ORGANIZATION

Section 2 provides details of data sources, coverage, and completeness, contributing to a better understanding of the quantitative data analysis in the following sections. Section 3 compares key parameters between domestic and imported fleets and among top-selling manufacturers and major segments from 2010 to 2014. Section 4 compares the adoption of engine and transmission technologies. Section 5 focuses on fuel consumption of top-selling manufacturers and analyzes the trends by independent automakers and joint ventures from 2010 to 2014. Section 6 summarizes the findings and provides preliminary policy recommendations.

2. DATA DESCRIPTION

Our data analysis is based on a customized dataset provided by Segment Y Automotive Intelligence Pvt. Ltd., a compiler of Asian auto market data that also provided the data for the ICCT's 2010 study. The data thus allows for a transparent and detailed contrast analysis between vehicle markets of 2010 and 2014.

To evaluate data quality for 2014, the fill-in rates are calculated by valid sales shown in **Table 2.1**. Since the fill-in rate for acceleration is relatively poor, we calculate power-to-weight ratios as an alternative performance indicator. For other key parameters and technologies with missing values, the analysis is based on available data in the raw database.

Table 2.1 Data availability of key parameters and technologies

		Small	Lower Medium	Medium	SUV	MPV	Mini-van
Engine Displacement (cc)	100%	100%	100%	100%	100%	100%	100%
Curb Weight (kg)	100%	100%	100%	100%	100%	100%	100%
Wheel base (mm)	100%	100%	100%	100%	100%	100%	100%
Front track (mm)	100%	100%	100%	100%	100%	100%	100%
Rear track (mm)	100%	100%	100%	100%	100%	100%	100%
HP (kW)	100%	100%	100%	100%	100%	100%	100%
HP (rpm)	99%	100%	100%	100%	100%	99%	93%
Torque (N.m)	100%	100%	100%	100%	100%	97%	99%
Torque (rpm)	99%	100%	100%	100%	99%	97%	93%
Max Speed (km/h)	100%	100%	100%	100%	99%	100%	100%
Acceleration 0-100km/h	**39%**	**47%**	**40%**	**57%**	**30%**	**23%**	**2%**
Compression Ratio	94%	98%	97%	92%	91%	95%	87%
Fuel Type	100%	100%	100%	100%	100%	100%	100%
Transmission Type	100%	100%	100%	100%	100%	100%	100%
No. of Gears	100%	100%	100%	100%	100%	100%	100%
Engine Type	100%	100%	100%	100%	100%	100%	100%
Valve Configuration	100%	100%	100%	100%	100%	100%	100%
No. of Cylinders	100%	100%	100%	100%	100%	100%	100%
Valve per Cylinder	100%	100%	100%	100%	100%	100%	100%
Fuel Supply	100%	100%	100%	100%	100%	100%	100%
Intake	100%	100%	100%	100%	100%	100%	100%
Valvetrain System	100%	100%	100%	100%	100%	100%	100%
Valve Lift	100%	100%	100%	100%	100%	100%	100%
Fuel Consumption-urban	93%	89%	95%	94%	92%	97%	93%
Fuel Consumption-extra urben	93%	89%	95%	94%	92%	97%	93%
Fuel Consumption-combined	93%	89%	95%	94%	92%	97%	93%
Emission Standard	100%	100%	100%	100%	100%	100%	100%
Emission Technology	100%	100%	100%	100%	100%	100%	100%

Data Fill-in Rate	**0%**	**25%**	**50%**	**≥75%**

3. KEY PARAMETERS

3.1 CHARACTERISTICS OF THE PV FLEET BY DOMESTIC VERSUS IMPORT

In 2014, domestic automakers accounted for 95% of China's PV market. Sharp differences in parameters were found between import and domestic fleets in 2014. Based on sales-weighted averages, cars in the import fleet had 50% larger engines, 35% heavier curb weight, 10% larger footprints, 77% more horsepower, 18% higher maximum speeds, and 30% higher power-to-weight ratios. Import prices were more than four times domestic prices. Meanwhile, the import fleet consumed 24% more fuel than the domestic fleet (**Fig 3.1.1**). Autos from independent carmakers accounted for 29% of the domestic fleet, and from joint ventures, 71%. The joint venture cars were on average 83% more expensive than cars sold by independent automakers.

Compared with 2010, the sales of both import and independent automakers showed minor increases while joint ventures had the largest sale growth, 59%. The independent automaker fleet had the biggest changes in fleet characteristics. The average engine displacement of the import fleet decreased by 9% while the average engine size of the independent automaker fleet was 18% larger. The average curb weight of the independent automaker fleet grew by 20% from 2010 to 2014 and footprint, by 15%. From 2010 to 2014, the gaps for average engine size, curb weight, and footprint between the independent automaker fleet and the joint venture fleet almost disappeared. Horsepower, maximum speed, and power-to-weight ratio increased across all fleets. The fuel consumption of the import fleet dropped by almost 13%. The joint venture fleet consumed around 8% less fuel at a per-vehicle level compared with 2010, while the average fuel consumption for the independent automaker fleet barely changed. Prices for independent automakers remained lower than for the joint venture fleet reflecting relatively poor vehicle performance.

Figure 3.1.2 compares distributions between key parameters of import and domestic fleets. The import fleet had a much wider distribution range than the domestic fleet in terms of engine displacement, horsepower, maximum speed, power-to-weight ratio, and fuel consumption.

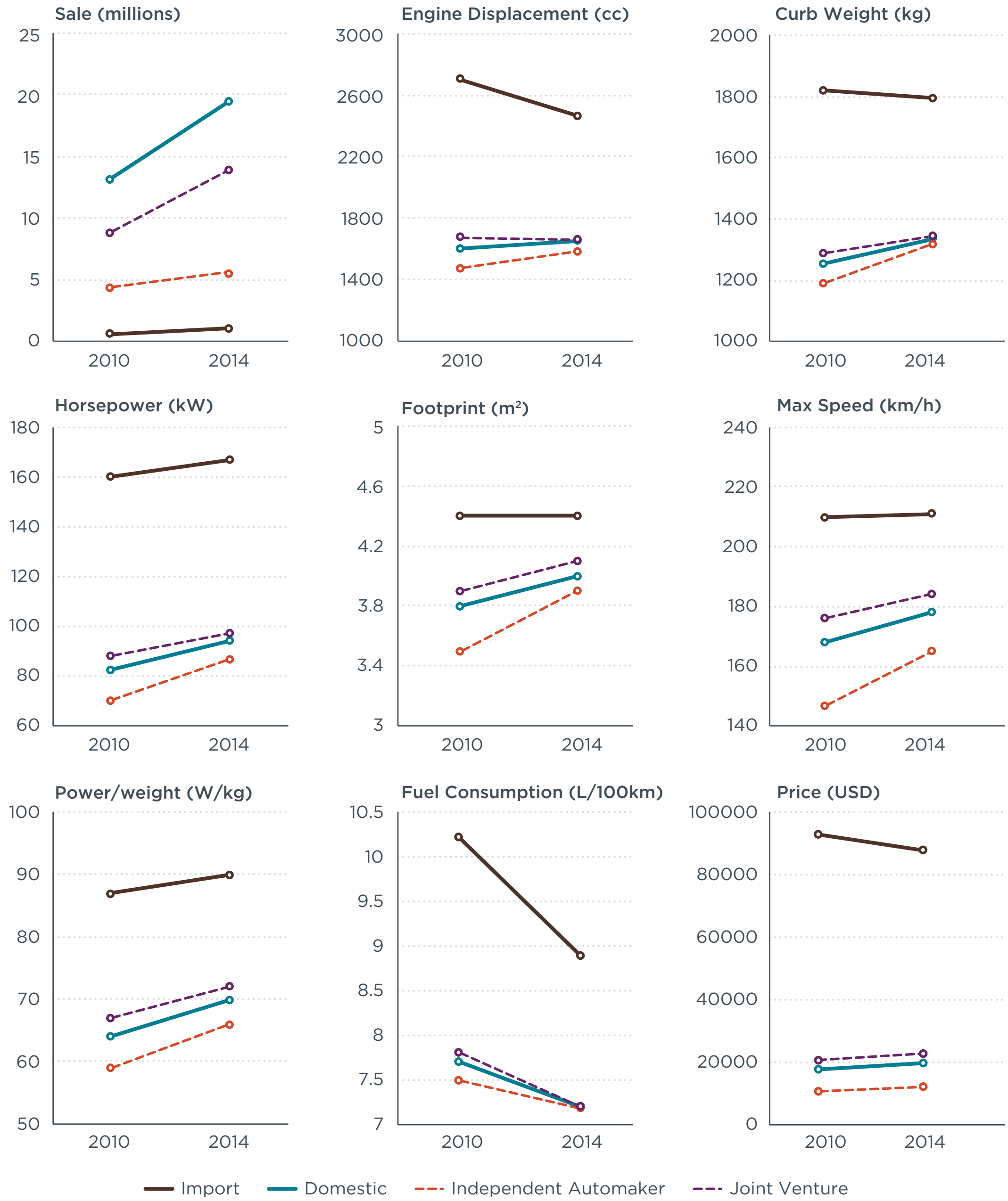

Figure 3.1.1 Averages of the key parameters by import vs. domestic

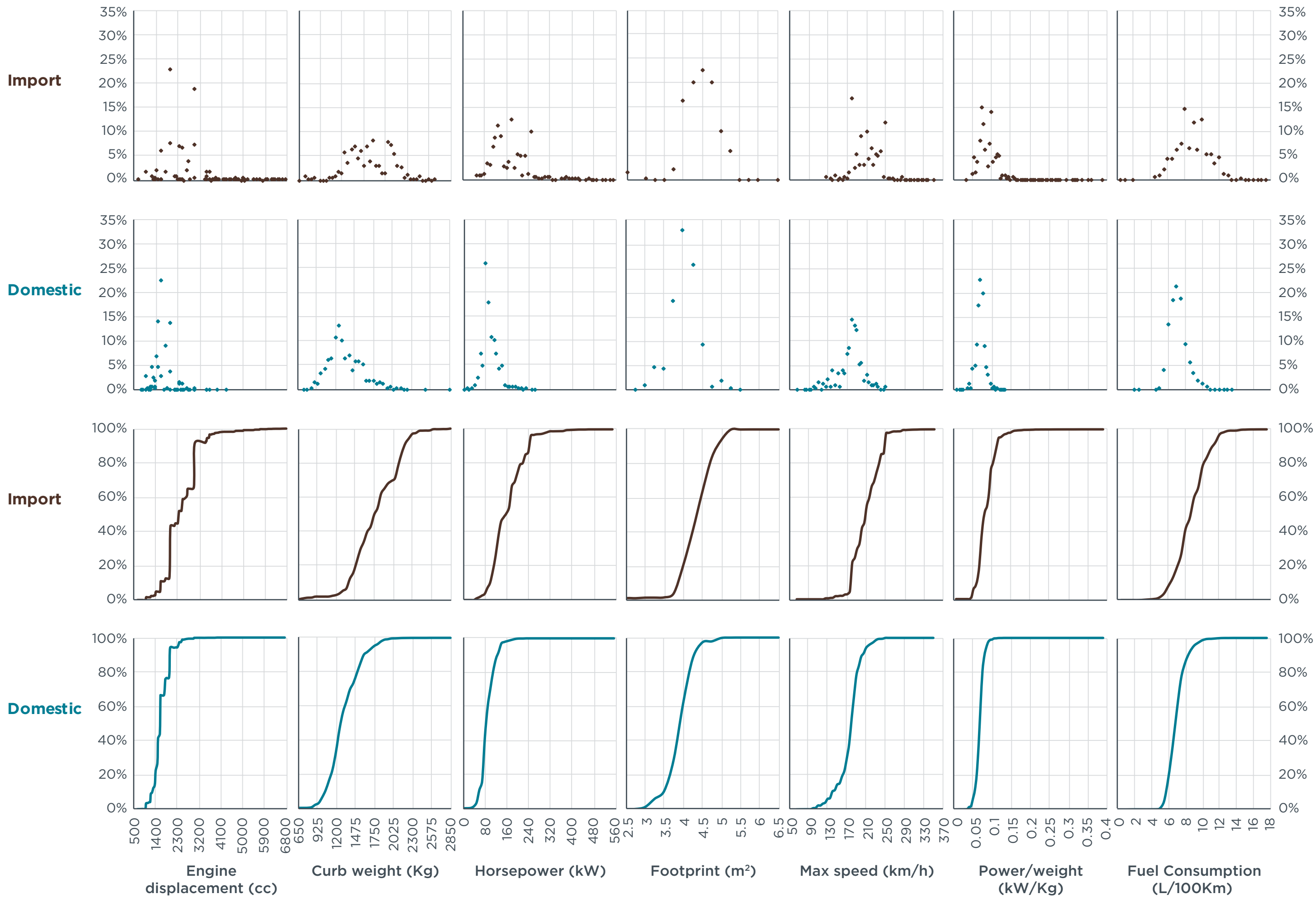

Figure 3.1.2 Distributions of the key parameters by import vs. domestic

3.2 CHARACTERISTICS OF DOMESTIC FLEET BY MANUFACTURER

This section analyzes fleet characteristics among the 18 top-selling manufacturers, including independent automakers and joint ventures, which together accounted for almost 80% of the market in 2014 (**Figure 3.2.1**). Two manufacturers were different from the top 18 in 2010. Dongfeng and SGM-Dongyue replaced FAW-car and Tianjin-FAW-Xiali. FAW-VW had the largest market share with 9%, closely followed by Shanghai-VW, and SGM-Wuling. As in 2010, six independent automakers made it into the top 18. However, the market shares of four independent automakers decreased compared with 2010. Chang'an, an independent automaker that occupied the largest market share in 2010, dropped 3.1 percentage points and fell to fifth.

Manufacturer / Sales volume (millions) / market share	Market share percentage point change (2010 vs. 2014)
FAW VW 1.76 / 9.0%	↑3.8
Shanghai VW 1.67 / 8.5%	↑0.9
SGM-Wuling 1.59 / 8.1%	↑0.1
Beijing-Hyundai 1.09 / 5.6%	↑0.3
Chang'an 1.06 / 5.4%	↓3.1
Dongfeng-Nissan 0.93 / 4.8%	↓0.5
Shanghai-GM 0.89 / 4.6%	↓3.7
Chang'an-Ford 0.81 / 4.1%	↑1.1
Dongfeng-PSA 0.66 / 3.4%	↑0.6
Dongfeng-Yueda-KIA 0.64 / 3.3%	↑0.7
Great Wall 0.61 / 3.1%	↑0.9
FAW Toyota 0.57 / 2.9%	→
Dongfeng 0.53 / 2.7%	N/A
SGM-Dongyue 0.49 / 2.5%	N/A
Guangzhou-Honda 0.47 / 2.4%	↓1.6
Chery 0.45 / 2.3%	↓1.9
BYD 0.43 / 2.2%	↓1.4
Geely 0.43 / 2.2%	↓0.7

18 Top-selling Manufactures 15.1 / 77.1% — Independent Automaker — Joint Venture

Figure 3.2.1 Sales volume and market share of the top-selling manufacturers

The charts in **Figure 3.2.2** compare sales-weighted average fleet characteristics of each manufacturer in 2014 with 2010 levels. In each chart, manufacturers are arranged from left to right by sales volume from large to small. The dashed lines represent average values across the fleet. The yellow dots represent available specifications by automaker for 2010. Dongfeng and SGM-Dongyue were not analyzed in the 2010 report, so there are no 2010 comparisons for them. Here's what the analysis shows by parameter:

Engine displacement. Five independent automakers were below the average 2014 engine size of 1645 cc. However, engines of most independent automakers in 2014 were much larger than in 2010. The average engine size of Chang'an increased from 1.2L to 1.5L, and for Chery, from 1.3L to 1.6L. At an average 1.3L, SGM-Wuling still had the smallest value among the top 18 manufacturers, but even that was up significantly from 1.0L in 2010. The increase was mainly because the automaker introduced a series of MPV models named Hongguang with engine displacements around 1.5L. Five of the 12 top joint ventures reduced average engine displacements. For Guangzhou-Honda, the decline was 6%, followed by Dongfeng-Nissan and Shanghai-VW, both with a decrease of 5%. The main reason might be that these joint ventures sold more vehicles with smaller engines in 2014, even though they applied engine downsizing technology to only a few models.

Curb weight and footprint. Among the top 18 manufacturers in 2014, Great Wall recorded the heaviest curb weight at 1,477 kg, followed by FAW Volkswagen at 1,426 kg and Shanghai-GM at 1,412 kg. The curb weights of all independent automakers increased by 7%-21% from 2010 to 2014. Five joint ventures produced lighter cars. The average curb weights of Guangzhou-Honda dropped 6%, and of Dongfeng-Nissan, 2%. Guangzhou-Honda's Crider model, new in 2014 with a relatively low curb weight of 1,275 kg, accounted for 53% of the joint venture's market share. Footprint increased across both independent manufacturers and joint ventures, except for Guangzhou-Honda, which stayed about the same. Although SGM-Wuling still had the lowest average curb weight and footprint among major manufacturers, its average curb weight increased 21% and footprint gained 31% from 2010 to 2014.

Horsepower. Most independent automakers in 2014 had average horsepower below the fleet average of 94 kW, except for Great Wall at 99 kW, mainly reflecting sales of its SUV model Haval. However, most manufacturers deployed greater horsepower than in 2010. Chang'an increased its vehicles' horsepower by 57% and SGM-Wuling, by 55%, as both automakers switched to producing heavier, larger cars.

Maximum speed and power-to-weight ratio. All independent automakers in 2014 were below the fleet averages. FAW Volkswagen had the highest maximum speed at 202 km/h. Guangzhou-Honda had the greatest power-to-weight ratio at 82 W/kg. While SGM-Wuling still had the lowest maximum speed and power-to-weight ratio, both values increased by 29% compared with 2010.

Fuel efficiency. Most independent automakers and joint ventures recorded significant gains in fuel efficiency. An exception was of Chery, whose 2014 fuel consumption increased 10% from 2010, mainly because the new SUV model Tiggo, accounting for almost 45% of Chery's sales in 2014, displaced the mini model QQ, which generated 28% of 2010 sales. On the other hand, Guangzhou-Honda's fuel consumption decreased a dramatic 17% as the joint venture introduced lighter models.

Pricing. All independent automakers in 2014 had price reductions, except for Geely. The average price of FAW Volkswagen was the highest among all manufactures, together with the highest price rise rate at 9% annually. On the contrary, Guangzhou-Honda recorded biggest price reduction rate at 6% annually.

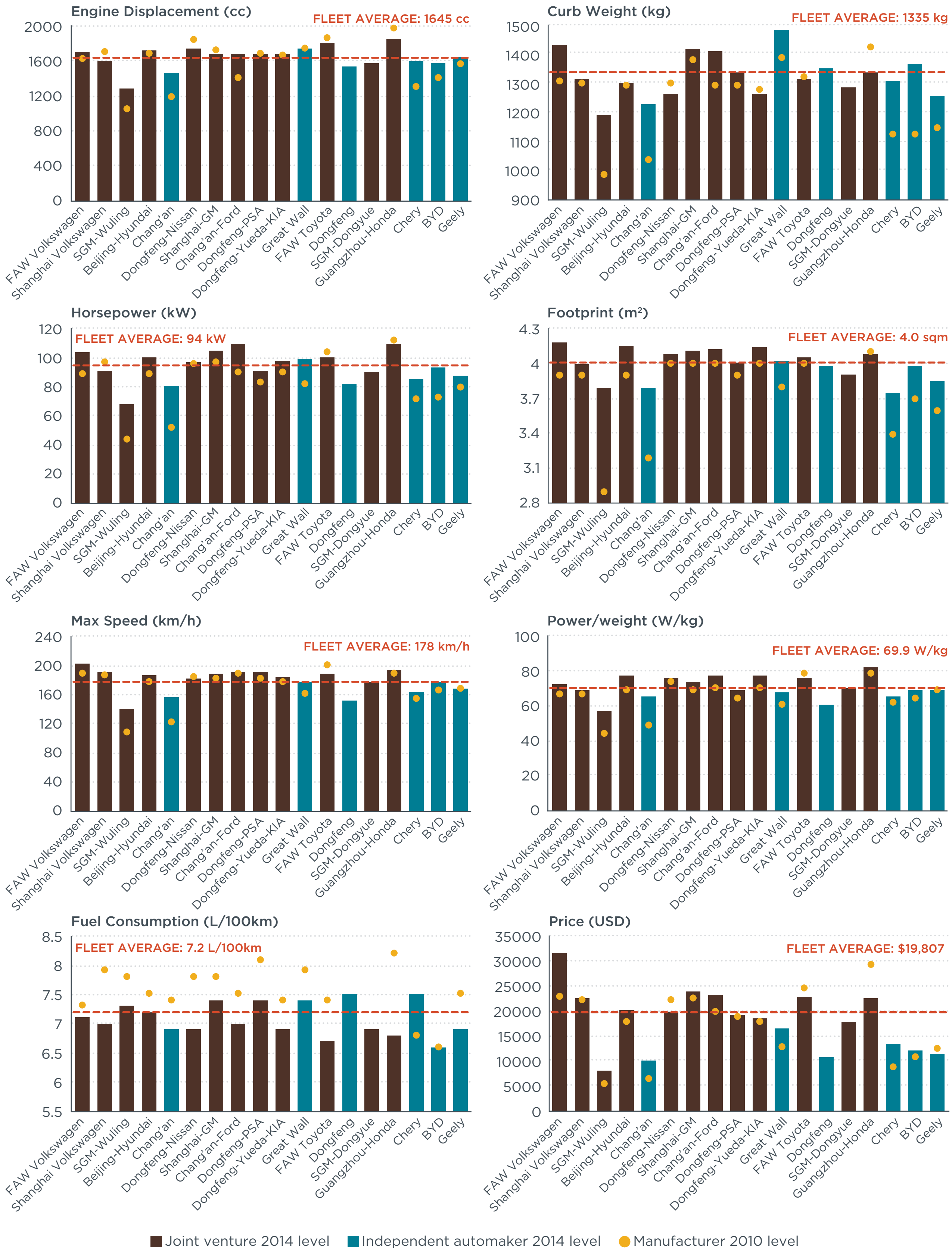

Figure 3.2.2 Averages of key parameters by top-selling manufacturers (independent automakers vs. joint ventures)

3.3 CHARACTERISTICS OF DOMESTIC FLEET BY SEGMENT

In this study, the same segmentation method is adopted as in the China 2010 analysis. The report focuses on seven major PV segments that account for around 96% of the market, including mini, small, lower medium, medium, SUVs, MPVs, and minivans. The market share of the mini segment declined from 6% to 2% and the large segment, from 4% to less than 1%. The large category was no longer considered a major segment in 2014, together with other minor segments classified as "others" in **Figure 3.3.1**, including upper medium, sport, luxury, etc. MPVs accounted for 10% of 2014 sales, up from 2% in 2010, becoming a major segment for this analysis. Independent automakers had higher market shares in the SUV and minivan segments than in other categories.

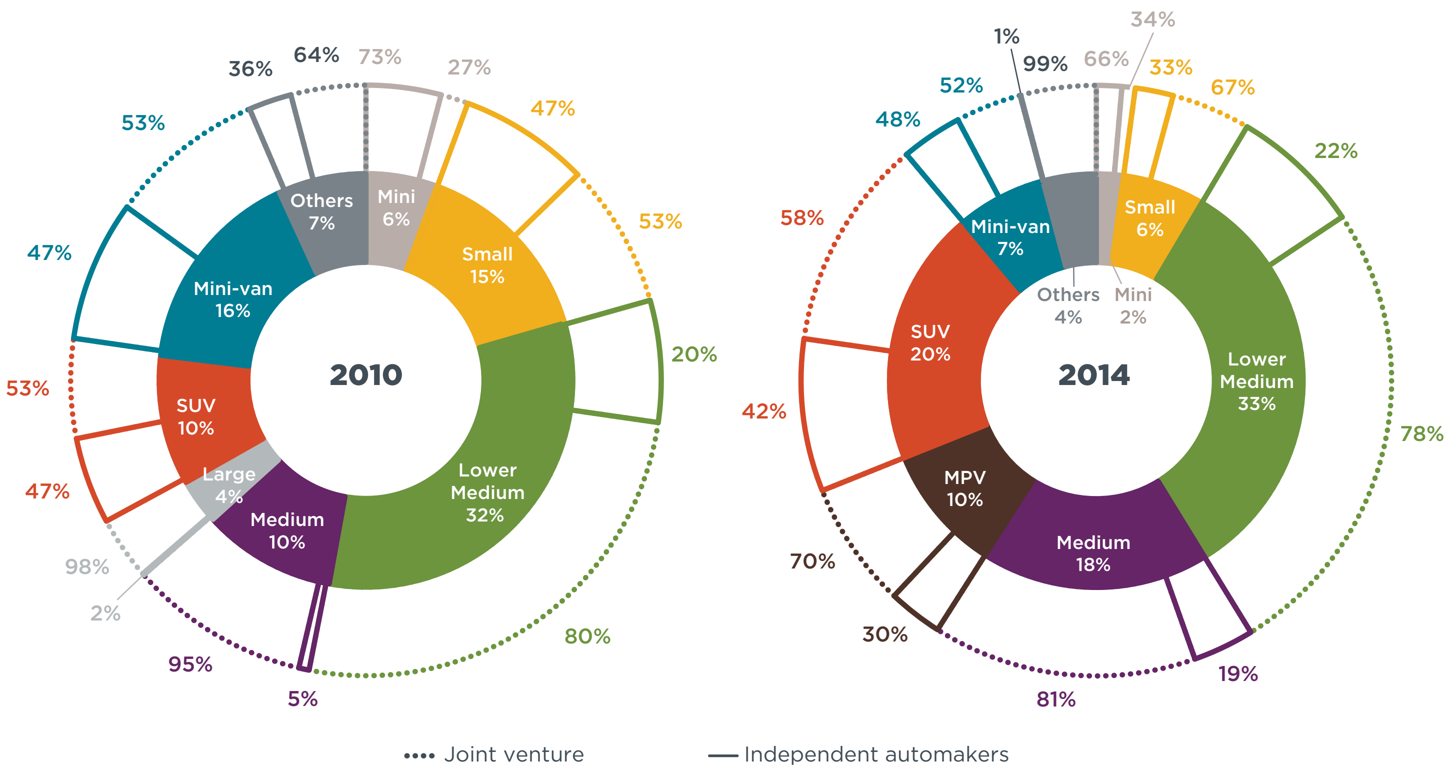

Figure 3.3.1 Major market segments for domestic fleet (2014 vs. 2010)

Figure 3.3.2 provides a snapshot of vehicle sales by market segment and vehicle characteristics in 2010 and 2014.

Figure 3.3.2 Averages of key parameters by segment (2014 vs. 2010)

The top-selling models by segment of 2014 are shown in **Figure 3.3.3** with key parameters labeled.

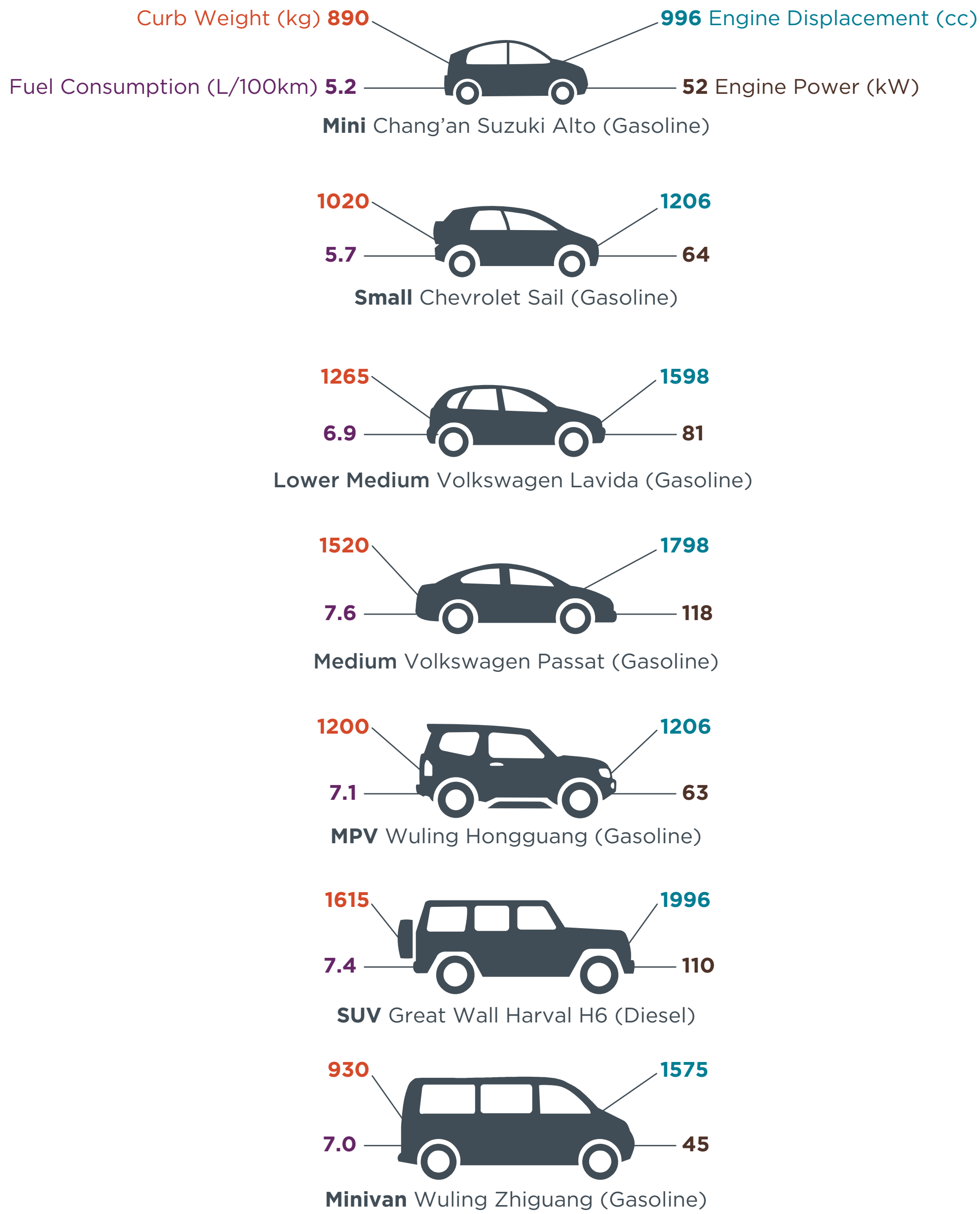

Figure 3.3.3 Top selling vehicle models by segment 2014

Based on the data, we make these observations for each market segment:

Mini. Market share decreased from 6% in 2010 to 2% in 2014. The fleet was slightly lighter but larger. In 2014, mini cars were more powerful with higher average maximum speeds. Average fuel consumption decreased 15.6%, more than twice the reduction rate of the overall domestic fleet.

Small. Market share shrank by almost two-thirds from 2010 to 2014, from 15% to 6%. However, characteristics of the small segment did not change much compared with 2010. The average fuel consumption was 6.1 L/100km in 2014, a 9% decrease from 2010.

Lower medium. This segment remained the largest in the Chinese domestic fleet, representing 33% of sales in 2014. Compared with 2010, the average engine size was 3.7% smaller. On average, lower medium cars became a little larger but also lighter. Average fuel consumption decreased 11% compared with 2010.

Medium. The segment's market share almost doubled from 2010 to 2014. On average, engines were downsized by 12%, curb weight decreased by 3%, and horsepower decreased by 4%. With all of these changes, fuel consumption of the medium segment was 14.1% lower in 2010.

MPV. Demand for vehicles in this segment grew the fastest, as sales accounted for 10% of the market in 2014, compared with 2% in 2010. MPVs in China covered a broad range of engine sizes, weights, footprints, performance, and fuel consumption, as shown in **Figure 3.3.4**, reflecting the variety of consumer demands as well as differences in technology adoption. The most popular MPV model, the Wuling Hongguang, was also the best-selling model across all segments in 2014. Compared with MPVs in the EU or U.S. markets, China-specific MPVs were cheaper with a listing range of 42,000 yuan to 60,000 yuan ($6,176 to $8,824) and with moderate performance for carrying passengers or goods for commercial purposes. The average price of MPVs in 2014 was 38% lower than in 2010. The 2014 MPV fleet showed the largest drops in engine power, horsepower, maximum speed, and power-to-weight ratio. The sales-adjusted weight dropped 9%, a more significant decrease than for the sales-weighted footprint. Fuel consumption of the MPV fleet had the sharpest decrease, 15.4%, compared with 2010. On average, engine size, weight, and footprint of MPVs were similar to lower those of medium cars, but they were substandard in terms of performance and fuel consumption.

SUV. Market share doubled to 20% from 2010 to 2014, making this the second-largest segment in the Chinese vehicle market. As with MPVs, SUVs cover a broad range of models with different characteristics. The Great Wall Haval, a diesel model produced by a domestic independent manufacturer, became the most popular SUV in China. The average engine size of SUVs decreased by 9% compared with 2010. Vehicles were a little lighter but larger and more powerful. Average performance improved slightly, and fuel consumption decreased by 10%.

Minivan. Similarly, to demand for smaller cars, minivans' market share dropped by more than half to 7% in 2014 from 18% in 2010. Among the seven segments considered, minivans recorded the largest increases in engine size, weight, and footprint. Compared with 2010, minivans on average were 10% heavier and 20% larger with 14% bigger engines. These changes primarily resulted from the best-selling minivan model in 2010, the Wuling Xingwang, becoming unavailable in 2014 and being replaced by Wuling Zhiguang. The new model's footprint was 3.2 m^2 compared with the old one's 2.1 m^2, while its power rating was 60 kW compared with 35 kW for the old model. Even with 33% more horsepower, 14% greater maximum speed, and 20% higher power-to-weight ratio, the performance of the minivan segment still fell behind that of other segments. Minivans were intended to be used in rural areas with relatively bad road conditions and were not designed to perform well in high-speed modes. Minivans had similar curb weight and footprint to small cars but with smaller engine displacements, less horsepower, lower maximum speeds, and much lower power-to-weight ratios. Although fuel consumption of minivans decreased by 5%, they were still the least efficient vehicles in the domestic fleet. The fuel consumption of minivans was significantly higher than for small cars and almost the same as for medium cars.

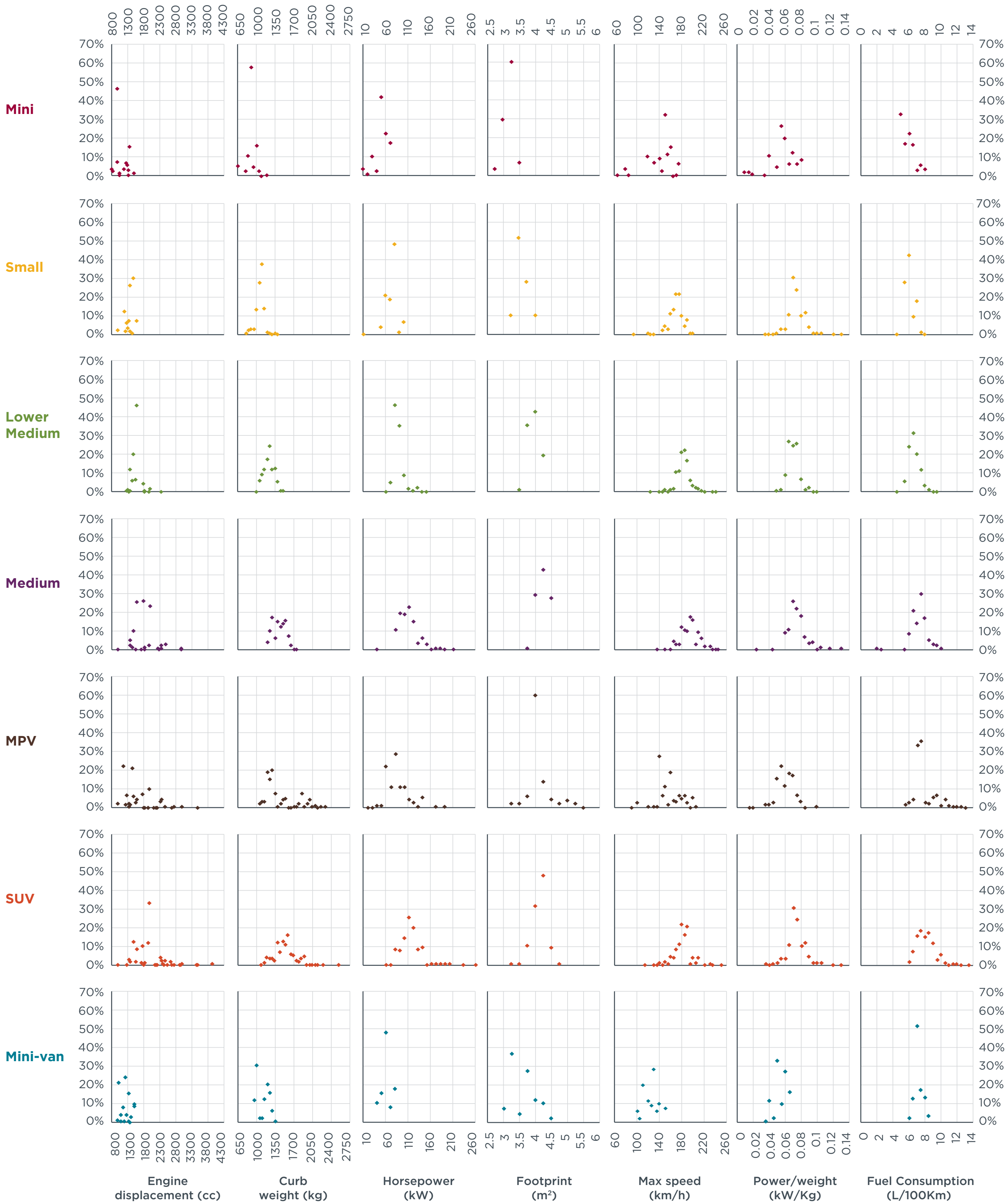

Figure 3.3.4 Distribution of key parameters by segment 2014

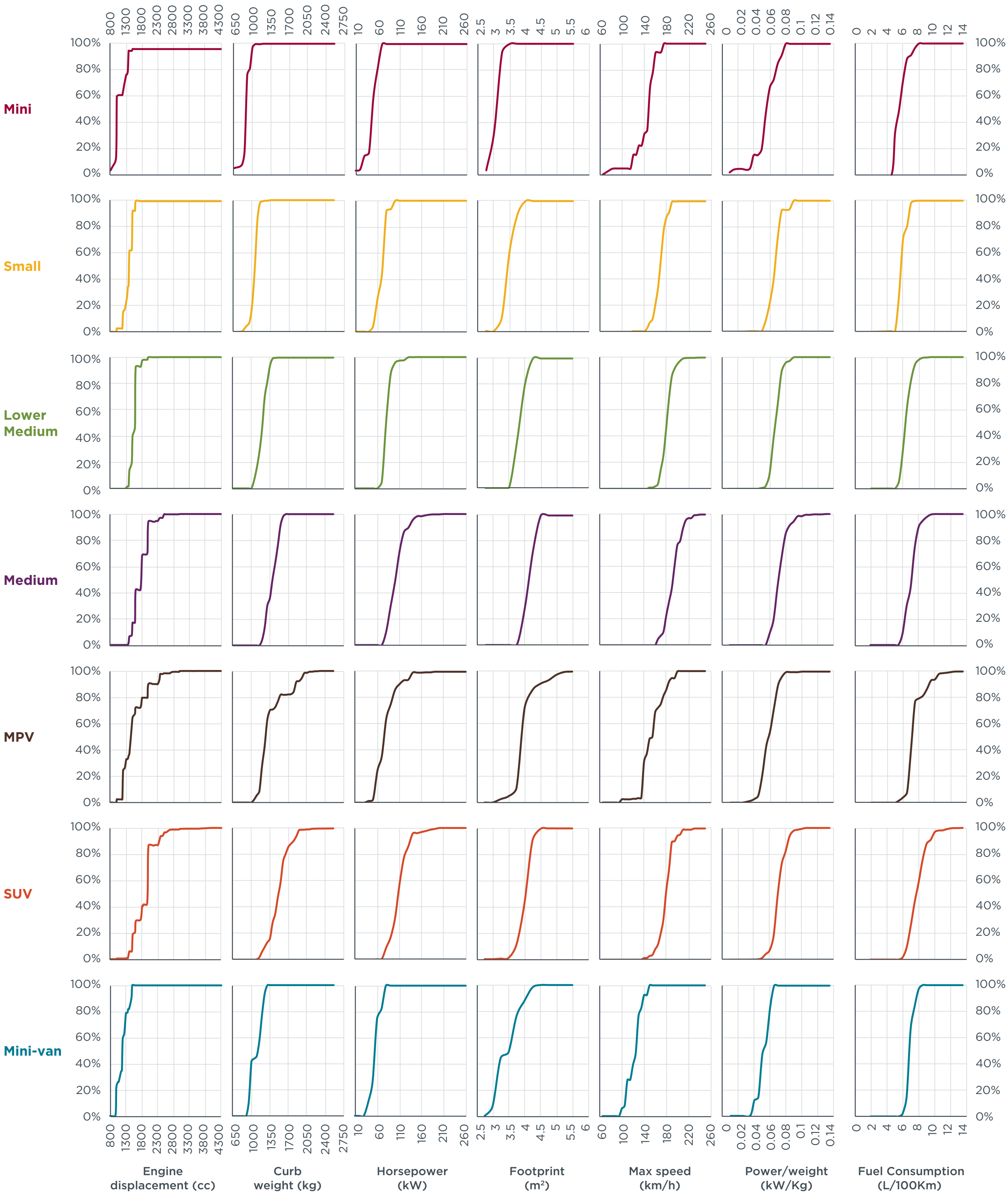

Figure 3.3.5 Cumulative distribution of key parameters by segment 2014

3.4 SUMMARY

In 2014, the characteristics of the domestic and imported fleets remained significantly different. Imported cars were 35% heavier, 10% larger, and 77% more powerful than domestic cars. Although the average engine size of the import fleet was still 50% larger than that of the domestic fleet, from 2010 to 2014 the import fleet tended to apply smaller engines while the engines of the domestic fleet grew by 3%. The fuel efficiency of the imported fleet improved faster than that of the domestic fleet.

Among the top-selling manufacturers, the market shares of joint ventures increased faster than those of independent automakers. The gaps between independent automakers and joint ventures almost disappeared in terms of the sales-weighted averages of engine size, curb weight, and footprint. Joint ventures still produced more-powerful vehicles with higher maximum speeds and power-to-weight ratios. By comparison, the engine sizes of most independent automakers increased sharply from 2010 to 2014 while the average engine sizes of a few joint ventures declined. The curb weights and footprints of all independent automakers increased by 6%-21% from 2010 to 2014. However, a few joint ventures, such as Guangzhou-Honda and Dongfeng-Nissan, tended to produce lighter vehicles. Compared with 2010, the fuel consumption of the independent automaker fleet barely improved.

Comparing fleet characteristics by segment, lower medium vehicles still dominated the Chinese domestic fleet in 2014. There was a clear trend that the market shares of the mini, small, and minivan segments significantly shrank from 2010 to 2014. However, the market shares of medium, MPV, and SUV segments boomed in 2014. The SUV segment became the second largest subdivision of the domestic fleet with larger and more powerful models. MPV was another emerging segment. They are similar to lower medium cars in engine size, kerbcurb weight, but were substandard in terms of performance and fuel consumption. From 2010 to 2014, the curb weight of each major segment decreased except for minivans. However, reflecting a shift of market preference to larger cars, the 2014 domestic vehicle fleet was 6% heavier than the 2010 fleet. In fuel consumption, minivans made the smallest fuel consumption reduction at 5%, and mini cars, the largest at 15.6%.

4. TECHNOLOGY ADOPTIONS

4.1 TECHNOLOGY ADOPTIONS OF THE PV FLEET BY DOMESTIC VERSUS IMPORT

Figures 4.1.1 and 4.1.2 provide the details of technology adoption rates in the import and domestic fleets. In general, the import fleet showed much more variation and higher-level adoptions of advanced technologies than the domestic fleet in 2014.

Engine technology. Gasoline engines still dominated both fleets in 2014, powering 98% of domestic autos and 93% of imports. Gasoline hybrids accounted for 2.5% of the import fleet and 0.1% of domestic cars. Electric vehicles amounted to 0.2% of both fleets. Compressed natural gas (CNG) vehicles were 0.3% of the domestic fleet.

Fuel injection. Multi-point injection (MPI) was most commonly used in the domestic fleet, and gasoline direct injection (GDI) was dominant in the import fleet. Single-point injection (SPI) was no longer used in major segments except for minivans in 2014, though deployment sharply dropped to 6%. The adoption of GDI by import and domestic fleets tripled from 2010 to 61% for imports and 22% for domestic autos.

Engine size. As indicated by number of cylinders, the average engine displacement of the domestic fleet was still significantly smaller than that of the import fleet. Nevertheless, the employment of six-cylinder engines in the import fleet decreased from 45% in 2010 to 37% in 2014. Almost the entire domestic fleet was equipped with four-cylinder engines.

Air intake. Multi-valve technology was mature in both import and domestic fleets, employed by 99% of imports and 98% of domestic vehicles. This adoption rate for domestics compares with a penetration of 80% in 2010. The adoption of advanced air intake technologies increased in both import and domestic fleets. Compared with 2010, the penetration of turbochargers doubled in the import fleet and nearly tripled in the domestic fleet. In 2014, more than half of the import fleet and 20% of the domestic fleet adopted advanced air intake technologies.

Valve train technology. Both import and domestic fleets widely adopted the dual overhead camshaft (DOHC) valve train configuration. DOHC took up 99% of the import fleet and 91% of the domestic fleet. Variable valve timing (VVT) and variable valve lift technology (VVL) became relatively mature in 2014, especially with the dramatic uptake of VVL. Compared with 2010, the import fleet maintained VVT employment at more than 90%, with adoption of inlet-and-outlet continuous VVT rising from 46% to 67%. The VVT adoption rate of the domestic fleet increased from 40% to more than 60%, including employment of inlet-and-outlet continuous VVT increasing from 4% to 29%. About 93% of the import fleet and 60% of the domestic fleet adopted VVL. From 2010 to 2014, discrete VVL technology changed from limited use on several premium models to 77% of the import fleet and 61% of domestic cars.

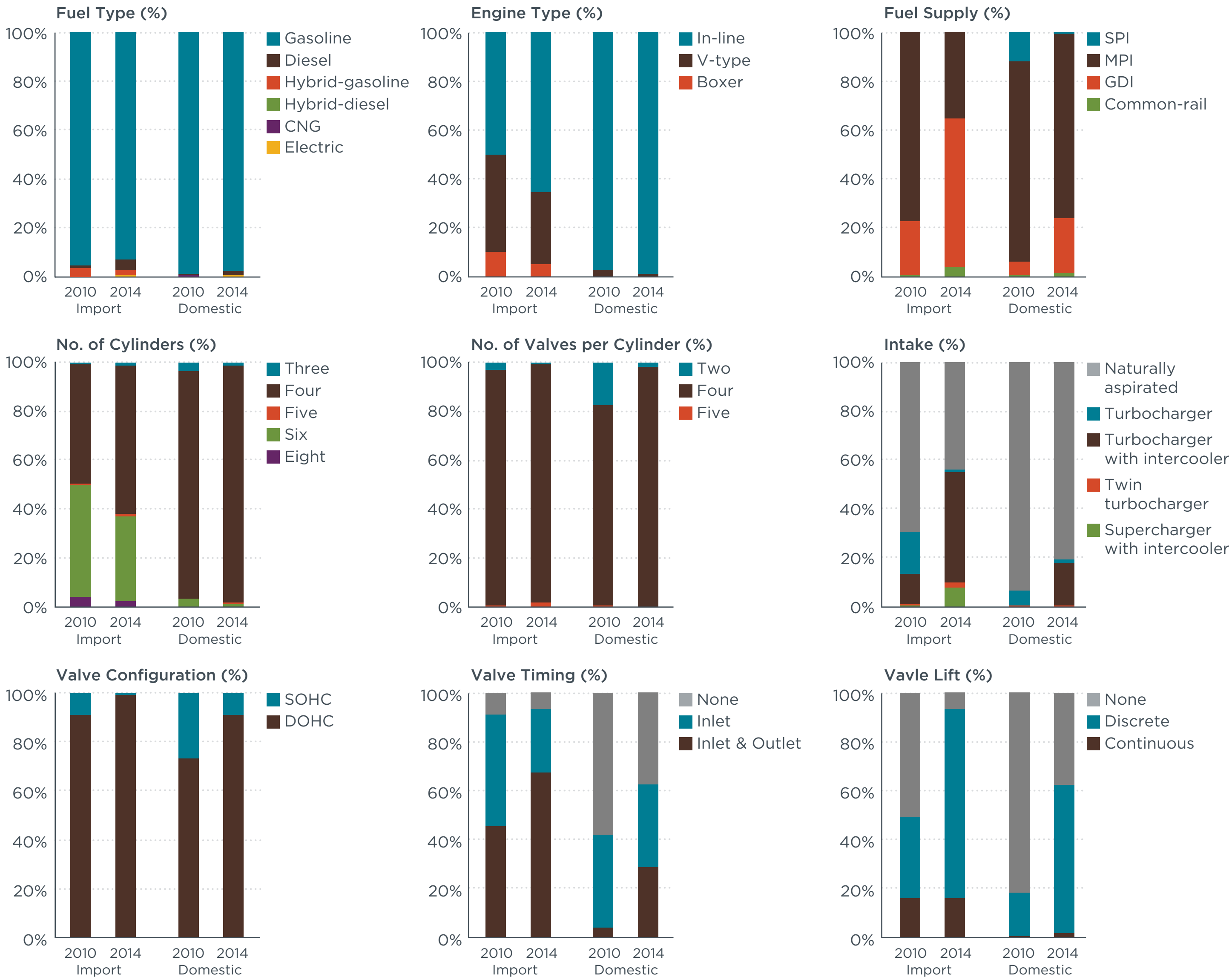

Figure 4.1.1 Engine technology adoptions by domestic and import (2010 vs. 2014)

Transmission technologies. Figure 4.1.2 shows the adoption of transmission technologies in the import and domestic fleets. The penetration of automatic transmissions was similar to the 2010 level in both fleets, while the adoption rates of CVTs and multi-clutch transmissions increased for both. The market share of CVTs in the import fleet was still more than twice as high as that of the domestic fleet, while the adoption of multi-clutch technology was similar between the two fleets. Compared with 2010, there was a sharp increase in the adoption of six gears in the domestic fleet and eight in the import fleet.

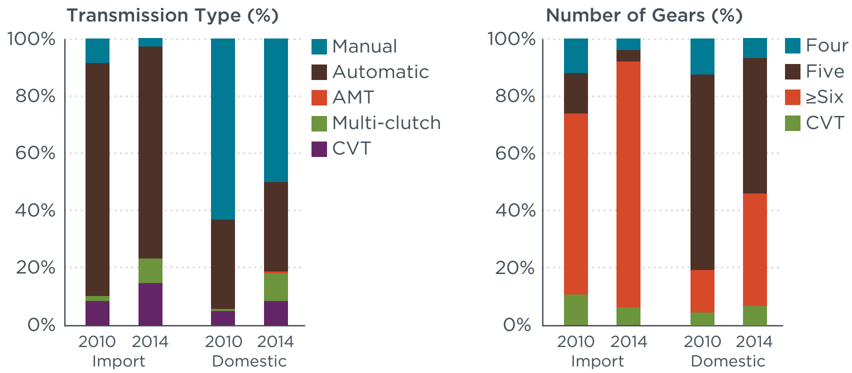

Figure 4.1.2 Transmission technology adoptions by domestic and import (2010 vs. 2014)

4.2 TECHNOLOGY ADOPTIONS OF THE DOMESTIC FLEET BY MANUFACTURER

Figures 4.2.1 and 4.2.2 show engine and transmission technologies adopted by major manufacturers. The selected independent automakers and joint ventures are separated from left to right to illustrate their differences in technology adoption rates. The designation “N/A” in these charts accounts for electric vehicles.

Fuel type. In 2014, most manufacturers almost exclusively used gasoline to power their cars. However, 36% of Great Wall’s cars burned diesel, up dramatically from 4% in 2010. The Haval H6, Great Wall’s top-selling SUV model, was powered by a diesel engine. Chang’an used diesel engines in 3% of its vehicles, all of them SUVs, including the Jiangling Yushen and the Jiangling Landwind X6/X8/X9. Dongfeng-PSA had a relatively large footprint of CNG cars, most of which were the lower middle Peugeot 308.

Sales of electric and hybrid vehicles were still minimal in 2014. BYD sold 3% of its vehicles with hybrid systems, and Shanghai-GM sold 44 units of the Buick LaCrosse hybrid. Among independent automakers, 2% of Chery’s fleet and 1% of BYD’s were electric vehicles. Dongfeng-Nissan, Geely, and SGM-Dongyue also sold electric vehicles in insignificant numbers.

Fuel injection systems. GDI was widely adopted by joint ventures. Nine out of 12 top joint ventures deployed GDI technology. Shanghai-GM had the highest GDI adoption rate at 97%, followed by SGM-Dongyue and FAW Volkswagen. Among independent automakers, only Great Wall and Chang’an adopted common rail injection. For gasoline vehicles, multi-point injection became more mature in 2014. Shanghai-Wuling increased the adoption of multi-point injection from 20% in 2010 to 100% in 2014. Meanwhile, Chang’an raised penetration of multi-point injection from 50% in 2010 to 90% in 2014.

Number of cylinders. Most models sold both by independent automakers and joint ventures had four cylinders. The independent automakers with three cylinder engines, Chery, Geely, and BYD, significantly decreased the share of these models from 2010. While independent automakers increased the number of cylinders from three to four, joint ventures started to reduce the number of cylinders. The market shares of six-cylinder vehicles in the Shanghai-GM, Dongfeng-Nissan, and FAW-Toyota fleets decreased significantly from 2010. The main reason was that manufacturers focused on engines with fewer cylinders to reduce cost and raise fuel efficiency. A four-cylinder engine with a turbocharger or supercharger turned out to be less costly and more efficient than a naturally aspirated six-cylinder engine.

Multi-valve technology. Chang'an, SGM-Wuling, Shanghai-VW, and FAW-VW made great progress in adopting multi-valve technology. The penetration of advanced air intake technologies increased dramatically in two independent automakers, Great Wall and BYD, and one joint venture, Chang'an-Ford. Great Wall recorded the largest increase in turbocharger penetration, from 4% in 2010 to 67% in 2014. Joint ventures that already employed advanced air intake technologies in 2010 continued increasing adoption rates of turbochargers and superchargers by more than 10 percentage points, including FAW-VW, Shanghai-VW, and Shanghai-GM.

Valve configuration. DOHC was mature in most joint ventures, except for Guangzhou-Honda, whose DOHC penetration decreased from 70% in 2010 to 40% in 2014. The main reason was that Guangzhou-Honda introduced a new model named Crider in 2014, which accounted for 53% of market share and adopted SOHC instead of DOHC. Two of six independent automakers, Chang'an and Great Wall, had significant uptake of DOHC since 2010, while BYD reduced its share of DOHC from 97% in 2010 to 50% in 2014. Four of six independent automakers adopted VVT on 15%-56% of their cars. Seven of 12 joint ventures had high shares of VVT adoption for both inlet and outlet. Except for SGM-Wuling, most of these already had high adoption rates of DOHC and VVT for inlet in 2010. Four independent automakers used discrete VVL on 15%-56% of their fleets, a great improvement from almost no use of VVL in 2010. All 12 joint ventures employed VVL technology with seven of them using discrete VVL on almost all cars. All valve train systems in China have VVT and VVL at the same time.

Figure 4.2.1 Engine technology adoptions by top-selling manufacturers

Transmission technologies. Independent automakers still showed higher deployment of manual transmissions than joint ventures (Figure 4.2.2). BYD adopted dual clutch on 29% of its cars. Two joint ventures, FAW-VW and Shanghai-VW, had higher deployment of multi-clutch transmissions, at 48% and 39% respectively. Compared with 2010, independent automakers showed greater adoption of six-speed transmissions, especially Great Wall, reaching 61%, and BYD, 51%. All joint ventures adopted six-speed transmissions in 2010 and started to increase use of seven-speed transmissions and CVTs in 2014. FAW-VW adopted seven-speed transmissions on 23% of its fleet, and Shanghai-VW, 22%. Dongfeng-Nissan adopted CVT on 46% of its cars; FAW-Toyota, 34%; and Guangzhou-Honda, 41%.

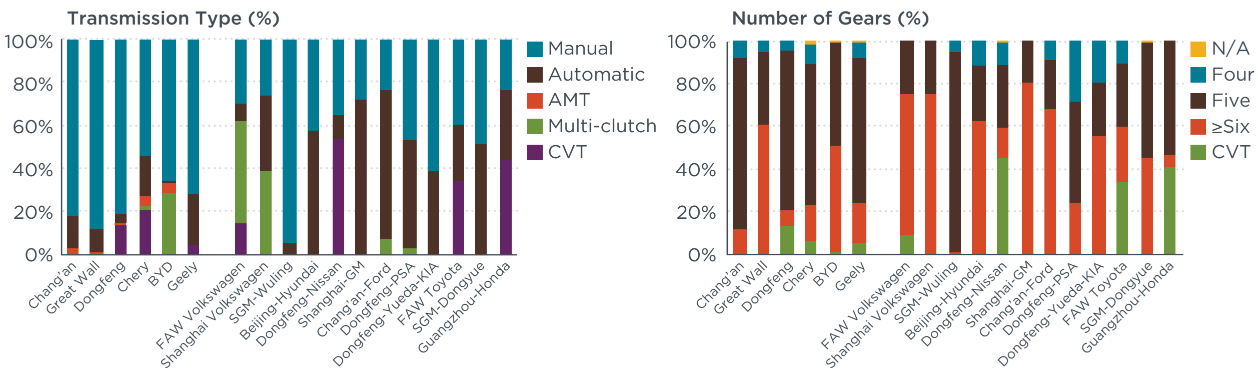

Figure 4.2.2 Transmission technology adoptions by top-selling manufacturers

Figure 4.2.3 compares technology adoption rates for 16 of 18 top vehicle manufacturers. Joint ventures still had higher adoption rates of most technologies, such as GDI, VVL, VVT, and advanced transmissions. However, turbochargers and superchargers were equally popular in both fleets. GDI became mature across joint ventures, whereas it was rarely adopted by independent automakers. Shanghai-GM had the greatest increase in GDI adoption. For independent automakers, Chery and Chang'an focused on promoting valve technologies, whereas BYD introduced turbocharger, supercharger and advanced transmission technologies. Great Wall has evenly developed various powertrain and transmission technologies.

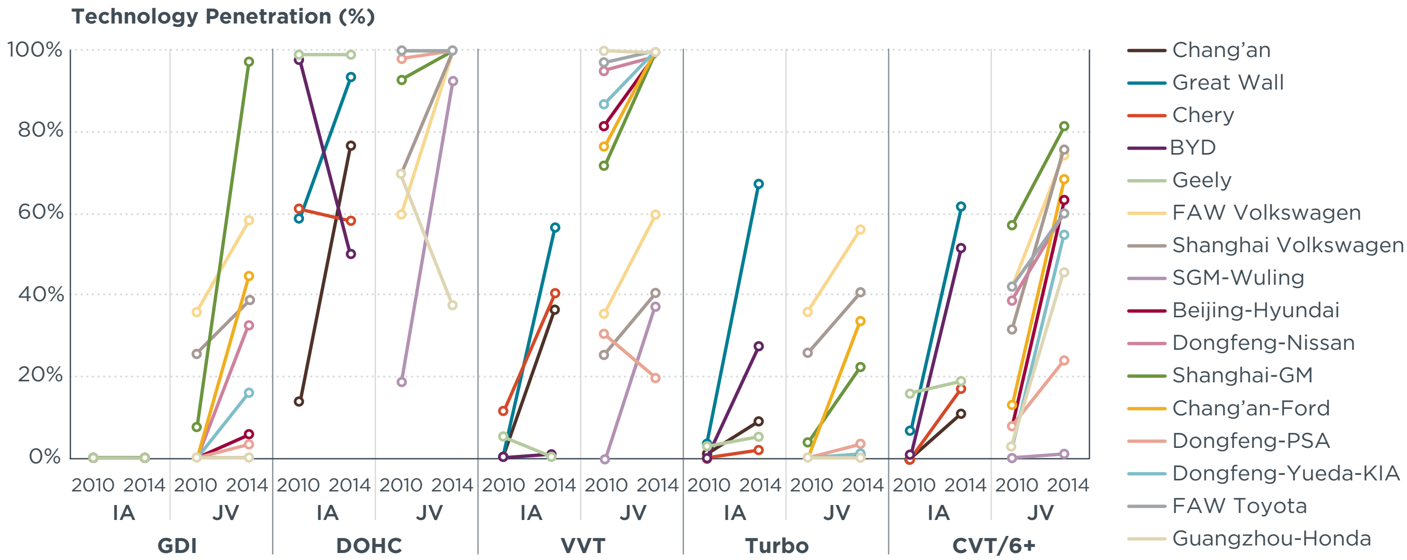

Figure 4.2.3 Advanced technology adoption rates by top-selling independent automakers (IA) and joint ventures (JV), 2010 versus 2014

4.3 TECHNOLOGY ADOPTIONS OF THE DOMESTIC FLEET BY SEGMENT

Fuel type. Almost all segments relied on gasoline engines, except SUVs, the only segment that included a significant number of cars — 8% — that were powered by diesels (**Figure 4.3.1**). The remaining diesel vehicles were MPVs, accounting for 1% of the fleet. All CNG vehicles were lower medium cars, accounting for 1%.

Fuel supply. There was a clear trend of increasing penetration rates of GDI across most segments. Medium cars and SUVs led GDI adoption. The minivan fleet dramatically increased the adoption of multi-point injection from 27% in 2010 to 94% in 2014.

Number of cylinders. The small segment replaced most three-cylinder engines with four cylinders, whereas the medium, MPV, and SUV segments downsized most six-cylinder cars to four cylinders.

Valves per cylinder. Multi-valve technology was mature across all segments, especially with increased penetration in the mini, lower medium, and minivan fleets. Medium cars no longer had vehicles with five valves per cylinder. The adoption of a turbocharger or supercharger in SUVs doubled from 2010 to 2014. Advanced air intake technology was also introduced to lower-medium cars, MPVs, and several small car models.

Valve configuration. Minivans showed much higher rates of adoption of DOHC. The increasing penetration of DOHC was also seen in the mini, small, lower medium, and SUV segments. The medium segment was still leading the adoption of VVT with a penetration rate of 80%, down 8 percentage points from 2010. Of the SUV fleet, 76% were equipped with VVT. There was rising adoption of VVT on both inlet and outlet and VVL across all segments. Some minivans also started to employ VVT and VVL technologies.

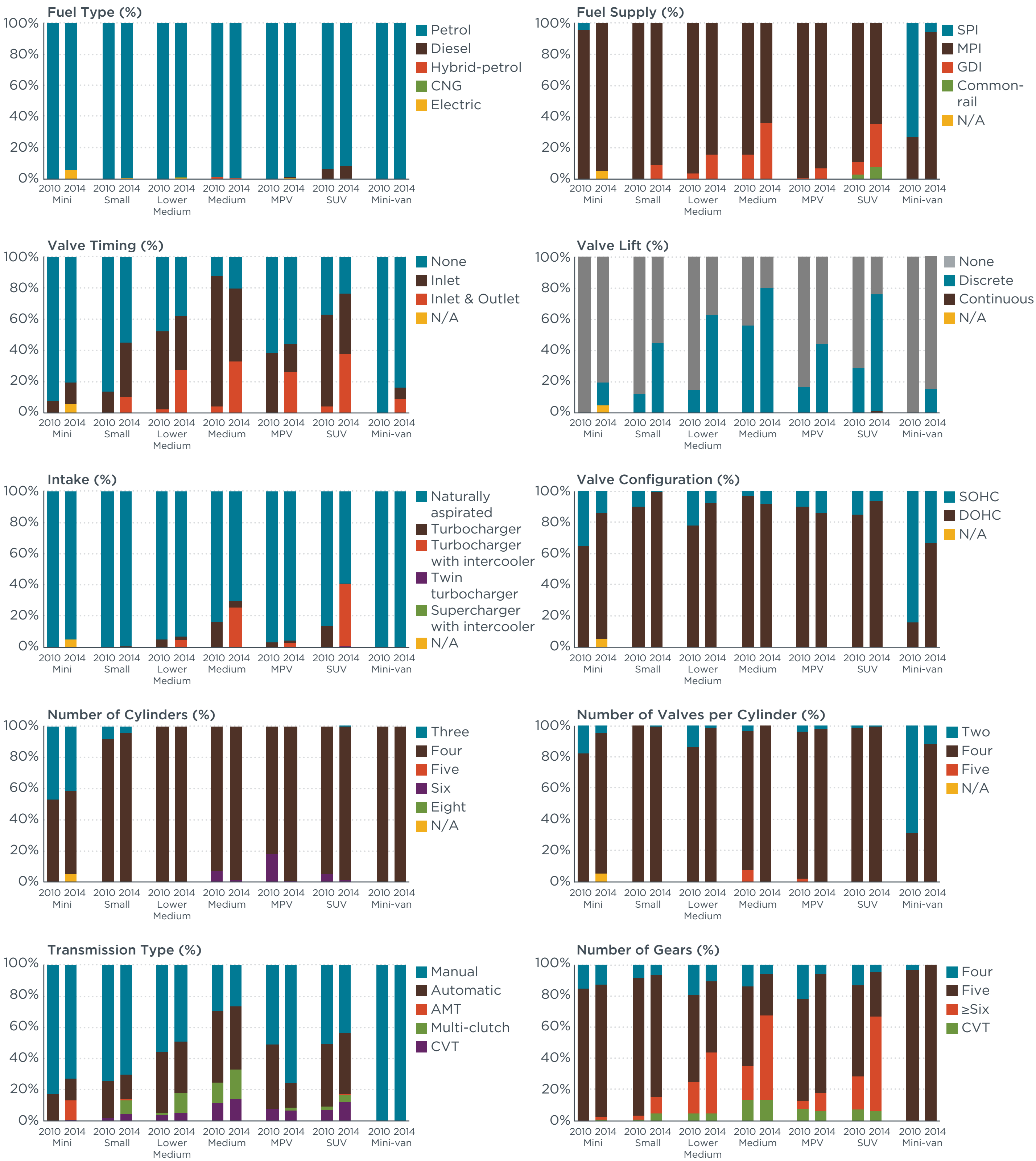

Figure 4.3.1 Engine technology adoptions by segment (2010 vs. 2014)

Transmission technologies. The adoption of automatic transmissions and CVTs continued increasing in the small, lower-medium, medium, and SUV segments (Figure 4.3.2). Manual transmissions still dominated in the MPV and minivan segments. Multi-clutch transmissions were available in most segments except for minivans. Medium cars had the highest adoption rate of multi-clutch transmissions at 19%, followed by lower-medium cars at 13%. In the SUV segment, 61% of vehicles were equipped with six speeds or more, followed by the medium segment at 54%. The same technology was much less-used on small cars, 15%, and MPVs, 18%, and was not applied on any minivans.

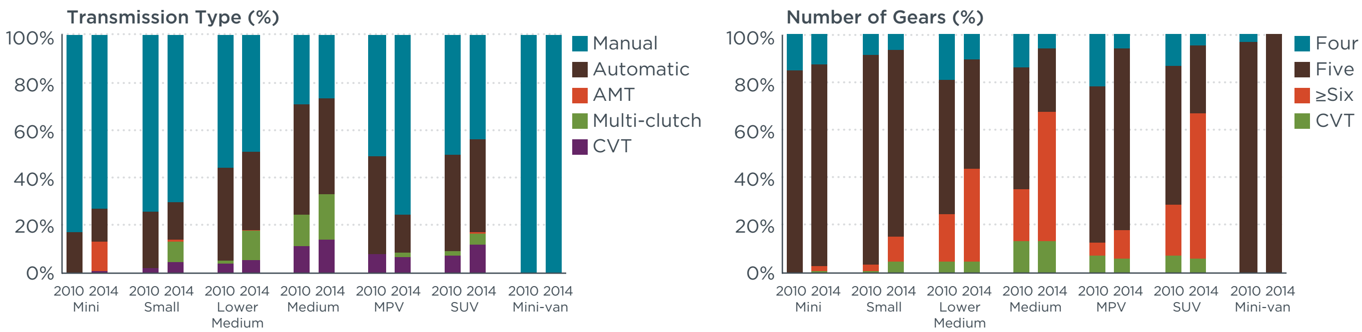

Figure 4.3.2 Transmission technology adoptions by segment (2010 vs. 2014)

4.4 SUMMARY

From 2010 to 2014, China's domestic and import fleets both made dramatic increases in adoption of advanced technology. Both fleets tripled the use of GDI, doubled the penetration of turbochargers and superchargers, and increased the adoption of VVT, VVL, CVT, and multi-clutch technologies. Imported cars still had a greater share of advanced engine and transmission technologies than domestic cars. Imported cars had smaller engines with advanced air intake technologies to boost various vehicle utility features.

Among the top 18 vehicle manufacturers, both independent automakers and joint ventures increased their deployment of advanced technologies. Joint ventures still had higher adoption rates of most technologies, such as GDI, VVL, VVT, and advanced transmissions. However, turbochargers and superchargers were equally popular in both fleets. GDI became mature across joint ventures but was rarely adopted by independent automakers. Shanghai-GM had the greatest increase of GDI adoption. For independent automakers, Chery and Chang'an focused on promoting valve technologies, whereas BYD emphatically introduced turbocharger, supercharger, and advanced transmission technologies. Great Wall has evenly developed various powertrain and transmission technologies.

Technology application levels improved across all segments compared with 2010. From small to medium and SUV segments, there was a clear trend of increasing penetration rates of GDI, DOHC, turbochargers, VVT, and VVL. However, levels of technology adoption still varied from segment to segment. Medium cars and SUVs showed higher adoption rates for advanced engine and transmission technologies in 2014. The MPV segment recorded adoption rates for efficiency technologies similar to those of the small car segment, lagging behind the larger segments. Along with the increase in weight and size, the minivan segment had the largest improvement in advanced technologies uptake, but the overall level was still the lowest among all segments. Comparatively, the technology improvement of mini cars was the slowest across all segments, which could be a result of the market shifting to larger vehicle segments.

5. FUEL CONSUMPTION

The evolution of key parameters, such as curb weight and footprint, testify to the development of vehicle design and manufacture over the past few years. CAFCs of the top-selling manufacturers are analyzed in this section, together with changes in sales-weighted average curb weights and footprints, which can provide insights into the effectiveness of current fuel consumption regulations and standards.

5.1 FUEL CONSUMPTION OF THE DOMESTIC FLEET BY MANUFACTURER

Figure 5.1.1 shows the 2014 CAFC values of each major manufacturer as a function of corporate-average curb weight and corporate-average footprint. The size of each bubble depicts relative sales volume. The figure also compares each manufacturer's CAFC with the domestic fleet average fuel consumption, the dashed line, and the Phase III fleet-average fuel consumption target, the dotted line. Six independent automakers are marked in blue while 12 joint ventures are marked in brown.

Independent automakers tended to make smaller cars than joint ventures in 2014. However, the smaller cars produced by independent automakers were not necessarily lighter. For example, Great Wall, 70% of whose sales consisted of SUVs, recorded a heavier corporate-average curb weight than most of the joint ventures but had fewer sales. Chery had the smallest footprint among all major manufacturers, but its average curb weight was higher than that of half of the major joint ventures. Chery's 2014 sales were almost 50% SUVs.

Dongfeng had similar average weight and footprint to those of BYD but with a much higher fleet average fuel consumption, mainly because two-thirds of Dongfeng sales were MPVs and minivans.

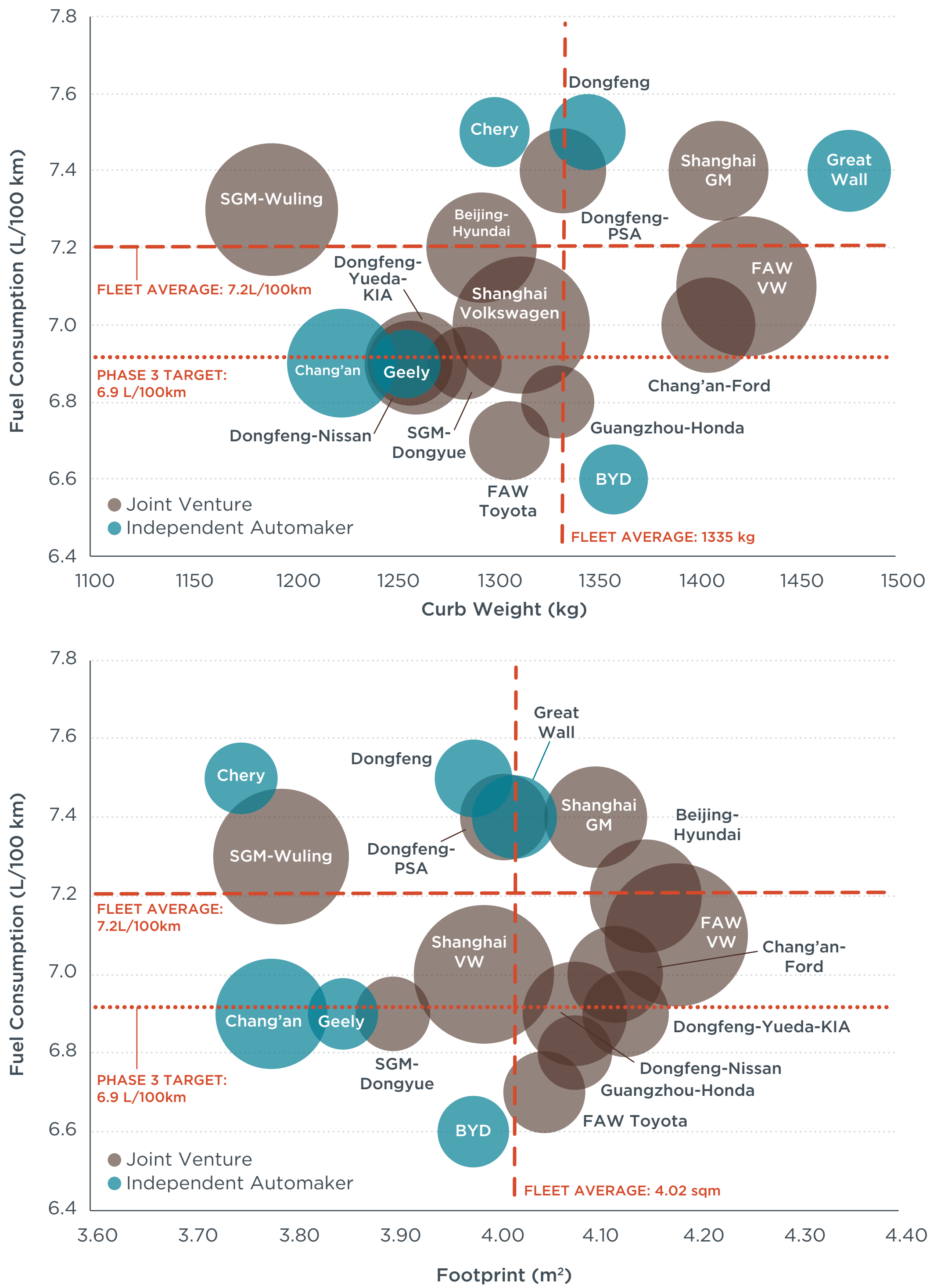

Figure 5.1.1 2014 CAFC as a function of curb weight and footprint by top selling manufacturers

5.2 PHASE III FUEL CONSUMPTION STANDARD

Given that the CAFC limits in the Phase III fuel consumption standard is weight-based, manufacturers with lighter curb weights face tighter CAFC targets. The target value of each manufacturer in 2015 was set to be 3% lower than in 2014. As shown in **Table 5.2.1**, BYD enjoyed the highest rate of over-compliance at 14% above the standard, while SGM-Wuling and Chery had a 4% gap to overcome.

Because of increased curb weights, 2015 targets for major manufacturers based on fleet average weight were mostly higher than 6.9 L/100km, which was the 2015 average fuel consumption target of the PV fleet. As a result, the fuel consumption of the PV fleet might not meet 6.9 L/100km even if all manufacturers hit their 2015 targets.

Table 5.2.1 CAFC (L/100km) target rates for top selling manufacturers

	Target 2015	Target 2014	Actual 2014	Meet Target 2014	Meet Target 2015	Gap To Target 2015
FAW Volkswagen	7.7	7.9	7.1	Yes	Yes	8%
Shanghai Volkswagen	7.4	7.6	7.0	Yes	Yes	5%
SGM-Wuling	7.0	7.2	7.3	No	No	-4%
Beijing-Hyundai	7.2	7.4	7.2	Yes	Yes	0%
Chang'an	6.9	7.1	6.9	Yes	No	-1%
Dongfeng-Nissan	7.3	7.5	6.9	Yes	Yes	5%
Chang'an-Ford	7.7	7.9	7.0	Yes	Yes	9%
Dongfeng-PSA	7.4	7.6	7.4	Yes	Yes	0%
Shanghai-GM	7.5	7.7	7.5	Yes	Yes	0%
Dongfeng-Yueda-KIA	7.1	7.3	6.9	Yes	Yes	2%
Great Wall	7.7	8.0	7.4	Yes	Yes	5%
FAW Toyota	7.2	7.4	6.7	Yes	Yes	7%
Dongfeng	7.6	7.8	7.5	Yes	Yes	1%
Guangzhou-Honda	7.4	7.6	6.8	Yes	Yes	8%
SGM-Dongyue	7.2	7.4	6.9	Yes	Yes	4%
Chery	7.2	7.4	7.5	No	No	-4%
BYD	7.5	7.7	6.6	Yes	Yes	14%
Geely	7.0	7.2	6.9	Yes	Yes	1%

5.3 FUEL CONSUMPTION TRENDS

To provide better insights into fuel consumption trends from 2010 to 2014, charts in this section show changes for the domestic fleet, independent automakers, and joint ventures.

Figure 5.3.1 shows a distribution movement toward the lower right, indicating that fuel consumption declined even as curb weight and footprint increased for top-selling automakers from 2010 to 2014. **Figure 5.3.2** presents the fuel consumption, weight, and size trend for independent automakers, and **Figure 5.3.3,** for joint ventures.

All five major independent automakers moved toward the right for both weight and size, reflecting the trend to produce heavier and larger cars (**Figure 5.3.2**). The increase in vehicle weight by independent automakers was much faster than the increase in vehicle size. Since the fuel-efficiency standards were based on vehicle weight, the improvement trend was not significant even though most of these manufacturers met 2014 standards with a higher adoption of advanced efficiency technologies compared with 2010.

According to the findings in **Figure 5.3.3,** major joint ventures also shifted to a heavier, larger fleet with some declines in fuel consumption. An exception was SGM-Wuling, which changed its market strategy from minivans to MPVs. The category's lower fuel consumption in 2014 compared with 2010 reflected higher-level adoption of advanced engine and transmission technologies along with limited growth of weight and size. The CAFC of Shanghai-GM decreased by 5% from 2010 to 2014 while the curb weight increased by 2% and footprint by 3%. In addition to its highest GDI adoption rate of 97%, Shanghai-GM also had 99% penetration for VVT and VVL in 2014.

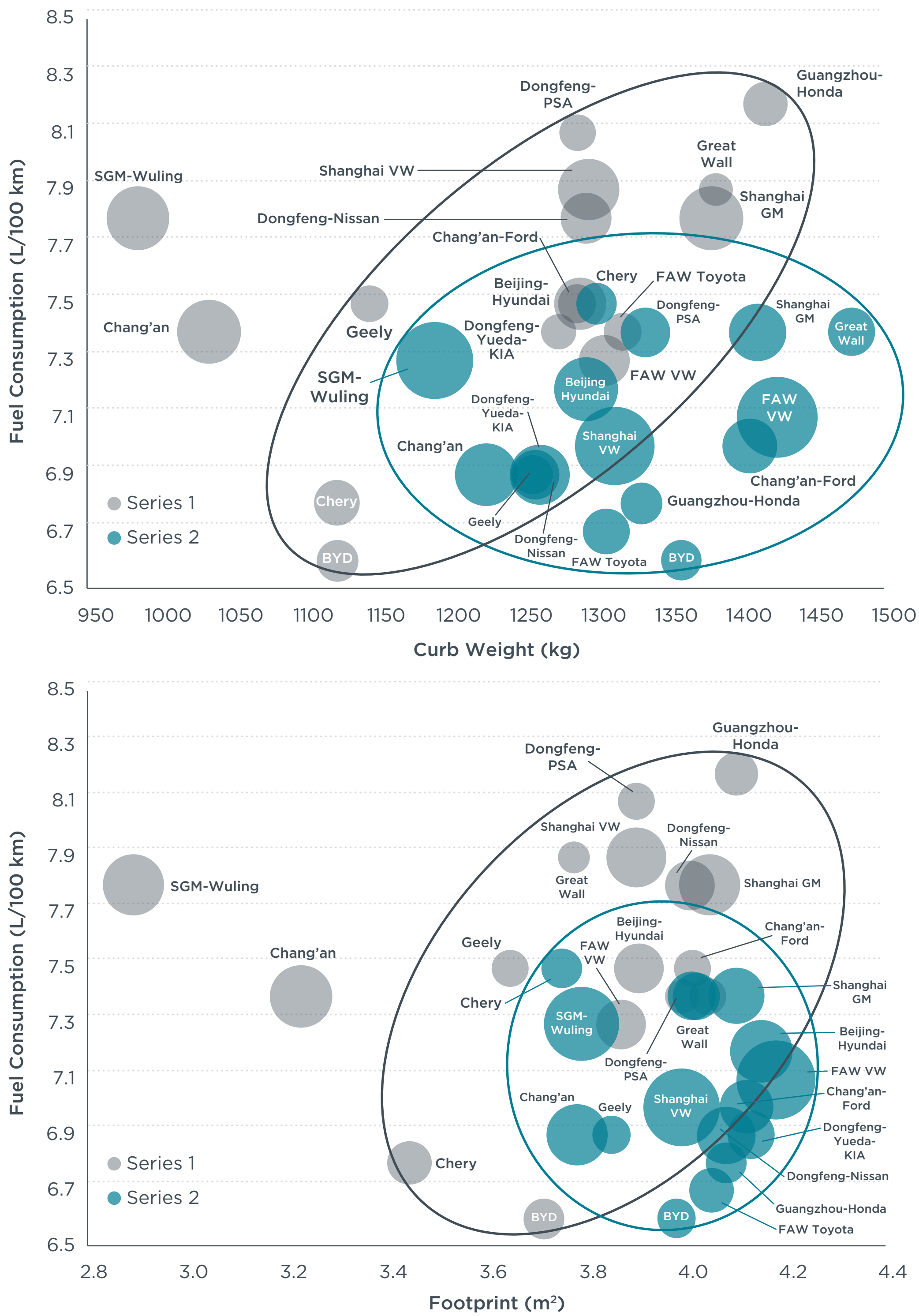

Figure 5.3.1 Fuel consumption, curb weight/footprint, and market size trend by top selling manufacturers 2010 and 2014

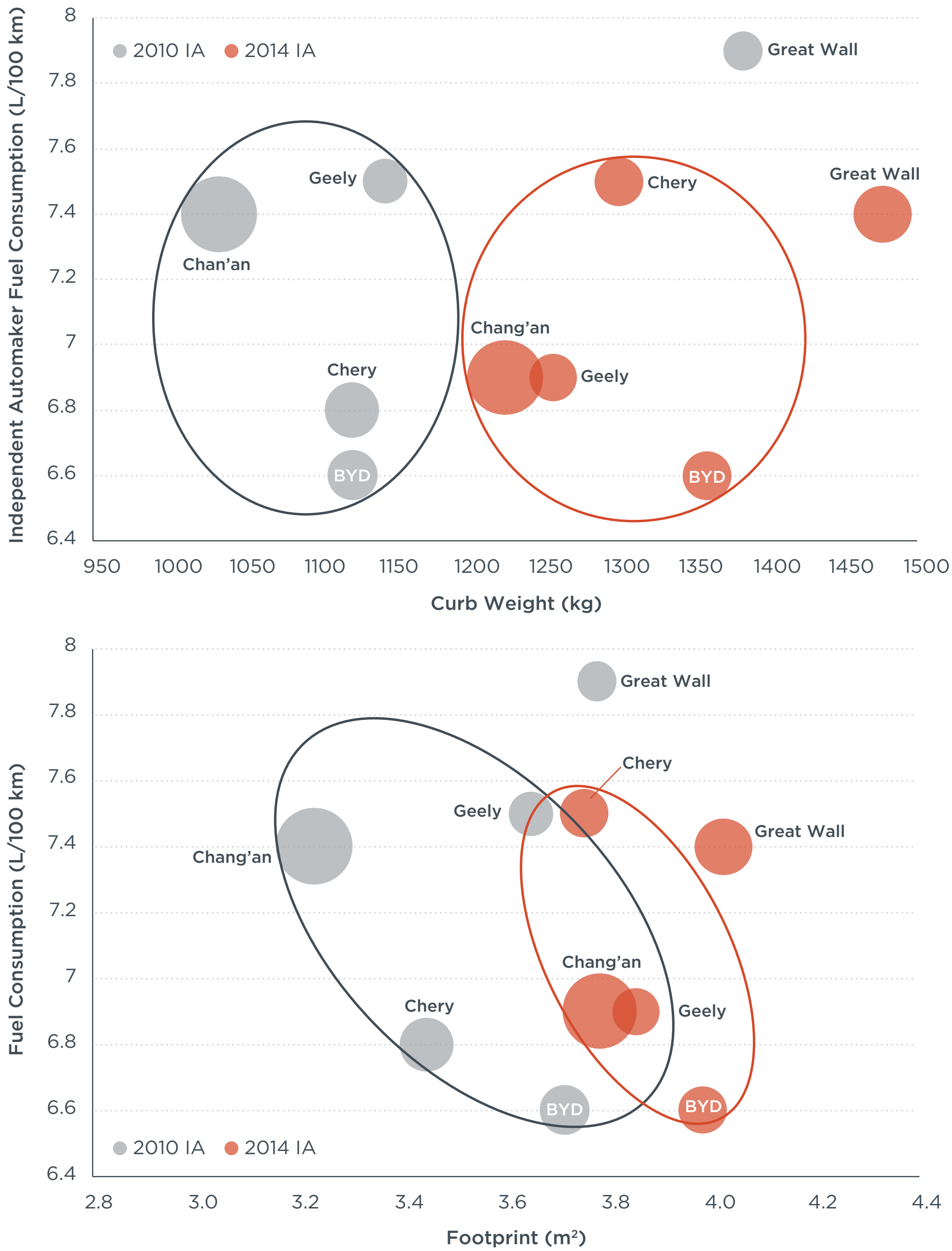

Figure 5.3.2 Fuel consumption trend, curb weight/footprint, and market size by independent automaker in 2010 and 2014

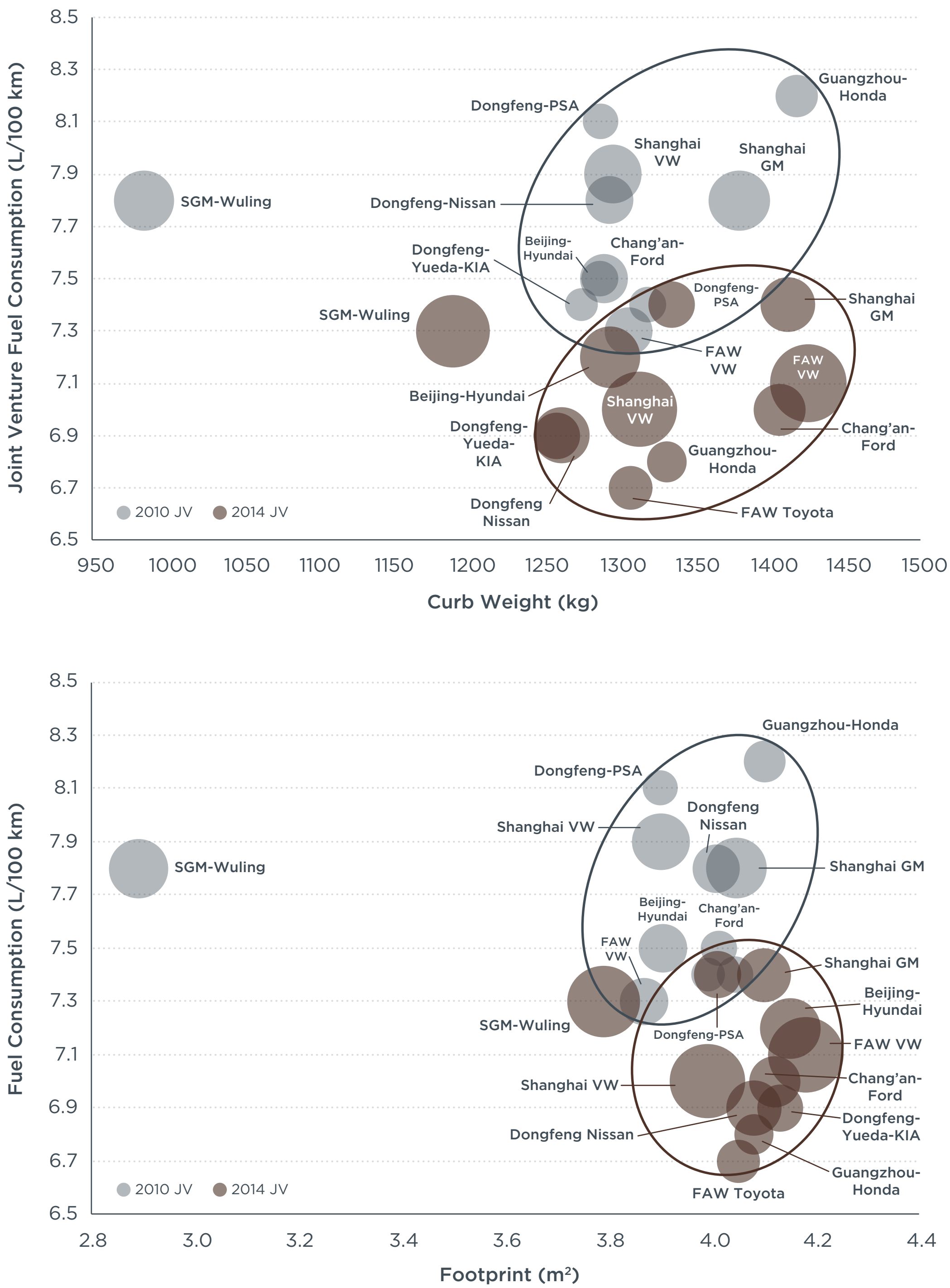

Figure 5.3.3 Fuel consumption trend, curb weight/footprint, and market size by joint venture in 2010 and 2014

Fig 5.3.4 combines the changes of curb weight, footprint, and fuel consumption of each manufacturer. Independent automakers are shown in orange and joint ventures in brown. The numbers in each bubble show the percentage change in fuel consumption from 2010 to 2014.

This analysis clearly shows that the weight growth of independent automakers was much faster than that of most joint ventures. Some joint ventures even had lighter fleets. All independent automakers and joint ventures had size increases, but the increases of independent automakers were faster. In general, weight increased more than size for independent automakers, whereas size increased more than weight for joint ventures.

A more significant reduction of fuel consumption occurred among manufacturers with relatively stable weight and size. An exception among joint ventures was SGM-Wuling, whose curb weight increased by 21% and footprint by 31% from 2010 to 2014. Even so, the fleet average fuel consumption of SGM-Wuling decreased by 6%, reflecting the introduction of advanced technologies such as VVT and DOHC. The independent automaker Chang'an followed a similar trend. The weight increase of BYD was as high as that of SGM-Wuling, but its fuel consumption remained almost the same as size grew 7%.

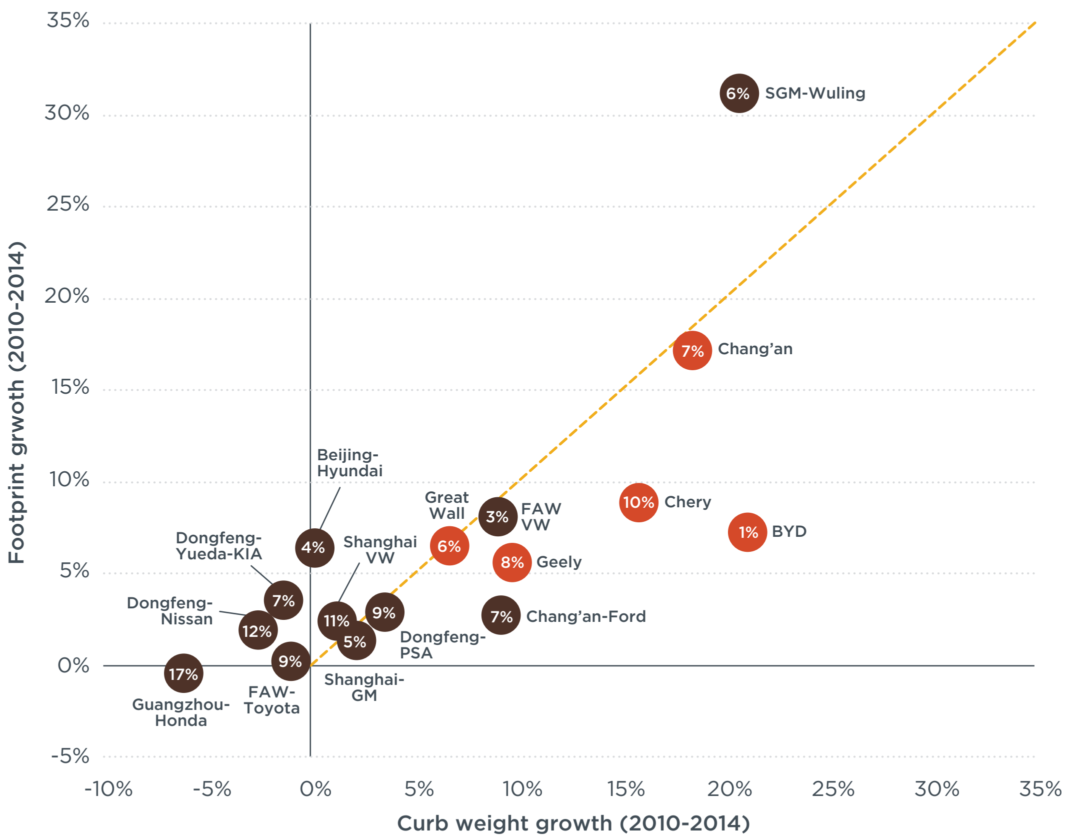

Figure 5.3.4 Changes of curb weight, footprint, and fuel consumption of top selling manufacturers

5.4 SUMMARY

Phase III fuel consumption standards successfully encouraged the introduction of advanced engine and transmission technologies in the new passenger car fleet in 2014. The sales-weighted average fuel consumption of the domestic fleet decreased by 6.5%

from 2010 to 2014, or 1.7% annually, and most manufacturers met the 2015 CAFC targets in advance.

However, the market shift to larger vehicles reduced the impact of advanced technology in reducing total fuel consumption. Curb weight rose faster than size across major manufacturers. The major independent automaker fleet had a much larger weight increase than the joint venture fleet. More significant fuel-consumption reduction was observed in manufacturers with relatively stable weight and size, which were mostly joint ventures. With a slight increase of 3% in curb weight and 5% in footprint, the fuel consumption of joint ventures decreased by 7.8% from 2010 to 2014, or 1.9% annually. By comparison, with a sharp increase of 20% in curb weight and 15% in footprint, the fuel consumption of independent automakers fell just 4.0% from 2010 to 2014, or 1.0% annually.

The changes in the individual joint venture fleet demonstrate that with proper adoption of advanced technologies, fuel consumption could be improved even as the fleet got heavier and larger. Therefore, it is suggested that independent automakers should change their strategies and adopt more-advanced technologies to further reduce fuel consumption.

In addition, the faster increase in vehicle weight is most likely attributable to the design of fuel consumption standards. Under the mass-based standard in China, increasing weight for individual vehicles eases the burden of compliance. Accordingly, because stringency increases with lighter weight, manufacturers do not have an equal incentive to adopt lightweighting technologies as to deploy other advanced technologies. However, it is harder to increase the size of individual vehicles without affecting performance and handling. Thus, the main reason for size increase is because of market demand shifts toward larger segments.

6. POLICY RECOMMENDATIONS

During the past decade, the rapid growth in automobile use has put increasing pressure on China's goals of oil independence and climate change mitigation. Realizing these challenges, China has been introducing a series of fuel consumption regulations since 2004. Based on our detailed analysis comparing the evolution between 2010 and 2014 of the import and domestic fleets, the products of major manufacturers, and demand by market segments, we make the following preliminary policy recommendations for future passenger car fuel-consumption regulations:

» Impose more-stringent fuel-consumption standards and long-term goals to continue encouraging deployment of advanced technologies.

» Press independent automakers to adopt advanced technologies more quickly to improve the Chinese industry's competitiveness.

» Switch to footprint-based fuel-efficiency standards to slow the fleet's weight increase and make the standards neutrally incentivize all technologies, including light-weighting.

» Provide special incentives to encourage sales of smaller vehicles and slow the market shift to larger vehicles.

» Impose additional special incentives to force improved efficiency in the growing MPV segment.

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