The Better They Are, the More They Give: Trade Promotions of Consumer Durables

Toyota offered performance-based trade promotions for the Camry to its dealers for 293 days during a two-year period from 1996 to 1997, whereas Chevrolet did not offer this type of promotion at all to its dealers for the Lumina during the same period. Both cars are top sellers in the mid-size market segment. What economic reasoning might explain why these differences are observed?

Our study centers on trade promotions in the automobile industry. Consequently, we are interested in trade promotions in which the manufacturer sets a sales quantity target for the dealer and offers a per-unit reward (or reduced wholesale price) if the dealer exceeds the specified sales level. Studying such trade promotions is important for two reasons. First, the automobile industry and its trade promotions represent a significant part of the economy, with retail sales in excess of $30 billion per year in the United States alone and trade promotions (i.e., discounts given to dealers) that often exceed $1,000 per automobile sold. Second, the vast majority of the existing research on trade promotions is most applicable to the consumer packaged goods (CPG) industry, in which trade discounts are normally based on wholesale sales or volume. In contrast, most trade promotions in the automobile industry are based on retail sales performance because auto manufacturers, unlike CPG manufacturers, can verify easily that their dealer has sold a specified quantity of cars greater than some fixed level (normally the dealer’s quota). Consequently, CPG retailers have an incentive to forward buy, whereas automobile dealers have no such incentive.

The differences imply that though there are many theoretical and empirical studies of the CPG industry’s trade promotions (see, e.g., Curhan and Kopp 1986; Dreze and Bell 2003; Kim and Staelin 1999; Lal, Little, and Villas-Boas 1996; Lal and Villas-Boas 1998; Murry and Heide 1998; Rao, Arjunji, and Murthi 1995; Tyagi 1999; Walters 1989), none captures the institutional aspects associated with a durable industry that has an active secondary market and performance-based promotions. Instead, most trade promotion models assume that (1) the retailers can forward buy; (2) the manufacturers cannot easily monitor the retailer’s sales; and (3) the product being sold is non-durable, and thus there is no secondary market for the used product. In addition, most trade promotion models are aimed at situations in which the retailer is able to carry multiple products produced by competing manufacturers. In contrast, automobiles (and many other durables) are sold through franchise dealers that can carry and display only one manufacturer’s line.

The overarching goal of this study is to provide an economic explanation for why manufacturers might consider providing their retailers with performance-based trade pro-
motions. We note that because the situation being studied involves a promotion policy aimed at encouraging the downstream channel member to sell more units (and thus lower its retail price), our study is related to the quantity discount and the associated channel coordination literature (Ingene and Parry 2000; Jeuland and Shugan 1983; McGuire and Staelin 1986). However, our interests are broader because we use this basic exploration to understand why trade promotions are more likely to be used by manufacturers that sell goods that deteriorate slowly (i.e., are more durable).

We proceed as follows: Building on the durable goods literature in a channels context (Desai, Koenigsberg, and Purohit 2004; Purohit 1995, 1997; Purohit and Staelin 1994), we first develop a model of consumer behavior that captures the key underlying factors of a durable market. Then, using game theoretic analyses, we derive equilibrium prices, quantities, and trade discounts as a function of product durability for a market in which manufacturers distribute their horizontally and vertically differentiated durables through private franchised dealers. We find that no matter how intense the interbrand competition, manufacturers give trade promotions if there are no administrative costs associated with the promotion, and retailers voluntarily participate in these promotions. We also find that manufacturers that sell products that hold their intrinsic value longer benefit more from performance-based trade promotions than do those that sell less durable products. Moreover, these high-durable manufacturers give deeper discounts. We subject these latter two analytic results to empirical tests using a unique, proprietary database that covers the period 1992–1997 and find strong support.

**MODEL DEVELOPMENT**

*Overview of Approach*

We want our model to capture the key observed aspects of the automobile market. Therefore, we assume a market composed of multiple manufacturers, each of which distributes its cars through exclusive but competing franchised dealerships. By including multiple players at both channel levels, we allow for competition in both the retail and the wholesale markets. We make this assumption because the results of prior analyses differ depending on whether there is competition in the model.1 We also assume that the manufacturers position their offering to appeal to consumers who particularly value their offering and thereby create real and perceived product differences. Finally, we assume that the cars they sell, as do most durables, deteriorate over time and have finite lives and that this rate of deterioration differs across manufacturers.

We use a parsimonious representation of competition in which we model two competing manufacturers, each selling one differentiated product through exclusive but competing franchised dealers. Similar to Bulow’s (1982) work, we capture the cars’ deterioration by postulating a two-period model.2 We assume that a car purchased in the first period is new and only becomes used in the second period. Moreover, we assume that by the end of the second period, this used car has deteriorated enough that its economic value is zero. Finally, we assume that there are no used cars at the beginning of the first period.5

We use this model to investigate the impact of trade promotions on manufacturers’ and retailers’ prices and profits over a wide range of product quality and market conditions. In our series of game-theoretic analyses, the manufacturer has the option of offering the retailer a performance-based trade promotion in the first period, and the retailer has the option of either accepting this promotion and modifying its pricing policy to achieve the quantity objective or declining to participate and thus maintaining its prior pricing policy. Such analyses require the specification of demand functions for the available products for both periods. We want these demand functions to reflect the aggregate effects of different buyer behavior patterns. Specifically, we want to represent a market in which some consumers replace their cars before they wear out (i.e., they trade in the old car and buy a new car), some buy a new car and then keep it until its economic life is zero, some only buy used cars, and some never buy either a new or a used car. To specify a logically consistent set of demand functions to represent such a market, we begin with a set of underlying buyer behavior assumptions and then derive the demand functions. We use this method rather than assume reduced-form demand functions to ensure that we hold the underlying situation fixed (e.g., same number of potential buyers, choice behavior) when we explore different situations by varying the underlying model parameters.

*Model Structure*

Given our desire to derive demand functions that reflect the aggregate effects of different buyer behaviors, we seek a set of parsimonious assumptions that will lead to this aggregate behavior; in this way, our model is conceptually similar to that of Desai (2001) and Desai and Purohit (1998). We begin by postulating two consumer segments: a high-value segment and a low-value segment. The high-value segment contains consumers who have greater need (perceived or real) and thus a greater willingness to pay for the product than do consumers in the other segment. We denote this willingness to pay with the parameter \( \theta_i \), where \( i = H \) (high) or \( L \) (low). There are \( n_H \) consumers in the high-value segment and \( n_L \) consumers in the low-value segment. Without a loss of generality, we normalize the number of consumers by setting \( n_H + n_L = 1 \). We next assume that the consumers within each segment are distributed uniformly on a \([0,1]\) line segment, as in Hotelling’s (1929) study, and the consumer’s location on the line segment, denoted as \( x \), describes the consumer’s ideal point. We assume that the two manufacturers’ products are located at the two extremes of Hotelling’s line. We refer to the manufacturer on the left extreme as Manufacturer a performance-based trade promotions on this durable market. The future effects of a trade promotion offered in the first period can be captured in the second period. Thus, adding more periods should not change our overall general insights.

