

Platform Strategies of Existing US Automobile Brands: Focusing on the Differences in Product Structure from Model Years 1996 to 2020

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[Abstract]

This study elucidates the platform strategies of existing automobile brands in the United States (US), focusing on the differences in product structure (monocoque or ladder frame). First, we analyze the relationship between the number of platforms and models. This approach allows us to understand how much platform development costs have been allocated to individual models. Second, we analyze the extent to which platforms covered different categories (focusing on total length) and different costs and performance (focusing on retail price ranges). This method gives us an idea of how much platforms cover a heterogeneous set of models. The analysis data include the platform designations of individual models and the list of specifications from model years 1996 through 2020 in Ward's Automotive Yearbook. This study's findings show that a single platform covered a wider range of overall lengths and retail prices over time. Therefore, existing US automobile brands aimed to avoid increasing development costs per model, even as the number of models decreased, by making the platform adaptable to heterogeneous models. The ladder-frame vehicle platform is considered the primary means of implementing this platform strategy, as overall platform integration was more strongly promoted for ladder-frame vehicles than for monocoque vehicles.

1. Introduction

Current automobiles (cars and light trucks in this study) are typically built with a monocoque structure; however, the American market is an exception, where about one-quarter of all vehicles sold in 2021 consisted of ladder frames.¹

Therefore, ladder frames cannot be ignored when considering the United States

(US) automotive market. Ladder frame-based vehicles have a greater degree of freedom in the design of the top hat section than monocoque-based vehicles. In ladder-frame vehicles, the frame section provides strength and rigidity. In contrast, the entire body provides strength and rigidity in monocoque-based vehicles; therefore, monocoque-based vehicles have less design freedom than ladder frame-based vehicles. Because of this difference, it is easier to develop various models from a single platform and launch models from a single platform over a long time with a ladder frame than with a monocoque.

A separate paper will discuss the life cycle of platforms, and this research will focus on the diversity of models covered by platforms. This study aims to elucidate the platform strategies of existing US automobile brands, focusing on the differences in product structure (monocoque or ladder frame). While this study suffers from some limitations (i.e., missing data and the background of the platform strategy was not analyzed), the findings are relevant and provide a solid foundation for future research.

The structure of this paper is as follows. Section 2 reviews previous studies on platform strategies and the platform itself, which is the premise of the platform strategy. Section 3 presents a research methodology to elucidate, first, the characteristics of the platform strategies of existing American automobile brands and, second, the differences between monocoque and ladder-frame vehicles. In Section 4, we present the extent of platform integration for existing US automobile brands, divided into the case of monocoque vehicles and ladder-frame vehicles. Section 5 discusses the platform strategies developed by existing US automobile brands, paying attention to the impact of differences in product structure (ladder frame versus monocoque). Finally, Section 6 presents conclusions, limitations, and future research directions.

¹ Ladder frames are used for vans, sport utility vehicles (SUVs), and pickup trucks; however, some vans, such as Chrysler's Pacifica and Honda's Odyssey, are built with monocoque. Therefore, we assume that ladder-frame vehicles are SUVs and pickup trucks and calculate that pickup trucks and SUVs account for about 28% of total US passenger car and light truck sales in 2021 (Wards Intelligence, 2022, pp. 180–182). SUVs do not include crossover utility vehicles (CUVs). Furthermore, some pickup trucks, such as Honda's Ridgeline, are monocoque vehicles, but monocoque vehicles account for only a small percentage of pickup trucks.

2. Literature review

2.1. Platform concepts

The platform concept can be divided into two categories. One is a platform related to products and technologies, and the other is related to transactions and markets. Product and technology platforms can be divided into cases where the platform vendor develops and produces both the platform itself and its complements, as in the case of Sony's Walkman, and cases where several external firms develop and produce its complements independently of the platform vendor, such as in Microsoft's Windows. A two-sided market with credit cards is a typical example of a transaction and market platform (Baldwin and Woodard, 2008, pp. 9–10).

The product and technology platform concept and the transaction and market platform concept share consistent characteristics in terms of diversity and reusability. Products, technologies, and systems can be divided into elements of low diversity and high reusability on the one hand and elements of high diversity and low reusability on the other; the former is the platform, and the latter is its complement (Baldwin and Woodard, 2008, p. 9), and reusability is also commonality. Subsystems and interfaces, which correspond to platforms commonly used in multiple products, allow for efficient development and production of related product groups (Meyer and Lehnerd, 1997, pp. □–□).

Since this study deals with automobile platforms, we mean platforms in terms of products and technologies when we refer to platforms in the following. In the case of automobiles, the platform and its complement may be developed by the same firm or by different firms. In the latter case, for example, Volkswagen developed the Modularer Elektrobaukasten (commonly known as MEB) platform, and Ford developed individual models based on it (Haas, 2021, p.15). Furthermore, complements (i.e., top hats) to the platform of the Ford Model T, the world's first mass-produced vehicle, were sometimes built by companies other than Ford in response to niche needs (Alizon *et al.*, p. 589, pp. 593–595, p. 603).

The automobile platform refers to the less diverse and more reusable elements of a vehicle; however, the scope of this element varies across automobile companies (Danilovic *et al.*, 2007, p. 8). For companies that take a narrower view, the platform refers to the floor,

engine compartment, and suspension. For companies that take a broader view, the platform refers to the transmission, fuel tank, exhaust system, floor, engine compartment, and suspension. For firms that take a flexible view of the above scope, the platform refers to the engine, powertrain, and suspension and the dies and production lines that press the floor. In this flexible view of the platform, the wheelbase itself can be sized flexibly (Muffatto, 1999, pp. 147–148).

Muffatto (1999) included production lines in his flexible view of platforms; similarly, production processes and supply chains are also recognized as platform categories (Robertson and Ulrich, 1998, p. 20). Fixing assembly methods, such as the order of assembly and standards for transporting vehicle bodies, reduces the diversity of the production process and increases its reusability, which is an advantage for interfirm competition (Diffner *et al.*, 2011, pp. 90–91). This advantage is a matter of platform strategy and is discussed in the following subsection.

2.2. Platform strategy

2.2.1. Effects and harms

Developing a family of products from a platform is referred to here as a platform strategy. The reason for pursuing a platform strategy is to maximize its benefits. This effect manifests in various phases, such as the design, production, procurement, and service phases, as quality, cost, lead time, and flexibility improvements (Harland and Uddin, 2014).

Thus, the promotion of platform strategy has various effects in different phases, but the main goal of promoting platform strategy in automobile companies is to spread development costs by reducing the number of platforms (Diffner *et al.*, 2011, p. 87; Korth, 2003, p. 14; Lampón *et al.*, 2017, p. 1).

Platform development projects avoid developing from scratch for individual products within a product family because they produce components shared across products (Uddin *et al.*, 2018, p. 443). Therefore, the development cost per product can be lowered if the number of platforms can be reduced and many products can be developed from fewer platforms.

A decline in the number of platforms was reported in the late 1990s and again in the mid-2000s (Muffatto, 1999, p. 150; Danilovic *et al.*, 2007, pp. 11–12)²; however, the more the number of platforms decreases, the greater the effect and the greater the risk of adverse

effects. Platform development is an investment (McGrath, 1995, p. 44–45). Since platform development starts before individual model development, uncertainty exists concerning future market changes (Uddin *et al.*, 2018, pp. 447–448). As the number of platforms decreases and models are developed from a single platform to long-term future models, the market and other factors may change contrary to expectations, and the prepared platform may be unable to respond (Boas *et al.*, 2012, pp. 9–10).

Suppose the market and other factors are relatively stable, and the uncertainty problem can be ignored. In this case, if the platform has a technical problem that is not discovered until individual product development that technical problem will spread to the entire product family. In addition, using a common platform can lead to performance limitations. Furthermore, cannibalization may occur when products share platforms in different price ranges (Weck *et al.*, 2004, pp. 7–8). Similarly, sharing platforms between mass-market and niche luxury cars would damage the image of niche luxury cars (Strach and Everett, 2006, p. 115).

Thus, reducing the number of platforms may cause automobile companies to suffer adverse effects. Because of such adverse effects, for example, in 1956, General Motors (GM) started to develop the Corvair platform, based on which it developed a two-door coupe and convertible, a rampside pickup truck, a four-door sedan and wagon, and a van. However, in the late 1960s, GM decided to revert from developing various models based on the common platform to responding to the market with individual and separate products rather than using the common platform (Marion and Simpson, 2006, p.74). As another example of the adverse effects, Chrysler’s development of a family of products using the K platform was successful in the early 1980s; however, by the late 1980s and early 1990s, the similarity of the products became a problem, resulting in damage to the brand image (Lutz, 1998, pp. 16–17; Marion and Simpson, 2006, p. 81).

Therefore, the platform strategy must address reducing the number of platforms to maximize their effectiveness and minimize the risk of adverse effects. In other words, a

² In the late 1990s, a difference in the number of models per platform was observed between passenger cars and commercial vehicles/minivans. The number of models per platform is about 3 for the former and about 1 for the latter (Muffatto, 1999, p. 150). Thus, it is likely that in the late 1990s, ladder-frame vehicle platforms (common in commercial vehicles and minivans) were less integrated than their monocoque counterparts (common in passenger cars).

platform integration approach is the point of contention.

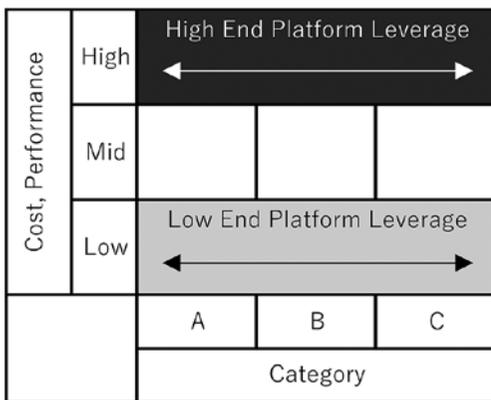
2.2.2. Platform integration approach

This integration approach can be divided into two main parts: horizontal and vertical (Figures 1 and 2). The horizontal axis is set on categories and genres, and the vertical axis is set on cost and performance. The horizontal approach is to integrate platforms across categories and genres. Conversely, the vertical approach integrates platforms from high-cost and high-performance areas to low-cost and low-performance areas or from low-cost and low-performance areas to high-cost and high-performance areas. Combining these two approaches is also possible (Meyer, 1997, pp. 19–21).

The horizontal and vertical approaches to platform integration are generally the same regarding their effectiveness in controlling costs in the development, production, and procurement phases. The adverse effects are also the same; the risk of a problematic platform spreading to the entire product family arises in horizontal and vertical directions. Nonetheless, there is also a critical difference in the harms, as shown below.

In the case of scale down in Figure 2, making sufficient profit is challenging if expensive components and materials are used for high-cost, high-performance product

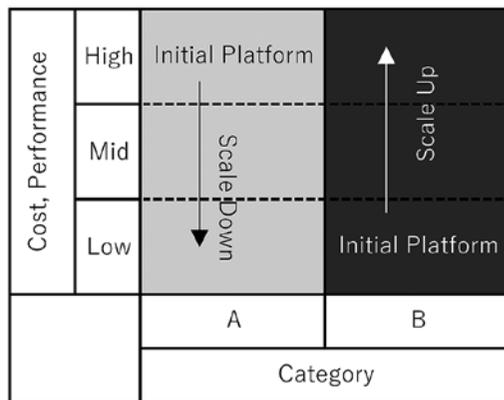
Figure 1. Horizontal platform integration



Note: "Segment" in the sources is denoted as "Category" to avoid confusion. "Segment" in the automobile may mean vehicle class. In this case, the difference between the horizontal and vertical axes in the figures becomes ambiguous.

Source: Meyer (1997), p.20, Figure 4

Figure 2. Vertical platform integration



Note: Same as Figure 1

Source: Meyer (1997), p.20, Figure 5

families, and they are also used for low-cost, low-performance ones (Meyer, 1997, p. 21). Moreover, even when scaling up, there may be a downside. In the early 1980s, GM developed the high-end Cadillac Cimarron based on the low-end Chevrolet Cavalier. The two models were nearly identical except for trim; thus, the Cimarron lost favor with consumers and became an example of a failed application of the platform from low to high brand (Marion and Simpson, 2006, pp. 80–81).

Thus, vertical platform integration makes it difficult to secure profits on the low brand side in scale down and gain customer favor on the high brand side in scale up. In other words, vertical platform integration requires more careful measures than horizontal integration, whether scaled down or up.

GM's Sigma platform is an example of a successful vertical platform integration approach. Models such as the CTS, CTSV, and STSV were developed and introduced based on the Sigma platform at three price ranges: 30,000 to 40,000 US dollars (USD), 40,000 to 50,000 USD, and 50,000 to 60,000 USD. This vertical integration did not cause problems reducing profits or losing customer loyalty. This success arguably occurred because the scope of integration was limited to high-end models rather than extending from low-end to high-end models (Marion and Simpson, 2006, p. 83).

3. Research methodology

3.1. Analysis perspective

As discussed in Section 2.2.1, the extent and degree of platform integration can be determined by first analyzing the relationship between the number of platforms and models. However, the level of platform integration would differ significantly if fewer platforms covered similar models (e.g., models of similar size) or fewer platforms covered heterogeneous models (e.g., models of widely varying size), even if the number of models per platform increased by the same amount in both cases. Therefore, as discussed in Section 2.2.2, the extent to which the platforms cover different categories, costs, and performance must be considered when analyzing the scope and degree of platform integration.³

This study analyzes the scope and degree of platform integration from the perspective of (1) the relationship between the number of platforms and models, (2) the degree of

platform integration across categories, and (3) the degree of platform integration beyond cost and performance.

3.2. Scope of monocoque and ladder-frame vehicles

Monocoque vehicles include passenger cars and monocoque-based light trucks, such as CUVs.⁴ We will discuss ladder frame-based light trucks and uniframe (semi-monocoque or built-in ladder frame) based light trucks as ladder-frame vehicles. The uniframe-based light truck is positioned as an intermediate between a monocoque vehicle and a ladder-frame vehicle; however, since it uses a ladder frame, we treat it as a ladder-frame vehicle.

3.3. Materials and periods of analysis

Ward's Automotive Yearbook, published by Ward Intelligence,⁵ lists the platform designations of passenger cars and light trucks produced in the US, Canada, and Mexico and subsequently sold in the US; however, Ward's Automotive Yearbook lists platform designations for passenger cars and light trucks only for the model years 1996 through 2020. Therefore, the period used for analysis was the model years 1996 through 2020.

Furthermore, Ward's Automotive Yearbook contains specifications that include body styles, dimensions, engine types, and retail prices for each passenger car and light truck. The specification list in the above document is used to examine the degree of platform integration across categories and price ranges.

We made the following adjustments when entering data from Ward's Automotive Yearbook. In the section on platform designations in Ward's Communications (2004, p. 163), the platform designations for model year 2003 are listed. However, the model year 2005 designation (2005, p. 161) and the model year 2003 designation are used in Ward's

³ More rigorously, focusing on time and region is also necessary, but this is not addressed in this study. Although platform integration over time can extend the life cycle of products that use the platform, the more this integration proceeds, the more likely it is that predictions about the market, etc., will be off. In addition, cross-regional platform integration has the problem of a segment gap between markets, e.g., medium cars in Europe correspond to compact cars in the US.

⁴ At certain times of the year, a small percentage of passenger cars, such as the Ford Crown Victoria and Lincoln Town Car, are ladder-frame-based.

⁵ The name of the company has changed from time to time. The company name in each year's Ward's Automotive Yearbook is "Ward's Communications" from 1996 to 2005, "Ward's Automotive Group" from 2006 to 2015, "Ward'sAuto" in 2016 and 2017, and "Ward's Intelligence" from 2018 to 2020.

Communications (2003, p. 157); therefore, the platform designations in Ward's Communications (2004, p. 163) were determined to be the model year 2004.

In the list of specifications for Cavalier (model years 1998 and 1999), the overall length of 108.1 inches was mentioned in part (Ward's Communications, 1998, p. 265; Ward's Communications, 1999, p. 284), which is a typographical error; hence, this information was not used. For the C/K pickup (model year 1996) and Sierra (model year 1996), the wheelbase and overall length were the same for some specifications (Ward's Communications, 1996, p. 265–266); thus, the overall length measurements in this section were not used. The overall length of the Fiat 500c (model year 2012) is 173.6 inches (Ward's Automotive Group, 2012, p. 286); however, in all subsequent cases, the total length of that model is listed as 133.9 inches. We believe the statement regarding the overall length for the model year 2012 is incorrect; therefore, the overall length for the 2012 model year was also set at 133.9 inches. In the specification list for the Focus (model year 2002), some of the specifications listed had a retail price of 0 USD (Ward's Communications, 2002, p. 292); we did not use this figure because it was a typographical error.

The specification list for the F-Series pickups (model years 2011 and 2012) mentioned a total length of 423.9 inches (Ward's Communications, 2002, p. 292); this information was not used because it was a typo (Ward's Automotive Group, 2011, p. 315; Ward's Automotive Group, 2012, p. 304). Since some of the MKX specifications were listed in the specifications column of the 2010 MKT (Ward's Automotive Group, 2010, p. 343), the data in this section were not used. Retail price data for the MKZ (model year 2016) was not used for the Hybrid because the retail price of the Hybrid model was misstated (925 USD) in the source document (WardsAuto, 2016, p. 285). The platform designation for the Mountaineer (model year 2004) is V229 (Ward's Communications, 2004, p. 163); however, since the platform designation for Mountaineer (model year 2003 and model year 2005) is U152 (Ward's Communications, 2003, p. 157; Ward's Communications, 2003, p. 161), we determined that the platform designation for Mountaineer (model year 2004) is also U152.

The names of the following models are listed on the platform designations pages but not on the specifications pages: Aurora (model year 2000), Avalanche (model year 2014), Caliber (model year 2013), Chevrolet City Express (model year 2019), Compass (based on PM platform) (model year 2018), Dakota (model year 2012), Durango (model year 2010),

Econoline (model years 2015–2020), Escalade, Escalade EXT (model year 2002), Escort ZX2 (model year 2003), Focus (model year 2019), G3 (model year 2009), L-Series (model year 2000), LaCrosse (model year 2020), Liberty (model year 2013), Lucerne (model year 2012), Malibu (Classic) (model year 2005), MKS (model year 2017), Montana (model year 2006), Chrysler Neon (model year 2001), Patriot (model year 2018), GMC P-Chassis (model year 1997), P-Model (model year 1996), Prowler (model year 2002), PT Cruiser Convertible (model year 2004), RAM Cargo Van (model years 2016 and 2017), SRX (model year 2017), SSR (model year 2007), Town & Country (model year 2017), Tracker (model year 2002), TrailBlazer (model year 2002), Venture (model year 2002), Voyager (model year 2004), Vue (model year 2002), W4 Forwad (model years 1996–2004), and W4 Tiltmaster (model years 1996–2004). Thus, we did not use data for these models, and we omit the page numbers where each is listed.

3.4. Scope of existing US automobile brands

As stated, the data covers passenger cars and light trucks produced in the US, Canada, and Mexico and sold in the US; therefore, we are concerned with the existing US automobile brands that cover these models. Table 1 shows the details. Hereafter, references to Chrysler, Ford, and GM indicate the scopes in Table 1.

3.5. Methodology for analyzing the relationship between the number of platforms and the number of models

It is impossible to determine the effect of the dispersion of development costs to individual models due to platform integration (Section 2.2.1) simply by looking at the change in the number of platforms. For example, if the reduction rate in the number of models is faster than in the number of platforms, the effect of spreading development costs tends to diminish.

Therefore, using the data in Section 3.3, we first count the number of models and platforms for monocoque and ladder-frame vehicles for Chrysler, Ford, and GM from model years 1996 to 2020. We then calculate the number of models per platform by dividing the models by the number of platforms.

These figures are affected by the timing of model changes and platform upgrades; thus, temporary large fluctuations are possible. Therefore, we derive the 25-year trend from model

Table 1. Range of existing US-based automobile brands covered in this study

Model Year	Chrysler						Ford			GM								
	Chrysler	Dodge	Eagle	Jeep	Plymouth	RAM	Ford	Lincoln	Mercury	Buick	Cadillac	Chevrolet	GMC	Hummer	Oldsmobile	Pontiac	Saab	Saturn
1996	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
1997	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
1998	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
1999	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
2000	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
2001	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
2002	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
2003	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
2004	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
2005	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2006	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2007	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2008	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2009	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2010	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2011	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2012	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2013	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2014	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2015	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2016	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2017	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2018	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2019	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					
2020	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓					

Note: Chrysler, Ford, and GM brands with passenger cars and light commercial vehicles manufactured in the US, Canada, and Mexico and sold in the US

Source: Compiled from Ward's Automotive Yearbook for each year

years 1996 to 2020 using an approximate straight line.

