Enabling the Willing: Consumer Rebates for Durable Goods

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For many consumers who use loans to acquire an expensive durable such as a car, the market value of their current (used) durable is less than the outstanding loan amount. If these consumers want to replace their used durable with a new one, they might not be able to do so because of the added burden of paying off the amount of negative equity. We develop and solve a model in which a durable goods manufacturer gives consumers a cash rebate, so that they can get out of the negative equity problem. We find that under certain conditions, the manufacturer offering a lower durability product is more likely to give cash rebates and, when such rebates are given, to offer a greater cash rebate. These rebates also lead to higher prices net of the rebate compared with the situation without any such rebates. We empirically test some of our equilibrium results and find support for our model predictions.

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1. Introduction

1.1. Background

In the automobile and other expensive durable goods markets, cash rebates from manufacturers directly to consumers constitute an important part of the manufacturers' marketing programs. These rebates represent marketing expenses in excess of $3 billion per year in the automobile industry alone and have attracted much attention in the business press (see, for example, Eldridge 2003). Although there is a large empirical literature on consumer promotions in marketing (see, for example, Neslin 2002), research in this area traditionally has focused on promotions other than cash rebates. Moreover, most of these studies have concentrated on consumer packaged goods. In this paper, we study cash rebates by manufacturers in durable goods markets.

We begin by noting that major durable goods, including automobiles, furniture, boats, motorcycles, and farm equipment, are expensive relative to most consumers' incomes. In particular, the average purchase price of automobiles often is in excess of $20,000. Because many consumers lack the liquid assets necessary to purchase the durable outright, they are required to finance their automobiles.[1] For durables

like automobiles where a second-hand market exists, consumers often want to use the proceeds from their existing (used) car as this liquid asset for their new car. However, approximately 40% of all car owners have negative equity (are "upside down" in the trade parlance), which means that they owe more money on their car than its current market value (Kiley 2003). If these consumers want to replace their existing cars with new cars, they must not only find a down payment but also must pay off the amount they are still upside down in their current car. This negative equity problem often acts as a barrier to stop consumers from replacing an old car with a new car.[2]

We develop and analyze a model in which a durable goods manufacturer provides cash rebates (often called customer cash by the trade) to help consumers solve their liquidity problems arising out of negative equity. The objective of this rebate is to increase new car demand. Conceptually, this firm action might increase demand by allowing the firm either to *slide down* a fixed demand curve, so that any increase in the quantity sold comes from a lower effective price after the rebate, or to *shift the demand curve outward*, so that the firm gets more sales for any

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[1] In a Power Information Network sample of 201,907 sales transactions for two midsize cars and two trucks in 2003, more than 80% of the vehicles sold were financed.

[2] We acknowledge that an individual's ability to obtain a new car may be constrained by other reasons. However, our focus is on the problem caused by the negative equity problem.

given effective price. In the former case, new consumers enter the market because the effective retail price is lower. In the latter case, they enter the market because receiving cash rebates provides them with value, independent of the lower effective retail price. In our model, both of these effects are present. When the manufacturer provides cash rebates to consumers who have a high valuation for the product but lack the ability to pay because of the negative equity problem, the rebate enables these consumers to obtain the product even if the effective purchase price remains the same, thereby shifting the demand curve outward. In addition, unless the retailer determines it is in its best interest to increase the retail price more than the size of the rebate, the effective retail price will decrease, which, in turn, enables the firm to slide down the demand curve.

We believe this paper makes several substantive and theoretical contributions. First, we explicitly allow for the empirical fact that not everyone who is willing to buy a durable has the ability to pay for that durable. We do this by augmenting the often-used construct "willingness to pay" with an additional construct: "ability to pay." We believe that this new approach can be applied to various durable goods markets. Second, we offer a new explanation of why a manufacturer might want to give a cash rebate directly to a consumer who is willing to pay but lacks the ability to pay, even though the retailer is free to modify the retail price in response to this cash rebate. Specifically, we show that this promotion action enables the manufacturer to increase sales by shifting the demand function outward instead of sliding down the demand curve. We also show that a manufacturer of a lower durability product is more likely to use cash rebates and give deeper discounts than is a higher durability manufacturer, and that the effective price to consumers rises when manufacturers give customer cash. Third, we provide a series of testable hypotheses regarding the profits and prices associated with cash rebates. For example, we show that margins decrease for both the manufacturer and the retailer though both derive increased profits from the rebate. Fourth, we provide empirical evidence that is consistent with three of our major results. We discuss these issues in more depth after we derive our results.

Our study is composed of two parts. After briefly reviewing the literature on price promotions, we derive a demand structure for new and used automobiles distributed through a third-party outlet (e.g., a franchised dealer). This demand structure is a function of the quality (durability) of the new and used cars, the retail prices of these competing cars and the customer rebate amount. We then use the demand structure to solve for equilibrium prices, quantities,

and profits, using a game-theoretic model of an industry composed of one manufacturer and one franchised dealer. This enables us to derive a series of implications on how profits, prices, and sales vary with the durability of the new product. In the second part of our study, we empirically test three of our equilibrium results using a proprietary database that includes all cash rebates promotions given in the United States by the three U.S. car manufacturers and the four major Japanese manufacturers for the 1992–1997 period.

1.2. Literature Review

To the best of our knowledge, there is no theoretical work studying customer rebates for a durable good that has an established secondary market and is sold through an independent retailer. However, extant literature not only provides some guidance in terms of how to approach this problem but also provides a benchmark in terms of the substantive findings. Thus we find a large literature about durable goods that provides a general approach for addressing the time-consistency problem associated with the coexistence of new and used markets (see, for example, Coase 1972, Bulow 1982). Various marketing academics have used this general framework (which recognizes that actions taken in one period have implication on the alternatives available in the next period) to model durables in a franchised dealer system (see, for example, Purohit and Staelin 1994, Desai et al. 2004). However, only one paper (Bruce et al. 2005) uses this time-consistency framework to consider promotions in a durable industry. In their case, the authors model promotions given to the retailer and not to the consumer.

A second relevant approach appears in a paper by Gerstner and Hess (1995). These researchers look at a situation where a manufacturer offers a pull promotion (e.g., a cash rebate) targeted at price-conscious consumers (more technically low willingness-to-pay consumers). Gerstner and Hess (1995) show that by giving a rebate, the manufacturer can better coordinate the channel because the retailer finds it optimal to lower its retail price enough to entice the low willingness to pay consumers to buy. As such, their approach is a way of reducing the double marginalization problem that exists in bilateral monopoly channels.

Our approach differs from theirs in several ways. First, Gerstner and Hess's (1995) approach does not allow for the effects of a secondary market. Second, their approach rests on the assumption that there exist only two groups of consumers who differ only in their willingness to pay for the brand. We generalize this setting to allow consumers to be distributed (uniformly) over the complete range of willingness to pay. Third, in their model, the rebate reduces only the price, and thus the firms slide down the demand curve. In contrast, we allow rebates to cause a shift in the demand curve as well.

Finally, there is a rich empirical literature concerned with consumer price promotions. Almost all of this literature centers on nondurables and even here most is concerned with trade promotions and not customer rebates. However, there are a few papers that directly study consumer rebates. Pauwels et al. (2002, 2003) find short-term (one week) and long-term (one to two months) increases in sales associated with unexpected retail price reductions. Busse et al. (2006) show consumers capture a larger percentage of a consumer promotion than a trade promotion. They attribute this to the difference in information available to consumers when negotiating with the dealer. Beltramini and Chapman (2003) report the results of a large survey that focused on assessing why consumers decided to buy or lease their particular model. They conclude consumers purchased their vehicle for reasons other than incentives.

In summary, none of these studies deals with issues of consumers' negative equity. In addition, none of these studies captures the secondary effect that increased new product sales reduce second-hand durable prices and thus decrease new durable prices because of the intrabrand competition between the new and used durables. With this in mind, we develop a model that captures the three key aspects of the situation of interest, i.e., some consumers face a negative equity problem, the existence of a competing second-hand market, and a distribution system that includes an independent retailer who sets the retail price after observing the size of the rebate.

2. Model

Our interest is in cash rebates within the automobile industry and how these rebates vary depending on the durability level of the manufacturer's product. This leads us to develop a parsimonious consumer behavior model that allows for consumer heterogeneity with respect to the location of the consumers' ideal product features, the consumers' desire for durability, and their ability to pay for any available option. Also, because rebates exist within a franchised system, we model the interaction between the manufacturer and the retailer. In addition, because the manufacturer's used cars (sold as new cars in a prior period) are partial substitutes for this period's new cars, our model allows for the sale of both new and used cars and the interaction between these two types of cars. The net effect of all these assumptions is a model of an industry with one manufacturer and one retailer, where new car demand is a function not only of the quality levels of the new car but also the quality level of the competing used car. Thus our model focuses on intrabrand competition rather than interbrand competition. We discuss this modeling decision at more

length subsequently; suffice it to say here that we believe our results hold as long as the manufacturer sells a differentiated product, i.e., faces a downward sloping demand curve.[3]

We acknowledge that in the automobile market, consumers can buy or lease automobiles. Interestingly, down payments and monthly payments for the often-used three-year lease and the often-used six-year loan are just about the same. Thus, from a consumer's point of view, financing via a lease or a loan are equivalent. Although papers such as Desai and Purohit (1998, 1999) have analyzed the strategic implications of leasing because of the time consistency problem, we abstract away from these issues by developing a single-period model. Moreover, because the lessor always purchases the leased car from the manufacturer, both types of transactions are equivalent in our model from the manufacturer's point of view as well. Thus, unless otherwise noted, we make no differences between the two types of transactions in our subsequent discussions.

2.1. Consumers
Our model reflects some of the key characteristics of automobile consumers. First, we recognize that many automobile consumers have an existing car that can still meet their needs, at least within the time period being analyzed, while other consumers do not have such usable cars. Second, we recognize that some consumers who have negative equity in their existing cars are precluded from buying or leasing a new car on their own. Finally, we allow for consumer heterogeneity with respect to their valuation for the durable, which in turn affects their desire to obtain a new or used car. This heterogeneity may reflect the appropriateness of the durable in terms of individual tastes (e.g., color, size) and/or the consumers' basic needs (e.g., some consumers must use a car to get to work, whereas others have viable options such as walking or public transportation).

We model these three types of consumer heterogeneity as follows. We assume that α fraction of consumers currently has a used car and that $1 - \alpha$ fraction of consumers does not own a used car. The consumers in the latter group may be entering the market for the first time, own an old car that has fully deteriorated, or have to turn in their leased car. We assume that c_0 ($0 \leq c_0 < 1$) fraction of consumers with a car does not have any liquidity problems and these consumers can buy a new car if they choose. The

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[3] As Shugan (2002) points out, there are often times when ignoring interbrand competition is appropriate. The appropriate question is whether adding competition will reverse any of our conclusions. We discuss this in more depth after presenting our model.

remaining $1 - c_0$ fraction of used car owners has liquidity problems because of the negative equity problem. Consequently, these consumers do not have the ability to buy a new car unless they get additional cash.

We also allow for variation in the consumers' valuation or willingness to pay for new and used cars. To do this, we first define the consumer j's willingness to pay for a car, v_j, to be $v_j = \theta_j \phi(\gamma)$, where θ_j is a consumer-specific parameter representing the consumer's valuation for the services provided by the car and $\phi(\gamma)$ is a car-specific valuation parameter that depends on its durability (γ), and its newness in that $\phi(\gamma) = n(\gamma)$ for new cars and $\phi(\gamma) = u(\gamma)$ for used cars. As in Desai and Purohit (1998), we assume that all used cars of a given durability are identical and that the durability parameter γ ($0 \leq \gamma \leq 1$) represents how well a car holds up after usage and measures its lack of physical deterioration as well as time of use. Because the durability directly affects the services that a used car provides, we assume that consumers prefer more durability to less when valuating a used car, so that $u'(\gamma) > 0$. Similarly, because consumers think about the future use of the car when buying a new car, durability also affects consumers' valuation of a new car, $n(\gamma)$. Again, we assume that consumers prefer more durability to less, so that $n'(\gamma) > 0$. Finally, we expect consumers to prefer new cars to old cars, except in the limit case when $\gamma = 1$.
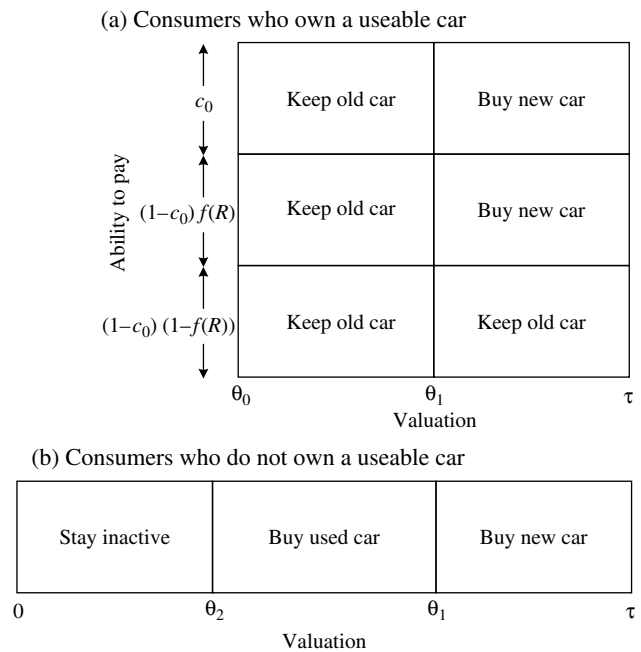
For the segment that currently has a usable car (i.e., the α segment), we make the following additional assumptions:

(1) The consumer-specific valuation parameter θ_j is uniformly distributed between parameters θ_0 and τ, where $0 < \theta_0 \leq \theta_j \leq \tau$. We assume that θ_0 is large enough to ensure that the consumers found it optimal to obtain their last car and τ represents the upper limit of valuation.

(2) The consumer's amount of negative equity and valuation are independent of each other. Thus, consumers are distributed over a rectangle in which the horizontal axis represents their valuation and the vertical axis represents the variation in their ability to pay because of negative equity (see Figure 1).[4]

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[4] We assume the independence between willingness to pay and negative equity problem (ability to pay) because of the lack of any specific data about the correlation between the two. It is possible that people with greater ability can have greater willingness. On the other hand, people with modest ability (e.g., recent graduates) can have very high willingness too. We also note that even when there is some (but not perfect) positive correlation between willingness to pay and the ability to pay, our main results are likely to go through. The reason is that even in such a model, there will be some high willingness-to-pay consumers who will not have the ability to get out of the negative equity problem and buy new cars. These consumers, when offered cash rebates, will buy new cars.

Figure 1   Consumers' Buying Behavior

(a) Consumers who own a useable car

(b) Consumers who do not own a useable car

For the segment of consumers who do not currently own a usable car, we assume the following:

(1) Consumers are distributed uniformly with respect to their valuations over the full range of the feasible line segment, i.e., $0 \leq \theta_j \leq \tau$.

(2) All consumers have the ability to buy a new car if they choose to do so.[5]

2.2. Demand Functions

To derive demand functions for new and used cars, we need to analyze consumers' optimal strategies for a given set of prices. Let p_n be the retail price of the new car, p_u be the price of a used car, and R be the size of the cash rebate given to buyers of a new car.

We begin with the consumers who currently have a car. They can either sell the old car and replace it with a new one, or keep the old car.[6] Then, for consumer j who currently has a car, the utility of replacing the old car with a new one, U_{rj}, is

$$U_{rj} = n(\gamma)\theta_j - p_n + R + p_u. \tag{1}$$

Similarly, the utility for keeping the existing car, U_{kj}, is

$$U_{kj} = u(\gamma)\theta_j. \tag{2}$$

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[5] We make this assumption because of our focus on the negative equity problem. In our world, consumers who do not own a used car cannot have negative equity. Adding consumers who do not own a usable used car and who lack the ability to buy only adds more consumers who might buy. However, this should result in only a main effect and should not interact with durability. Consequently, this complexity should not provide any new insights.

[6] Note that consumers could also sell their car and go without car transportation. However, we assume our parameters are such that this option is dominated by the other two options.

We first determine how many consumers who have the ability to buy a new car find it better to obtain a new car than to keep their existing car. We do this by equating Equations (1) and (2) and solving for θ_j, which yields the following:

$$\theta_1 = \frac{p_n - R - p_u}{n(\gamma) - u(\gamma)}. \qquad (3)$$

Consumers with $\theta_j \geq \theta_1$ find it best to obtain a new car, whereas those with $\theta_j < \theta_1$ find it best to keep their old car (see Figure 1). In the absence of negative equity problems, the new car demand from the α segment is $\alpha(\tau - \theta_1)$. However, the negative equity consumers, who make up $(1 - c_0)$ fraction of these consumers, are willing to replace their old cars with new cars, but cannot do so without a rebate. Let $f(R)$ be the fraction of these negative equity consumers who will be able to buy a new car if the rebate amount is R. Because the pool of consumers who are upside down by $\$X$ or less should logically increase at a decreasing rate, we assume $f(R)$ is a weakly concave function: $f'(R) > 0$, $f''(R) \leq 0$.[7] Thus the new car demand from the α segment is given by $\alpha[(1 - c_0)f(R) + c_0](\tau - \theta_1)$, where the term $(1 - c_0)f(R)$ represents the buyers who are unable to obtain a new car without the rebate. Note that the remaining consumers in this segment will continue to hold their used cars.

We now consider consumers who do not own a car. They have three options: (1) obtain a new car, (2) buy a used car, or (3) remain inactive. The three utilities for customer j are, respectively,

$$U_{nj} = n(\gamma)\theta_j - p_n + R, \qquad (4)$$

$$U_{uj} = u(\gamma)\theta_j - p_u, \qquad (5)$$

$$U_{wj} = 0, \qquad (6)$$

where the n, u, and w subscripts represent buying a new car, buying a used car, and remaining without a car, respectively. Equating Equations (4) and (5) yields the boundary between the group that obtains a new car and the group that buys a used car. Interestingly, this indifference point is equal to θ_1, i.e., the same as the one for the segment owning a car. Equating Equations (5) and (6) yields the indifference point between buying a used car and remaining without a car. This latter indifference point, which we denote as θ_2, is given by $\theta_2 = p_u/u(\gamma)$ (see Figure 1). The new car demand from this segment is given by $(1 - \alpha)(\tau - \theta_1)$.

We now have enough information to write the total demand for new cars and the supply and demand for used cars. The demand for new cars, q_n, is given by

adding the demands for both consumer segments and substituting in for θ_1:

$$
\begin{aligned}
q_n &= \alpha c_0(\tau - \theta_1) + \alpha(1 - c_0)f(R)(\tau - \theta_1) + (1 - \alpha)(\tau - \theta_1) \\
&= [\alpha c_0 + \alpha(1 - c_0)f(R) + (1 - \alpha)] \\
&\quad \cdot \left[\tau - \frac{p_n - R}{n(\gamma) - u(\gamma)} + \frac{p_u}{n(\gamma) - u(\gamma)}\right].
\end{aligned} \qquad (7)
$$

In Equation (7), the demand from consumers who have a usable car and do not have a negative equity problem is given by $\alpha c_0(\tau - \theta_1)$, the demand from consumers who have a usable car and face the negative equity problem is $\alpha[(1 - c_0)f(R)](\tau - \theta_1)$, and the demand from consumers without usable cars is $(1 - \alpha)(\tau - \theta_1)$. Note that the demand is downward sloping in p_n and upward sloping in p_u. The $f(R)$ term captures the shifting out of the demand curve because of the rebate, and $R/(n(\gamma) - u(\gamma))$ term captures the increase in the intercept because of the rebate.

We next acknowledge that the used car prices are endogenous and derive them by equating the supply and demand of used cars. The supply of used cars comes directly from the segment of size α of previous car owners who trade in their cars to buy a new car, so that

$$s_u = \alpha[c_0 + f(R)(1 - c_0)](\tau - \theta_1). \qquad (8)$$

The demand for used cars can be determined from the segment of size $(1 - \alpha)$ of consumers who now don't own a usable car and find it best to buy a used car, so that

$$q_u = (1 - \alpha)(\theta_1 - \theta_2). \qquad (9)$$

Equating Equations (8) and (9) and substituting for θ_1 and θ_2 yields used car prices as a function of new car prices and the cash rebate and our four model parameters, α, c_0, τ, and γ:

$$
\begin{aligned}
p_u &= \big\{u(\gamma)[(p_n - R)(1 - (1 - c_0)\alpha) - c_0\alpha\tau(n(\gamma) - u(\gamma)) \\
&\quad + (1 - c_0)\alpha f(R)(p_n - R - \tau(n(\gamma) - u(\gamma)))]\big\} \\
&\quad \cdot \big((1 - \alpha)n(\gamma) + \alpha(c_0 + (1 - c_0)f(R))u(\gamma)\big)^{-1}. \qquad (10)
\end{aligned}
$$

Substituting Equation (10) into (7), we get new car demand after taking into account the endogenous used car prices,

$$q_n = \frac{(1 - \alpha)(1 - \alpha + c_0\alpha + (1 - c_0)\alpha f(R))(\tau n(\gamma) - p_n + R)}{(1 - \alpha)n(\gamma) + \alpha(c_0 + (1 - c_0)f(R))u(\gamma)}. \qquad (11)$$

Before using Equation (11) to derive equilibrium prices and quantities, we briefly summarize our approach. We want to reflect the fact that the cash rebate increases the pool of available buyers. However, we also want to capture the fact that this increase is not costless. Specifically, from Equation (10), we

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[7] We discuss this assumption in more detail in a latter section.

Table 1   Equilibrium Values

$$p_u = \frac{u(\gamma)[kR^*(1-\alpha+\alpha c_0)+(3-(3+c_0)\alpha)\tau n(\gamma)+4c_0\alpha\tau u(\gamma)-(1-c_0)\alpha f(R^*)(\tau n(\gamma)-kR^*-4\tau u(\gamma))]}{4(1-\alpha)n(\gamma)+4\alpha(c_0+(1-c_0)f(R^*))u(\gamma)}$$

$$w_n^* = \frac{R^*(2+k)+\tau n(\gamma)}{2}$$

$$p_n^* = R^* + \frac{kR^*}{4} + \frac{3\tau n(\gamma)}{4}$$

$$\pi_r = \frac{(1-\alpha)(1-\alpha+\alpha(c_0+(1-c_0)f(R^*)))(\tau n(\gamma)-kR^*)^2}{16((1-\alpha)n(\gamma)+\alpha(c_0+(1-c_0)f(R^*))u(\gamma))}$$

$$\pi_m = \frac{(1-\alpha)(1-\alpha+\alpha(c_0+(1-c_0)f(R^*)))(\tau n(\gamma)-kR^*)^2}{8((1-\alpha)n(\gamma)+\alpha(c_0+(1-c_0)f(R^*))u(\gamma))}$$

see that an increase in R lowers the price of used cars. This is because of the fact that increasing the sales of new cars also increases the supply of used cars. Because used cars compete with new cars, there may exist some upper bound on how much of a cash rebate the manufacturer would want to give. Our model development yields a demand function that directly links to these two opposing forces, i.e., the expansion of the pool of potential buyers and the reduction in used car prices. The net result is a demand structure in which the slope and intercept are complicated functions of our model parameters.

3.   Analysis

We make the usual assumption that the manufacturer is the Stackelberg leader, i.e., it takes into account the profit-maximizing actions of the dealer and simultaneously sets the per unit wholesale price and the per unit cash rebate amount. The dealer takes as given the wholesale price and the rebate amount and sets a retail price to maximize its retail profit. The retailer's profit function is then $\pi_R = (p_n - w_n)q_n$, where w_n is the manufacturer's wholesale price for new cars. In calculating manufacturer profit, we assume that the only marginal costs for the manufacturers are the customer rebate, i.e., R, and its associated administrative costs. We define the latter to be kR, where $k > 0$. Thus the manufacturer's profit function is $\pi_M = (w_m - kR_n - R)q_n$. By using the demand function stated in Equation (11) and the rules of the game stated above, we determine retail and wholesale prices, the magnitude of the cash rebate given, and manufacturer and retailer profits. We provide the results in Table 1.

3.1.   Equilibrium Outcomes

We examine whether the manufacturer finds it optimal to offer cash rebates. Our underlying model indicates that cash rebates expand demand by shifting the demand function outward and allow the manufacturer to slide down the demand curve because of its lower effective price. The former effect is captured by the $f(R)$ term and the latter effect is captured by the

$p_n - R$ term as seen in Equation (7). As this equation makes clear, the shift outward occurs only if $\alpha > 0$ and $c_0 < 1$. Consequently, it is not surprising that Lemma 1 indicates that the manufacturer does not always find it profitable to give customer rebates.

LEMMA 1. *The optimal rebate, R^*, is positive only when*

$$-2k(1-(1-c_0)\alpha)(n(\gamma)-\alpha n(\gamma)-\alpha c_0 u(\gamma))$$
$$+ (1-c_0)(1-\alpha)\alpha\tau n(\gamma)(n(\gamma)-u(\gamma))f'(R=0) > 0.[8]$$

From the above condition, it is clear that if the cost of offering promotions, k, is low, the fraction of upside-down consumers $(1 - c_0)$ is high, and/or the effectiveness of the rebate in solving the upside problem—as represented by $f'(R)$—is high, then the manufacturer is more likely to offer the cash rebates.

We next explore what happens to prices, quantities, and profits when the manufacturer offers a rebate. As discussed previously, offering the rebate has two effects: (1) For a given retail price, it reduces the effective price that the consumer pays by the rebate amount, and (2) it allows some upside-down consumers to replace their used cars with new cars. These two effects can potentially increase new car sales. However, there are other effects of rebates that could temper this sales increase. First, the retailer might increase its retail price. This could be because demand increases, the manufacturer increases its wholesale price, or the retailer knows customers are getting a rebate. Second, any increase in the supply of used cars will result in a decrease in used car prices, thereby increasing the competition between the two substitutable products. Manufacturers influence all this via their wholesale price and the size of the rebate.

The net result of this complex interact is as follows.

PROPOSITION 1. *When $R^* > 0$, the new car price, p_n^*, and the effective price, $(p_n^* - R^*)$, are greater than the retail price, the retailer would have charged without a rebate. Interestingly, even though the effective price increases, new*

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[8]All proofs are in the appendix.

car sales increase and used car prices decrease with the rebate.

PROPOSITION 2. *When $R^* > 0$, the manufacturer increases its wholesale price more than the amount of the cash rebate but not enough to cover all of its marginal costs. Thus the manufacturer's margin decreases. Likewise, the retailer does not find it best to raise its retail price enough to cover the increase in the wholesale price. Thus the retailer's margin decreases. However, both parties' profits are higher with the rebate than without.*

Propositions 1 and 2 provide a detailed description of each agent's actions. Two factors lead the retailer to increase its price. First, the manufacturer's rebate reduces the effective retail price for consumers. The retailer takes advantage of this condition by increasing his retail price. Second, the manufacturer, anticipating the shift in the demand curve and the increased marginal costs associated with the rebate, increases its wholesale price, which drives up the retailer's marginal cost. The net result is that the retailer's margins decrease even though the effective retail price exceeds the price without rebate. However, because the quantity sold also increases with the rebate, the net result is that the retailer's profits increase.

The rebate has a mixed impact on consumers. Upside-down consumers are better off with the rebate because their liquidity constraints are relaxed, and thus they can now buy a new car, which increases their net utility. However, consumers who could have bought a new car without the rebate are worse off with the rebate. Some of these consumers buy the new car, but pay a higher price even after they receive the rebate. Others do not buy a new car because the effective price has increased. Instead, they either keep their used car or buy a used car. Thus, as with many marketing actions, there are both "winners" and "losers."

Finally, we note the counterbalancing effects of the higher effective retail price and the outward shift of the demand function. The higher effective price keeps some of the liquid consumers from buying a new car, which shifts θ_1, the identity of the marginal new car buyer to the right toward τ, which in turn will shift θ_2, the identity of the marginal used car buyer to the right (see Figure 1b). On the other hand, the rebate allows some nonliquid consumers to buy a new car, which in turn increases the stock of used cars that need to be sold. This has the opposite effect, i.e., it shifts θ_2 to the left and farther away from θ_1. Our analysis shows that the latter effect is stronger than the former, and hence θ_2 shifts to the left when rebates are given.

We next study how the durability of the car, γ, affects the manufacturer's cash rebates decisions.

3.2. