



Discussion Papers In Economics And Business

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Discussion Paper 26-07

June 2026

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Abstract

Original equipment manufacturing (OEM) agreements between competing firms play a significant role in improving production efficiency through scale economies. At the same time, however, they can also reduce market competition. This study empirically examines the effects of OEM agreements on competition and welfare in the Japanese automobile industry. I develop and estimate structural models incorporating OEM agreements, market competition, and scale economies. The results indicate that efficiency improvements lead to significant welfare gains, even when these agreements reduce competition. These findings provide empirical insights into the trade-off involved in such agreements and contribute to competition policy regarding modern supply chains.

Keywords: OEM, horizontal subcontracting, scale economies, vertical relationships

JEL codes: L13, L22, L62

*I would like to thank Masato Nishiwaki, Noriaki Matsushima, Shingo Ishiguro, Naoshi Doi, Kosuke Hirose, Yuta Toyama, and Mitsuru Igami, as well as the participants at the JEMIOW 2024 (Osaka), the Japanese Economic Association Spring Meeting 2025 (Nagoya), the Japan Fair Trade Commission CPRC Seminar (Tokyo), EARIE 2025 (Valencia), and APIOC 2025 (Brisbane) for their comments and feedback. I am grateful to Komei Fujita and Naoki Wakamori for generously sharing their data. This work was supported by a Grant-in-Aid for JSPS Fellows (Grant Number 25KJ1704). All errors, of course, are mine.

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1 Introduction

Original equipment manufacturing (OEM) agreements are a pervasive form of outsourcing in which one firm manufactures products for sale under another firm’s brand. While these arrangements are traditionally understood as vertical relationships between non-competing firms, they increasingly involve horizontal competitors. This creates a hybrid market structure that combines upstream cooperation with downstream competition, challenging standard views in industrial organization (IO). A notable example emerged in the 2000s, when Taiwanese manufacturers such as Acer and ASUS produced PCs and mobile phones for major firms like Apple and Hewlett-Packard, while expanding their own competing brands.¹ Similar arrangements are now widespread across a diverse range of sectors, including electronics, automobiles, and consumer staples.

From a social welfare perspective, these horizontal OEM arrangements entail a fundamental trade-off between productive efficiency and potential anticompetitive effects. On the one hand, outsourcing can significantly enhance efficiency by optimizing production allocation across firms or by consolidating production to exploit scale economies. Indeed, industry practitioners explicitly cite reductions in unit costs through scale economies as a key motivation for these agreements, consistent with the view that OEM arrangements generate efficiency gains with positive welfare implications.² On the other hand, such cooperative ties may reduce price competition or even facilitate coordination. While these concerns have drawn attention from antitrust authorities, reaching definitive conclusions about their competitive effects remains challenging. In Japan, for instance, regulators have reviewed many cases involving horizontal alliances, with mixed assessments. In Europe, related practices such as cross-supplies among Italian flat-glass manufacturers faced initial antitrust fines that were subsequently overruled by the courts.³

Despite the expansion of horizontal OEM agreements and the associated regulatory concerns, empirical evidence on their welfare implications remains scarce. This paper addresses this gap by quantifying this welfare trade-off through a structural analysis of the Japanese automobile industry (2006–2016). The analysis focuses specifically on the kei car segment, which offers an ideal setting for this investigation.⁴ In this market, horizontal OEM relationships between rival firms are widespread: in 2016, over one-third of the models (13 of 34) were supplied by direct competitors. Crucially, this setting provides a distinct advantage for identification: the existence of well-documented “twin

¹See Vance (2009) in *The New York Times*. For additional examples, see Caldieraro (2016), among others.

²Section 3.3 presents related statements by industry practitioners.

³Baake, Oechssler, and Schenk (1999) review this case and provide a theoretical analysis of cross-supplies.

⁴A kei car is a Japanese category of ultra-compact, highway-legal passenger vehicle defined by strict limits on size and engine displacement and designed to qualify for reduced taxes and fees. A detailed discussion of the kei car market is provided in Section 3.2.

automobiles”—vehicles produced on the same production lines but sold under different brands.⁵ Furthermore, the kei car market is effectively closed, with production and sales conducted almost entirely within Japan. This self-contained structure ensures that the entire production network and supply relationships are observable within a single market. These features make the kei car segment a uniquely tractable setting for studying horizontal OEM arrangements.⁶

To quantify the welfare trade-off inherent in horizontal OEM arrangements, this study develops a structural model that captures the complexity of the supply side. The specification incorporates two key features. First, I model the hybrid nature of these agreements, which simultaneously involve vertical contracting (between an upstream producer and a downstream brand) and horizontal rivalry (between competing brands). This dual structure generates multiple plausible price-setting behaviors. The analysis therefore estimates a set of candidate models representing alternative assumptions about firms’ conduct and then applies the Rivers-Vuong test (Vuong, 1989; Rivers and Vuong, 2002) to determine which models are most consistent with the data.

Second, I explicitly incorporate scale economies into the cost specification to capture both the source of efficiency gains and the strategic motive for outsourcing. Specifically, marginal costs are modeled as a function of the aggregate production volume of twin automobiles, which are substantially identical vehicles sharing the same assembly process. This specification captures the efficiency rationale underlying OEM arrangements. By pooling output across competing brands, manufacturers can achieve lower unit costs than would be possible through independent production. Ultimately, this framework allows me to quantify the welfare trade-off by comparing the estimated efficiency gains (lower marginal costs) against potential anticompetitive effects (higher markups).

The primary finding is that the efficiency gains generated by horizontal OEM arrangements outweigh any potential anticompetitive harm. The estimated marginal cost function reveals scale economies associated with consolidated production. Counterfactual simulations in which OEM arrangements are entirely prohibited show that total welfare would fall by 20–200 billion JPY. To put this magnitude into perspective, this welfare loss is at least as large as that under the most adverse competitive benchmark—full collusion among all firms in the segment—which reduces welfare by roughly 20 billion JPY. These results demonstrate that the cost efficiencies achieved by horizontal OEM agreements dominate the welfare loss, underscoring the strongly positive role of such collaboration.

Consistent with this dominance of efficiency gains, the results indicate that the anticompetitive effects associated with these agreements are minimal. The model selection

⁵The existence of “twin automobiles” has also been exploited in empirical work. For example, Sullivan (1998) used it to examine the effect of brand names.

⁶By contrast, in other industries where OEM arrangements are also common, such as smartphones or PCs, supply chains are global, and detailed information on production or supply-side relationships is typically hard to obtain.

procedure identifies two supply-side structures consistent with the data. Specifically, one allows for competition softening, while the other features no anticompetitive component. However, the quantitative distinction between them is negligible. Indeed, a counterfactual exercise that switches between these specifications yields a total welfare difference of only approximately 0.5 billion JPY. This magnitude is economically insignificant, particularly when compared to the substantial efficiency gains discussed above. These findings suggest that the potential for anticompetitive harm in this setting is highly limited.

These findings provide empirical evidence on the welfare consequences of “horizontal subcontracting,” a concept originally formalized by Spiegel (1993), which refers to subcontracting to a rival within the same market. While the empirical setting is not identical to Spiegel’s theoretical framework, the results are broadly consistent with the trade-off he identifies: such arrangements can lower production costs while potentially weakening competition. This study contributes by empirically quantifying this trade-off, demonstrating that the efficiency gains outweigh the competition-weakening effects in the Japanese automobile market. More broadly, the analysis connects to the extensive literature on outsourcing and strategic interaction.⁷ Additionally, it contributes to the literature on vertical relationships and their anticompetitive effects (Chen, 2001; Sappington, 2005), which suggests that upstream relationships can dampen downstream competition. The analysis tests for such effects within the structural framework developed here and finds little support for such vertical mechanisms in the Japanese automobile market.

Methodologically, this study builds on the literature identifying and testing firm conduct in structural models. The analysis extends this line of inquiry to OEM arrangements between competitors. To capture the vertical contracting inherent in these arrangements, the model draws on the frameworks of Berto Villas-Boas (2007) and Bonnet and Dubois (2010). Furthermore, recent methodological advances in conduct testing are employed to select among competing models. Specifically, the testing procedures developed by Backus, Conlon, and Sinkinson (2021) and Duarte et al. (2024), which operationalize the falsification arguments of Berry and Haile (2014), are applied to the OEM context.

Finally, this study underscores the importance of scale economies, a central source of efficiency gains in OEM arrangements. In the automobile industry, scale has long been recognized as fundamental to production (Berry, Levinsohn, and Pakes, 1995) and is frequently cited as a primary motive for outsourcing (Cachon and Harker, 2002; Shy and Stenbacka, 2003). Despite this importance, scale economies have often been underemphasized in empirical studies. Recent methodological work by Duarte et al. (2025) addresses this gap, demonstrating that ignoring scale in markets where it matters can lead to misspecified model selection and biased conduct inferences. By accounting for

⁷This literature discusses a range of theoretical issues, including strategic outsourcing to shared suppliers (Shy and Stenbacka, 2003; Buehler and Haucap, 2006; Arya, Mittendorf, and Sappington, 2008), cooperative outsourcing for entry deterrence (Chen, 2011), and cross-supplies between competitors (Baake, Oechssler, and Schenk, 1999).

scale-dependent cost structures, the analysis empirically demonstrates the magnitude of scale economies and their substantial positive impact on social welfare.

Overall, this paper makes three main contributions. First, to the best of my knowledge, this study provides the first empirical analysis of OEM arrangements between direct competitors. A structural model is developed that formalizes the hybrid nature of these agreements, and alternative price-setting behaviors consistent with observed market outcomes are estimated. Given the growing global prevalence of such arrangements among competing firms, a rigorous assessment of their welfare effects yields important implications for competition policy. Second, this study contributes to the limited empirical literature on horizontal subcontracting. The analysis takes advantage of the Japanese automobile industry as a unique setting where subcontracting among rivals is widespread and rebadged “twin” models are directly observable. This feature allows horizontal subcontracting to be analyzed with a level of detail that is often difficult to achieve in other settings. Third, the paper provides structural evidence on the welfare role of scale economies. By incorporating scale economies into the cost specification, it quantifies the cost savings from consolidated production and demonstrates their substantial positive impact on social welfare.

The structure of this paper is as follows. Section 2 introduces the concept of OEM arrangements between competitors using a simple model. Section 3 provides an overview of the dataset and background on OEM arrangements. Section 4 develops the structural model of supply in Japan’s automobile market, while Section 5 explains the estimation methodology and model selection process. Section 6 discusses the estimation results and their implications, and Section 7 presents counterfactual simulations to assess the welfare effects of OEM arrangements. Finally, Section 8 concludes. Additional calculations and supplementary analyses are provided in the Appendix.

2 Competitive Implications of OEM Arrangements Between Competitors

This section introduces OEM arrangements between competitors and provides a conceptual discussion of their potential anticompetitive implications. The discussion shows that, depending on the contractual pricing structure, OEM arrangements can have the effect of relaxing competition.

OEM arrangements represent a specific form of outsourcing in which a firm contracts out the manufacturing of a finished product to be sold under its own brand. Unlike conventional outsourcing, which typically involves component-level production or specific stages of assembly, OEM operates at the level of finished-product manufacturing. In the literature, upstream producers are typically referred to as contract manufacturers (CMs),

while downstream brands are denoted as original equipment manufacturers (OEMs).⁸ When the CM also operates in the downstream market by selling its own products, it becomes not only a vertical production partner but also a horizontal rival.

To clarify the key mechanisms underlying OEM arrangements between competitors, I present a series of simplified three-by-three models (three firms and three products). The discussion begins with a baseline model of independent competition. It then introduces three alternative pricing regimes—linear pricing, OEM-led non-linear pricing, and CM-led non-linear pricing—which differ in whether wholesale prices are used and in how pricing decisions are made under OEM arrangements. Each of these pricing regimes is illustrated in Figure 1.

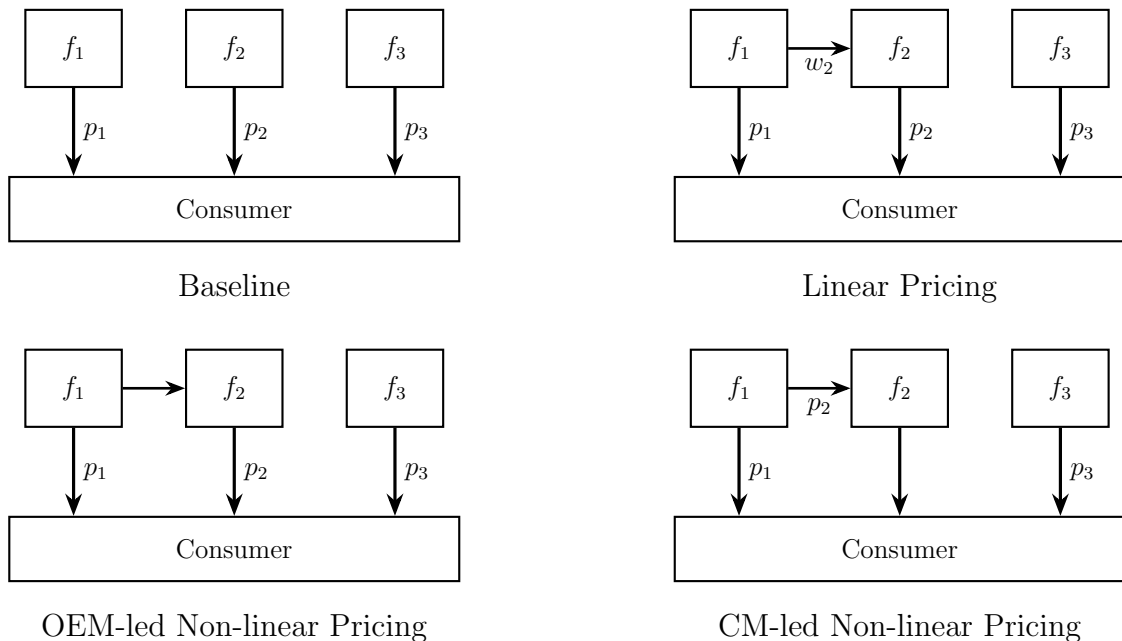


Figure 1: Market Structure Scenarios under OEM Arrangements

Notes: The figure illustrates the baseline model and the three pricing regimes introduced in this section. In the OEM scenarios, firm f_2 outsources production to firm f_1 , which acts as the contract manufacturer (CM).

Baseline: Independent Pricing This subsection starts by describing the baseline case without OEM arrangements. Consider a market with three products, indexed by $j = 1, 2, 3$, where each product j is produced and sold by a distinct firm $f = j$. Let q_j , p_j , and c_j denote the sales quantity, retail price, and marginal cost of product j , respectively, and \mathbf{p} denotes the vector of all prices. Under this framework, the profit of firm f is given by $\pi_f = (p_j - c_j)q_j(\mathbf{p})$. Assuming firms compete in a Bertrand-Nash equilibrium, the

⁸In this paper, the term OEM is used to refer either to original equipment manufacturing (the practice) or to the original equipment manufacturer (the firm), depending on the context.

first-order conditions yield the following markup structure:

$$\begin{pmatrix} p_1 - c_1 \\ p_2 - c_2 \\ p_3 - c_3 \end{pmatrix} = - \begin{bmatrix} \frac{\partial q_1}{\partial p_1} & 0 & 0 \\ 0 & \frac{\partial q_2}{\partial p_2} & 0 \\ 0 & 0 & \frac{\partial q_3}{\partial p_3} \end{bmatrix}^{-1} \begin{pmatrix} q_1 \\ q_2 \\ q_3 \end{pmatrix}. \quad (1)$$

Equation (1) reflects the standard result that each firm sets its price independently, taking into account only the direct effect of its own price on its own demand. This benchmark provides a basis for evaluating how OEM arrangements alter competitive interactions.

Linear Pricing The next step is to introduce an OEM arrangement between Firms 1 and 2. Suppose Firm 2 (the OEM) outsources the production of Product 2 to Firm 1 (the CM), implying that Firm 1 manufactures both Product 1 and Product 2. Under a linear pricing contract, Firm 1 sets a per-unit wholesale price w_2 for Product 2, and Firm 2 sets the retail price p_2 . This structure creates a vertical relationship between the two firms, with Firm 1 acting as both an upstream supplier to Firm 2 and a downstream competitor. The profit functions under this arrangement are given by⁹

$$\pi_1 = (p_1 - c_1)q_1(\mathbf{p}, w_2) + (w_2 - c_2)q_2(\mathbf{p}, w_2), \quad (2)$$

$$\pi_2 = (p_2 - w_2)q_2(\mathbf{p}, w_2), \quad (3)$$

$$\pi_3 = (p_3 - c_3)q_3(\mathbf{p}, w_2). \quad (4)$$

From the first-order conditions, the markup structure can be derived as

$$\begin{pmatrix} p_1 - c_1 \\ w_2 - c_2 \\ p_2 - w_2 \\ p_3 - c_3 \end{pmatrix} = - \begin{bmatrix} \frac{\partial q_1}{\partial p_1} & \frac{\partial q_2}{\partial p_1} & 0 & 0 \\ \frac{\partial q_1}{\partial w_2} & \frac{\partial q_2}{\partial w_2} & 0 & 0 \\ 0 & 0 & \frac{\partial q_2}{\partial p_2} & 0 \\ 0 & 0 & 0 & \frac{\partial q_3}{\partial p_3} \end{bmatrix}^{-1} \begin{pmatrix} q_1 \\ q_2 \\ q_2 \\ q_3 \end{pmatrix}. \quad (5)$$

Equation (5) highlights two channels through which the vertical relationship reduces the intensity of competition between Firms 1 and 2. First, when setting the retail price p_1 , Firm 1 internalizes the cross-price effect on its wholesale profits from Product 2, as reflected in the term involving $\frac{\partial q_2}{\partial p_1}$. Second, when choosing the wholesale price w_2 , Firm 1 recognizes that a higher w_2 induces Firm 2 to raise p_2 , which in turn shifts demand towards Product 1, as captured by $\frac{\partial q_1}{\partial w_2}$. Both effects reduce Firm 1's incentive to compete aggressively on price.

Together, these mechanisms imply that Firm 1 partially internalizes profits from Prod-

⁹While the specific equilibrium outcomes depend on the timing of price setting (e.g., whether the wholesale price is set prior to or simultaneously with the retail price), the general profit-maximization framework is presented here.

uct 2 through the OEM contract, leading to weaker competition between the two firms. Although the presence of double marginalization complicates a direct comparison with the baseline, the main implication is the OEM-induced vertical pricing structure creates strategic interdependence in pricing and reduces competitive pressure. This mechanism is consistent with prior theoretical work on outsourcing between competitors, such as Chen (2001) and Sappington (2005).

OEM-led Non-linear Pricing Next, the analysis turns to the case of non-linear pricing, which takes the form of a two-part tariff. Under this regime, the double marginalization distortion is eliminated. Profits are instead allocated ex post through a fixed transfer that does not affect pricing decisions. This structure allows for the examination of two polar cases for OEM-branded products, depending on who makes the retail pricing decisions: the OEM or the CM.¹⁰ The discussion first focuses on the former case, in which the OEM determines the final retail price.¹¹

Under this structure, Firm 2 sets p_2 to maximize the profit from Product 2, and the resulting profit is then divided between the two firms, which is equivalent to wholesale pricing at marginal cost. Importantly, because Firm 2 controls the retail price, it chooses p_2 independently of Firm 1's pricing decision for Product 1. As a result, the markup structure in this case is identical to that in the baseline in Equation (1): each product is priced as if it were produced and sold by an independent firm. Consequently, no additional anticompetitive concern arises in this case, and any welfare impact is driven solely by efficiency gains from production outsourcing.

CM-led Non-linear Pricing Finally, the analysis turns to considering the case in which the CM, rather than the OEM firm, sets the retail price of the outsourced product. This arrangement corresponds to a resale price maintenance (RPM) mechanism, where the upstream firm controls the final price. Such a structure may arise when the upstream CM holds a relatively strong negotiating position compared to the downstream OEM. For example, this can occur if the OEM seeks to avoid the high fixed costs of in-house production, making it heavily dependent on the CM's manufacturing capabilities.

Under this arrangement, Firm 1 controls the pricing of both Product 1 and Product

¹⁰That is, whether the retail price is set by the downstream brand or by the upstream producer. While real-world contracts may allow for more flexible arrangements, this stylized setting is adopted to illustrate the potential anticompetitive effects.

¹¹Because the fixed transfer does not depend on prices or quantities, it does not affect pricing incentives. This case therefore captures a broad class of non-linear pricing arrangements in which double marginalization is eliminated and the downstream firm retains control over retail pricing.

2. The profit functions become:

$$\pi_1 = (p_1 - c_1)q_1(\mathbf{p}) + (p_2 - c_2)q_2(\mathbf{p}), \quad (6)$$

$$\pi_3 = (p_3 - c_3)q_3(\mathbf{p}). \quad (7)$$

Thus, the markup structure is

$$\begin{pmatrix} p_1 - c_1 \\ p_2 - c_2 \\ p_3 - c_3 \end{pmatrix} = - \begin{bmatrix} \frac{\partial q_1}{\partial p_1} & \frac{\partial q_2}{\partial p_1} & 0 \\ \frac{\partial q_1}{\partial p_2} & \frac{\partial q_2}{\partial p_2} & 0 \\ 0 & 0 & \frac{\partial q_3}{\partial p_3} \end{bmatrix}^{-1} \begin{pmatrix} q_1 \\ q_2 \\ q_3 \end{pmatrix}. \quad (8)$$

Equation (8) implies that the resulting pricing structure is identical to that under a merger between Firms 1 and 2. In this case, Firm 1 jointly sets p_1 and p_2 to maximize combined profits, thereby internalizing the competitive externality between the two products. Consequently, the cross-price effects are fully incorporated into the pricing decision, leading to higher markups for both products relative to the baseline. This outcome suggests that OEM arrangements between competitors can be economically equivalent to a horizontal merger, thereby raising potential anticompetitive concerns.¹²

3 Data and Industry Background

To examine OEM arrangements between competing firms, this study examines the Japanese automobile industry, focusing on the kei car segment. The analysis combines multiple data sources to construct a detailed dataset suitable for this analysis. This section provides an overview of the institutional background and presents descriptive statistics on the Japanese automobile market, the kei car segment, and the prevalence of OEM relationships within this segment.

3.1 Data

The analysis uses data on the Japanese automobile market from 2006 to 2016, combining information on sales, product characteristics, OEM relationships, market size, and household demographics. Sales data are obtained from Japanese automobile industry associations and cover regular passenger cars, kei cars, and imported vehicles, while product characteristics, including prices, are collected from automobile catalog sources. A key feature of the dataset is its vehicle-model-level information on OEM relationships. This information identifies whether each model is produced in-house or procured from another manufacturer and makes it possible to match “twin” models that share the same

¹²Note that this result relies on the three-by-three structure. In a general multi-firm, multi-product setting, the effects are likely to be ambiguous.

production process but are sold under different brand names. Market size and household demographics are obtained from public statistical sources. Market size is defined as the number of households, and household expenditure patterns by income group are used to capture consumer heterogeneity in the demand estimation. Details on data construction are provided in Appendix A.

3.2 The Japanese Automobile Market and the Kei Car Segment

This section provides the institutional background of the Japanese automobile market, which serves as the foundation for the analysis of OEM relationships. A distinctive feature of the market is the presence of the kei car (mini-vehicle) segment, an institutionally unique part of the domestic passenger car industry.

Kei cars are designed to accommodate Japan’s road and urban conditions and are defined by a regulatory framework that grants preferential tax treatment in exchange for strict limits on vehicle size and engine displacement. Specifically, regulations mandate that kei cars have an engine displacement of 660cc or less, a length of up to 3.4 meters, a width of up to 1.48 meters, and a height of up to 2.0 meters. These dimensions make them generally smaller than Europe’s A-segment vehicles. Throughout this paper, all other passenger vehicles are referred to as “regular cars.”

To characterize the kei car segment, it is convenient to compare kei car attributes with those of regular cars. Following the standard literature, the focus is on three key characteristics. First is fuel efficiency, measured in kilometers per liter (km/L). Second is vehicle size, defined as the sum of length, width, and height. Third is the power-to-weight ratio, calculated as horsepower divided by vehicle weight, which serves as a proxy for driving performance.

Table 1 compares the product characteristics and market composition of regular and kei cars. Panel A reports descriptive statistics, indicating that kei cars are significantly smaller and exhibit lower power-to-weight ratios, reflecting the physical and technical constraints imposed by Japan’s regulatory standards. Consistent with these specifications, the panel also shows that kei cars are priced lower than regular cars and, on average, achieve higher sales per model. Panel B shows that, driven by these economic advantages, kei cars consistently account for over 30 percent of total new vehicle sales, establishing them as a crucial segment of the industry.

Finally, the market structure of the regular car and kei car segments differs sharply. Using annual data over the 11-year sample period, Table 2 reports manufacturer market shares for eight domestic automakers—Toyota, Honda, Nissan, Mazda, Subaru, Suzuki, Mitsubishi, and Daihatsu—as well as foreign brands.¹³ In the regular car segment, Toyota alone accounts for roughly one half of total sales on average, with Nissan and Honda

¹³During the sample period, Daihatsu was a subsidiary of Toyota. Given the associated voting rights, I treat the two firms as a single entity in the structural analysis.

Table 1: Product Characteristics and Market Composition: Descriptive Statistics

| <i>Panel A: Product characteristics ($N_{products} = 1,670$)</i> | | | | |
|---|-----------|-----------|--------|------------|
| | Mean | Std. Dev. | Min | Max |
| Sales (units) | 26,662.52 | 41,457.96 | 51.00 | 317,675.00 |
| Regular cars | 22,441.43 | 35,572.01 | 51.00 | 317,675.00 |
| Kei cars | 40,108.65 | 54,145.07 | 104.00 | 234,994.00 |
| Price (million JPY) | 1.95 | 0.74 | 0.68 | 3.97 |
| Regular cars | 2.20 | 0.67 | 0.97 | 3.97 |
| Kei cars | 1.17 | 0.24 | 0.68 | 1.98 |
| Fuel efficiency (km/L) | 16.83 | 5.32 | 7.70 | 40.80 |
| Regular cars | 15.56 | 4.71 | 7.70 | 40.80 |
| Kei cars | 20.87 | 5.13 | 13.60 | 37.00 |
| Size (m) | 11.21 | 2.47 | 5.91 | 19.15 |
| Regular cars | 12.14 | 2.06 | 7.52 | 19.15 |
| Kei cars | 8.25 | 0.70 | 5.91 | 9.56 |
| Power-to-weight ratio (HP/kg) | 0.091 | 0.025 | 0.045 | 0.226 |
| Regular cars | 0.099 | 0.023 | 0.058 | 0.226 |
| Kei cars | 0.065 | 0.007 | 0.045 | 0.082 |
| <i>Panel B: Market composition ($N_{years} = 11$)</i> | | | | |
| | Mean | Std. Dev. | Min | Max |
| Market share (%) | | | | |
| Regular cars | 64.15 | 2.77 | 58.52 | 68.12 |
| Kei cars | 35.85 | 2.77 | 31.88 | 41.48 |

Notes: Panel A reports descriptive statistics for product characteristics. Price is in million JPY; fuel efficiency is kilometers per liter (km/L); size is the sum of length, width, and height (in meters); and the horsepower-per-weight ratio is horsepower divided by total weight. Statistics are reported for the full sample, regular cars, and kei cars. The sample is restricted to general passenger cars priced at or below 4 million JPY. Panel B summarizes annual market shares for regular cars and kei cars.

trailing at some distance. By contrast, the kei car segment is dominated by Daihatsu and Suzuki, which together account for approximately 60 percent of sales on average. Foreign manufacturers are effectively absent from the kei car segment.¹⁴ Reflecting the institutional specificity of the segment, both entry by foreign manufacturers and exports are extremely limited. Production therefore takes place almost exclusively at domestic plants. The effectively closed nature of the kei car market simplifies the empirical analysis by allowing the model to largely abstract from international factors.

3.3 OEM in the Kei Car Segment

Next, to inform the empirical analysis, this section describes the structure of OEM arrangements, their historical evolution, and the economic motivations and benefits under-

¹⁴Nearly all kei cars are domestically produced. The only notable exception is the Caterham Seven 160, which sources its engine from Suzuki. Owing to its negligible market share, this imported kei car is excluded from the dataset.

Table 2: Maker Shares within Segment: Regular vs. Kei (% , across years)

| Maker | Regular cars | | | | Kei cars | | | |
|------------|--------------|-----------|-------|-------|----------|-----------|-------|-------|
| | Mean | Std. Dev. | Min | Max | Mean | Std. Dev. | Min | Max |
| Toyota | 49.97 | 1.67 | 46.90 | 52.38 | 0.72 | 0.86 | 0.00 | 2.08 |
| Honda | 15.88 | 1.59 | 13.58 | 18.42 | 15.66 | 5.42 | 8.48 | 22.56 |
| Nissan | 14.57 | 2.37 | 11.24 | 18.47 | 9.24 | 1.48 | 7.26 | 11.63 |
| Mazda | 6.07 | 0.60 | 5.46 | 7.68 | 2.79 | 0.33 | 2.20 | 3.18 |
| Subaru | 3.86 | 0.88 | 2.89 | 5.09 | 2.93 | 1.24 | 1.44 | 4.70 |
| Suzuki | 3.11 | 0.38 | 2.32 | 3.71 | 30.50 | 1.92 | 28.20 | 33.19 |
| Mitsubishi | 2.06 | 0.53 | 1.17 | 2.87 | 4.58 | 1.76 | 2.77 | 8.26 |
| Daihatsu | 0.25 | 0.20 | 0.07 | 0.73 | 33.59 | 2.91 | 29.70 | 37.83 |
| Foreign | 4.24 | 1.08 | 2.77 | 5.60 | 0.00 | 0.00 | 0.00 | 0.00 |

Notes: Values are percentage shares of annual sales within each segment, computed across years ($N_{\text{years}} = 11$). A value of 0 denotes no entry by the maker in that segment-year. Lexus is included in Toyota because it is Toyota’s luxury sub-brand.

lying outsourcing in this market.

To illustrate the prevalence of OEM arrangements, Table 3 documents the annual number of OEM-branded models. Over the sample period, the total number of available kei car models ranges from 33 to 39 per year. Notably, in some years, nearly 40 percent of these models are OEM-branded. These figures confirm that OEM is not a niche practice but a pervasive feature of the market.¹⁵

Table 3: OEM and In-House Model Counts in the Kei Car Segment

| Product type | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|-----------------|------|------|------|------|------|------|------|------|------|------|------|
| In-house models | 30 | 29 | 30 | 27 | 27 | 21 | 22 | 22 | 19 | 20 | 21 |
| OEM models | 7 | 9 | 10 | 10 | 12 | 13 | 15 | 15 | 14 | 13 | 13 |
| Total | 37 | 38 | 40 | 37 | 39 | 34 | 37 | 37 | 33 | 33 | 34 |

Notes: Each cell reports the number of models. “In-house” denotes models manufactured and sold by the same firm, whereas “OEM models” are supplied by a contract manufacturer and sold under another brand.

Crucially, all OEM contracts in the kei car market are formed between competing firms. Table 4 details the supply relationships observed in 2016. The table reveals a clear separation of roles among the manufacturers. While Daihatsu, Suzuki, Honda, and Mitsubishi retain in-house production capabilities, actual production is highly concentrated. Daihatsu and Suzuki serve as the primary CMs, supplying vehicles to multiple rival brands. Honda, by contrast, operates independently, neither supplying others nor procuring OEM vehicles. The remaining firms primarily sell products manufactured by the CMs under their own brand names.

¹⁵Although OEM production occurs in other vehicle segments, it is comparatively limited: only six non-kei OEM-branded models appear over the sample period. For simplicity, the analysis focuses exclusively on the kei car segment.

Table 4: OEM Relationships in the Kei Car Market (2016)

| CM \ OEM | Daihatsu | Suzuki | Honda | Nissan | Mitsubishi | Mazda | Subaru | Toyota |
|------------|----------|--------|-------|--------|------------|-------|--------|--------|
| In-house | 7 | 7 | 5 | | 1 | | | |
| Daihatsu | | | | | | | 4 | 1 |
| Suzuki | | | | 2 | 1 | 5 | | |
| Mitsubishi | | | | 1 | | | | |
| Total | 7 | 7 | 5 | 3 | 2 | 5 | 4 | 1 |

Notes: The “In-house” row reports the number of models manufactured and sold by each firm. Subsequent rows list contract manufacturers (CMs); columns list original equipment manufacturers (OEMs). Cell values denote the number of models supplied by the CM in each row to the OEM in each column. Blank cells indicate no supply. Suzuki supplies to Nissan, Mitsubishi, and Mazda; Daihatsu supplies to Toyota and Subaru.

The current market structure reflects a long-term divergence between manufacturing and retail. Historically, the number of manufacturers in the kei car market has declined, even as the number of companies participating in sales has increased. In 1955, Japan’s Ministry of International Trade and Industry (MITI) introduced the “People’s Car Concept,” which called for the development of affordable and accessible automobiles for the general public. Kei cars were especially well suited to meet this demand. That year, six manufacturers—Daihatsu, Suzuki, Subaru, Mazda, Honda, and Mitsubishi—were engaged in both production and sales. However, from the late 1990s onward, Mazda and Subaru exited in-house production and shifted to OEM supply arrangements. Furthermore, after 2000, companies such as Nissan and Toyota entered the market by sourcing products on an OEM basis. As a result, while upstream production consolidated into four firms, the downstream sales market expanded to eight brands (see Table 5).

Table 5: Historical Timeline of Kei Car Manufacturers

| Year | Events |
|-------------|--|
| Before 1998 | Six manufacturers (Daihatsu, Suzuki, Subaru, Mazda, Honda, Mitsubishi) produced and sold kei cars. |
| 1998 | Mazda completes shift to Suzuki OEM for all kei cars. |
| 2002 | Nissan enters via Suzuki OEM supply. |
| 2011 | Subaru completes shift to Daihatsu OEM for all kei cars. |
| 2012 | Toyota enters via Daihatsu OEM supply. |

These OEM agreements are tied to the Japanese distribution system. In this market, manufacturers distribute vehicles to consumers through dealership networks. A defining feature of this system is exclusive dealing: most dealers, whether manufacturer-operated or independent, sell vehicles from only a single manufacturer. As a result, manufacturers can effectively be viewed as vertically integrated firms spanning production and retail

distribution.

In this context, OEM agreements offer mutual benefits by utilizing these distinct dealer networks. For CMs, supplying OEM-branded vehicles allows them to distribute their manufactured units through their partners' exclusive networks, thereby increasing total production volume and achieving scale economies. Osamu Suzuki, then-chairman of Suzuki, emphasized the significant impact of scale economies in 2002, stating, "Automobiles benefit greatly from mass production. The difference between producing 120,000 units and 60,000 units of a single model can reduce per-unit costs by as much as 30 percent."¹⁶ Conversely, for OEM firms, sourcing products allows them to utilize their existing sales networks to reach new customer segments without incurring the substantial development costs. Carlos Ghosn, then-CEO of Nissan, stated in 2002 that "OEM agreements provide opportunities to reach customers I had not previously engaged with," highlighting the benefits of product lineup expansion and customer acquisition for companies that previously focused solely on regular passenger cars.¹⁷

4 Model

To evaluate the competitive implications of OEM arrangements, I develop a multi-firm, multi-product model that closely reflects the institutional features of the industry. Section 4.1 discusses alternative candidate models of firm conduct on the supply side, while Section 4.2 formally specifies the marginal cost function.

4.1 Candidate Supply Models

This section examines four candidate scenarios, focusing on the alternative pricing structures introduced in Section 2. The key distinction concerns the pricing of OEM-branded products: whether linear pricing results in double marginalization, whether the downstream OEM determines prices, or whether the upstream CM determines prices. Scenario 1 features linear pricing, while Scenarios 2 and 3 consider non-linear pricing with OEM-led and CM-led arrangements, respectively. In addition, a fourth, supplemental scenario with coordinated non-linear pricing is considered, which is not introduced in Section 2.

Scenario 1: Linear Pricing Model The analysis first clarifies the timing of price determination under linear pricing in the model. In the market under study, most firms sell in-house products and engage in OEM-branded production, either by supplying products as a CM or by selling them at retail. The price of an in-house product is set directly, denoted by p^{in} , whereas the price of an OEM-branded product is determined under linear pricing as the sum of the wholesale price w and the retail margin m^r , that

¹⁶Taguchi (2012), Nikkei Business Daily, August 10, 2002. The cost reduction here likely includes fixed costs, lowering the average cost per unit.

¹⁷Taguchi (2012), Nikkei Business Daily, April 11, 2002.

is, $p = m^r + w$. I assume that p^{in} , w , and m^r are determined simultaneously. This assumption reflects the fact that a firm sets the final retail prices of its in-house products while choosing either the wholesale price or the retail margin for OEM-branded products. In such an environment, it is theoretically difficult to justify a sequential structure in which the wholesale price w is set first, followed by the determination of in-house product prices and retail margins.¹⁸ Although sequential pricing frameworks are also used in settings with a clear manufacturer–retailer separation, such frameworks are less directly applicable to the horizontal subcontracting environment analyzed here, where a single firm may play both upstream and downstream roles across different products.

Within the supply-side framework described above, products are classified into three groups: (1) in-house models; (2) models that the firm manufactures as a CM for partner brands; and (3) models that the firm sells under its own brand but sources from other manufacturers as an OEM. Let J_t denote the set of all products in period t , including regular and kei cars, and let J_{ft}^{in} , J_{ft}^{cm} , and $J_{ft}^{oem} \subseteq J_t$ denote the respective sets of products for firm f in period t . The firm directly determines the retail price p_{jt}^{in} for products in J_{ft}^{in} . For products in J_{ft}^{cm} , it sets the wholesale price w_{jt} , while for products in J_{ft}^{oem} , it chooses the retail markup m_{jt}^r . These sets are not necessarily non-empty for all firms. For instance, Honda, which primarily engages in in-house production and sales, would have $J_{ft}^{cm} = \emptyset$ and $J_{ft}^{oem} = \emptyset$. The profit function for firm f in period t is given by

$$\begin{aligned} \pi_{ft} = & \sum_{j^{in} \in J_{ft}^{in}} p_{j^{in}t}^{in} q_{j^{in}t}(\mathbf{p}_t(\mathbf{p}_t^{in}, \mathbf{w}_t, \mathbf{m}_t^r)) + \sum_{j^{cm} \in J_{ft}^{cm}} w_{j^{cm}t} q_{j^{cm}t}(\mathbf{p}_t(\mathbf{p}_t^{in}, \mathbf{w}_t, \mathbf{m}_t^r)) \\ & + \sum_{j^{oem} \in J_{ft}^{oem}} m_{j^{oem}t}^r q_{j^{oem}t}(\mathbf{p}_t(\mathbf{p}_t^{in}, \mathbf{w}_t, \mathbf{m}_t^r)) - C_{ft}(\mathbf{q}_{ft}(\mathbf{p}_t(\mathbf{p}_t^{in}, \mathbf{w}_t, \mathbf{m}_t^r))), \end{aligned} \quad (9)$$

where $q_{jt}(\cdot)$ denotes the quantity of product j sold in period t , which depends on the vector of retail prices $\mathbf{p}_t(\mathbf{p}_t^{in}, \mathbf{w}_t, \mathbf{m}_t^r)$, and $C_{ft}(\cdot)$ represents firm f 's total variable cost in period t .

Under the assumption of Bertrand-Nash equilibrium, the first-order conditions with

¹⁸Simultaneous price determination is often assumed in the literature on vertical relationships (e.g., Draganska, Klapper, and Berto Villas-Boas, 2010; Ho and Lee, 2017; Crawford et al., 2018).

respect to p_{jt}^v , w_{kt} , and m_{tt}^r are given by¹⁹

$$\begin{aligned}
q_{j^{in}t} + \sum_{j'^{in} \in J_{ft}^{in}} \left(p_{j'^{in}t}^{in} - \frac{\partial C_{ft}}{\partial q_{j'^{in}t}} \right) \frac{\partial q_{j'^{in}t}}{\partial p_{j^{in}t}^{in}} + \sum_{j'^{cm} \in J_{ft}^{cm}} \left(w_{j'^{cm}t} - \frac{\partial C_{ft}}{\partial q_{j'^{cm}t}} \right) \frac{\partial q_{j'^{cm}t}}{\partial p_{j^{in}t}^{in}} \\
+ \sum_{j'^{oem} \in J_{ft}^{oem}} \left(m_{j'^{oem}t}^r - \frac{\partial C_{ft}}{\partial q_{j'^{oem}t}} \right) \frac{\partial q_{j'^{oem}t}}{\partial p_{j^{in}t}^{in}} = 0, \quad \forall j^{in} \in J_{ft}^{in}, \quad \text{for } f = 1, \dots, N_f,
\end{aligned} \tag{10}$$

$$\begin{aligned}
q_{j^{cm}t} + \sum_{j'^{in} \in J_{ft}^{in}} \left(p_{j'^{in}t}^{in} - \frac{\partial C_{ft}}{\partial q_{j'^{in}t}} \right) \frac{\partial q_{j'^{in}t}}{\partial w_{j^{cm}t}} + \sum_{j'^{cm} \in J_{ft}^{cm}} \left(w_{j'^{cm}t} - \frac{\partial C_{ft}}{\partial q_{j'^{cm}t}} \right) \frac{\partial q_{j'^{cm}t}}{\partial w_{j^{cm}t}} \\
+ \sum_{j'^{oem} \in J_{ft}^{oem}} \left(m_{j'^{oem}t}^r - \frac{\partial C_{ft}}{\partial q_{j'^{oem}t}} \right) \frac{\partial q_{j'^{oem}t}}{\partial w_{j^{cm}t}} = 0, \quad \forall j^{cm} \in J_{ft}^{cm}, \quad \text{for } f = 1, \dots, N_f,
\end{aligned} \tag{11}$$

$$\begin{aligned}
q_{j^{oem}t} + \sum_{j'^{in} \in J_{ft}^{in}} \left(p_{j'^{in}t}^{in} - \frac{\partial C_{ft}}{\partial q_{j'^{in}t}} \right) \frac{\partial q_{j'^{in}t}}{\partial m_{j^{oem}t}^r} + \sum_{j'^{cm} \in J_{ft}^{cm}} \left(w_{j'^{cm}t} - \frac{\partial C_{ft}}{\partial q_{j'^{cm}t}} \right) \frac{\partial q_{j'^{cm}t}}{\partial m_{j^{oem}t}^r} \\
+ \sum_{j'^{oem} \in J_{ft}^{oem}} \left(m_{j'^{oem}t}^r - \frac{\partial C_{ft}}{\partial q_{j'^{oem}t}} \right) \frac{\partial q_{j'^{oem}t}}{\partial m_{j^{oem}t}^r} = 0. \quad \forall j^{oem} \in J_{ft}^{oem}, \quad \text{for } f = 1, \dots, N_f.
\end{aligned} \tag{12}$$

Thus, there are $n_{J_t^{in}} + n_{J_t^{cm}} + n_{J_t^{oem}}$ first-order conditions. Correspondingly, $(n_{J_t^{in}} + n_{J_t^{cm}} + n_{J_t^{oem}}) \times (n_{J_t^{in}} + n_{J_t^{cm}} + n_{J_t^{oem}})$ a block response matrix Δ_t^{Model1} and an ownership matrix T_t^{Model1} are introduced, defined as

$$\Delta_t^{Model1} \equiv \begin{bmatrix} \frac{\partial q_{J_{ft}^{in}}}{\partial p_{J_{ft}^{in}}^{in}} & \frac{\partial q_{J_{ft}^{cm}}}{\partial p_{J_{ft}^{in}}^{in}} & \frac{\partial q_{J_{ft}^{oem}}}{\partial p_{J_{ft}^{in}}^{in}} \\ \frac{\partial q_{J_{ft}^{in}}}{\partial w_{J_{ft}^{cm}}} & \frac{\partial q_{J_{ft}^{cm}}}{\partial w_{J_{ft}^{cm}}} & \frac{\partial q_{J_{ft}^{oem}}}{\partial w_{J_{ft}^{cm}}} \\ \frac{\partial q_{J_{ft}^{in}}}{\partial m_{J_{ft}^{oem}}^r} & \frac{\partial q_{J_{ft}^{cm}}}{\partial m_{J_{ft}^{oem}}^r} & \frac{\partial q_{J_{ft}^{oem}}}{\partial m_{J_{ft}^{oem}}^r} \end{bmatrix}, \quad T_{t,(j,j')}^{Model1} = \begin{cases} 1 & \text{if } (j, j') \in J_{ft}^{in} \cup J_{ft}^{cm} \cup J_{ft}^{oem}, \\ 0 & \text{otherwise.} \end{cases} \tag{13}$$

Under the assumption of simultaneous price determination, the response matrix Δ_t^{Model1} in Equation (13) has a simpler interpretation. Specifically, under simultaneous determination, it is assumed that for any product $j \in J_t$ and any other product $k \in J_t \setminus \{j\}$, the

¹⁹The assumption of Bertrand-Nash price competition underlying these first-order conditions is standard in the automobile literature and is especially plausible in the Japanese automobile market, where manufacturers typically announce a manufacturer's suggested retail price.

following relationships hold:

$$\begin{bmatrix} \frac{\partial p_{jt}}{\partial w_{jt}} & \frac{\partial p_{kt}}{\partial w_{jt}} \\ \frac{\partial p_{jt}}{\partial w_{kt}} & \frac{\partial p_{kt}}{\partial w_{kt}} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad \begin{bmatrix} \frac{\partial p_{jt}}{\partial m_{jt}^r} & \frac{\partial p_{kt}}{\partial m_{jt}^r} \\ \frac{\partial p_{jt}}{\partial m_{kt}^r} & \frac{\partial p_{kt}}{\partial m_{kt}^r} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}. \quad (14)$$

This implies that each price p_{jt} depends only on its own markup and wholesale price, without direct cross-effects across products.²⁰ Therefore, for any product $l \in J_t$, the following relationship holds:²¹

$$\frac{\partial q_{jt}}{\partial p_{lt}^{in}} = \frac{\partial q_{jt}}{\partial p_{lt}}, \quad \frac{\partial q_{jt}}{\partial w_{lt}} = \sum_{j' \in J_t} \frac{\partial q_{jt}}{\partial p_{j't}} \frac{\partial p_{j't}}{\partial w_{lt}} = \frac{\partial q_{jt}}{\partial p_{lt}}, \quad \frac{\partial q_{jt}}{\partial m_{lt}^r} = \sum_{j' \in J_t} \frac{\partial q_{jt}}{\partial p_{j't}} \frac{\partial p_{j't}}{\partial m_{lt}^r} = \frac{\partial q_{jt}}{\partial p_{lt}}. \quad (15)$$

Taken together, these expressions imply that changes in p^{in} , w , and m^r affect demand only through the induced change in the final retail price. That is, in terms of their impact on demand, an increase in the in-house price, wholesale price, or retail margin translates into the same increase in the final retail price faced by consumers.

Incorporating this structure, the first-order conditions are rewritten in matrix notation. Let $\frac{\partial C_{ft}}{\partial q_{j^{in}t}} = c_{j^{in}t}$, $\frac{\partial C_{ft}}{\partial q_{j^{cm}t}} = c_{j^{cm}t}$, and $\frac{\partial C_{ft}}{\partial q_{j^{oem}t}} = c_{j^{oem}t}$ denote marginal costs, and let these terms be collected in the vectors c_t^{in} , c_t^{cm} , and c_t^{oem} . The markup is then expressed as

$$\begin{pmatrix} p_t^{in} - c_t^{in} \\ w_t - c_t^{cm} \\ m_t^r - c_t^{oem} \end{pmatrix} = -(T_t^{Model1} \circ \Delta_t^{Model1})^{-1} \bar{q}_t(\mathbf{p}_t(p_t^{in}, \mathbf{w}_t, \mathbf{m}_t^r)), \quad \text{where } \bar{q}_t = \begin{pmatrix} q_{ft}^{in} \\ q_{ft}^{cm} \\ q_{ft}^{oem} \end{pmatrix}. \quad (16)$$

Equation (16) performs essentially the same operation as Equation (5) in Section 2. Under this pricing structure, the firm sets the retail prices of its own products while taking OEM-branded products into account and determines the wholesale prices of OEM-branded products while considering its own products, reflecting the vertical pricing mechanisms. This leads to a weakening of retail price competition.

Scenario 2: OEM-led Non-linear Pricing Model Under non-linear pricing, the final retail price is determined directly for all products, while the allocation of profits between firms is fixed ex post, as discussed in Section 2. In this scenario, the downstream

²⁰In the literature on vertical relationships, these situations are described as “vertical Nash” pricing games and have been extensively studied (Choi, 1991; Besanko, Gupta, and Jain, 1998; Sudhir, 2001). For clarity, this paper supposes that downstream firms determine the retail margin, but this is essentially equivalent to such a vertical Nash framework.

²¹For a more detailed discussion on the response matrix, see Appendix B

OEMs determine the final retail price. The profit for firm f is given by

$$\pi_{ft} = \sum_{j \in J_{ft}^{Model2}} p_{jt} q_{jt}(\mathbf{p}_t) - C_{ft}(\mathbf{q}_{ft}(\mathbf{p}_t)), \quad (17)$$

where $J_{ft}^{Model2} \subseteq J_t$ denotes the set of products supplied by firm f in period t , including products sold under OEM arrangements but excluding products manufactured as a CM for other firms; that is, it consists only of products that the firm sells at retail. As in the previous scenario, $q_{jt}(\cdot)$ denotes the quantity of product j , and $C_{ft}(\cdot)$ represents the firm's total cost. Under the assumption of Bertrand-Nash equilibrium, the first-order conditions are

$$q_{jt} + \sum_{j' \in J_{ft}^{Model2}} (p_{j't} - \frac{\partial C_{ft}}{\partial q_{j't}}) \frac{\partial q_{j't}}{\partial p_{jt}} = 0, \quad \forall j \in J_{ft}^{Model2}, \quad \text{for } f = 1, \dots, N_f. \quad (18)$$

Let T_t^{Model2} denote the ownership matrix, while Δ_t represents the matrix of quantity responses to prices. The (j, j') element of the ownership matrix T_t^{Model2} is given by

$$T_{t,(j,j')}^{Model2} = \begin{cases} 1 & \text{if } (j, j') \in J_{ft}^2, \\ 0 & \text{otherwise,} \end{cases}$$

so that $T_{t,(j,j')}^{Model2}$ equals 1 if products j and j' are sold by the same firm, and 0 otherwise. The elements of Δ_t are given by $\frac{\partial q_{jt}}{\partial p_{j't}}$. Thus, the ownership and response matrices are $n_{J_t} \times n_{J_t}$; Equation (17) is then rewritten as follows:

$$p_t - c_t = -(T_t^{Model2} \circ \Delta_t)^{-1} q_t(\mathbf{p}_t). \quad (19)$$

This case presents no additional anticompetitive effects and serves as a competitive benchmark. Even in the absence of OEM production, the ownership matrix would remain unchanged, raising no competitive concerns.

Scenario 3: CM-led Non-linear Pricing Model In this scenario, a situation is considered in which the upstream CM determines the pricing for OEM-branded vehicles. Here, let $J_{ft}^{Model3} \subseteq J_t$ represent the set of products supplied by firm f in period t , including the products it manufactures as a CM for other firms, but excluding the products it sells under OEM arrangements. Similar to Scenario 2, let the ownership matrix be denoted by T_t^{Model3} . The markup is then given by

$$p_t - c_t = -(T_t^{Model3} \circ \Delta_t)^{-1} q_t(\mathbf{p}_t). \quad (20)$$

In this scenario, upstream CMs internalize the profits from OEM-branded models they

produce. By accounting for cannibalization between their own brands and the partners' brands, the CMs engage in merger-like pricing behavior that potentially softens price competition in the kei car segment. Conversely, relative to the OEM-led models, the OEMs' market power is reduced, which may intensify competition. Thus, the net effect is an empirical question.

Scenario 4: Coordinated Non-linear Pricing Model Scenario 4 additionally considers the possibility of collusion within the kei car segment. Several features of this segment make coordinated behavior particularly plausible. First, due to the institutional and technological uniqueness of kei cars, entry by foreign manufacturers is difficult. Second, all eight domestic automobile manufacturers that could plausibly operate in this segment are already present, leaving virtually no potential entrants. The absence of potential entry reduces competitive pressure and facilitates the sustainability of coordination.

Moreover, OEM relationships between competing firms may further reinforce this tendency toward coordination. In practice, effective production in the kei car segment is concentrated among four manufacturers, with Daihatsu and Suzuki standing out as the two largest producers with comparable scale. When price-setting decisions are delegated upstream, as in Scenario 3 where the CM determines prices, the limited number of firms involved makes coordination easier to sustain.²² In addition, communication associated with subcontracting arrangements may further facilitate coordination within the market.

Pricing in this setting is modeled such that firms coordinate pricing within the kei car segment, while engaging in standard Bertrand competition in the regular car segment. This distinction is captured by the ownership matrix T_t^{Model4} , in which all elements corresponding to pairs of products within the kei car segment are set to one, while ownership relationships for regular cars follow those in the previous scenarios. The resulting markup is given by

$$p_t - c_t = -(T_t^{Model4} \circ \Delta_t)^{-1} q_t(\mathbf{p}_t). \quad (21)$$

4.2 Marginal Cost

This section specifies the marginal cost structure required to capture scale economies, which are central to efficiency gains from OEM arrangements. For a given product j in period t , the marginal cost c_{jt} , defined as $c_{jt} \equiv \frac{\partial C_{jt}}{\partial q_{jt}}$, is specified as follows:

$$\ln(c_{jt}) = \gamma_x x_{jt}^s + \gamma_q \ln(Q_{jt}) + \eta_j + \omega_{jt}, \quad (22)$$

²²This mechanism is closely related to the notion of coordinated effects in the merger literature. See Asker and Nocke, 2021; Fabra and Motta, 2018.

where Q_{jt} denotes the total production quantity of vehicles that share the same base platform as product j . Specifically, let q_{jt} denote the production quantity of product j in period t , and let J_{jt} be the set of sibling models built on the same base platform (i.e., twin models). Accordingly, Q_{jt} is given by

$$Q_{jt} = \sum_{b \in J_{jt}} q_{bt}. \quad (23)$$

The presence of scale economies is a natural feature of the automobile industry, implying $\gamma_q < 0$. Scale economies in automobile production may arise for several reasons, including increased bargaining power with input suppliers and greater production efficiency from concentrating output on a single production line. Empirically, a large body of the automotive industry literature documents substantial scale economies in production, with empirical evidence for the U.S. automobile market provided by Berry, Levinsohn, and Pakes (1995) and more recently by Duarte et al. (2025).²³ Anecdotal evidence from industry insiders further underscores the importance of scale economies. As discussed in Section 2, the former chairman of Suzuki explicitly stated that one of the primary motivations for engaging in OEM production was to exploit scale economies.

Next, the remaining variables are described. In the specification given by Equation (22), x_{jt}^s represents observable product characteristics in period t , including fuel efficiency, vehicle size, power-to-weight ratio, and an OEM-switch dummy, with the coefficient vector γ_x capturing their effects on marginal cost. The purpose of the OEM-switch dummy is to capture model transitions from Subaru’s in-house production to an OEM arrangement with Daihatsu, as well as a limited number of similar transitions from Mitsubishi’s in-house production to an OEM arrangement with Suzuki. This variable is included to control for any systematic shifts in marginal costs associated with the switch from in-house manufacturing to OEM sourcing or vice versa, such as transportation expenses or contractual costs, in order to separate them from scale economies. Finally, η_j denotes product fixed effects, capturing time-invariant cost heterogeneity across models, and ω_{jt} represents unobserved cost shocks.

5 Estimation and Inference

This section presents the estimation and inference procedure. The analysis begins by estimating demand to recover substitution patterns. Using these estimates, markups are inferred under the candidate supply models presented in Section 4.1. The preferred model is then selected, and marginal costs are estimated.

²³Scale economies are also related to learning-by-doing, as documented in automobile assembly by Levitt, List, and Syverson (2013). In this analysis of OEM arrangements, however, the focus is on static or engineering sources of scale, such as higher line utilization and bulk purchase discounts.

5.1 Demand Estimation

This section summarizes the demand model, estimation procedure, and key results. Demand is estimated using a standard random-coefficients logit model (Berry, Levinsohn, and Pakes, 1995; Nevo, 2001). The resulting estimates characterize consumer preferences and substitution patterns, providing the foundation for the subsequent supply-side analysis.

Consumers choose among the set of products J_t available in year t and either purchase one vehicle or choose the outside option.²⁴ The indirect utility of consumer i from choosing product j in year t is

$$u_{ijt} = \alpha_i p_{jt} + x_{jt}^d \beta + \lambda_j + \lambda_t + \xi_{jt} + \varepsilon_{ijt}, \quad (24)$$

where the parameter α_i , representing consumer i 's marginal disutility of price, is defined as:

$$\alpha_i = \alpha + \Pi D_i + \Sigma v_i. \quad (25)$$

Here, α captures mean price sensitivity. D_i denotes an observable indicator for the consumer's income group {low, middle, high}, with Π capturing the associated observable heterogeneity. The term v_i represents unobserved heterogeneity, assumed to follow a standard normal distribution, and Σ denotes its standard deviation.

Incorporating income-related heterogeneity into price sensitivity is crucial for recovering realistic substitution patterns, particularly between kei cars and regular cars. As shown in Appendix C, the data exhibit a clear positive relationship between household income and average new-vehicle expenditures. Given the substantial price gap between the kei and regular segments (see Section 3.2), this income heterogeneity serves as a key driver of sorting behavior across vehicle types. Since higher prices typically reflect superior product attributes, accounting for this heterogeneity is essential to recover substitution patterns consistent with observed market realities.²⁵

The term x_{jt}^d denotes a vector of observed product characteristics—including fuel efficiency, vehicle size, and the power-to-weight ratio—with β capturing consumer responses to these attributes. Fixed effects λ_j and λ_t are included to control for systematic variation across brand-type combinations and time periods, where “brand” refers to the company name shown at retail and “type” indicates whether a vehicle is a regular car or a kei car. Unobserved demand shocks specific to product j and time t are captured by ξ_{jt} , while ε_{ijt} denotes individual-level idiosyncratic shocks, assumed to follow a Type I extreme value distribution. The utility of the outside option is normalized as $u_{i0t} = \varepsilon_{i0t}$.

²⁴The market size is defined as the number of households in each year.

²⁵Due to data limitations, consumer heterogeneity cannot be directly modeled for other product characteristics.

The inclusion of brand-type fixed effects is essential to isolate brand equity in the presence of OEM twin cars. Physically identical vehicles sold under different brands often command different market shares, reflecting differences in brand reputation. For example, as noted in Section 3.2, while Daihatsu possesses a strong reputation in the kei car market, its brand power may not extend equally to the regular car segment. By defining fixed effects at the brand-type level (benchmarked relative to Toyota’s regular cars), the analysis controls for these segment-specific brand perceptions.

The demand parameters $\theta := (\alpha, \beta, \Pi, \Sigma)$ are estimated using the generalized method of moments (GMM). The estimation relies on two sets of moments. The first is the standard orthogonality condition between unobserved demand shocks ξ_{jt} and instrumental variables (IV). The second is a micro moment that matches observed expenditure by income group. Using observed demographic data that include average household expenditures on new cars and the income distribution, households are categorized into low-, middle-, and high-income groups, and the corresponding observed averages are matched. This income-based heterogeneity helps pin down price sensitivity in a realistic manner. Estimation follows the BLP algorithm implemented in *PyBLP* (Conlon and Gortmaker, 2020; 2024).

To address the endogeneity of price, I employ two types of IVs. First, following Gandhi and Houde (2019) and Conlon and Gortmaker (2020), differentiation instruments are constructed based on distances in product characteristics x_{jt}^d . Second, cost shifters excluded from demand are utilized. Specifically, these are indicators for the transition of certain Subaru and Mitsubishi kei models from in-house production to OEM sourcing. These regime changes represent shifts in marginal costs that do not directly affecting consumer demand and therefore serve as valid instruments.

Table 6 presents the demand estimates. The mean price coefficient α is negative, confirming that the average consumer derives disutility from higher prices. The estimated interaction terms Π reveal heterogeneity: lower-income consumers exhibit higher price sensitivity, whereas higher-income households are less responsive to price changes. The positive estimate for Σ indicates additional unobserved heterogeneity in price sensitivity. Furthermore, the positive coefficients for β confirm that consumers value improvements in observed product attributes. Taken together, these estimates imply an average own-price elasticity of -2.92. This magnitude is similar to those reported for automobiles. Since elasticity estimates differ across studies, the estimate is reasonable given differences in sample composition and the market studied.

The right panel of Table 6 reports selected brand-type fixed effects λ_j . The results indicate that consumers highly value kei cars sold by Daihatsu and Suzuki. In contrast, kei models supplied via OEM arrangements by Toyota, Nissan, and Subaru are less valued by consumers. This suggests that Daihatsu and Suzuki enjoy substantial brand equity specific to the kei segment, a finding consistent with their dominant market positions. For

context, the table also reports coefficients for foreign manufacturers, which are generally perceived as luxury brands in the domestic market. See Appendix C for full results.

Table 6: Demand Estimation Results

| Variable | Coef. (SE) | Variable | Coef. (SE) |
|-----------------------|-----------------|---------------------------|----------------|
| α, β | | λ_j | |
| Constant | -14.859 (0.555) | Daihatsu \times Kei | 0.968 (0.161) |
| Price | -2.290 (0.211) | Daihatsu \times Regular | -3.099 (0.147) |
| Fuel efficiency | 0.190 (0.008) | Nissan \times Kei | 0.300 (0.221) |
| Size | 0.505 (0.038) | Nissan \times Regular | -0.236 (0.100) |
| Power-to-weight ratio | 20.795 (3.504) | Subaru \times Kei | -1.375 (0.165) |
| Π | | Subaru \times Regular | -0.473 (0.165) |
| Price: low-income | -0.432 (0.086) | Suzuki \times Kei | 1.002 (0.189) |
| Price: middle-income | 0.380 (0.066) | Suzuki \times Regular | -1.748 (0.148) |
| Price: high-income | 0.652 (0.063) | Toyota \times Kei | -1.851 (0.234) |
| Σ | | Mercedes | 1.148 (0.278) |
| Price | 0.480 (0.115) | Volkswagen | 0.705 (0.208) |
| Observations | 1,670 | | |

Notes: Standard errors in parentheses. Only a subset of λ_j estimates is reported; remaining variables omitted for brevity.

5.2 Model Selection

This section describes the model selection procedure among the four supply-side models and the estimation of cost function parameters. Given the estimated demand parameters and using the domestic nature of kei cars, the analysis computes implied markups and marginal costs for each candidate model, eliminates implausible specifications, and then proceeds with formal model selection.

A critical prerequisite for this analysis is obtaining accurate production quantities. To precisely quantify scale economies with respect to quantities Q_{jt} , a key variable determining cost efficiency, the supply-side estimation sample is restricted to kei cars. While sales quantities provide a reasonable proxy for production q_{jt} , this assumption does not hold for imported vehicles or globally marketed models (Berry, Levinsohn, and Pakes, 1995). In contrast, kei cars are subject to Japan-specific regulations and are generally not exported directly overseas, allowing domestic sales quantities to serve as a reliable proxy. Given that this study focuses on competition in the kei car market, this restriction is reasonable. It is important to note that while the first-stage demand estimation utilizes the full sample (as product characteristics are observable for all types), the formal model selection and cost parameter estimation are limited strictly to the kei car subsample.

To distinguish between the competing supply-side specifications, the analysis employs the Rivers–Vuong (Vuong, 1989; Rivers and Vuong, 2002) test based on differences in

GMM objective functions. The implementation specifically follows the practical guidance of Duarte et al. (2025). Their approach builds on the falsification framework of Berry and Haile (2014) and is particularly tailored to settings with scale economies, making it suitable for this context.

The joint estimation and model selection proceeds in four steps. (i) Using the demand estimates, markups and marginal costs are recovered for each candidate supply model m from $p_{jt} = \text{markup}_{jt}(\theta) + c_{jt}(w_x, \gamma_q)$ and models that imply implausible outcomes (e.g., negative marginal costs) are discarded. (ii) For each remaining model, (γ_x^m, γ_q^m) is estimated using two-stage least squares (2SLS) to address the endogeneity of Q_{jt} with respect to the supply shock ω_{jt}^m , using instruments z_{jt} . (iii) Given that the cost function is pinned down in (ii), model selection relies only on the variation in the instruments not already used to identify the cost parameters. To isolate the remaining exogenous variation, z is residualized with respect to the regressors used in the cost equation, and the residual is denoted by z^e . If the (unknown) true model is Model m^* , the orthogonality condition $E[\omega_{jt}^{m^*} | x_{jt}^s, z_{jt}] = 0$ should hold. Lack of fit is measured with the GMM objective function, $\mathcal{Q}_m = g_m' W g_m$, where $g_m = E[z_{jt}^e \omega_{jt}^m]$ and W is the weight matrix.²⁶ (iv) Finally, for a pairwise comparison between two models, the null hypothesis is $H_0^{RV} : \mathcal{Q}_1 = \mathcal{Q}_2$, with alternative hypotheses $H_1^{RV} : \mathcal{Q}_1 < \mathcal{Q}_2$ or $H_2^{RV} : \mathcal{Q}_2 < \mathcal{Q}_1$. The Rivers-Vuong test statistic is defined as

$$T^{RV} = \frac{\sqrt{n}(\mathcal{Q}_1 - \mathcal{Q}_2)}{\sigma}, \quad (26)$$

where σ/\sqrt{n} represents the asymptotic standard error of the difference in objective functions. Instrument strength is diagnosed with the Duarte et al. (2024) F statistic tailored to the RV test to guard against weak IV size distortions. In addition, because multiple models are compared, model confidence set (MCS) is constructed, allowing more than one model to be retained while controlling the family-wise error rate.

To identify both firm conduct and the cost structure, the procedure requires two or more economically distinct IVs, as emphasized by Duarte et al. (2025). Three sets of IVs are employed, each with a distinct source of variation. The first instrument counts the number of rival products in the same segment (kei car segment) as product j , excluding products sold by j 's own firm. This captures within-segment competitive pressure and affects markups. The second set consists of dummies for 2008 and 2013, corresponding to exogenous demand shocks from the global financial crisis and the pre-tax surge in purchases ahead of the 2014 consumption tax increase. These shocks shifted demand—especially in 2013—and thereby altered markups and production quantities. The third instrument is a dummy for the post-OEM-switch period for Subaru, constructed analogously to the post merger indicator in Miller and Weinberg (2017). During the sample

²⁶For details, see Appendix D.

period, Subaru entered into an OEM arrangement, leading to a concentration of production among the top three manufacturers. This structural change may have affected firm conduct, increasing the likelihood of cooperative behavior. These three sets of instruments capture distinct sources of exogenous variation and affect outcomes through different economic channels, satisfying the requirement for economically distinct IVs.

6 Results

This section reports the supply-side findings: it assesses markups, conducts model selection tests, and estimates marginal costs. Section 6.1 eliminates linear pricing based on the recovered markups. Section 6.2 performs formal model selection tests to reject coordinated pricing, evaluates the remaining two models, and draws conclusions regarding anti-competitive effects. Finally, Section 6.3 presents the marginal cost estimates, with a particular focus on OEM efficiency.

6.1 Price-Cost Margin

Based on the estimated demand parameters, the markups under each supply-side model are recovered. As a preliminary step, the validity of the linear pricing model (Model 1) is examined. The price-cost margin (PCM) is defined as the ratio of the recovered markup to the retail price.²⁷

Figure 2(a) plots the distribution of PCMs for each model. The results for Model 1 reveal a fundamental inconsistency: the distribution extends beyond one. A PCM greater than one implies a negative marginal cost, which is economically implausible. As shown in Table 7, approximately 2 percent of observations under linear pricing exhibit negative marginal costs, with the maximum PCM reaching 131 percent. These findings clearly indicate model misspecification, leading to the exclusion of Model 1 from the subsequent analysis.

Next, the non-linear pricing models (Models 2, 3, and 4) are considered. Figure 2(b) displays the PCM distributions restricted to kei cars. In contrast to linear pricing, under all non-linear specifications no observations exhibit PCMs greater than one. Consistent with the theoretical predictions, mean markups are highest for Model 4 (coordinated), followed by Model 3 (CM-led) and Model 2 (OEM-led), although the differences are relatively small.

In particular, the difference between Model 2 and Model 3 is modest. This is partly because the difference between the two models is confined to the ownership structure of OEM-branded kei car models. More importantly, however, this similarity reflects the countervailing incentives discussed in Section 4: the upward pricing pressure derived from

²⁷Under linear pricing, the total markup corresponds to the sum of the wholesale and retail markups.

the CM’s profit internalization is largely offset by the downward pressure resulting from the OEM’s reduced market power. Consistent with this mechanism, the estimates indicate that under the CM-led model (relative to the OEM-led benchmark), markups for kei cars tend to increase, whereas markups for the OEM’s standard cars tend to decrease. On net, the number of models exhibiting markup increases exceeds the number with decreases. Detailed results are provided in Appendix E. Given these descriptive findings, the next section conducts formal model selection tests.

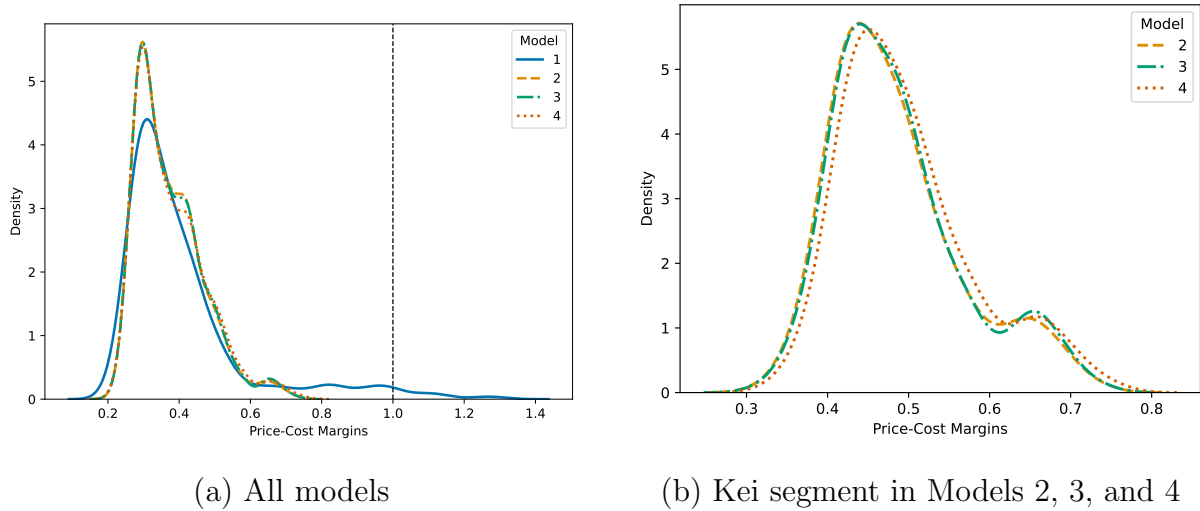


Figure 2: Distribution of Price-Cost Margins

Notes: The figures show the distribution of the price-cost margin (PCM), markup_j/p_j , for each model. A value of PCM > 1 indicates negative marginal costs. Panel (a) reports results for all models; panel (b) focuses on the kei car segment under non-linear pricing models.

Table 7: Summary Statistics of Price-Cost Margin

| Model | Mean (%) | Std. Dev. (%) | Min (%) | Max (%) | > 1 (%) |
|----------------|----------|---------------|---------|---------|-----------|
| 1: Linear | 40.77 | 18.02 | 21.33 | 131.41 | 2.10 |
| 2: OEM-led | 37.11 | 9.28 | 21.33 | 73.91 | 0.00 |
| 3: CM-led | 37.16 | 9.36 | 21.33 | 73.91 | 0.00 |
| 4: Coordinated | 37.43 | 9.70 | 21.33 | 75.55 | 0.00 |

Notes: For each model, the table reports the mean, standard deviation, minimum, and maximum of the price-cost margin (PCM), expressed as percentages. The rightmost column shows the share of observations with PCM > 1 , which implies negative marginal cost.

6.2 Model Selection Test

To identify the underlying supply-side structure among the remaining specifications, this section presents formal model selection tests, first outlining the testing procedure and then presenting the results. Based on the Rivers–Vuong test, the coordinated model (Model 4) is rejected at conventional significance levels, whereas the OEM-led and CM-led models

(Models 2 and 3) cannot be rejected. Ultimately, these findings demonstrate that the anti-competitive effects of the OEM arrangement are negligible.

The test statistic used in the model selection procedure, defined in Equation (25), is the difference between the GMM objective function of the row model and that of the column model. A positive value favors the column model, while a negative value favors the row model. The results are reported in Table 8. At the 5 percent significance level, the critical values are ± 1.96 . The test statistics for the OEM-led model versus the coordinated model (Model 2 vs. Model 4) and the CM-led model versus the coordinated model (Model 3 vs. Model 4) are negative and exceed the critical threshold in absolute value, leading to the rejection of the coordinated model. This conclusion is robust to concerns regarding weak instruments and the family-wise error rate, assessed via the F statistic and the model confidence set p-value, respectively; see Appendix E for details.

By contrast, the test statistic for the OEM-led model versus the CM-led model (Model 2 vs. Model 3) is 1.019. Because this value does not exceed the critical threshold, these two models cannot be statistically distinguished. As discussed in the previous section, this statistical ambiguity reflects the fundamental similarity of the outcomes under the two regimes; the differences are too small to be detected with the IVs used here.²⁸ However, this result does not undermine the broader conclusions.

To quantify the economic magnitude of this difference, I conduct a counterfactual simulation using data from the final sample year, 2016.²⁹ Assuming that the market operates under the CM-led model, I simulate the welfare impact of replacing CM-led conduct with the OEM-led benchmark while holding all other factors fixed. The results show that consumer surplus improves by 0.51 billion JPY under the OEM-led regime. While this confirms the theoretical prediction that the CM-led arrangement reduces welfare, the magnitude of this effect is economically negligible. Specifically, an impact of 0.54 billion JPY corresponds to the value of roughly 250 average vehicles, representing a mere 0.01 percent of the total market revenue (0.54 billion relative to 6.74 trillion JPY). Additionally, this figure is minuscule relative to the results of the subsequent counterfactual simulations. Therefore, the evidence suggests that in the context of the Japanese automobile market, the anti-competitive effects associated with the OEM arrangements are practically non-existent.

Furthermore, it is important to recognize that both the purely OEM-led and purely CM-led models represent polar theoretical assumptions. The true underlying conduct likely involves an intermediate degree of authority shared between the firms. Given this, the analysis does not impose a definitive selection between the two. Instead, it proceeds by treating both models as plausible baselines. In Section 7, these two models are used to conduct the main counterfactual simulations, which aim to quantify the magnitude of

²⁸Additionally, restricting the test sample to kei cars is likely a contributing factor.

²⁹See Section 7 for detailed procedures.

production efficiencies generated by OEM arrangements.

Table 8: Results of Rivers-Vuong Tests

| Model | T^{RV} | | | F | | | MCS p-value |
|----------------|----------|--------|--------|--------------------|--------|-------|-------------|
| | 2 | 3 | 4 | 2 | 3 | 4 | |
| 2: OEM-led | 1.019 | -3.378 | | 6.147 [†] | 15.356 | | 0.330 |
| 3: CM-led | | | -3.376 | | | 7.423 | 1.000 |
| 4: Coordinated | | | | | | | 0.002 |

Notes: Model 2 is the OEM-led non-linear pricing model, Model 3 is the CM-led non-linear pricing model, and Model 4 is the coordinated non-linear pricing model. For T^{RV} , the 5 percent critical values are ± 1.96 . F -statistics marked with [†] are below the critical value for best power above 0.95. The rightmost column reports model confidence set (MCS) p-values.

6.3 Marginal Cost

The findings support the presence of OEM-induced efficiencies, specifically, a reduction in marginal costs driven by scale economies. Table 9 presents the estimation results for the marginal cost parameters across the OEM-led and CM-led (Models 2 and 3) specifications. For comparative purposes, the table also reports the estimates for Model 3 under the assumption of constant marginal costs.

The key parameter of interest, γ_q , captures the effect of production volume. The estimated coefficient indicates the presence of scale economies in production across all the estimated specifications. This result is consistent with the industry practitioner statements discussed in Section 3.3 and with prior literature documenting scale economies in the automobile industry. Importantly, this finding provides a clear economic rationale for interfirm OEM agreements: consolidating production is essential for achieving productive efficiency in this market.

While the estimates naturally confirm that improvements in product characteristics—such as fuel efficiency and vehicle size—increase marginal costs, they also reveal a significant cost penalty associated with the transition to OEM sourcing. This effect is captured using an OEM-switch dummy. The dummy equals one for models transitioning from Subaru’s in-house production to OEM supply, as well as for a few Mitsubishi models. Although it applies to a limited subset of cars, the dummy induces substantial variation and consistently raises the estimated marginal cost. Plausible channels for this increase include model changeover expenses, interplant logistics, and administrative frictions. Supporting this interpretation, Subaru stated that the profit margin on its kei car models would decline as the shift to OEM production progressed.³⁰ This is in line with the observed

³⁰Subaru, *Analyst Briefing on Financial Results for the Fiscal Year Ending March 2010*, available at https://www.subaru.co.jp/ir/library/pdf/fr/2010/2010_4qf_qa.pdf (available only in Japanese).

increase in production costs after the switch.

Table 9: Cost Parameter Estimates

| Model | 2 | | 3 | | Constant MC | |
|------------------|--------|-------|--------|-------|-------------|-------|
| | Coef. | SE | Coef. | SE | Coef. | SE |
| γ_x | | | | | | |
| Constant | -5.220 | 0.733 | -5.229 | 0.726 | -5.345 | 0.637 |
| Fuel eff. (km/L) | 0.015 | 0.002 | 0.015 | 0.002 | 0.014 | 0.002 |
| Size (m) | 0.517 | 0.075 | 0.518 | 0.074 | 0.482 | 0.065 |
| HP/kg | 9.436 | 2.121 | 9.317 | 2.102 | 6.003 | 1.750 |
| OEM switch | 0.298 | 0.025 | 0.259 | 0.046 | 0.146 | 0.035 |
| γ_q | | | | | | |
| ln(Quantity) | -0.074 | 0.015 | -0.074 | 0.015 | | |

Notes: Each row represents a variable, and the columns report coefficients and standard errors for each model.

7 Simulation

The analysis proceeds by conducting counterfactual simulations using the non-rejected specifications, the OEM-led model (Model 2) and the CM-led model (Model 3), as the baselines. Section 7.1 presents the main counterfactual analysis, which simulates the effects of banning OEM arrangements between competitors. Within this analysis, two broad scenarios are considered: one where OEM-branded products are withdrawn from the market and another where they are not. Subsequently, Section 7.2 examines a scenario of collusion within the kei car segment to contextualize the efficiency gains from OEM activity. The overall results provide strong evidence of substantial efficiency improvements driven by scale economies facilitated by OEM arrangements.

7.1 Policy Counterfactual: OEM Ban

The analysis first evaluates the welfare impact of prohibiting OEM arrangements. This directly addresses the central research question of the paper: whether OEM agreements between competitors enhance or harm overall social welfare. Competition authorities might consider restricting such activity due to potential anticompetitive concerns. However, in this empirical setting, the findings in Section 6 indicate that such anticompetitive effects are practically non-existent. Consequently, the primary objective of this counterfactual analysis is to quantify the magnitude of the efficiency losses, specifically the forgone scale economies, that would result from an OEM ban.

Following the model selection results from Section 6, the simulations are performed using the two non-rejected specifications as the baselines. The theoretical implications

of an OEM ban differ slightly depending on the baseline. Under Model 2, a ban simply eliminates the efficiency gains from scale economies. Under Model 3, however, the simulation is structurally analogous to a standard merger evaluation: an OEM ban eliminates the merger-like upstream pricing behavior (the anticompetitive effect) but simultaneously destroys the production concentration (the efficiency effect). Thus, Model 3 theoretically embodies the classic competition–efficiency trade-off. In practice, however, because the anticompetitive margin is demonstrably negligible in the empirical setting examined here, the outcomes under both baselines are expected to be virtually identical, driven almost entirely efficiency losses.

To conduct these simulations, I impose an additional assumption on regular cars, namely that their marginal costs are held fixed at the baseline estimates. Effectively, this assumes constant marginal costs for these vehicles. Because data on the total global production volume of regular cars are not available, the scale parameter (γ_q) cannot be estimated for them. This assumption is reasonable: regular cars are produced globally in volumes vastly exceeding those of kei cars, implying that their marginal costs are fundamentally unaffected by domestic scale variations, as indicated by Equation (21). Given that the objective is to evaluate the welfare impact of OEM arrangements within the kei car segment, focusing on this segment is appropriate. The simulations follow standard procedures.³¹

To evaluate the welfare impact under different post-ban market structures, two simulation scenarios are constructed regarding firms’ responses to an OEM ban. In the main scenario (S1), it is assumed that most firms withdraw their OEM-branded products from the market. Based on the historical context described in Section 3, only Subaru (which exited in-house kei production during the sample period) and Mitsubishi (which maintained it) are assumed capable of sustaining their lineups. Other firms simply withdraw the models previously outsourced. I view this as the most reasonable and empirically plausible market outcome.

The second scenario (S2) explicitly controls for the “variety effect” to isolate the pure efficiency gains. In discrete choice demand models, the presence of the idiosyncratic error term (ε_{ijt}) mechanically increases consumer surplus as the number of available products increases. Thus, S1 may overestimate the welfare loss due to product withdrawal. To address this, S2 considers a hypothetical case where all manufacturers maintain their product lineups by sourcing from outside the market or producing in-house.³² While not realistic, this scenario allows identification of the strict lower bound of welfare improvements attributable exclusively to scale economies.

³¹Specifically, the reformulated fixed-point iteration approach proposed by Morrow and Skerlos (2011) and Conlon and Gortmaker (2020) is used to recalculate markups.

³²This treatment, intended to remove the mechanical preference for variety, has been adopted in prominent empirical studies, including Akerberg and Rysman (2005), Ciliberto, Moschini, and Perry (2019), Grieco, Murry, and Yurukoglu (2024), and Igami et al. (2024).

Panel A of Table 10 reports the simulation results. As expected, the results using Model 2 and Model 3 as baselines are virtually identical. Focusing on the Model 3 baseline, the simulations show a substantial decline in producer surplus, consumer surplus, and total welfare across both scenarios. Under the main withdrawal scenario (S1), the OEM ban leads to a total welfare reduction of approximately 200 billion JPY. Crucially, even under the conservative assumption of S2, where the variety effect is completely eliminated, total welfare still declines by roughly 20 billion JPY. This welfare loss confirms that the pure efficiency gains from OEM-induced scale economies are significant.

7.2 Alternative Scenario: Collusion

Finally, the analysis demonstrates that the efficiency gains from OEM arrangements remain substantial even under a worst case market scenario.

To further highlight the magnitude of these gains, I evaluate an alternative scenario: explicit collusion. Although the coordinated pricing specification (Model 4) was statistically rejected in Section 6, joint profit maximization represents the most severe anticompetitive outcome that OEM agreements could facilitate. Maintaining the baseline estimates from Models 2 and 3, the simulations compute welfare outcomes assuming firms collude within the kei car segment, corresponding to Model 4, while holding existing OEM relationships and product lineups fixed.

Panel B of Table 10 reports the simulation results for this collusion scenario. As expected, coordinated pricing substantially reduces consumer surplus. However, there is also a decline in total firm profits. This unexpected result arises because collusion confined to the kei car segment induces consumer substitution toward regular cars, thereby reducing overall profitability. Moreover, the resulting decrease in kei car production diminishes scale economies and increases marginal costs, further depressing firm profits. Consequently, kei car collusion does not appear to be profitable in this setting.

A central implication emerges from the comparison with Scenario S2 in Panel A. In terms of total welfare, even under kei car collusion, maintaining OEM arrangements yields a superior outcome compared to standard Bertrand competition under an OEM ban. While consumer surplus is marginally lower under collusion, the difference is limited.³³ In essence, the welfare loss caused by prohibiting OEM agreements could be comparable to, or potentially outweigh, the damage from the worst-case kei car collusion. This finding underscores the main conclusion: the efficiency gains derived from OEM arrangements dominate any associated anticompetitive concerns.

³³Recall that Scenario S2 is an unrealistic, highly conservative baseline designed specifically to remove the variety effect.

Table 10: Simulation Results

| Scenario | Model 2: OEM-led | | | Model 3: CM-led | | |
|---|------------------|-------------|----------------|-----------------|-------------|----------------|
| | Δ Profit | Δ CS | Δ Total | Δ Profit | Δ CS | Δ Total |
| <i>Panel A: Policy Counterfactual (OEM Ban)</i> | | | | | | |
| S1: Withdrawal | -83.68 | -109.19 | -192.87 | -83.35 | -108.29 | -191.64 |
| S2: In-house | -12.29 | -15.26 | -27.54 | -12.14 | -14.57 | -26.71 |
| <i>Panel B: Collusion Scenario</i> | | | | | | |
| Kei collusion | -0.30 | -18.98 | -19.28 | -0.25 | -18.45 | -18.70 |

Notes: All values in billions of JPY. Panel A shows the welfare effects of removing OEM arrangements. S1 assumes firms withdraw OEM products; S2 assumes firms shift to in-house production. Panel B shows welfare effects under collusion in the kei segment (Model 4). Baseline Model 2 represents OEM-led pricing; Model 3 represents CM-led pricing.

8 Conclusion

This study examined both the anticompetitive effects and the efficiency gains arising from scale economies in OEM relationships between competitors, an issue of growing relevance for competition policy in today’s increasingly complex supply chains. Using the Japanese automobile industry as the empirical setting, the analysis quantified the relative magnitude of these forces. While prior research has examined anticompetitive effects and efficiency gains from scale economies, empirical evidence remains limited. By developing structural models that explicitly incorporate OEM relationships and estimating them using real-world data, this study provides empirical support for the view that OEM arrangements can, under certain conditions, enhance overall welfare.

This finding has important implications for competition policy. Because OEM agreements between competitors involve both horizontal competition and vertical relationships, their welfare effects cannot be assessed by focusing on only one aspect of the relationship. The results suggest that competition authorities should evaluate such arrangements by considering both potential competitive harm and productive efficiency gains, with particular attention to industry-specific conditions such as the strength of scale economies. This highlights the importance of careful, context-sensitive regulatory assessment rather than uniform regulatory approaches.

Finally, two limitations regarding the analysis in this study should be noted. First, the analysis relies on a static framework that abstracts from forward-looking behavior by consumers and firms, and may therefore omit dynamic strategic interactions. Second, the organizational choice between OEM and in-house production is not explicitly modeled and remains exogenous in this setting. Future work should analyze the determinants of the firm boundary decision to provide a more comprehensive understanding of these arrangements.

Appendix

A Details on Data Construction

The dataset used in this study is constructed from three main components: sales and product characteristics, OEM relationships, and market size and demographic information. The data cover the period from 2006 to 2016.

The sales and product characteristics data are constructed by integrating multiple sources and are adjusted for the analysis of the kei car market. Sales data are obtained from industry associations for three market segments: regular passenger cars, kei cars, and imported vehicles. Specifically, the analysis uses data published by the Japan Automobile Dealers Association, the Japan Mini Vehicle Association, and the Japan Automobile Importers Association.³⁴ Information on product characteristics, including prices, is collected from two online automobile catalog websites, *Car View!* and *Navikuru*. Prices are converted to real terms using the Consumer Price Index. To focus on new vehicle purchases for general passenger use, the sample excludes high-priced vehicles.³⁵ Finally, electric vehicles are excluded due to the unavailability of fuel efficiency data, and models discontinued mid-year with extremely low sales volumes (fewer than 100 units) are also excluded.

A key component of the analysis is vehicle-model-level data on OEM relationships, which make it possible to determine whether a given model is produced in-house or outsourced to another manufacturer. Information on OEM relationships is obtained from the *Automobile Yearbook* and from the official websites of automakers and parts suppliers. In a typical OEM arrangement, the supplied model is substantially identical to the base model in its underlying design and production, with differences limited primarily to badging and minor cosmetic features. This structural similarity facilitates the systematic and reliable detection of OEM relationships. These data clearly identify, for each vehicle model, the manufacturing firm and the marketing firm, which may differ under OEM arrangements. Moreover, they make it possible to match pairs of “twin” models (base vehicles and their OEM counterparts) that share identical production processes but are sold under different brand names.³⁶

Finally, market size and demographic information used for realistic demand estimation are obtained from public statistical sources. Market size is defined as the number of households and is obtained from statistics published by the Ministry of Internal Affairs

³⁴The Japan Automobile Dealers Association publishes the *Annual Report on New Car Registrations (Shinsha Toroku Daisu Nempo)*. Sales data from the other associations are obtained from their official websites. For imported vehicles, the data cover the top 20 models by annual sales.

³⁵In particular, vehicles priced above 4 million yen are excluded; even in the overall automobile market, such vehicles account for only about 3 percent of total sales.

³⁶For example, Nissan’s *Moco* is an OEM version of Suzuki’s *MR Wagon*.

and Communications.³⁷ In addition, I use demographic information on the relationship between household income and expenditures on new automobiles. These data are drawn from the *Survey of Household Economy* conducted by the Statistics Bureau of Japan. The survey collects monthly data on household expenditures for new automobiles from approximately 30,000 households, which are aggregated and published on an annual basis. The data reveal a positive relationship between income levels and expenditures on new vehicles, providing empirical motivation for incorporating consumer heterogeneity into the demand model.

B Detailed Analysis of Linear Pricing

This appendix provides additional details on the linear pricing framework.

To highlight the implications of simultaneous determination, the analysis first contrasts simultaneous and sequential price–quantity determination, as depicted in Figure B.1. Under simultaneous determination, the wholesale price w and the retail margin m^r directly and jointly determine the final retail price p of a given product. In contrast, under sequential determination, wholesale prices are set first, and both parties observe these prices before p is determined. While such sequential determination might be plausible in completely separated vertical settings, such as wholesaling to supermarkets, it is highly unlikely in the setting examined here, where OEM and in-house products coexist.

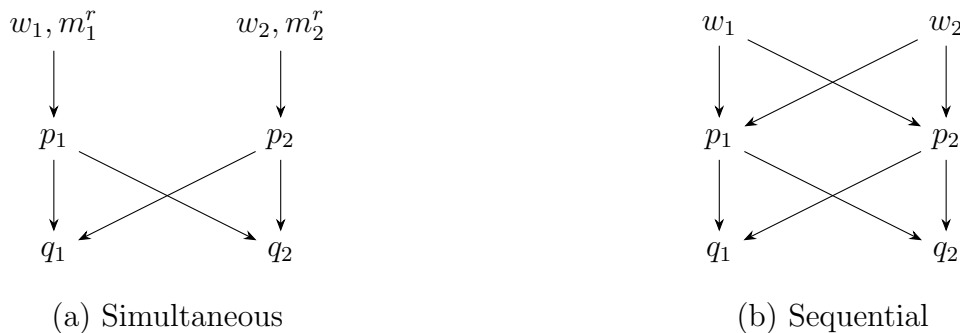


Figure B.1: Price–quantity determination: simultaneous vs. sequential

Note: Panels (a) and (b) illustrate the dependence structure of price and quantity determination under simultaneous and sequential decision-making, respectively.

These structural differences dictate how demand responds to wholesale prices and retail markups. Under simultaneous determination, as shown in the figure, $\frac{\partial \mathbf{p}_t}{\partial \mathbf{w}_t} = I$ and $\frac{\partial \mathbf{p}_t}{\partial \mathbf{m}_t^r} = I$, which yields $\frac{\partial \mathbf{q}_t}{\partial \mathbf{w}_t} = \frac{\partial \mathbf{q}_t}{\partial \mathbf{p}_t}$ and $\frac{\partial \mathbf{q}_t}{\partial \mathbf{m}_t^r} = \frac{\partial \mathbf{q}_t}{\partial \mathbf{p}_t}$. On the other hand, in a sequential game, retail prices are set after observing rivals' wholesale prices; hence the impact on rivals' outputs is more direct, whereas under simultaneous determination it is indirect,

³⁷Specifically, the analysis uses the *Population, Demographics, and Number of Households Based on the Basic Resident Register*.

operating through price competition. In either case, the competitive softening effects of pricing are properly captured.

The demand responses are straightforward to derive. In my setting, the own-price derivative with respect to the retail markup is given by:

$$\begin{aligned}
& \frac{\partial q_{jt}(\mathbf{p}_t(\mathbf{p}_t^{\text{in}}, \mathbf{w}_t, \mathbf{m}_t^r))}{\partial w_{jt}} \\
&= \partial \left(\int \frac{\exp(\alpha_i p_{jt} + x_{jt}^d \beta + \lambda_j + \lambda_t + \xi_{jt})}{1 + \sum_{j' \in J_t} \exp(\alpha_i p_{j't} + x_{j't}^d \beta + \lambda_{j'} + \lambda_t + \xi_{j't})} dF(D) dF(v) \right) / \partial m_{jt}^r \\
&= \partial \left(\int \frac{\exp(\alpha_i (m_{jt}^r + w_{jt}) + x_{jt}^d \beta + \lambda_j + \lambda_t + \xi_{jt})}{1 + \sum_{j' \in J_t} \exp(\alpha_i (m_{j't}^r + w_{j't}) + x_{j't}^d \beta + \lambda_{j'} + \lambda_t + \xi_{j't})} dF(D) dF(v) \right) / \partial m_{jt}^r \\
&= \int \alpha_i s_{jti} (1 - s_{jti}) dF(D) dF(v).
\end{aligned}$$

The same argument holds for the wholesale price: $\frac{\partial q_{jt}(\mathbf{p}_t(\mathbf{p}_t^{\text{in}}, \mathbf{m}_t^r, \mathbf{w}_t))}{\partial m_{jt}^r} = \int \alpha_i s_{jti} (1 - s_{jti}) dF(D) dF(v)$. Furthermore, this equivalence naturally extends to the cross-price derivatives. For any $k \neq j$, the impact of a rival's pricing component on product j 's quantity is

$$\frac{\partial q_{jt}}{\partial p_{kt}} = \frac{\partial q_{jt}}{\partial m_{kt}^r} = \frac{\partial q_{jt}}{\partial w_{kt}} = - \int \alpha_i s_{jti} s_{kti} dF(D) dF(v).$$

C Demand Estimation

This appendix presents additional details on demand estimation. Specifically, it describes consumer heterogeneity in new-car expenditures across income groups and reports the full demand estimation results.

Demographic data indicate heterogeneity among consumers, particularly in relation to income. Figure C.1 presents the average household expenditure on new cars by income group in 2006, revealing, as expected, that higher-income households allocate more resources to car purchases. When considered alongside Table 1, which highlights that kei cars are concentrated in the lower price segments, this suggests that kei cars serve as an accessible option for low-income households. Therefore, the empirical model explicitly accounts for this income-driven heterogeneity. Further details on how this heterogeneity is incorporated into the empirical framework are provided in Section 5.

Table C.1 presents the full results of the demand estimation, including the time fixed effects and brand-type fixed effects omitted from the main text. The time fixed effects, λ_t , indicate that average demand declined over time, while the brand-type fixed effects, λ_j , capture consumers' perceptions of each brand-type combination, with Toyota's regular vehicles as the reference category.

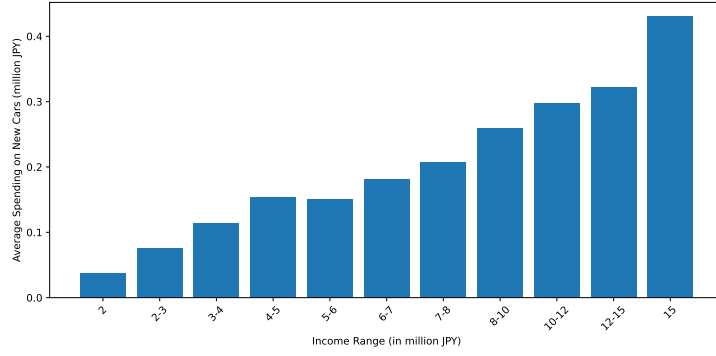


Figure C.1: Average New Car Expenditure by Income Group (2006)

Note: Relationship between income group and average new car expenditure in 2006. Higher expenditures are observed for higher income groups.

Table C.1: Full Demand Estimation Results

| Variable | Coef. (SE) | Variable | Coef. (SE) |
|-----------------------|-----------------|-----------------------------|----------------|
| α, β | | λ_j (Brand-type) | |
| Constant | -14.859 (0.555) | Audi | 1.132 (0.309) |
| Price | -2.290 (0.211) | BMW | 2.064 (0.270) |
| Fuel efficiency | 0.190 (0.008) | Daihatsu \times Kei | 0.968 (0.161) |
| Size | 0.505 (0.038) | Daihatsu \times Regular | -3.099 (0.147) |
| Power-to-weight ratio | 20.795 (3.504) | Fiat | 0.709 (0.230) |
| Π | | Honda \times Kei | 1.038 (0.236) |
| Price: low-income | -0.432 (0.086) | Honda \times Regular | -0.322 (0.124) |
| price: middle-income | 0.380 (0.066) | Lexus | 0.077 (0.473) |
| price: high-income | 0.652 (0.063) | Mazda \times Kei | -1.013 (0.175) |
| Σ | | Mazda \times Regular | -0.563 (0.125) |
| Price | 0.480 (0.115) | Mercedes | 1.148 (0.278) |
| λ_t (Years) | | Mitsubishi \times Kei | -0.001 (0.223) |
| 2007 | 0.044 (0.118) | Mitsubishi \times Regular | -1.419 (0.148) |
| 2008 | -0.279 (0.123) | Nissan \times Kei | 0.300 (0.221) |
| 2009 | -0.439 (0.122) | Nissan \times Regular | -0.236 (0.100) |
| 2010 | -0.406 (0.135) | Peugeot | 0.208 (0.149) |
| 2011 | -0.743 (0.130) | Subaru \times Kei | -1.375 (0.165) |
| 2012 | -0.547 (0.125) | Subaru \times Regular | -0.473 (0.184) |
| 2013 | -0.810 (0.133) | Suzuki \times Kei | 1.002 (0.189) |
| 2014 | -0.868 (0.138) | Suzuki \times Regular | -1.748 (0.148) |
| 2015 | -0.952 (0.141) | Toyota \times Kei | -1.851 (0.234) |
| 2016 | -1.082 (0.150) | Volkswagen | 0.705 (0.208) |
| | | Volvo | 1.036 (0.242) |
| Observations | 1,670 | | |

Notes: Standard errors in parentheses.

D Details of the Model Selection Test

This appendix presents the computational details and results of the model selection test. The following focuses primarily on the implementation of the test and the interpretation of the F statistics and the model confidence set.

Calculation In step (iii) of Section 5.2, the procedure residualizes the instrument vector with respect to the regressors used in the 2SLS cost equation. Let \tilde{q}_{jt} denote the best linear predictor of $\log Q_{jt}$ from the 2SLS first stage, and define $X_{jt} \equiv (\tilde{q}_{jt}, x_{jt}^s)$. The residualized instruments are

$$z_{jt}^e = z_{jt} - \Pi_X X_{jt}, \quad \Pi_X \equiv E[z_{jt} X_{jt}'] E[X_{jt} X_{jt}']^{-1}.$$

In practice, the estimation uses the sample analog $\hat{\Pi}_X = (\frac{1}{n} \sum_{jt} z_{jt} X_{jt}') (\frac{1}{n} \sum_{jt} X_{jt} X_{jt}')^{-1}$, and computes $\widehat{W} = (\frac{1}{n} \sum_{jt} \hat{z}_{jt}^e \hat{z}_{jt}^{e'})^+$. Intuitively, one effective dimension of the instrument vector is consumed to identify the scale economies parameter through \tilde{q}_{jt} , reducing the available degrees of freedom for model selection by one. Consequently, although the population weighting matrix is, in principle, $E[z_{jt}^e z_{jt}^{e'}]$, its rank is lower by one; accordingly, the Moore–Penrose pseudoinverse is used and is set to $W = E[z_{jt}^e z_{jt}^{e'}]^+$. All other implementation details—including the computation of σ , F statistics, and the p values for the model confidence set—are omitted for brevity; see Duarte et al. (2024, 2025) for a complete description.

Results Based on the evaluation of both the F statistics and the model confidence set (MCS), the analysis concludes that Models 2 and 3 cannot be rejected.

First, the F statistic is examined. Duarte et al. (2024) highlight that weak instruments can distort model selection tests and propose an F test framework to evaluate instrument strength. They identify two concerns: size distortions and low power. While size distortions are not a significant issue when the number of instruments lies in the range of 2 to 9, the problem of low power persists and requires careful consideration. Applying this framework, the results indicate that weak instruments are not a concern in the comparisons of Model 2 versus Model 4 and Model 3 versus 4, as the F statistics comfortably exceed the critical thresholds. By contrast, in the comparison of Model 2 versus Model 3, the F statistic falls short of the threshold, suggesting that the instruments may be weak. Consistent with this, the test statistic itself also lies below the critical value, preventing rejecting of the null hypothesis.³⁸

Second, the analysis evaluates the set of candidate models using the model confidence set (MCS) procedure of Hansen, Lunde, and Nason (2011), which provides a formal

³⁸When the best-case power is set to 0.95, the statistic falls below the critical value. In contrast, for best-case power levels of 0.5 or 0.75, the threshold is exceeded, making the results somewhat sensitive. Nevertheless, in all cases, neither Model 2 nor Model 3 can be rejected, and the overall conclusions remain unchanged.

method to control family-wise error rates. The procedure begins with all models included in the MCS and iteratively removes the worst-performing model at each step. The results, reported in Table 8 in the main text, show that Model 4 is excluded from the confidence set, while Models 2 and 3 remain. Accordingly, the final model confidence set is given by $\text{MCS} = \{2, 3\}$. Taken together with the F statistic, the MCS results reinforce the empirical conclusions presented in the main text.

E Models 2 and 3

The comparison between Models 2 and 3 is central to the discussion of anticompetitive effects. This appendix supplements the main text by providing a detailed comparison of the results from both models.

To clarify the differences in markups between Models 2 and 3, Figure E.1 presents the distribution of markup differences for each car model. Specifically, Model 2 represents the OEM-led pricing structure, whereas Model 3 represents the CM-led structure. The primary distinction between the two lies in the shift of the price-setting entity for OEM-supplied kei cars. Figure E.1 shows that, relative to Model 2, markups under Model 3 are higher for 773 product-year observations (gray), lower for 393 (hatched), and the same for 504 (black). Under Model 3, the market power of CMs such as Suzuki and Daihatsu is higher, while the market power of OEMs like Nissan is lower than in Model 2. The distribution of markup differences indicates that the stronger market power of CMs dominates the overall effect.

To understand the mechanics behind this variation, the analysis compares the price-cost margins (PCMs) of the four representative car models listed in Table E.1. First, for the *MR Wagon* (a kei car produced and sold by Suzuki), Suzuki’s market share—and thus market power—is higher under Model 3, directly leading to a higher markup. Second, for the *Moco* (a Nissan kei car supplied by Suzuki via OEM), the markup is also higher under Model 3. This reflects Suzuki’s greater market power, although the size of the markup change depends on the relative market shares of Suzuki and Nissan. Third, for the *Note* (a regular car manufactured and sold by Nissan), the markup is lower because Nissan’s overall kei car market share is smaller under Model 3. Finally, the markup for the *Fit* (a regular car produced by Honda) is identical in both models, as Honda’s ownership structure and supply chain are unaffected by the Suzuki-Nissan OEM arrangement.

Although these product-level responses are heterogeneous, creating some ambiguity regarding the net competitive effect at the micro level due to substitution between regular and kei cars, the aggregate implications are clear. Supported by the main estimation results and counterfactual simulations, the anticompetitive implications of Model 3 are evident. Moreover, under Model 3, prices for kei cars are higher, reducing surplus for price-sensitive consumers and materially lowering overall welfare. These findings suggest that

OEM arrangements between competitors may provide a more flexible form of horizontal coordination than mergers, allowing firms to reallocate segments of their operations while still softening competition.

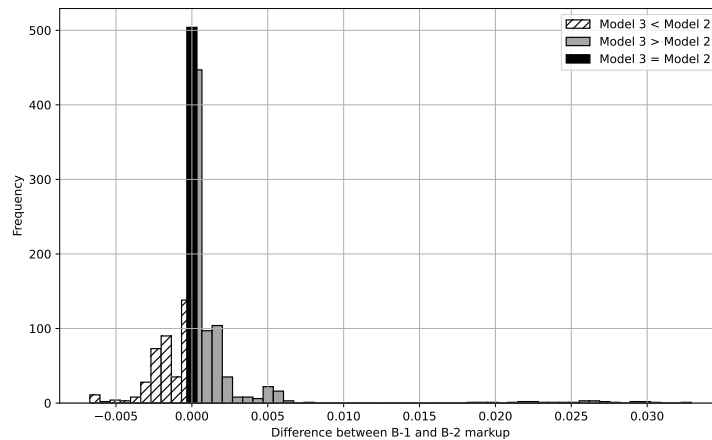


Figure E.1: Distribution of Differences between Model 2 and Model 3 Markups

Notes: Blue bars indicate model–year observations with higher markups under Model 2; red bars indicate higher markups under Model 3; gray bars indicate the same markups under both models (observations: 393, 773, 504). Overall, a larger share of observations shows higher markups under Model 3.

Table E.1: PCMs of Representative Car Models under Models 2 and 3 (2016)

| Model | Seller | Manufacturer | Type | 2 | 3 |
|----------|--------|--------------|---------|-------|-------|
| MR Wagon | Suzuki | Suzuki | Kei | 45.10 | 45.14 |
| Moco | Nissan | Suzuki | Kei | 45.51 | 45.55 |
| Note | Nissan | Nissan | Regular | 38.78 | 38.69 |
| Fit | Honda | Honda | Regular | 42.93 | 42.93 |

References

Abe, Tatsuya, “Welfare Effects of Fuel Tax and Purchase Incentives for Low-Emission Vehicles,” 2025. Working Paper.

Akerberg, Daniel A. and Marc Rysman, “Unobserved Product Differentiation in Discrete-Choice Models: Estimating Price Elasticities and Welfare Effects,” *The RAND Journal of Economics*, 2005, 36 (4), 771–788.

Armstrong, Mark and David E.M. Sappington, “Recent Developments in the Theory of Regulation,” in M. Armstrong and R. Porter, eds., *Handbook of Industrial Organization*, Vol. 3, Elsevier, 2007, pp. 1557–1700.

- Arya, Anil, Brian Mittendorf, and David E. M. Sappington**, “The Make-or-Buy Decision in the Presence of a Rival: Strategic Outsourcing to a Common Supplier,” *Management Science*, 2008, *54* (10), 1747–1758.
- Asker, John and Volker Nocke**, “Collusion, Mergers, and Related Antitrust Issues,” in Kate Ho, Ali Hortaçsu, and Alessandro Lizzeri, eds., *Handbook of Industrial Organization*, Vol. 5, Elsevier, 2021, pp. 177–279.
- Baake, Pio, Jörg Oechssler, and Christoph Schenk**, “Explaining Cross-Supplies,” *Journal of Economics*, 1999, *70* (1), 37–60.
- Backus, Matthew, Christopher Conlon, and Michael Sinkinson**, “Common Ownership and Competition in the Ready-to-Eat Cereal Industry,” NBER Working Paper 28350, National Bureau of Economic Research 2021.
- Berry, Steven, James Levinsohn, and Ariel Pakes**, “Automobile Prices in Market Equilibrium,” *Econometrica*, 1995, *63* (4), 841–890.
- Berry, Steven T. and Philip A. Haile**, “Identification in Differentiated Products Markets Using Market Level Data,” *Econometrica*, 2014, *82* (5), 1749–1797.
- Berto Villas-Boas, Sofia**, “Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data,” *The Review of Economic Studies*, 2007, *74* (2), 625–652.
- Besanko, David, Sachin Gupta, and Dipak Jain**, “Logit Demand Estimation under Competitive Pricing Behavior: An Equilibrium Framework,” *Management Science*, 1998, *44* (11), 1533–1547.
- Bonnet, Céline and Pierre Dubois**, “Inference on Vertical Contracts between Manufacturers and Retailers Allowing for Nonlinear Pricing and Resale Price Maintenance,” *The RAND Journal of Economics*, 2010, *41* (1), 139–164.
- Bühler, Stefan and Justus Haucap**, “Strategic Outsourcing Revisited,” *Journal of Economic Behavior & Organization*, 2006, *61* (3), 325–338.
- Cachon, Gérard P. and Patrick T. Harker**, “Competition and Outsourcing with Scale Economies,” *Management Science*, 2002, *48* (10), 1314–1333.
- Caldieraro, Fabio**, “The Role of Brand Image and Product Characteristics on Firms’ Entry and OEM Decisions,” *Management Science*, 2016, *62* (11), 3327–3350.
- Chen, Yongmin**, “On Vertical Mergers and Their Competitive Effects,” *The RAND Journal of Economics*, 2001, *32* (4), 667–685.
- Chen, Yutian**, “Strategic Sourcing for Entry Deterrence and Tacit Collusion,” *Journal of Economics*, 2011, *102* (2), 137–156.
- Choi, S. Chan**, “Price Competition in a Channel Structure with a Common Retailer,” *Marketing Science*, 1991, *10* (4), 271–296.
- Ciliberto, Federico, GianCarlo Moschini, and Edward D. Perry**, “Valuing Product Innovation: Genetically Engineered Varieties in US Corn and Soybeans,” *The RAND Journal of Economics*, 2019, *50* (3), 615–644.

- Conlon, Christopher and Jeff Gortmaker**, “Best Practices for Differentiated Products Demand Estimation with PyBLP,” *The RAND Journal of Economics*, 2020, 51 (4), 1108–1161.
- and –, “Incorporating Micro Data into Differentiated Products Demand Estimation with PyBLP,” *Journal of Econometrics*, 2025, p. 105926.
- Crawford, Gregory S., Robin S. Lee, Michael D. Whinston, and Ali Yurukoglu**, “The Welfare Effects of Vertical Integration in Multichannel Television Markets,” *Econometrica*, 2018, 86 (3), 891–954.
- Draganska, Michaela, Daniel Klapper, and Sofia B. Villas-Boas**, “A Larger Slice or a Larger Pie? An Empirical Investigation of Bargaining Power in the Distribution Channel,” *Marketing Science*, 2010, 29 (1), 57–74.
- Duarte, Marco, Lorenzo Magnolfi, Daniel Quint, Mikkel Sølvsten, and Christopher Sullivan**, “Conduct and Scale Economies: Evaluating Tariffs in the US Automobile Market,” 2025. Working Paper.
- , –, Mikkel Sølvsten, and Christopher Sullivan, “Testing Firm Conduct,” *Quantitative Economics*, 2024, 15 (3), 571–606.
- Fabra, Natalia and Massimo Motta**, “Assessing Coordinated Effects in Merger Cases,” in “Handbook of Game Theory and Industrial Organization, Volume II,” Edward Elgar Publishing, 2018, pp. 91–122.
- Gandhi, Amit and Jean-François Houde**, “Measuring Substitution Patterns in Differentiated-Products Industries,” NBER Working Paper 26375, National Bureau of Economic Research 2019.
- Grieco, Paul L E, Charles Murry, and Ali Yurukoglu**, “The Evolution of Market Power in the U.S. Automobile Industry,” *The Quarterly Journal of Economics*, 2024, 139 (2), 1201–1253.
- Ho, Kate and Robin S. Lee**, “Insurer Competition in Health Care Markets,” *Econometrica*, 2017, 85 (2), 379–417.
- Igami, Mitsuru and Takuo Sugaya**, “Measuring the Incentive to Collude: The Vitamin Cartels, 1990–99,” *The Review of Economic Studies*, 2022, 89 (3), 1460–1494.
- Kaneko, Shuhei and Yuta Toyama**, “Demand Estimation with Flexible Income Effect: An Application to Pass-Through and Merger Analysis,” *The Journal of Industrial Economics*, 2025, 73 (1), 186–233.
- Khmelnitskaya, Ekaterina, Guillermo Marshall, and Scott Orr**, “Identifying Scale and Scope Economies Using Product Market Data,” *RAND Journal of Economics*, forthcoming.
- Kitano, Taiju**, “Environmental Policy as a De Facto Industrial Policy: Evidence from the Japanese Car Market,” *Review of Industrial Organization*, 2022, 60 (4), 511–548.
- Levitt, Steven D., John A. List, and Chad Syverson**, “Toward an Understanding of Learning by Doing: Evidence from an Automobile Assembly Plant,” *Journal of Political Economy*, 2013, 121 (4), 643–681.

- Li, Wei, Jing Chen, and Bintong Chen**, “Sourcing Strategy of Original Equipment Manufacturer with Quality Competition,” *Decision Sciences*, 2020, 51 (5), 1110–1130.
- Marion, Justin**, “Sourcing from the Enemy: Horizontal Subcontracting in Highway Procurement,” *The Journal of Industrial Economics*, 2015, 63 (1), 100–128.
- Miller, Nathan H. and Matthew C. Weinberg**, “Understanding the Price Effects of the MillerCoors Joint Venture,” *Econometrica*, 2017, 85 (6), 1763–1791.
- Morrow, W. Ross and Steven J. Skerlos**, “Fixed-Point Approaches to Computing Bertrand-Nash Equilibrium Prices Under Mixed-Logit Demand,” *Operations Research*, 2011, 59 (2), 328–345.
- Motta, Massimo**, *Competition Policy: Theory and Practice*, Cambridge ; New York: Cambridge University Press, 2004.
- Nevo, Aviv**, “Measuring Market Power in the Ready-to-Eat Cereal Industry,” *Econometrica*, 2001, 69 (2), 307–342.
- Rivers, Douglas and Quang Vuong**, “Model Selection Tests for Nonlinear Dynamic Models,” *The Econometrics Journal*, 2002, 5 (1), 1–39.
- Sappington, David E. M.**, “On the Irrelevance of Input Prices for Make-or-Buy Decisions,” *American Economic Review*, 2005, 95 (5), 1631–1638.
- Shy, Oz and Rune Stenbacka**, “Strategic Outsourcing,” *Journal of Economic Behavior & Organization*, 2003, 50 (2), 203–224.
- Spiegel, Yossef**, “Horizontal Subcontracting,” *The RAND Journal of Economics*, 1993, 24 (4), 570–590.
- Sudhir, K.**, “Structural Analysis of Manufacturer Pricing in the Presence of a Strategic Retailer,” *Marketing Science*, 2001, 20 (3), 244–264.
- Sullivan, Mary W.**, “How Brand Names Affect the Demand for Twin Automobiles,” *Journal of Marketing Research*, 1998, 35 (2), 154–165.
- Taguchi, Fuyuki**, “Study on OEM Strategy: Its Roles and Problems,” *Senshu Management Journal*, 2012, 1 (1–2), 65–78. [in Japanese].
- Vance, Ashlee**, “Taiwan Tech Firms Strive to Be Global,” *The New York Times* June 2009. June 3. <https://www.nytimes.com/2009/06/04/technology/companies/04compute.html>.
- Vuong, Quang H.**, “Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses,” *Econometrica*, 1989, 57 (2), 307–333.