3.6. Methodology for analyzing the degree of platform integration across categories

As discussed in Section 2.2.2, the horizontal approach implies platform integration across categories of individual models. Cross-categorical platform integration means, for example, using the same platform for different engine displacements or using the same platform for different body types, such as sedans, CUVs, and hatchbacks.

The greater the range of engine displacements used in a product family, the greater the range of body sizes required to accommodate engines of different displacements. Similarly,

the greater the variety of body types in a product family, the greater the range of body sizes required to accommodate that variety. The range of body sizes appears in three categories: overall length, width, and height. Among these categories, the classification criterion for the passenger car segments of minicompact, subcompact, compact, mid-size, and full-size is generally overall length. Therefore, this study focuses on the difference between each product family's maximum and minimum overall length.

The following information is used to calculate the total length range for each platform. The document shown in Section 3.3 lists each model's name and the platform's designation used for each model. The document also includes a list of the specifications provided for each model. We integrate these two pieces of information so that each platform's entire length range can be determined according to the following procedure.

First, we create a list of models per platform from model years 1996 through 2020. Next, we identify each model's maximum and minimum overall length values during the same period, and these two values are entered for each model. Then, for each model group that shares the same platform, i.e., for each platform, the overall length range by platform is calculated by subtracting the minimum overall length value from the maximum overall length value.

The figures calculated in this way are simply a series of numbers for the total length range of each platform over 25 years, from model years 1996 to 2020. This approach does not allow us to determine the trend in the overall length range of existing US automobile brands or the difference between ladder-frame and monocoque vehicles concerning the trend in that range.

Therefore, we created classifications for the total length range of each platform, measured in 10-inch increments, and counted the number of platforms in each classification. The maximum value of the total length range among the individual platforms was 67.4 inches; therefore, the largest classification was defined as 60 inches or more but less than 70 inches.

If the number of platforms falling into each classification thus counted were used as a criterion, it would still be impossible to compare the range of total platform lengths for monocoque and ladder-frame vehicles because the total number of platforms differs for the two vehicle types; therefore, we calculate the ratio of each of the above classifications. The

obtained ratios are compared for monocoque and ladder-frame vehicles to indicate the range differences regarding the total length of the platforms for each vehicle type.

We show the differences between the Chrysler, Ford, and GM brands and the changes over time from model years 1996 to 2020. If determining the overall trend of the existing US automobile brands is challenging when the data are divided among Chrysler, Ford, and GM, we average the composition ratios of the total length range among the three brands. We then use this average to examine the overall trend of the brands.

3.7. Methodology for analyzing the degree of platform integration beyond cost and performance

As discussed in Section 2.2.2, the vertical approach indicates platform integration beyond the cost and performance of individual models. Previous studies have used price range to indicate the cost and performance (Marion and Simpson, 2006, p. 83). Following previous research, we examine the vertical approach from a price perspective. The specific procedures are as follows.

First, we use the material presented in Section 3.3 to identify the maximum and minimum retail price for each model. Second, these two values are entered for each model. The platforms used for each model are known in the procedure described in Section 3.6; therefore, in the third step, we subtract the minimum from the maximum retail price for each platform to calculate the range of retail prices by platform. We adjust retail prices yearly using the 2015-based gross domestic product (GDP) deflator.

The figures calculated in this way are merely a list of figures for 25 years, similar to Section 3.6; therefore, these figures cannot be used to identify trends in the range of retail prices. As such, we set the classifications in 5,000 USD increments and count the number of platforms that fall into each classification. Since the maximum retail price range was 68,964 USD, the largest classification is between 65,000 and 70,000 USD.

Next, we calculate each classification's composition ratio for the reasons described in Section 3.6. The calculated ratios are compared between monocoque and ladder-frame vehicles to show the differences in the retail price range of platforms for the two types of vehicles. Differences between Chrysler, Ford, and GM vehicles are also presented, along with diachronic changes from model years 1996 to 2020. This analysis of diachronic change

examines each brand and the average for each brand.

4. Results

4.1. Relationship between the number of platforms and the number of models

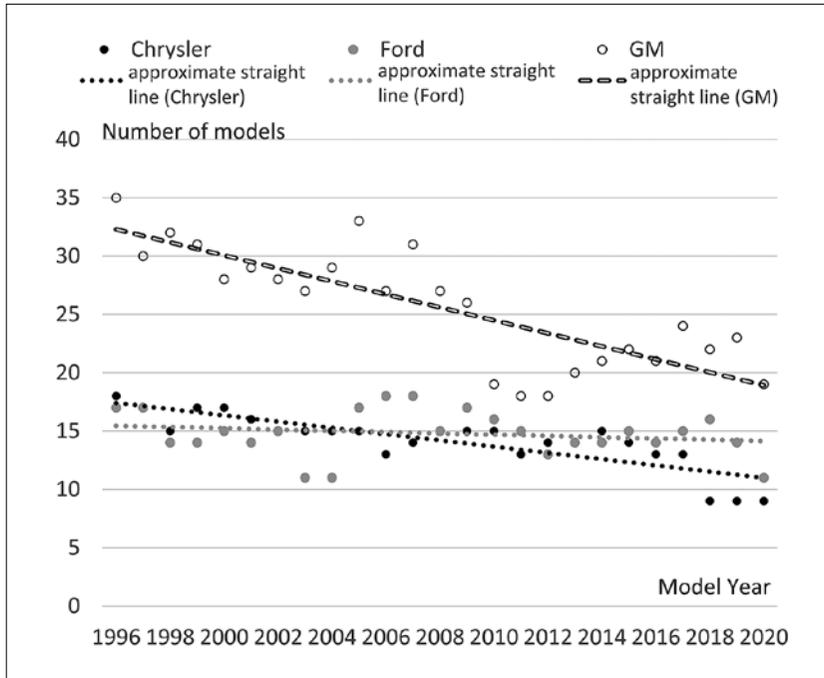
Figures 3 and 4 compare the number of models of monocoque and ladder-frame vehicles, indicating that the former is greater than the latter over the entire period and all brands from model years 1996 to 2020. Similarly, Figures 5 and 6 compare the number of platforms for monocoque vehicles with those for ladder-frame vehicles, showing that the former is greater than the latter for all brands over the entire period from model years 1996 to 2020. Thus, monocoque vehicles outnumber ladder-frame vehicles in the number of models and platforms, regardless of brand and period.

Conversely, Figures 7 and 8 show differences in the number of models per platform by period and brand. For Chrysler, monocoque vehicles per platform exceed ladder-frame vehicles in all periods except model year 2020. The difference between the two is particularly pronounced from model years 1996 to 2005. For Ford, the number of models per platform is equal for ladder-frame and monocoque vehicles in model year 1998. Although the number of models per platform for ladder-frame vehicles exceeds monocoque vehicles from model years 1999 to 2004, the number of models per platform for monocoque vehicles is more significant in subsequent periods. For GM, the number of models per platform for ladder-frame vehicles exceeds monocoque vehicles for the entire period, from model years 1996 through 2020. The difference is particularly pronounced from model years 2008 through 2013.

Next, we use the approximate lines from Figures 3 to 6 to examine the trends in the number of models and platforms, finding that both monocoque and ladder-frame vehicles show a declining trend from model years 1996 to 2020 for all brands. This decrease is particularly strong for GM.

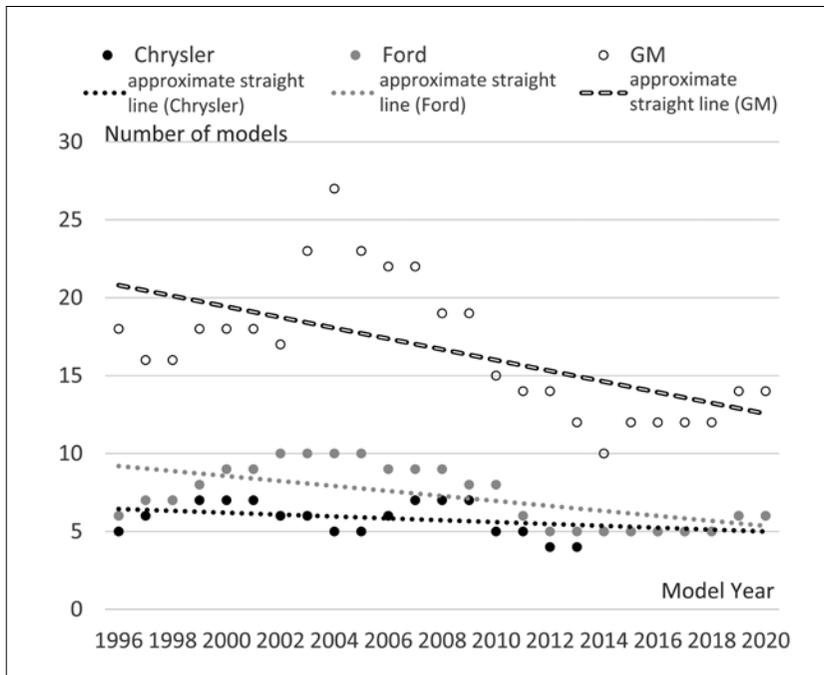
The approximate straight line in Figure 7 indicates that the number of models per platform for monocoque vehicles has a decreasing trend for Chrysler and GM and an increasing trend for Ford. The approximate straight line in Figure 8 shows that the number of models per platform for ladder-frame vehicles has a weak increasing trend for Chrysler, a

Figure 3. Number of models in monocoque vehicles



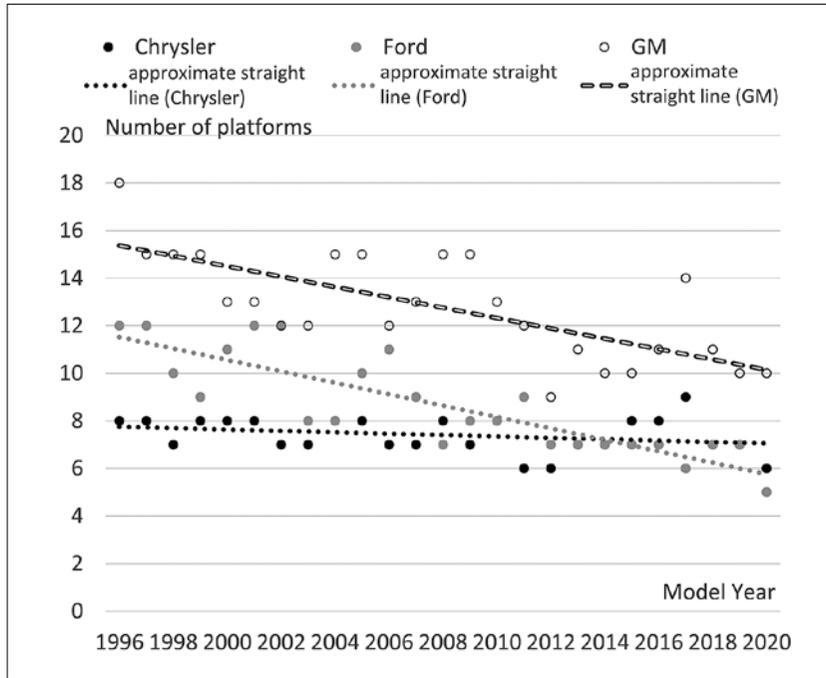
Source: Prepared from the data presented in Section 3.3

Figure 4. Number of models in ladder-frame vehicles



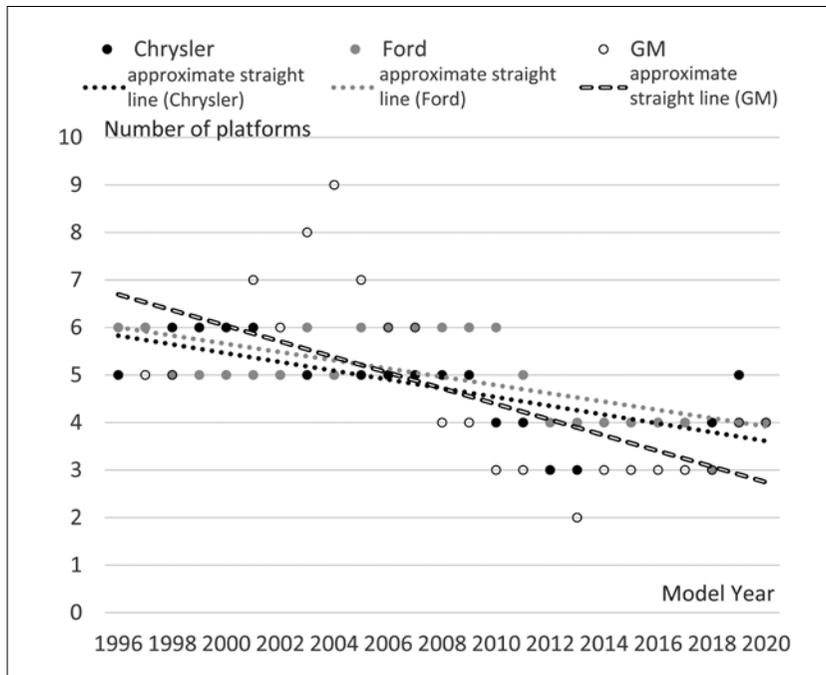
Source: Prepared from the data presented in Section 3.3

Figure 5. Number of platforms in monocoque vehicles



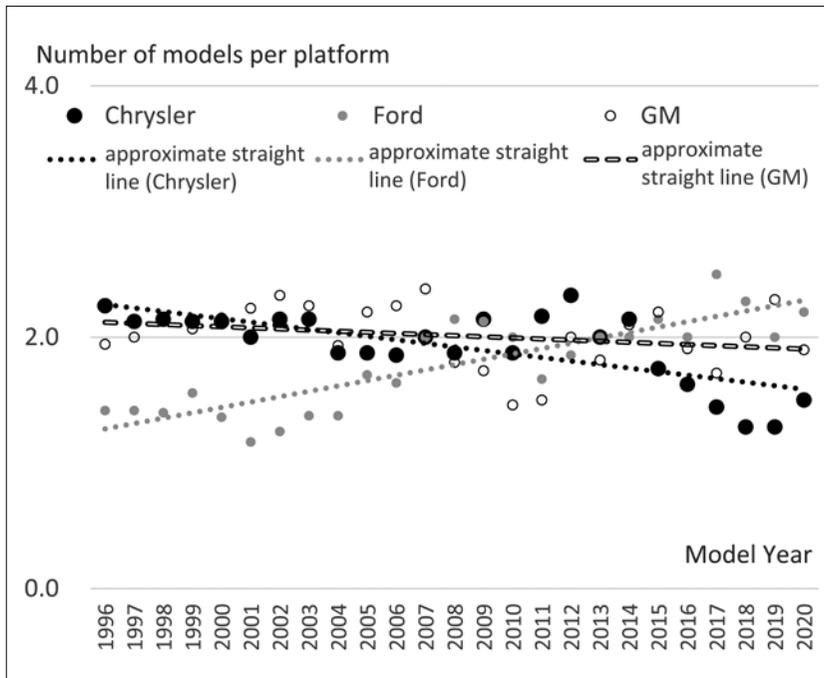
Source: Prepared from the data presented in Section 3.3

Figure 6. Number of platforms in ladder-frame vehicles



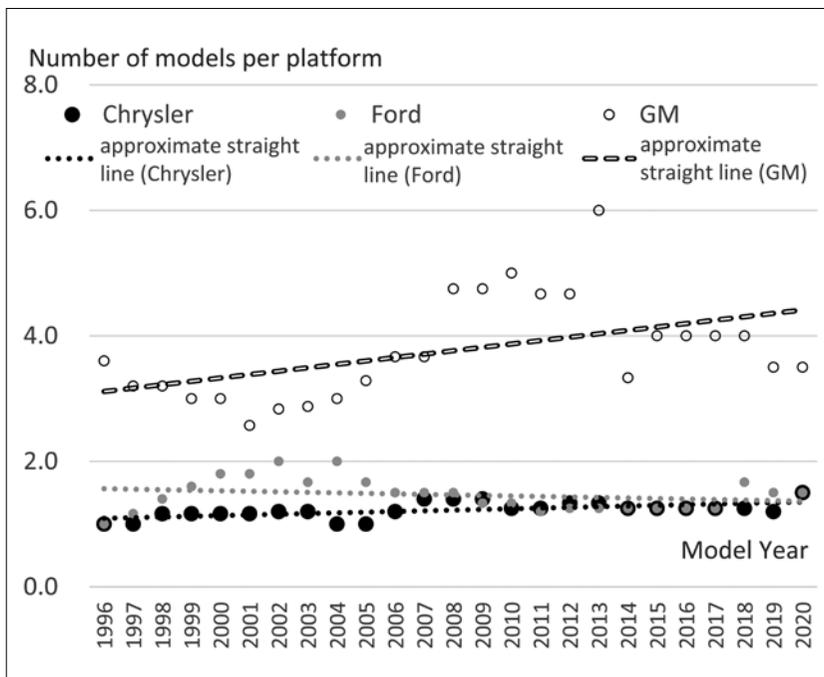
Source: Prepared from the data presented in Section 3.3

Figure 7. Number of models per platform in monocoque vehicles



Source: Prepared from the data presented in Section 3.3

Figure 8. Number of models per platform in ladder-frame vehicles



Source: Prepared from the data presented in Section 3.3

strong increasing trend for GM, and a weak decreasing trend for Ford.

4.2. Total length range covered by each platform

Following the method described in Section 3.6, we counted the number of platforms in each classification for the overall length range and calculated their composition ratios, as shown in Tables 2 and 3.

Table 2 shows that the total length range of each platform for monocoque vehicles is either 0 inches to less than 10 inches or 10 inches to less than 20 inches from model years 1996 to 2020. In contrast, Table 3 shows that while the total length range of ladder-frame vehicle platforms for all brands is between 0 inches and less than 10 inches or between 10 inches and less than 20 inches, the range is also between 20 inches and less than 30 inches, between 30 inches and less than 40 inches, between 40 inches and less than 50 inches, and sometimes even between 50 inches and less than 60 inches. In the case of GM ladder-frame vehicle platforms, there are periods when the platform's length range is between 60 and 70 inches.

We next examine the changing composition ratios. For monocoque vehicle platforms, Table 2 shows a decreasing trend in the 0 inches to less than 10 inches classification and an increasing trend in the 10 inches to less than 20 inches classification for Ford and GM from the early 2010s. In contrast, for Chrysler, the 10 inches to less than 20 inches classification peaked from model years 1996 through 2001 and has trended downward since model year 2002.

Regarding ladder-frame vehicle platforms, we first examine the composition ratios using the average for each brand. Table 4 shows that the trend for all brands is a decrease in the ratio of 0 inches to less than 10 inches and an increase of 50 inches to less than 60 inches from model years 1996 to 2020.

Table 3 presents the composition ratios by brand, showing that for all brands, the ratio of 0 inches to less than 10 inches tends to decrease from model years 1996 to 2020; conversely, the ratio of 50 inches to less than 60 inches tends to increase. In other words, the overall trend observed earlier applies to all brands; however, some differences exist in the trend's strength among brands.