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1Specifically, McGuire and Staelin (1986), by extending Jeuland and Shugan’s (1983) monopoly formulation to a situation in which there are two competing manufacturers, find that it is not always optimal for two competing manufacturers to use quantity discounts.

2Although the automobile market clearly exists for longer than these two periods, our main interest is in determining current and future effects of

5Adding a supply of used cars in the first period should not affect our results because these used cars, by assumption, would have no economic life by the second period and thus would not compete in the new-car market in the second period.
and the manufacturer on the right extreme as Manufacturer b. Next, we define a lack-of-fit (transportation cost) parameter, k, so that the consumer incurs a lack-of-fit disutility of kx when buying Manufacturer a’s product and k(1 - x) when buying Manufacturer b’s product. This way, we capture the differences among consumers in their preferences for the two manufacturers’ products.

Because the product is a durable, we make the common assumption that consumers value it for the services it provides over multiple periods. We define consumer utility on a per-period basis and allow consumers to decide to purchase or sell each period. A consumer in valuation segment i located at a distance x from Manufacturer a has a per-period gross utility of \( \phi_i \theta_i - k d_i \) from using Manufacturer j’s car, where \( \phi_i = 1 \) if the car is new, \( \phi_i = \gamma_i(0 < \gamma_i \leq 1) \) if the car is old, and \( d_i \) is the distance between the consumer and Manufacturer j. Note that the first term captures the consumer’s valuation for the ideal new car (\( \theta_i \)) appropriately degraded if it is used (i.e., \( \gamma_i \)), and the second term reflects the disutility associated with the available car that does not meet the consumer’s ideal specifications. The parameter \( \gamma_i \) represents durability or the lack of physical deterioration of the car from usage, that is, how well the car holds up after use. To allow for differences in the durability between the two manufacturers, we let \( \gamma_i \geq \gamma_f \). We investigate the effects of \( \gamma \) on the outcomes of our model subsequently.

We obtain a consumer’s net utility (i.e., perceived value) by subtracting the relevant prices from the gross utility. We denote new-car prices in the first and second periods by \( p_{1j} \) and \( p_{2j} \), respectively, and used-car prices by \( r_{2uj} \), where \( j(a,b) \) denotes the manufacturer. The price of a new car, \( p_{1j} \), reflects the disutility associated with the available car that does not meet the consumer’s ideal specifications. The parameter \( \gamma_i \) represents durability or the lack of physical deterioration of the car from usage, that is, how well the car holds up after use. To allow for differences in the durability between the two manufacturers, we let \( \gamma_i \geq \gamma_f \). We investigate the effects of \( \gamma \) on the outcomes of our model subsequently.

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Consumer Choice and Product Demand

Consumers in each period have the option to buy Manufacturer a’s new car or Manufacturer b’s new car or not buy any car at all. Consumers who purchased in the first period also have the choice of selling the first-period new car (hereafter referred to as a used car) in the second period. Consequently, in the second period, all consumers also have the option to buy a used car. Because each consumer buys at most one car per period, the number of consumers who find it optimal to buy a given manufacturer’s new or used car at the prevailing price determines the demand for that new or used car in that specific period. For all consumers, we determine their optimal choice (i.e., whether to buy a car and, if so, which brand and type) for a given set of prices. We provide technical details of this analysis in the Appendix. Not all values of our parameter set yield well-behaved two-period demand functions that also reflect the desired set of behaviors: Specifically, some consumers buy cars and trade in their old car every period, some buy new cars periodically and keep the car until it has no more economic life, others only buy used cars, and still others do not buy any cars. Consequently, we make several assumptions about our parameter set. Specifically, we must assume that the willingness-to-pay parameter for low-value consumers, \( \theta_L \), is high enough that some low-value consumers find it best to buy a new car in the first period but is low enough that some low-value consumers find it best to buy only used cars and others find it best not to buy any car. Such a value for \( \theta_L \) ensures that the industry-level demands for new cars in the first period and for used cars in the second period can vary with the relevant prices and thus are not exogenously fixed. We also assume that \( \theta_H \) is high enough that all high-value consumers find it optimal to buy a new car in the first period, which ensures that there is inter-brand competition in the first period. In the absence of this assumption, some high-value consumers in the middle of the [0,1] line segment might remain inactive in the first period, and then each manufacturer would enjoy a local monopoly in the first period. We also assume that \( \theta_H \) is high enough that all high-value consumers find it optimal to trade in their current car and buy a new car in the second period. High-value consumers also have the option to keep their currently owned cars. However, the difference in utilities provided by these two options is independent of the consumer’s location, x. Therefore, in our model, either all high-value consumers buy a new car in the second period or no high-value consumers buy a new car in the second period. Our assumption about \( \theta_H \) ensures the former, because the latter results in zero demand for new cars in the second period. Finally, because we want to assume that the cars traded in by the high-value consumers are purchased (i.e., the used market clears), we must assume that there are enough low-value consumers to absorb all the used cars and still leave some consumers who do not own a car. If we do not make this assumption, some of the high-value consumers will not be able to employ their optimal strategy because of their inability to sell their used cars. The net of all these parameter assumptions is eight possible groups of consumers defined in terms of their two-period purchase behavior (see Figure 1).

We show in the Appendix that with this set of parameter assumptions, a formal analysis of the consumer choices leads to the following linear in-price demand functions:

\[
\begin{align*}
q_{1a} &= \{2 - n_H\}[2(1 - n_H)\theta_L + k n_H] + (4 - n_H)(1 - n_H) \\
&\quad (y_n, \theta_L - p_{1a} - (1 - n_H)\gamma_n, \theta_L - p_{1b})/[4k(2 - n_H)].
\end{align*}
\]

\[
\begin{align*}
q_{1b} &= \{2 - n_H\}[2(1 - n_H)\theta_L + k n_H] + (4 - n_H)(1 - n_H) \\
&\quad (y_n, \theta_L - p_{1b} - (1 - n_H)\gamma_n, \theta_L - p_{1a})/[4k(2 - n_H)].
\end{align*}
\]

and

\[
q_{2a} = \frac{n_H(k - p_{2a} + p_{2b})}{2k}, \quad q_{2b} = \frac{n_H(k + p_{2a} - p_{2b})}{2k},
\]

where \( q_{ij} \) is the tth period (t = 1, 2) demand for Manufacturer j. Note that five of our underlying parameters (i.e., \( \theta_i \),

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6We analyzed another model formulation in which the lack-of-fit disutility, k, is lower for used cars than for new cars, which allows some high-value consumers to find it best to keep their currently owned car in the second period. This formulation results in a more complex model but still supports our main results. For simplicity and parsimony, we have opted for the current model.
Overview of Analysis

In the interest of readability, we describe the rules of the games and briefly explain how we solve each game. Because our interest is the future effects of trade promotions, we limit our attention to the situation in which a manufacturer can give a promotion only in the first period so we can assess the future effect of the first-period promotion, namely, its effect on the second-period used market. We consider four games: (1) Neither manufacturer offers a trade promotion (NN); (2) only Manufacturer a offers a trade promotion (PN); (3) only Manufacturer b offers a trade promotion (NP); or (4) both manufacturers offer trade promotions (PP), where P denotes promotion, N denotes no promotion, and the first and second letters refer to Manufacturers a and b, respectively. Although our main interest is comparing outcomes of the NN and PP games, we need to analyze the PN and NP games to analyze the PP game and to establish whether it is an equilibrium. In all four games, we employ backward induction so that we solve the retailer/manufacturer game beginning with the last stage of the game, though the sequence of events and decision variables differ across games.

In the NN game, we begin by using our derived second-period demand functions to determine the two retailers’ optimal second-period retail prices as functions of the second-period wholesale prices. We then derive the two manufacturers’ optimal second-period retail prices, assuming Stackelberg price leadership within a channel. We also determine second-period used-car prices by equating the demand and supply of used cars in the second period, which results in used-car prices that are endogenous (i.e., depend on first- and second-period new-car prices). The first-period analysis proceeds in a similar way; we use the derived first-period demand functions from Equations 1 and 2 to solve the retailers’ and manufacturers’ maximization problems, in that order. Thus, first-period wholesale prices affect not only first-period retail prices but also second-period used-car prices. That is, there is a specific link between first-period actions and second-period outcomes.

In the PN game, the second-period analysis proceeds as in the NN game. However, the first period is different because of the trade promotion offered by Manufacturer a, which offers a quantity target and an associated wholesale price that the dealer qualifies for if it achieves the quantity target. In choosing the quantity target and the associated wholesale price, Manufacturer a ensures voluntary participation by its dealer. That is, Manufacturer a chooses optimal wholesale prices and a quantity target, subject to the constraint that its dealer gets at least $\pi_a^{NN*}$ profit with the promotion, where $\pi_a^{NN*}$ is Dealer a’s profit in the NN game. If Dealer a does not accept the promotion, the PN game becomes an NN game. In effect, the menu of wholesale prices that Manufacturer a offers is

$$w_{la} = \begin{cases} w_{la}^{PN*} & \text{if } q_{la} \geq q_{la}^{PN*}, \\ w_{la}^{NN*} & \text{otherwise}, \end{cases}$$

where $q_{la}^{PN*}$ is the sales quantity target set by Manufacturer a in the PN game.

The NP game is identical to the PN game except that Manufacturer b instead of Manufacturer a offers the trade promotion. In this game, Manufacturer b must ensure that its dealer gets at least $\pi_b^{NN*}$ profit, where $\pi_b^{NN*}$ is Dealer b’s profit in the NN game. In this way, our trade promotion is different from a quantity-forcing solution.
In the PP game, the second-period analysis proceeds as in the other games. However, the first-period analysis is different because each manufacturer offers a trade promotion by specifying a quantity target and a wholesale price. If Dealer a (b) does not accept the promotion, the PP game becomes an NP (PN) game. Therefore, Manufacturer a must ensure that its dealer gets at least $\pi^{NP}_a$ profit from the trade promotion scheme, where $\pi^{NP}_a$ is the dealer’s profit in the NP game in which only Manufacturer b offers a trade promotion. Similarly, Manufacturer b must ensure that its dealer gets at least $\pi^{PN}_b$, where $\pi^{PN}_b$ is the dealer’s profit in the NP game in which only Manufacturer a promotes. Manufacturer a’s menu of wholesale prices is as follows:

\begin{equation}
(5) \quad w_{lb} = \begin{cases} w^{PP}_{lb} & \text{if } q_{lb} \ge q^{PP}_{lb}, \text{ and} \\ w^{NP}_{lb} & \text{otherwise}, \end{cases}
\end{equation}

where $q^{PP}_{lb}$ is the sales quantity target set by Manufacturer a in the PP game. Manufacturer b’s menu of wholesale prices is

\begin{equation}
(6) \quad w_{lb} = \begin{cases} w^{PP}_{lb} & \text{if } q_{lb} \ge q^{PP}_{lb}, \text{ and} \\ w^{NP}_{lb} & \text{otherwise}, \end{cases}
\end{equation}

where $q^{PP}_{lb}$ is the sales quantity target set by Manufacturer b in the PP game.

Solving the four games is straightforward, though the algebra becomes complicated quickly. Still, we are able to obtain closed-form solutions for all prices, quantities, and profits as functions of our model parameters, which in turn enables us to compare solutions across all four games for all sets of feasible parameters. In addition, because we derived our demand functions from underlying buyer behavior, we can compare solutions across varying sets of parameter values within a game and be assured that we are holding other aspects of our model fixed, which means that we can interpret comparative static results. We now discuss some of our most interesting findings.

**Key Results**

Our main interest is understanding the differences between PP and NN games and how these differences vary by our durability parameter, $\gamma$. However, before we describe these durability-related differences, we note the following basic finding that holds over the total range of feasible parameter values:

**Result 1:** In equilibrium, both manufacturers offer performance-based trade promotions when there are no financial costs associated with administering the promotions.

The reason behind this result is the net influence of three different outcomes of our model. The first and second outcomes are lower-second-period used-car prices and lower-first-period new-car retail prices. These decreases in prices occur because the increased sales in the first period come from some consumers who would have otherwise bought used cars in the second period. The net effects are lower-first-period retail prices designed to attract these marginal customers and lower-second-period used-car prices because the marginal consumer who decides between buying a used car and not purchasing a car at all when trade promotions are given is located farther from the end points. In turn, this marginal consumer has a lower gross utility, which leads to a lower-second-period used-car market clearing price.\(^8\) The net impact of these lower prices is that the manufacturers must lower their wholesale price to ensure that the retailer will choose to participate in the trade promotion.

Acting in the opposite direction is the influence of financial incentives to the retailers to increase the quantity sold, which enables the manufacturers to mitigate the double marginalization problem partially and better coordinate channels. We note, however, that trade promotions only partially solve this problem because, as we show in the Appendix, the quantity sold in the PP case, though higher than in the NN case, is still lower than the sales quantity if each channel was integrated or fully coordinated. Thus, we do not replicate McGuire and Staelin’s (1986) result that dup- oly manufacturers may not want to use quantity discounts, because their findings are based on a fully coordinated channel. However, we find that the net result of these opposing factors is that, in equilibrium, both manufacturers run trade promotions.

In reaching this conclusion, we note that our analysis does not include any financial costs of administering the trade promotion. If such costs are included, then depending on their magnitude, one or both firms may not offer trade promotions in equilibrium. We return to this issue subsequently.

We now compare PP and NN outcomes and describe how they are affected by the durability of the two competitors’ products.

$P_1$: The depth of a trade promotion offered by a manufacturer $(w^{NN}_{lj} - w^{PP}_{lj})$ increases as the manufacturer’s product durability increases.\(^9\)

This comparative static result represents a within-firm finding. The underlying economic reasons for it are twofold. First, as we noted previously, a performance-based trade promotion is a mechanism for manufacturers to increase the quantity sold by the independent dealer and thereby partially solves the double marginalization problem. Second, with all else held constant, as the durability of a product increases, there is a greater difference between the sales quantity that an integrated manufacturer prefers and the sales quantity that results with no promotions; that is, a more severe double marginalization problem exists. More formally,

\begin{equation}
(7) \quad q^{PP}_{lj} - q^{NN}_{lj} > 0, \text{ and}
\end{equation}

\begin{equation}
(8) \quad \frac{\partial(q^{PP}_{lj} - q^{NN}_{lj})}{\partial \gamma_j} > 0,
\end{equation}

where $q^{PP}_{lj}$ denotes Manufacturer j’s (j = a, b) optimal sales quantity in the first period when both manufacturers are integrated. Therefore, it is in the manufacturer’s best self-
interest to provide more (deeper) incentives to its dealer to sell more units.

P2: The manufacturer selling the more durable product offers a greater depth of trade promotion and gains more profit from the trade promotion than does the manufacturer with less product durability.

P3: The manufacturer selling the more durable product offers a greater depth of trade promotion and gains more profit from the trade promotion than does the manufacturer with less product durability.

P3: When both manufacturers offer trade promotions, the manufacturer with higher product durability will have greater (a) percentage decline in same-period retail price, (b) percentage increase in same-period sales, and (c) percentage decline in next-period used-car prices because of trade promotions.

As we discussed previously, trade promotions result in an increase in first-period sales, a decrease in first-period retail prices, and a decrease in second-period used-car prices. P3 shows that all of these effects are higher for the higher-durability manufacturer.

Parts (a) and (b) of P3 result from the notion that the manufacturer with higher product durability can benefit more from solving its double marginalization problem and therefore sets a higher target for and offers a deeper cut in the trade promotion to its retailer. Part (c) is related to Part (b) in that the higher-durability manufacturer’s trade promotion results in more low-volatization consumers buying a new car, which reduces the pool of potential used-car buyers. This results in a greater reduction in used-car prices for the higher-durability firm, because the marginal consumer has a lower gross utility. P3 is notable because it shows that larger (deeper) trade promotions are actually a signal of strength, not weakness, in that high-durability manufacturers provide the incentive to their dealers to give greater discounts on their cars. Moreover, it points out that depreciation values should not be used to measure durability, because the former reflects used-car prices that are affected by the promotional strategies of the two types of firms, whereas the latter represents a physical characteristic of the car.

P1, P2, and P3 make it clear that trade promotions help manufacturers address the double marginalization problem. We now examine how retailers are affected by trade promotions.

P4: Each retailer makes less profit when both manufacturers offer trade promotions (PP case) than when both manufacturers do not offer trade promotions (NN case).

P4 is surprising because retailers participate voluntarily in any trade promotion scheme. Thus, in our model, the manufacturers must ensure that their retailer is not worse off if it takes advantage of the promotion. For example, in the PN game, Manufacturer a must ensure that Dealer a receives $\pi^N_{a,N}$ with the promotion. However, each retailer is adversely affected by the other manufacturer’s trade promotion. That is, $\pi_{a,P} < \pi_{a,N}$ and $\pi_{a,N} < \pi_{a,N}$. When both manufacturers offer trade promotions, Manufacturer a must ensure that its retailer receives $\pi_{a,P}$ profit with the trade promotion. Therefore, in the PP game, Dealer a gets its guaranteed profit $\pi_{a,N}$, which is less than $\pi_{a,N}$, its profit in the NN game. The same logic holds for Manufacturer b.

Another way to look at the result of P4 is that trade promotions, by better coordinating the channels, partially remove the buffering actions of the retailers and thereby make retail competition more intense. This increased competition reduces the retailers’ market power.10

An implication of this result is that one manufacturer’s trade promotion enables the other manufacturer to provide a smaller surplus to its retailer. This implication does not nec-
necessarily mean that one manufacturer’s promotion increases the other manufacturer’s profits, however, because the other manufacturer’s profits are hurt by higher sales of the competing manufacturer’s product. To investigate the effect of one manufacturer’s promotion on the other manufacturer further, we examine how the status of one manufacturer’s promotion affects the incremental benefits of promotion that the other manufacturer enjoys. For example, for Manufacturer a, we compare the incremental benefits of promotion when Manufacturer b does not promote, $\Pi^{\Pi^*}_a - \Pi^{\Pi^*}_a$, with the incremental benefits of Manufacturer a’s promotions when Manufacturer b does promote, $\Pi^{\Pi^*}_a - \Pi^{\Pi^*}_a$. Given the complexity of our model, it is not possible to characterize these effects fully. However, Corollary 2 shows a surprising possibility.

Corollary 2: There exists a set of parameter values for which a low-durability manufacturer’s promotion can increase the incremental benefit of promotion for the higher-durability manufacturer, so that $\Pi^{\Pi^*}_a - \Pi^{\Pi^*}_a > \Pi^{\Pi^*}_a - \Pi^{\Pi^*}_a$.

Thus, Manufacturer a might experience greater increases in profits as a result of promotion when its competitor is already promoting than if Manufacturer a is the only one to promote. We have not been able to identify a set of parameters for which a similar result would hold for Manufacturer b; however, we also have not been able to rule out this possibility analytically.

These propositions and corollaries follow directly from our model, which we acknowledge is an abstraction of the “real world.” Consequently, it might be questioned whether our conclusions are observed empirically. With this in mind, we next present an analysis of six years of trade promotions in the U.S. automobile market and compare the results of this analysis with some of our model assumptions and predictions. Then, we discuss the implications and limitations of our theoretical and empirical results in the “Summary and Conclusion” section.

**EMPIRICAL ANALYSIS**

We test two central hypotheses that come from and one underlying assumption of our theoretical model.

$H_1$: Trade promotions are more likely to be given for products with higher durability.

$H_2$: The depth of a trade promotion is higher for products with higher durability.

$H_1$ is based on the result that the firm with the more durable product gains more from the trade promotion. As we describe in Corollary 1, depending on the administrative costs of running the promotions, it is possible that neither or both firms offer trade promotions to their retailers. Therefore, $H_1$ is valid for the instances in which the fixed administrative trade promotion costs are low enough to make trade promotions profitable for the more durable product but not so low that trade promotions are profitable for the less durable product. Our theory provides a sharper prediction for trade promotion depth; conditional on both firms holding trade promotions, we predict that the trade promotion for the more durable product always has a greater depth. $H_2$ derives directly from $P_1$ and $P_2$. Finally, our model assumes that if firms give trade promotions, they give them throughout the period. Consequently, we analyze the promotion frequency of firms over each model year.

**Empirical Model**

We investigate $H_1$ and $H_2$ by specifying and simultaneously testing a two-equation system that models an automobile manufacturer’s decision to offer a trade promotion and the depth of the resulting trade promotion. The proposed specification controls for nameplate-specific effects and the potential selectivity bias that result from the fact that we observe trade promotion depth if and only if automobile manufacturers promote. Formally, we investigate $H_1$ and $H_2$ together using a random-effects variant of the widely applied sample selection model (Verbeek 1990; Verbeek and Nijman 1992; Zabel 1992). By simultaneous estimation, we can estimate the slope parameters of interest and test for the covariance of our endogenous variables with a single econometric specification.11

11We thank an anonymous reviewer for suggesting this simultaneous estimation.
We obtain estimates of our model parameters by maximizing the theoretical unconditional likelihood of the ith nameplate using LIMDEP 8.0. We derive this likelihood function by first stating the contribution of the ith nameplate in year t to the likelihood conditional on the random effects. This conditional likelihood is made up of three parts: the conditional probability that a firm offers a trade promotion, the distribution of the trade depth, and the probability that the firm does not offer a trade promotion. We obtain the theoretical unconditional likelihood of the ith nameplate by numerically integrating out the random effects, as follows:

\[
L_i(\beta, \lambda, \Sigma) = \int \int \cdots \int \prod_{t=1}^{T} f(\xi_{it}, u_{it}|\alpha_i, \eta_i) \ dG(\alpha_i, \eta_i).
\]

We are able to fit the model in LIMDEP 8.0 using the maximum simulated likelihood.

Data Description and Measures

Our primary data source is a proprietary data set of automobile promotions that provides a description of every dealer incentive program offered by DaimlerChrysler, Ford, General Motors, and the major Japanese (Honda, Mazda, Nissan, and Toyota) automobile manufacturers during 1992–1997. Each of the 69 nameplates (e.g., Toyota Camry, Ford Escort) on promotion was recorded, along with the duration and target (e.g., dealer, consumer) of the promotion. The rest of the data came from three leading public sources of automotive information: Automotive News Market Data Book, Consumer Reports, and Automotive Leasing Guide. Because not every nameplate was sold in all six years, we were left with a total of 317 nameplate/year observations. For each of these observations, we used the following measures.

Trade promotion. Our dependent measure for \( H_t \) is the indicator that a nameplate was on promotion in a given model year. We define a model year to be 16 months long, starting in September preceding the year of the model and ending in the following December. Because we are able to attach the specific promotion to a specific nameplate, there is no confusion in the months in which multiple model years are available (September–December).

Trade promotion depth. For every trade promotion for a nameplate in a given model year, we calculate the per-car value of the trade promotion incentive and divide it by the dealer’s invoice. We then calculate the weighted average of these promotions for a given nameplate in a given model year by weighting each of the ratios by the proportion of time that the particular promotion was in effect. Finally, we assume that trade depth is normally distributed (and thus varies from minus infinity to plus infinity), we rescale this weighted average proportion by taking the log odds of the weighted average.

Durability. Durability is our primary independent variable. We follow the lead of Desai and Purohit (1999) and use predicted reliability, as given in Consumer Reports, as our measure of durability for a nameplate. Thus, predicted reliabilities are measured on a five-point scale for each nameplate and are based on the frequency of repair data for earlier vintages of the same nameplate, as well as Consumer Reports’ assessment of the new car’s durability. Consequently, it is a measure of the expected durability available to consumers when they make the buying decision.

Control Variables

We also include four variables to control for other factors that might influence the firm’s decision to give trade promotions and the depth of the promotions. The variables are the degree of product differentiation, the level of excess inventory, whether the vehicle being sold is a truck or car, and whether the manufacturer is foreign or domestic.

Degree of product differentiation. Our analytic model contains the parameter \( k \), which captures the degree to which the nameplates are differentiated. Although we did not present any specific hypotheses pertaining to this parameter, we control for any effect by including a Herfindahl index measure to capture the extent of competition or concentration in each segment. We divided the automobile market into segments using the scheme adopted by the Automotive News Market Data Book. For each of the segments, we calculate the Herfindahl index as \( H_{it} = \sum m_{it}^2 \), where \( m_{it} \) is the market share of nameplate i in year t. Note that \( H_{it} \) is similar to \( k \), which is higher for markets with higher concentration (lower competitive intensity and thus more product differentiation) and lower for markets with lower concentration (higher competitive intensity).

Average monthly excess inventory. To control for the possibility that trade promotions are a response to inventory backlog, we first created a measure for monthly changes in inventory levels. Specifically, for month t, we use \( \Delta I_{it} = (P_{it} - 1 - S_{it} - 1)X_{it} \), where \( P_{it} \) is the production in month t and \( S_{it} \) is the sales in the same month. This equation is mathematically equivalent to the difference between the ending and the beginning inventory in the previous month as a fraction of the current month’s sales, which both reflects the industry practice of considering inventory in terms of the number of days of sales (referred to as days supply by the trade) and controls for different rates of sales. Because only positive values of \( \Delta I_{it} \) lead to excess inventory levels, we use the sum of positive values of \( \Delta I_{it} \) as our measure of excess inventory, where the summation is taken over a model year. Thus, nameplate model years with higher values of our measure indicate that the nameplate model year had (at least at times) higher (excess) inventory levels than did those with lower values of our measure. The production and sales data for all nameplates in all calendar years in this study are available in the Automotive News Market Data Book.

Car versus truck. Because trade promotion policies may depend in part on whether the nameplate is a car or a truck, we include a dummy variable to reflect that the promotion was for a car.

Foreign versus domestic. We also created an indicator to flag whether the nameplate was a foreign car. This distinction is important because empirically Japanese nameplates have higher average predicted reliability than domestic nameplates. By including the foreign dummy along with our durability measure, we are able to control for other fac-

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\[12\] Although we did not have the data on absolute levels of inventory, we calculated the change in inventory from production and sales data that are publicly available.
tors, such as management policy, that might serve as alternative explanations.

Results

The results of our analysis appear in Table 1. We find that the durability coefficient in both promotion and depth equations is statistically significant and positive; that is, the likelihood of trade promotion increases with durability ($H_1$), and conditional on the firm giving a trade promotion, the depth of promotion increases with durability ($H_2$). We take this finding as strong support for our model development and predictions.

Although our primary interest is the effect of durability on the likelihood of using trade promotions and the depth of these promotions, the estimates for our control variables are also informative. The foreign car indicator is positive and significant in both the promotion and the depth equations. We noted previously that the Japanese nameplates have a higher average durability level than U.S. nameplates. By including both our durability measure and the foreign car indicator, we are able to rule out the possibility that our durability results ($H_1$ and $H_2$) are due entirely to differences in the management practices of the Japanese and U.S. carmakers. That is, we find our hypothesized durability effects even after accounting for any differences in managerial practices. This finding provides us with more confidence about our assertion that higher durability causes manufacturers to use trade promotions and give deeper promotions.

We also note that the Herfindahl index is negative and significant in the promotion likelihood equation, suggesting that trade promotions are more likely to occur when markets are less concentrated (and thus more competitive) but that increased competition does not affect the depth of the trade promotion. We suggest that the first finding—how likely promotions are to occur—is due to market share issues. Manufacturers may use trade promotions to capture market share, but the depth of promotion finding only reflects the manufacturers’ concerns about the double marginalization problem.

Promotions in the automobile industry are commonly believed to be a way to manage inventory levels. Table 1’s results support this belief, at least in terms of the depth of the trade promotion. However, we find no impact of excess inventory levels on the likelihood that a firm offers a trade promotion. Thus, it appears that manufacturers increase target sales levels when they have extra inventory on hand.

We further explore the impact of inventory levels on trade promotions and, in doing so, provide credence for one of our model assumptions. We observe the frequency of trade promotions during the 16 months associated with a given model year and aggregate the data across models and model years. Our analytic model assumes that trade promotions are offered throughout the period to alleviate (partially) the double marginalization problem. The hypothesis that trade promotions are used to clear inventories should show a different pattern because excess inventories often exist at the end of the model year.

We provide the results of our analysis in Table 2, which contains three notable patterns. First, trade promotions are offered throughout the model year. Second, there are more trade promotions in effect at the end of the model year than is average, though this increase is not large. This finding is consistent with the idea that at least some trade promotions are intended to lower retail prices to minimize excess end-of-year inventories. Perhaps more surprising is that there is a slight increase in promotion frequency beginning in the second month and running through the fourth month. This latter observation is consistent with an outward shift in demand due to the new model year. The shift increases the double marginalization problem and thus increases the benefits of giving a trade promotion. These two observations lead us to conclude that though there is some indication that

<table>
<thead>
<tr>
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<th>Estimate</th>
<th>Standard Error</th>
<th>t-Statistic</th>
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<td><strong>Promotion Likelihood ($H_1$)</strong></td>
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<tr>
<td><strong>Trade Depth ($H_2$)</strong></td>
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*Significant at 1% significance level.
**Significant at 5% significance level.

Notes: Sample size: n = 317; panels: 69 nameplates.
trade promotions are used to lower retail prices in periods of low demand, we also find strong evidence that these promotions are used throughout the model year, in support of our belief that manufacturers use trade promotions to alleviate the double marginalization problem.

Third, the highly significant, negative estimate of \( \rho \) suggests that when trade promotions are given for reasons not included in our model (and therefore assumed to be random), the resulting promotion has a smaller depth. Although we do not have a theoretical explanation for this finding, it has strong face validity because it suggests that unplanned trade promotions have lower trade depth than do planned trade promotions.

**SUMMARY AND CONCLUSION**

Beginning with observations about key aspects of the automobile market, we develop and analyze a model that enables us to capture these aspects parsimoniously. Our results provide several notable insights.

Perhaps the most general insight is that trade promotions can partially mitigate the double marginalization problem by better coordinating the channel. Moreover, in contrast to McGuire and Staelin’s (1986) finding that it is not always best for the manufacturer to obtain total channel coordination, this form of (partial) channel coordination provides benefits to manufacturers across the total feasible parameter space, namely, all levels of product differentiation. The benefits of channel coordination are greater for the manufacturer that sells a higher-durability product. Therefore, if there are administrative costs independent of durability associated with running trade promotions, we find that the firm with higher durability is more likely to offer trade promotions. Moreover, regardless of administrative costs, this firm will offer trade promotions at a greater depth.

When trade promotions are used, our model shows that the increase in current sales comes from converting some potential used-car buyers into new-car buyers. This conversion has the effect of reducing the first-period retail price.

In addition, the remaining pool of potential used-car buyers is made up of people who have a relatively lower valuation for the used cars, which, independent of the supply of used cars, puts downward pressure on the future used-car prices of the manufacturer running the trade promotion. Because supporting high used-car prices can be an important concern for automakers, especially those that have substantial leasing programs, our model emphasizes the need for manufacturers to consider this trade-off when they decide to use trade promotions.

We also find that retailers are negatively affected by trade promotions when both manufacturers run trade promotions, even though program participation is voluntary, because the necessary minimum profit is reduced when the competing manufacturer also runs a trade promotion. Thus, a manufacturer’s trade promotion enables the other manufacturer to extract a greater surplus from its retailer. We also find that the incremental benefits of promotion to a manufacturer may be greater when the other manufacturer also runs a promotion. This finding provides an interesting contrast to results that pertain to promotions that arise from the prisoner’s-dilemma formulations that are often discussed in the CPG promotions.

We test two of our theoretical results and one of our basic model assumptions and find that U.S. automobile market trade promotion data are consistent with our assumption that trade promotions occur throughout the model year and with our propositions that the promotions are more likely to be used by manufacturers of high-quality cars and that when these high-quality manufacturers give trade promotions, they give deeper promotions.

In reaching these conclusions, we note the limitations in our model. By using a two-period model, we are able to capture, to some degree, the impact of first-period sales on the second-period outcomes. We say “to some degree” because our formulation assumes that all high-valuation consumers buy new cars in the second period, which results in fixed second-period new-car sales. Consequently, we do not allow first-period sales to affect second-period new-car sales. To do this, we would need to allow some high-valuation consumers to keep their first-period cars if new-car prices are too high in the second period—that is, if the cost of trading up is too high. We have separately analyzed such a model and find that, as in the model presented here, the higher durability of a car makes the first-period demand for the product stronger by shifting the demand curve out. However, the second-period demand is weaker, because the lower used-car prices make it less economical for high-valuation consumers to replace their old cars with new cars in the second period. Therefore, first-period trade promotions are followed by a reduction in new-car sales in the second period. When we modify our model accordingly, we find that our main results still hold.13

In our model, we do not consider trade promotions in the second period. Allowing trade promotions in the second period and determining the effects of durability would require us to model a third period and analyze third-period used-car prices. We believe that adding a third period to our model increases the complexity without any significant ben-

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13These results are available from the authors.
efits; the primary reason we include a second period is to capture the future effects of first-period trade promotions.

In this study, we have restricted our attention to trade promotions. A more general model would allow manufacturers to offer trade or consumer promotions (i.e., promotions given directly to the consumer) or both. We did not pursue this more general model because the underlying motivation for consumer promotions must be different from trade promotions. Retailers are free to adjust their retail price upward to match the size of the consumer promotion but must lower their retail price if they are to take advantage of the trade promotion. Consequently, our explanation for trade promotions cannot be directly applied to customer promotions. Instead, researchers need to postulate another mechanism for why they occur. We leave this postulation to further research.

We acknowledge that there may be other possible explanations for why manufacturers run trade promotions. For example, trade promotions may help manufacturers motivate dealers or may reflect a reduction of the wholesale price during periods of weak demand. However, we believe that our model and empirical evidence provide a deeper understanding of why we observe manufacturers using trade promotions differentially within the auto industry and the impact of these trade promotions on dealer profits and new- and used-car prices.

**APPENDIX: CONSUMER CHOICE AND DEMAND GENERATION**

In the second period, consumers who bought a new car in the first period can choose to sell their current car and either buy another new car or remain inactive or to keep the car and use it for the second period. It is easy to show that the dominant strategy is to trade in the old car and then be inactive. Thus, we only need to determine whether the consumer prefers to trade up to a new car or keep the old one. If the consumer keeps the current car, his or her utility is \( \theta_2Y - r_{2ub} - kd \). If he or she replaces the current car with a new car, the utility is \( \theta_2Y - p_{2ub} - kd \), where \( m = a, b \) is the brand of the new car, and \( j \) is the brand of the sold old car. The consumer’s choice depends on whether \( \theta_2Y - r_{2ub} - kd \) is greater (less) than \( \theta_2Y - p_{2ub} - kd \). To simplify the analysis and yet capture both types of behavior, we assume that \( \theta_1 \) and \( \theta_2 \) are such that \( \theta_1(1 - \gamma) > (p_{2ub} - r_{2ub}) + kd \) and \( \theta_2(1 - \gamma) < (p_{2ub} - r_{2ub}) + kd \). That is, the high-value consumers trade up, and the low-value consumers keep their previously purchased new car.

The high-value consumers in the second period buy the brand that gives them the higher utility. We determine the location of the high-value consumer who is indifferent toward the two brands in the second period by equating the two second-period net utilities and solving for \( x \). We denote this location by \( x_2 \), where \( x_2 = (k - p_{2a} + p_{2b})/2k \). Therefore, because consumers are assumed to be uniformly distributed over the unit lines, \( d_{2a} = nHx_2 \), and \( d_{2b} = nH(1 - x_2) \). Let \( x_1 \) be the location of the high-value consumer who is indifferent toward the two brands in the first period (we determine this value subsequently). Because \( x_1 \), \( x_2 \), \( y_1 \), and \( y_2 \) may not equal \( x_2 \), there may be some brand switching. If \( x_1 > x_2 \), consumers who lie between \( x_1 - x_2 \) switch from Brand a to Brand b. If \( x_1 < x_2 \), the converse is true (see Figure 1).

By assumption, the only potential buyers for used cars in the second period are low-value consumers who did not buy any car in the first period. Because we do not force all of these potential buyers to buy used cars, we must ensure that the market of used cars is cleared and there still are some consumers who do not buy a used car. Thus, there are three subsegments among the potential buyers of used cars: buys Brand a used cars, remains inactive, or buys Brand b used cars. A consumer who did not buy a car in the first period has the utility \( \theta_1Y - r_{2ub} - kd \) from buying a Brand a used car and the utility \( \theta_2Y - r_{2ub} - kd(1 - x) \) from buying a Brand b used car. The option of not buying any car gives the consumer zero utility. Comparing the utilities of buying a used car and staying inactive, it is clear the consumers who buy Brand a used cars will be to the left of inactive consumers, and consumers who buy Brand b used cars will be to the right of inactive consumers (see Figure 1). We obtain the cutoff points that appear in Figure 1 by finding the indifference points between buying a used car and not buying—that is, \( x_4 = (-r_{2ub} + \gamma \theta_1)k \), and \( x_5 = (k + r_{2ub} - \gamma \theta_2)k \). We use these values to derive used-car prices.

We now derive the demand for new cars in the first period. Because by assumption there are no used cars in the first period, consumer choice is limited to buying a new Brand a car, buying a new Brand b car, or remaining inactive. The net utility of buying a Brand j car is \( \theta_j - r_{1j} - kd \). Buying a new car in the first period does not commit the consumer to any specific strategy in the second period. Therefore, consumers will buy a new car as long as \( \theta_j - r_{1j} - kd \) is positive. We assume that all consumers in the high-value segment value new cars enough that they will always buy a new car. Consumers to the left of product space will buy Brand a and those toward the right will buy Brand b, and the indifference point between buying Brand a and Brand b, \( x_1 \), is the point where the two net utilities are equal: \( x_1 = (k - r_{1a} + r_{1b})/2k \). We assume that only a fraction of the low-value consumers will find positive utility from buying a new car. We determine the group of low-value consumers who will buy Brand a by identifying the value of \( x \) for which the net utility in the first period from buying Brand a is zero. This value of \( x \), denoted by \( x_3 \), is given by \( x_3 = (-r_{1a} + \gamma \theta_1)k \). Similarly, the value of \( x \) for which the net utility from buying Brand b is zero is denoted by \( x_6 \) and given by \( x_6 = (k + r_{1b} - \gamma \theta_1)k \). In the low-value segment, consumers in the range \( x \in [0, x_3] \) buy...
Brand a, consumers in the range $x \in (x_6, 1]$ buy Brand b, and consumers in the range $x \in [x_3, x_6]$ stay inactive in the first period. The demand for Brand a in the first period is given by $q_{ia} = n_Hx_1 + n_Lx_3$, whereas the demand for Brand b is $q_{ib} = n_H(1 - x_1) + n_L(1 - x_3)$. After simplification, we obtain the following:

\[ q_{ia} = \chi_i \left( \frac{2 - n_H}{2k} \right) r_{ia} + \left( \frac{n_H}{2k} \right) r_{ib}, \]
\[ q_{ib} = \chi_i \left( \frac{2 - n_H}{2k} \right) r_{ib} + \left( \frac{n_H}{2k} \right) r_{ia}, \]
\[ \chi_i = \frac{k_{ia} + 2n_H - 2n_L r_{ia}}{2k} \]

Next, we derive used-car prices ($r_{2ua}$, $r_{2ub}$) by equating the supply of used cars from consumers who replace their cars in the second period and the total demand generated by used-car consumers in the second period. Thus, $n_Hx_1 = n_L(x_4 - x_3)$ and $n_H(1 - x_1) = n_L(1 - x_3)$. Solving for $r_{2ua}$ and $r_{2ub}$ yields

\[ r_{2ua} = \alpha_{11} + \left( \frac{2 - n_H}{2 - 2n_H} \right) r_{ia} - \left( \frac{n_H}{2 - 2n_H} \right) r_{ib}, \]
\[ r_{2ub} = \alpha_{12} - \left( \frac{n_H}{2 - 2n_H} \right) r_{ib} + \left( \frac{2 - n_H}{2 - 2n_H} \right) r_{ia}, \]
\[ \alpha_{11} = \frac{k_{ia} + 2(1 - \gamma_i) x_1 (1 - n_H) r_{ia}}{-2(1 - n_H)}, \]
\[ \alpha_{12} = \frac{k_{ib} + 2(1 - \gamma_i) (1 - n_H) r_{ib}}{-2(1 - n_H)}. \]

\section*{Analysis}

Neither firm promotes (NN). We assume that the two retailers move simultaneously to choose their retail prices for a given set of wholesale prices by the manufacturers. The manufacturers act as Stackelberg leaders with respect to the dealers but move simultaneously against each other in choosing their wholesale prices. The second-period analysis with this sequence of moves provides the following equilibrium solution:

\[ w_{2a}^{NN} = w_{2b}^{NN} = 3k, \quad p_{2a}^{NN} = p_{2b}^{NN} = 4k. \]

In the first period, retailers and manufacturers maximize their two-period profits. Note that first-period new-car prices will reflect the cost of owning the car for both periods: $p_{1a} = r_{1a} + r_{2ua}$ and $p_{1b} = r_{1b} + r_{2ub}$. Because used-car prices are endogenous, Dealer a chooses $r_{1a}$ to maximize $\pi_{1a} = (p_{1a} - w_{1a} + r_{2ua}) + p_{2a}^{NN}$, and Dealer b chooses $r_{1b}$ to maximize $\pi_{1b} = (p_{1b} - w_{1b} + r_{2ub}) + p_{2b}^{NN}$, where $p_{2j}^{NN}$ (j = a, b) is Dealer j's second-period profit. The first-period equilibrium outcome is as follows:

\[ r_{1a}^{NN} = \frac{z_1(w_{1a} - \alpha_{11}) + z_2(w_{1b} - \alpha_{12})}{(8 - 5n_H)x_8 - 7n_H + n_H^2}, \]
\[ r_{1b}^{NN} = \frac{z_1(w_{1b} - \alpha_{11}) + z_2(w_{1a} - \alpha_{12})}{(8 - 5n_H)x_8 - 7n_H + n_H^2}, \]
\[ w_{1a}^{NN} = \frac{[1 - (n_H)k_{ia} + h_2 \alpha_{12}] + 4k(32 - 22n_H + n_H^2)}{(8 - 7n_H + n_H^2)x_8(1 - n_H)32 - 22n_H + n_H^2}, \]
\[ w_{1b}^{NN} = \frac{[1 - (n_H)k_{ib} + h_2 \alpha_{11}] + 4k(32 - 22n_H + n_H^2)}{(8 - 7n_H + n_H^2)x_8(1 - n_H)32 - 22n_H + n_H^2}, \]
\[ p_{1a}^{NN} = \frac{(1 - n_H)k_{ia} + h_2 \alpha_{11}}{2(1 - n_H)}, \]
\[ p_{1b}^{NN} = \frac{(1 - n_H)k_{ib} + h_2 \alpha_{12}}{2(1 - n_H)}. \]

where $z_1 = (2 - n_H)^2(4 - 3n_H)$, and $z_2 = (2 - n_H)n_H(3 - 2n_H)$. Both firms promote (PP). The second-period analysis is the same as in the NN case. In the first period, both manufacturers simultaneously choose optimal quantity objectives (targets) and wholesale prices. To ensure voluntary dealer participation, each manufacturer competes by offering its exclusive dealer a trade deal that leaves the dealer just indifferent toward accepting and not accepting the promotion. Thus, we need to analyze PN and NP games and determine retailers’ profits in PN and NP games. The equilibrium prices and quantities in the PP game are as follows:

\[ r_{1a}^{PP} = \frac{k[2\chi_i - (2 - n_H)q_{1a}^{PP} - n_Hq_{1b}^{PP}]}{2(1 - n_H)}, \]
\[ r_{1b}^{PP} = \frac{k[2\chi_i - n_Hq_{1a}^{PP} - (2 - n_H)q_{1b}^{PP}]}{2(1 - n_H)}, \]
\[ q_{1a}^{PP} = \frac{4(20 - 2n_H)x_8 + 4n_H^2 \alpha_{11} + 2(-1 + n_H)n_H \alpha_{12}}{8(32 - 36n_H + 3n_H^2)}, \]
\[ q_{1b}^{PP} = \frac{4(20 - 2n_H)x_8 + 4n_H^2 \alpha_{12} + 2(-1 + n_H)n_H \alpha_{11}}{8(32 - 36n_H + 3n_H^2)}, \]
\[ w_{1a}^{PP} = \frac{4(4 - n_H)[2 - 4 + n_H]k_{1a} + n_H \alpha_{12}}{z_5 t_5}, \]
\[ w_{1b}^{PP} = \frac{4(4 - n_H)[2 - 4 + n_H]k_{1b} + n_H \alpha_{11}}{z_5 t_5}. \]

17The used-car supply-demand equations clarify why we must assume $n_L > n_H$ to ensure that the supply of used cars is cleared.
(A13) \[ w_{P^*}^{FR} = \frac{4(4-n_H)(2-4+n_H)\alpha_{12} + n_H\alpha_{11}}{z_3z_5} + \frac{8k(4-n_H)\gamma_1}{(1-n_H)z_5} + \frac{k(8-n_H)(-8+3n_H)(k\pi_{11} - \pi_{01}^P)}{z_6z_5}, \]

where \( z_3 = -8 + 3n_H, \) \( z_4 = (1 - n_H)(2[-4 + n_H]\alpha_{11} + n_H\alpha_{12}) + 2k(-8 + 5n_H)\gamma_1, \) \( z_5 = 4(8 - n_H), \) and \( z_6 = (1 - n_H)(2[-4 + n_H]\alpha_{12} + n_H\alpha_{11}) + 2k(-8 + 3n_H)\gamma_1. \)

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