Table 3 also shows differences by brand. For Chrysler and GM, the percentages between

Table 2. Composition of the number of monocoque vehicle platforms in each classification when the difference between the maximum and minimum overall length is classified in 10-inch increments

Model Year	Chrysler							Ford							GM							
	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"	
1996	75%	25%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	94%	6%	0%	0%	0%	0%	0%	0%
1997	75%	25%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	87%	13%	0%	0%	0%	0%	0%	0%
1998	71%	29%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	87%	13%	0%	0%	0%	0%	0%	0%
1999	75%	25%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	87%	13%	0%	0%	0%	0%	0%	0%
2000	75%	25%	0%	0%	0%	0%	0%	91%	9%	0%	0%	0%	0%	0%	85%	15%	0%	0%	0%	0%	0%	0%
2001	75%	25%	0%	0%	0%	0%	0%	92%	8%	0%	0%	0%	0%	0%	92%	8%	0%	0%	0%	0%	0%	0%
2002	86%	14%	0%	0%	0%	0%	0%	92%	8%	0%	0%	0%	0%	0%	92%	8%	0%	0%	0%	0%	0%	0%
2003	86%	14%	0%	0%	0%	0%	0%	88%	13%	0%	0%	0%	0%	0%	92%	8%	0%	0%	0%	0%	0%	0%
2004	88%	13%	0%	0%	0%	0%	0%	88%	13%	0%	0%	0%	0%	0%	93%	7%	0%	0%	0%	0%	0%	0%
2005	88%	13%	0%	0%	0%	0%	0%	90%	10%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
2006	86%	14%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
2007	86%	14%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	92%	8%	0%	0%	0%	0%	0%	0%
2008	100%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	93%	7%	0%	0%	0%	0%	0%	0%
2009	100%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	87%	13%	0%	0%	0%	0%	0%	0%
2010	100%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
2011	100%	0%	0%	0%	0%	0%	0%	78%	22%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
2012	100%	0%	0%	0%	0%	0%	0%	71%	29%	0%	0%	0%	0%	0%	78%	22%	0%	0%	0%	0%	0%	0%
2013	100%	0%	0%	0%	0%	0%	0%	71%	29%	0%	0%	0%	0%	0%	73%	27%	0%	0%	0%	0%	0%	0%
2014	100%	0%	0%	0%	0%	0%	0%	71%	29%	0%	0%	0%	0%	0%	80%	20%	0%	0%	0%	0%	0%	0%
2015	88%	13%	0%	0%	0%	0%	0%	71%	29%	0%	0%	0%	0%	0%	60%	40%	0%	0%	0%	0%	0%	0%
2016	88%	13%	0%	0%	0%	0%	0%	86%	14%	0%	0%	0%	0%	0%	73%	27%	0%	0%	0%	0%	0%	0%
2017	89%	11%	0%	0%	0%	0%	0%	67%	33%	0%	0%	0%	0%	0%	79%	21%	0%	0%	0%	0%	0%	0%
2018	100%	0%	0%	0%	0%	0%	0%	71%	29%	0%	0%	0%	0%	0%	73%	27%	0%	0%	0%	0%	0%	0%
2019	86%	14%	0%	0%	0%	0%	0%	71%	29%	0%	0%	0%	0%	0%	60%	40%	0%	0%	0%	0%	0%	0%
2020	83%	17%	0%	0%	0%	0%	0%	80%	20%	0%	0%	0%	0%	0%	60%	40%	0%	0%	0%	0%	0%	0%

Source: Prepared from the data presented in Section 3.3

Table 3. Composition of the number of ladder-frame vehicle platforms in each classification when the difference between the maximum and minimum overall length is classified in 10-inch increments

Model Year	Chrysler							Ford							GM							
	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"	
1996	40%	20%	0%	20%	20%	0%	0%	33%	33%	17%	17%	0%	0%	0%	20%	20%	30%	0%	20%	0%	0%	40%
1997	50%	17%	0%	0%	33%	0%	0%	33%	33%	17%	0%	17%	0%	0%	20%	20%	20%	20%	0%	0%	0%	20%
1998	50%	0%	17%	0%	33%	0%	0%	40%	20%	20%	20%	0%	0%	0%	20%	20%	40%	0%	0%	0%	20%	
1999	50%	0%	17%	0%	33%	0%	0%	0%	40%	20%	40%	0%	0%	0%	17%	17%	33%	0%	17%	0%	17%	
2000	50%	0%	17%	0%	33%	0%	0%	20%	20%	20%	40%	0%	0%	0%	17%	17%	33%	17%	17%	0%	0%	
2001	50%	0%	17%	0%	33%	0%	0%	0%	40%	20%	40%	0%	0%	0%	57%	14%	14%	0%	0%	14%	0%	
2002	40%	0%	20%	0%	40%	0%	0%	0%	20%	40%	40%	0%	0%	0%	50%	0%	33%	0%	0%	17%	0%	
2003	40%	0%	20%	0%	40%	0%	0%	17%	33%	17%	33%	0%	0%	0%	38%	25%	25%	0%	0%	13%	0%	
2004	40%	40%	0%	0%	20%	0%	0%	0%	40%	20%	20%	20%	0%	0%	44%	22%	22%	0%	0%	11%	0%	
2005	60%	20%	0%	0%	0%	20%	0%	17%	33%	17%	33%	0%	0%	0%	43%	29%	14%	0%	0%	14%	0%	
2006	60%	20%	0%	0%	20%	0%	0%	50%	17%	0%	33%	0%	0%	0%	17%	33%	33%	0%	0%	17%	0%	
2007	60%	0%	20%	0%	20%	0%	0%	0%	50%	17%	33%	0%	0%	0%	17%	17%	33%	0%	0%	33%	0%	
2008	60%	0%	20%	0%	20%	0%	0%	0%	50%	17%	33%	0%	0%	0%	25%	0%	50%	0%	0%	25%	0%	
2009	60%	0%	20%	0%	20%	0%	0%	0%	50%	17%	33%	0%	0%	0%	25%	0%	50%	0%	0%	25%	0%	
2010	50%	0%	25%	0%	0%	25%	0%	0%	50%	17%	33%	0%	0%	0%	0%	0%	67%	0%	0%	33%	0%	
2011	25%	25%	25%	0%	0%	25%	0%	0%	40%	20%	40%	0%	0%	0%	0%	33%	33%	0%	0%	33%	0%	
2012	0%	33%	33%	0%	0%	33%	0%	0%	25%	25%	50%	0%	0%	0%	0%	33%	33%	0%	0%	33%	0%	
2013	0%	33%	33%	0%	0%	33%	0%	0%	25%	25%	50%	0%	0%	0%	0%	0%	50%	0%	0%	50%	0%	
2014	0%	25%	25%	0%	0%	50%	0%	0%	25%	25%	50%	0%	0%	0%	0%	0%	67%	0%	0%	33%	0%	
2015	0%	25%	25%	0%	25%	25%	0%	0%	25%	0%	25%	50%	0%	0%	0%	33%	33%	0%	0%	33%	0%	
2016	0%	25%	25%	0%	0%	50%	0%	0%	25%	0%	25%	50%	0%	0%	0%	33%	33%	0%	0%	33%	0%	
2017	0%	25%	25%	0%	0%	25%	0%	0%	25%	0%	25%	50%	0%	0%	0%	33%	33%	0%	0%	33%	0%	
2018	0%	25%	25%	0%	25%	25%	0%	0%	0%	0%	0%	67%	33%	0%	0%	33%	33%	0%	0%	33%	0%	
2019	0%	20%	40%	20%	20%	0%	0%	25%	0%	0%	0%	50%	25%	0%	0%	25%	50%	0%	25%	0%	0%	
2020	0%	25%	0%	25%	0%	50%	0%	25%	0%	0%	0%	50%	25%	0%	0%	25%	50%	25%	0%	0%	0%	

Source: Prepared from the data presented in Section 3.3

10 and 20 inches, between 20 and 30 inches, and between 50 and 60 inches are on the increase. For Ford, the percentages between 40 and 50 inches and between 50 and 60 inches are on the increase. In particular, Ford's percentage between 40 and 50 inches has reached more than half of the entire classification since model year 2015. Compared to Chrysler and GM, Ford has extended the of platform lengths for ladder-frame vehicles by limiting the classification.

4.3. Retail price range covered by each platform

Following the method described in Section 3.7, we counted the platforms for each retail price range and calculated their composition ratios. For the composition ratio, we calculated the average value of the three brands: Chrysler, Ford, and GM. Table 5 presents the averages for the monocoque vehicle platform, and Table 6 shows those for the ladder-frame vehicle platform.

Tables 5 and 6 show that the 0 to 5,000 USD classification percentage is always higher for the monocoque vehicle platforms than for the ladder-frame vehicle platforms, except for model year 2014. In contrast, the ladder-frame vehicle platforms have outperformed the monocoque vehicle platforms in the 25,000 to 30,000 USD classification, except for model years 2016, 2018, and 2020.

We next examine the changing composition ratios. Table 5 shows a decreasing trend in the classifications of 0 to less than 5,000 USD and 5,000 to less than 10,000 USD. Conversely, the 15,000 to 20,000 USD, 20,000 to 25,000 USD, 25,000 to 30,000 USD, 30,000 to 35,000 USD, and 35,000 to 40,000 USD classifications show relatively strong upward trends.

Table 6 shows strong downward trends for all brands in the 0 to 5,000 USD and 10,000 to 15,000 USD classifications for ladder-frame vehicle platforms. In contrast, relatively strong upward trends occur in the 5,000 to 10,000 USD and 35,000 to 40,000 USD classifications.

Therefore, the range of retail prices covered by each platform for monocoque and ladder-frame vehicles tends to decrease for platforms in the relatively narrow classification and increase for platforms in the relatively broad classification.

We next investigate trends by brand, including the composition ratios for Chrysler

monocoque vehicle platforms (Table 7), Ford monocoque vehicle platforms (Table 8), GM monocoque vehicle platforms (Table 9), Chrysler ladder-frame vehicle platforms (Table 10), Ford ladder-frame vehicle platforms (Table 11), and GM ladder-frame vehicle platforms (Table 12).

From these six tables, we try to understand the differences between monocoque and ladder-frame vehicle platforms in decreasing and increasing trends. When an approximate straight line is drawn, a strong decreasing trend is defined as a classification with a decrease of 10 points or more between model years 1996 and 2020. In contrast, a strong increasing trend is defined as a classification with an increase of 10 points or more over the above 25-year period (Table 13).

Table 4. Average of the three brands with respect to the composition of the number of ladder-frame vehicle platforms in each classification when the difference between the maximum and minimum overall length is classified in 10-inch increments

Model Year	0" to less than 10"	10" to less than 20"	20" to less than 30"	30" to less than 40"	40" to less than 50"	50" to less than 60"	60" to less than 70"
1996	31%	24%	6%	19%	7%	0%	13%
1997	34%	23%	12%	7%	17%	0%	7%
1998	37%	13%	26%	7%	11%	0%	7%
1999	22%	19%	23%	13%	17%	0%	6%
2000	29%	12%	23%	19%	17%	0%	0%
2001	36%	18%	17%	13%	11%	5%	0%
2002	30%	7%	31%	13%	13%	6%	0%
2003	31%	19%	21%	11%	13%	4%	0%
2004	28%	34%	14%	7%	13%	4%	0%
2005	40%	27%	10%	11%	0%	11%	0%
2006	42%	23%	11%	11%	7%	6%	0%
2007	26%	22%	23%	11%	7%	11%	0%
2008	28%	17%	29%	11%	7%	8%	0%
2009	28%	17%	29%	11%	7%	8%	0%
2010	17%	17%	36%	11%	0%	19%	0%
2011	8%	33%	26%	13%	0%	19%	0%
2012	0%	31%	31%	17%	0%	22%	0%
2013	0%	19%	36%	17%	0%	28%	0%
2014	0%	17%	39%	17%	0%	28%	0%
2015	0%	28%	19%	8%	25%	19%	0%
2016	0%	28%	19%	8%	17%	28%	0%
2017	0%	28%	19%	8%	25%	19%	0%
2018	0%	19%	19%	0%	31%	31%	0%
2019	8%	15%	30%	7%	32%	8%	0%
2020	8%	17%	17%	17%	17%	25%	0%

Source: Prepared from the data presented in Section 3.3

Table 13 shows a strong decreasing trend for each brand in the classification of monocoque vehicle platforms between 0 and 10,000 USD and in the classification of ladder-frame vehicle platforms between 0 and 25,000 USD. A strong upward trend occurs for the monocoque vehicle platform in the 35,000 to 40,000 USD and under the classification for Ford, in the 25,000 to 30,000 USD and under for GM. Regarding ladder-frame vehicle platforms, a strong upward trend occurs even in the above 60,000 USD classification for both Ford and GM. Only Chrysler shows no difference between ladder-frame and monocoque vehicle platforms, with a strong upward trend in the 35,000 to 40,000 USD and smaller classifications.

Table 5. Average of the three brands concerning the composition of the number of monocoque vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	44%	41%	6%	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	35%	48%	8%	3%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	35%	35%	14%	7%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	51%	27%	16%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	44%	27%	16%	0%	7%	0%	3%	0%	0%	0%	3%	0%	0%	0%
2001	40%	33%	10%	5%	10%	0%	3%	0%	0%	0%	0%	0%	0%	0%
2002	26%	30%	31%	3%	8%	0%	3%	0%	0%	0%	0%	0%	0%	0%
2003	16%	37%	28%	8%	5%	4%	3%	0%	0%	0%	0%	0%	0%	0%
2004	19%	39%	23%	6%	8%	2%	2%	0%	0%	0%	0%	0%	0%	0%
2005	16%	29%	34%	12%	2%	0%	2%	4%	0%	0%	0%	0%	0%	0%
2006	22%	19%	33%	11%	10%	0%	0%	3%	0%	0%	3%	0%	0%	0%
2007	13%	40%	21%	10%	8%	4%	0%	0%	0%	0%	3%	0%	3%	0%
2008	18%	40%	20%	4%	5%	4%	0%	0%	2%	0%	0%	2%	0%	5%
2009	18%	22%	26%	10%	11%	5%	4%	0%	0%	2%	0%	0%	2%	0%
2010	17%	24%	26%	4%	15%	7%	4%	0%	0%	0%	0%	0%	3%	0%
2011	14%	13%	39%	6%	14%	3%	7%	3%	0%	0%	0%	0%	0%	3%
2012	12%	11%	21%	13%	24%	7%	8%	0%	0%	0%	0%	0%	4%	0%
2013	8%	20%	14%	11%	30%	3%	3%	8%	0%	0%	0%	0%	3%	0%
2014	0%	11%	27%	26%	14%	7%	0%	11%	0%	0%	0%	3%	0%	0%
2015	3%	5%	22%	39%	5%	7%	5%	11%	0%	3%	0%	0%	0%	0%
2016	6%	12%	22%	14%	7%	11%	9%	13%	3%	0%	0%	3%	0%	0%
2017	5%	18%	14%	16%	8%	2%	18%	9%	8%	0%	0%	2%	0%	0%
2018	6%	9%	15%	14%	10%	10%	6%	12%	7%	3%	6%	3%	0%	0%
2019	10%	10%	14%	24%	6%	6%	8%	6%	9%	5%	0%	3%	0%	0%
2020	12%	6%	7%	18%	12%	3%	7%	8%	6%	14%	8%	0%	0%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 6. Average of the three brands concerning the composition of the number of ladder-frame vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	13%	11%	50%	7%	12%	7%	0%	0%	0%	0%	0%	0%	0%	0%
1997	13%	11%	40%	6%	18%	12%	0%	0%	0%	0%	0%	0%	0%	0%
1998	13%	6%	24%	31%	19%	7%	0%	0%	0%	0%	0%	0%	0%	0%
1999	6%	11%	29%	7%	30%	6%	0%	12%	0%	0%	0%	0%	0%	0%
2000	6%	6%	34%	12%	18%	6%	7%	6%	7%	0%	0%	0%	0%	0%
2001	0%	20%	16%	26%	0%	15%	12%	0%	7%	0%	5%	0%	0%	0%
2002	0%	11%	19%	38%	0%	7%	13%	6%	7%	0%	0%	0%	0%	0%
2003	0%	5%	39%	16%	12%	12%	6%	6%	0%	5%	0%	0%	0%	0%
2004	4%	4%	54%	0%	7%	7%	13%	0%	7%	4%	0%	0%	0%	0%
2005	10%	0%	47%	10%	11%	12%	6%	0%	0%	5%	0%	0%	0%	0%
2006	6%	6%	42%	12%	0%	22%	0%	7%	0%	6%	0%	0%	0%	0%
2007	6%	0%	37%	18%	6%	17%	6%	7%	0%	6%	0%	0%	0%	0%
2008	0%	0%	39%	15%	0%	19%	18%	0%	0%	8%	0%	0%	0%	0%
2009	0%	6%	33%	19%	8%	19%	7%	0%	0%	0%	0%	0%	8%	0%
2010	0%	6%	36%	6%	0%	33%	8%	0%	0%	0%	0%	11%	0%	0%
2011	0%	13%	39%	8%	7%	7%	15%	0%	0%	0%	0%	11%	0%	0%
2012	0%	8%	33%	0%	8%	19%	8%	11%	0%	0%	0%	0%	11%	0%
2013	0%	25%	11%	0%	8%	17%	22%	0%	0%	0%	0%	0%	17%	0%
2014	0%	28%	8%	17%	0%	19%	8%	8%	11%	0%	0%	0%	0%	0%
2015	0%	19%	8%	19%	8%	17%	17%	0%	0%	0%	0%	11%	0%	0%
2016	0%	28%	8%	11%	0%	8%	17%	17%	0%	0%	0%	0%	0%	11%
2017	0%	28%	0%	8%	11%	8%	8%	25%	0%	0%	0%	0%	0%	11%
2018	0%	31%	0%	8%	11%	0%	11%	17%	0%	0%	0%	0%	11%	11%
2019	0%	8%	17%	13%	15%	15%	0%	8%	0%	0%	7%	8%	8%	0%
2020	0%	8%	25%	17%	0%	0%	8%	17%	0%	8%	8%	0%	8%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 7. Composition of the number of monocoque vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD for Chrysler brands

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	50%	38%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	29%	57%	0%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	43%	43%	0%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	63%	25%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	63%	13%	13%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	50%	25%	13%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2002	29%	14%	43%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2003	14%	29%	29%	14%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2004	38%	13%	25%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	13%	25%	38%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2006	14%	14%	29%	14%	29%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2007	0%	29%	29%	29%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2008	13%	38%	25%	13%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%
2009	14%	14%	14%	29%	14%	14%	0%	0%	0%	0%	0%	0%	0%	0%
2010	25%	25%	13%	13%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%
2011	0%	17%	67%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2012	0%	33%	33%	17%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2013	14%	14%	29%	0%	43%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2014	0%	0%	43%	14%	43%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2015	0%	0%	29%	43%	0%	0%	14%	14%	0%	0%	0%	0%	0%	0%
2016	0%	13%	25%	13%	13%	0%	13%	25%	0%	0%	0%	0%	0%	0%
2017	0%	22%	11%	33%	0%	0%	22%	11%	0%	0%	0%	0%	0%	0%
2018	0%	17%	17%	33%	0%	0%	0%	17%	0%	0%	17%	0%	0%	0%
2019	0%	14%	14%	43%	0%	0%	14%	0%	0%	14%	0%	0%	0%	0%
2020	17%	17%	0%	33%	0%	0%	0%	0%	17%	17%	0%	0%	0%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 8. Composition of the number of monocoque vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD for Ford brands

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	50%	42%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	42%	33%	17%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	40%	20%	20%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	44%	22%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	36%	36%	18%	0%	0%	0%	0%	0%	0%	0%	9%	0%	0%	0%
2001	25%	50%	8%	8%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2002	25%	42%	25%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2003	0%	50%	38%	0%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%
2004	0%	50%	38%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	10%	30%	50%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2006	36%	18%	36%	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2007	22%	44%	11%	0%	11%	11%	0%	0%	0%	0%	0%	0%	0%	0%
2008	29%	29%	14%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	14%
2009	25%	13%	38%	0%	13%	0%	13%	0%	0%	0%	0%	0%	0%	0%
2010	25%	13%	25%	0%	25%	0%	13%	0%	0%	0%	0%	0%	0%	0%
2011	25%	13%	25%	0%	25%	0%	13%	0%	0%	0%	0%	0%	0%	0%
2012	14%	0%	29%	0%	43%	0%	14%	0%	0%	0%	0%	0%	0%	0%
2013	0%	29%	14%	14%	29%	0%	0%	14%	0%	0%	0%	0%	0%	0%
2014	0%	14%	29%	43%	0%	0%	0%	14%	0%	0%	0%	0%	0%	0%
2015	0%	14%	29%	43%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2016	0%	14%	14%	29%	0%	14%	14%	14%	0%	0%	0%	0%	0%	0%
2017	0%	17%	17%	0%	17%	0%	17%	17%	17%	0%	0%	0%	0%	0%
2018	0%	0%	20%	0%	20%	20%	0%	20%	20%	0%	0%	0%	0%	0%
2019	0%	17%	17%	0%	17%	17%	0%	17%	17%	0%	0%	0%	0%	0%
2020	0%	0%	0%	0%	25%	0%	0%	25%	0%	25%	25%	0%	0%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 9. Composition of the number of monocoque vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD for GM brands

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	33%	44%	17%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	33%	53%	7%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	21%	43%	21%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	47%	33%	13%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	33%	33%	17%	0%	8%	0%	8%	0%	0%	0%	0%	0%	0%	0%
2001	46%	23%	8%	8%	8%	0%	8%	0%	0%	0%	0%	0%	0%	0%
2002	25%	33%	25%	0%	8%	0%	8%	0%	0%	0%	0%	0%	0%	0%
2003	33%	33%	17%	8%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%
2004	20%	53%	7%	7%	0%	7%	7%	0%	0%	0%	0%	0%	0%	0%
2005	27%	33%	13%	0%	7%	0%	7%	13%	0%	0%	0%	0%	0%	0%
2006	17%	25%	33%	8%	0%	0%	0%	8%	0%	0%	8%	0%	0%	0%
2007	15%	46%	23%	0%	0%	0%	0%	0%	0%	0%	8%	0%	8%	0%
2008	13%	53%	20%	0%	0%	0%	0%	0%	7%	0%	0%	7%	0%	0%
2009	13%	40%	27%	0%	7%	0%	0%	0%	0%	7%	0%	0%	7%	0%
2010	0%	33%	42%	0%	8%	8%	0%	0%	0%	0%	0%	0%	8%	0%
2011	17%	8%	25%	17%	0%	8%	8%	8%	0%	0%	0%	0%	0%	8%
2012	22%	0%	0%	22%	11%	22%	11%	0%	0%	0%	0%	0%	11%	0%
2013	9%	18%	0%	18%	18%	9%	9%	9%	0%	0%	0%	0%	9%	0%
2014	0%	20%	10%	20%	0%	20%	0%	20%	0%	0%	0%	10%	0%	0%
2015	10%	0%	10%	30%	0%	20%	0%	20%	0%	10%	0%	0%	0%	0%
2016	18%	9%	27%	0%	9%	18%	0%	0%	9%	0%	0%	9%	0%	0%
2017	14%	14%	14%	14%	7%	7%	14%	0%	7%	0%	0%	7%	0%	0%
2018	18%	9%	9%	9%	9%	9%	18%	0%	0%	9%	0%	9%	0%	0%
2019	30%	0%	10%	30%	0%	0%	10%	0%	10%	0%	0%	10%	0%	0%
2020	20%	0%	20%	20%	10%	10%	20%	0%	0%	0%	0%	0%	0%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 10. Composition of the number of ladder-frame vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD for Chrysler brands

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	0%	0%	80%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	0%	17%	67%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	0%	17%	33%	33%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	0%	33%	33%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	0%	17%	33%	17%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	0%	17%	33%	17%	0%	17%	17%	0%	0%	0%	0%	0%	0%	0%
2002	0%	0%	40%	20%	0%	20%	20%	0%	0%	0%	0%	0%	0%	0%
2003	0%	0%	60%	0%	20%	20%	0%	0%	0%	0%	0%	0%	0%	0%
2004	0%	0%	80%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
2005	0%	0%	80%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%
2006	0%	0%	60%	20%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
2007	0%	0%	60%	20%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
2008	0%	0%	60%	20%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
2009	0%	0%	40%	40%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
2010	0%	0%	75%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%
2011	0%	0%	50%	25%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%
2012	0%	0%	33%	0%	0%	33%	0%	33%	0%	0%	0%	0%	0%	0%
2013	0%	0%	33%	0%	0%	0%	67%	0%	0%	0%	0%	0%	0%	0%
2014	0%	25%	25%	0%	0%	0%	25%	25%	0%	0%	0%	0%	0%	0%
2015	0%	0%	25%	0%	0%	25%	50%	0%	0%	0%	0%	0%	0%	0%
2016	0%	25%	25%	0%	0%	0%	25%	25%	0%	0%	0%	0%	0%	0%
2017	0%	25%	0%	25%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%
2018	0%	25%	0%	25%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%
2019	0%	0%	0%	40%	20%	20%	0%	0%	0%	0%	20%	0%	0%	0%
2020	0%	0%	25%	25%	0%	0%	25%	0%	0%	0%	25%	0%	0%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 11. Composition of the number of ladder-frame vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD for Ford brands

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	0%	33%	50%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	0%	17%	33%	17%	17%	17%	0%	0%	0%	0%	0%	0%	0%	0%
1998	0%	0%	20%	60%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	0%	0%	20%	20%	40%	0%	0%	20%	0%	0%	0%	0%	0%	0%
2000	0%	0%	20%	20%	20%	0%	20%	0%	20%	0%	0%	0%	0%	0%
2001	0%	0%	0%	60%	0%	0%	20%	0%	20%	0%	0%	0%	0%	0%
2002	0%	0%	0%	60%	0%	0%	20%	0%	20%	0%	0%	0%	0%	0%
2003	0%	0%	0%	33%	17%	17%	17%	17%	0%	0%	0%	0%	0%	0%
2004	0%	0%	20%	0%	20%	20%	20%	0%	20%	0%	0%	0%	0%	0%
2005	0%	0%	17%	17%	33%	17%	17%	0%	0%	0%	0%	0%	0%	0%
2006	0%	17%	33%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
2007	0%	0%	33%	17%	17%	33%	0%	0%	0%	0%	0%	0%	0%	0%
2008	0%	0%	33%	0%	0%	33%	33%	0%	0%	0%	0%	0%	0%	0%
2009	0%	17%	33%	17%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
2010	0%	17%	33%	17%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
2011	0%	40%	0%	0%	20%	20%	20%	0%	0%	0%	0%	0%	0%	0%
2012	0%	25%	0%	0%	25%	25%	25%	0%	0%	0%	0%	0%	0%	0%
2013	0%	25%	0%	0%	25%	50%	0%	0%	0%	0%	0%	0%	0%	0%
2014	0%	25%	0%	50%	0%	25%	0%	0%	0%	0%	0%	0%	0%	0%
2015	0%	25%	0%	25%	25%	25%	0%	0%	0%	0%	0%	0%	0%	0%
2016	0%	25%	0%	0%	0%	25%	25%	25%	0%	0%	0%	0%	0%	0%
2017	0%	25%	0%	0%	0%	25%	25%	25%	0%	0%	0%	0%	0%	0%
2018	0%	33%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	33%	0%
2019	0%	0%	50%	0%	0%	0%	0%	25%	0%	0%	0%	25%	0%	0%
2020	0%	0%	50%	0%	0%	0%	0%	25%	0%	0%	0%	0%	25%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 12. Composition of the number of ladder-frame vehicle platforms in each classification when the difference between the maximum and minimum retail price is classified in increments of 5,000 USD for GM brands

Model Year	0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
1996	40%	0%	20%	0%	20%	20%	0%	0%	0%	0%	0%	0%	0%	0%
1997	40%	0%	20%	0%	20%	20%	0%	0%	0%	0%	0%	0%	0%	0%
1998	40%	0%	20%	0%	20%	20%	0%	0%	0%	0%	0%	0%	0%	0%
1999	17%	0%	33%	0%	17%	17%	0%	17%	0%	0%	0%	0%	0%	0%
2000	17%	0%	50%	0%	0%	17%	0%	17%	0%	0%	0%	0%	0%	0%
2001	0%	43%	14%	0%	0%	29%	0%	0%	0%	0%	14%	0%	0%	0%
2002	0%	33%	17%	33%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%
2003	0%	14%	57%	14%	0%	0%	0%	0%	0%	14%	0%	0%	0%	0%
2004	13%	13%	63%	0%	0%	0%	0%	0%	0%	13%	0%	0%	0%	0%
2005	29%	0%	43%	14%	0%	0%	0%	0%	0%	14%	0%	0%	0%	0%
2006	17%	0%	33%	17%	0%	17%	0%	0%	0%	17%	0%	0%	0%	0%
2007	17%	0%	17%	17%	0%	17%	17%	0%	0%	17%	0%	0%	0%	0%
2008	0%	0%	25%	25%	0%	25%	0%	0%	0%	25%	0%	0%	0%	0%
2009	0%	0%	25%	0%	25%	25%	0%	0%	0%	0%	0%	0%	25%	0%
2010	0%	0%	0%	0%	0%	67%	0%	0%	0%	0%	0%	33%	0%	0%
2011	0%	0%	67%	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%
2012	0%	0%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%
2013	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%
2014	0%	33%	0%	0%	0%	33%	0%	0%	33%	0%	0%	0%	0%	0%
2015	0%	33%	0%	33%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%
2016	0%	33%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%
2017	0%	33%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	33%
2018	0%	33%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	33%
2019	0%	25%	0%	0%	25%	25%	0%	0%	0%	0%	0%	0%	25%	0%
2020	0%	25%	0%	25%	0%	0%	0%	25%	0%	25%	0%	0%	0%	0%

Note: The 2015-based GDP deflator was used to adjust the retail price for each year.

Source: Prepared from the data presented in Section 3.3

Table 13. Increasing/decreasing trends in the share of the number of platforms by retail price range

		0 to less than 5,000 USD	5,000 to less than 10,000 USD	10,000 to less than 15,000 USD	15,000 to less than 20,000 USD	20,000 to less than 25,000 USD	25,000 to less than 30,000 USD	30,000 to less than 35,000 USD	35,000 to less than 40,000 USD	40,000 to less than 45,000 USD	45,000 to less than 50,000 USD	50,000 to less than 55,000 USD	55,000 to less than 60,000 USD	60,000 to less than 65,000 USD	65,000 to less than 70,000 USD
Chrysler	monocoque	Down	Down	Up	Up		Up	Up	Up						
	ladder frame			Down		Down		Up	Up						
Ford	monocoque	Down	Down			Up			Up						
	ladder frame		Up		Down	Down	Up		Up					Up	
GM	monocoque	Down	Down		Up		Up								
	ladder frame	Down	Up	Down										Up	Up

Note: "Down" indicates a downward trend of 10 points or more, and "Up" indicates an upward trend of 10 points or more for the period from model year 1996 through model year 2020.

Source: Prepared from Tables 7 to 12

5. Discussion

5.1. Spreading development costs through platform integration

As discussed in Section 2.2.1, previous studies argued that automakers reduced the number of platforms in the late 1990s and mid-2000s to spread development costs across individual models. As discussed in Section 4.1, the number of platforms has decreased for all brands from model years 1996 to 2020; however, during this period, the number of models also showed a decreasing trend for all brands. When examining the number of models per platform, Chrysler showed a decreasing trend for monocoque vehicles and a slightly increasing trend for ladder-frame vehicles. Furthermore, Ford showed an increasing trend for monocoque vehicles and a slightly decreasing trend for ladder-frame vehicles, while GM showed a decreasing trend for monocoque vehicles and an increasing trend for ladder-frame vehicles.

Over the 25 years from model years 1996 to 2020, while progress was made in reducing the number of platforms, the dispersion of development costs to individual models through platform integration was insufficient—progress in spreading development costs varied by brand and product structure (monocoque or ladder frame).

5.2. Horizontal platform integration approach

As Section 2.2 described, horizontal platform integration means integrating platforms across the categories of individual products. Furthermore, as discussed in Section 3.6, the category is reflected in the vehicle's overall length; therefore, the degree of horizontal integration of platforms was measured by the difference between the maximum and minimum overall length in each product family. The result of this measurement was 4.2, which suggests the following two characteristics of the platform strategies for existing US automobile brands.

First, the diversity of categories given to monocoque and ladder-frame vehicle platforms by the existing US automobile brands differs. From model years 1996 through 2020, the overall length range for monocoque vehicle platforms was less than 20 inches. In contrast, the range for ladder-frame vehicle platforms was at times more than 50 inches long. Therefore, the categories of individual models developed from a single platform were limited for monocoque vehicle platforms and varied for ladder-frame vehicle platforms.

The second characteristic is the difference in the progress of horizontal integration between monocoque vehicle platforms and ladder-frame vehicle platforms. For the Ford and GM monocoque vehicle platforms, the classification from 0 inches to less than 10 inches showed a decreasing trend, and the classification from 10 inches to less than 20 inches showed an increasing trend over time from model years 1996 to 2020; however, ladder-frame vehicle platforms showed a decreasing trend in the 0 to 10 inches classification and an increasing trend in the 50 to 60 inches classification for all brands. Therefore, although platform integration across categories was promoted, horizontal integration was promoted more in ladder-frame vehicles than in monocoque vehicles.

5.3. Vertical platform integration approach

Vertical platform integration means the integration of platforms among products with different costs and performance, as we saw in Section 2.2. Furthermore, as discussed in Section 3.7, this study considered that cost and performance are reflected in the vehicle's retail price. Therefore, the difference between the maximum and minimum retail prices in each product family can measure the degree of vertical integration of platforms. The result of this measurement was 4.3, which suggests the following two characteristics of the platform strategy of the existing US automobile brands.

The first characteristic is the difference in cost and performance variety between the existing US automobile brands' monocoque and ladder-frame vehicle platforms. From model years 1996 through 2020, monocoque vehicles generally outperformed ladder-frame vehicles in classifications with retail prices between 0 and 5,000 USD, while ladder-frame vehicles generally outperformed monocoque vehicles in classifications with retail prices between 25,000 and 30,000 USD. Therefore, the cost and performance of individual models developed on a single platform were more diverse for ladder-frame vehicles than for monocoque vehicles.

The second characteristic is the difference in the progress of vertical integration between monocoque vehicle platforms and ladder-frame vehicle platforms. The average retail price range of each product family across brands from model years 1996 to 2020 showed a decreasing trend in the relatively narrow retail price range for both monocoque and ladder-frame vehicle platforms. In contrast, an increasing trend occurred in the broader range for monocoque and ladder-frame vehicle platforms. Thus, there was no apparent difference between monocoque and ladder-frame vehicles in terms of the average value for each brand; however, when the above changes were examined by brand, for each brand, monocoque vehicles showed a solid decreasing trend in the 0 to less than 10,000 USD classification, while ladder-frame vehicles showed a strong decreasing trend even in the 10,000 USD or more classification. For Ford and GM, a strong upward trend in retail prices occurred over a much more comprehensive range for ladder-frame vehicle platforms than for monocoque vehicle platforms; we could not confirm this trend for Chrysler. Therefore, for Ford and GM, platform integration was more strongly encouraged in ladder-frame vehicles than in monocoque vehicles regarding cost and performance.

5.4. Synthesis of the above points

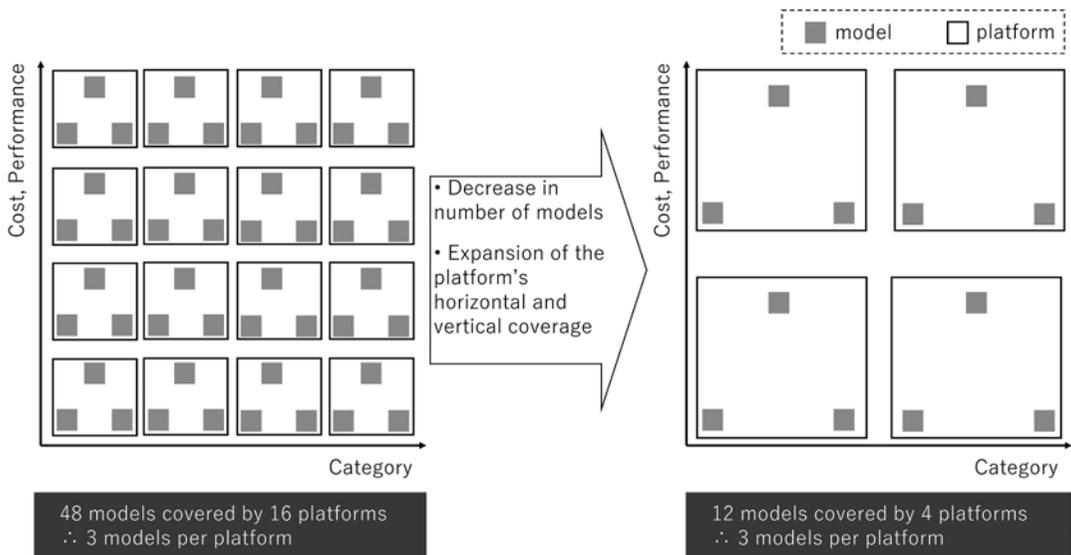
The answer to whether the distribution of platform development costs over individual models has progressed from model years 1996 to 2020 depends first on the brand and second on whether the vehicle is a monocoque or a ladder-frame vehicle.

Although the number of models per platform has not necessarily increased, the qualitative level of platform integration appears to have increased. This result occurs for two reasons. First, the total length range for each product family showed a strong decreasing

trend over time in the classification with a relatively narrow total length range while simultaneously showing a strong increasing trend with a relatively wide total length range. Second, the range of retail prices for each product family also showed a strong decreasing trend over time in the classification with a relatively narrow range of retail prices; at the same time, it showed a strong increasing trend in the classification with a relatively wide range of retail prices. That is, from model years 1996 through 2020, the platform was applied to models in a wider range of categories from a narrower range of categories and in a wider range of price zones from a narrower range of price zones. Thus, as Figure 9 shows, we can assume that the expansion of the horizontal and vertical coverage of the platform prevented a significant decrease in the number of models per platform, even though the number of models decreased.

Furthermore, this trend was more pronounced for ladder-frame vehicle platforms than for monocoque vehicle platforms. Whether in the overall length range (which was the case for all three brands) or in the retail price range (which was the case for Ford and GM), ladder-frame vehicle platforms showed a stronger increasing trend than monocoque vehicle platforms in a broader range of classifications (Tables 2, 3, and 13). The differences between

Figure 9. Conceptual diagram of changes in platform coverage



Note: Values are hypothetical.

Source: Prepared by the author from previous discussions

monocoque and ladder-frame vehicle platforms in overall length and retail price range continued from model years 1996 through 2020, with some exceptions. From model years 1996 to 2020, the existing US automobile brands implemented a strategy of horizontal and vertical platform integration. This strategy was implemented particularly in ladder-frame vehicles.

6. Conclusions, limitations, and future research directions

This study aimed to clarify the platform strategies of existing US automobile brands, focusing on the differences between monocoque and ladder-frame vehicle platforms.

From model years 1996 to 2020, the downward trend in the number of models per platform was unclear because the number of models themselves decreased. As a result, the main objective of platform integration, i.e., spreading platform development costs across individual products, has not necessarily progressed over time for existing US automobile brands; however, during the above period, a single platform covered a more comprehensive range of overall lengths and a wider range of retail prices. In other words, platform integration was accelerated horizontally (along the category axis) and vertically (along the cost and performance axis). In this respect, the existing US automobile brands' platform strategy during the study period was to avoid increasing development costs per model, even as the number of models decreased, by making the platform adaptable to heterogeneous models, both in terms of categories and cost and performance. Furthermore, since platform integration, both horizontally and vertically, was promoted more in the ladder-frame vehicles than in the monocoque vehicles,⁶ we can assume that the ladder-frame vehicle platform was the primary means of implementing this strategy.

This study has two limitations, discussed here. The first concerns missing data. The data in Section 4 were limited to models and platforms of existing US automobile brands produced in three North American countries and sold in the US. As a result, cases (e.g., Volvo models) are missing from the data in Section 4, even though the same platforms are used as those of existing US automobile brands. This lack of data limits the analysis of the

⁶ Regarding Chrysler's vertical platform integration, we found no clear difference between the ladder-frame and monocoque vehicle platforms (Table 13).

number of models per platform and the extent and degree of horizontal and vertical platform integration.

The second limitation is that the background of the platform strategy was not analyzed. Why did the existing US automobile brands reduce not only the number of platforms but also the number of models? Why did the existing US automobile brands focus on ladder-frame vehicles rather than monocoque vehicles in their horizontal and vertical platform integration? The lack of analysis of this background makes it unclear what logic led the existing US automobile brands to develop and implement the platform strategies discussed in this paper.

Future studies can challenge the second boundary because filling in the missing data in the first boundary is extremely difficult for the 25 model years from 1996 to 2020. As a background to the reduction in models, we will need to analyze the competition in the US automobile market from at least the late 1990s. Furthermore, as a background to the strong push for platform integration in ladder-frame vehicles, it will be necessary to analyze automobile consumption trends (e.g., sales volume by displacement for internal combustion engine vehicles), the relationship between the diversity of consumer needs or objectives for pickup trucks and the product characteristics of ladder-frame vehicles, and the tax system (e.g., the difference between passenger cars, which are almost entirely monocoque vehicles, and light trucks, which include many ladder-frame vehicles).

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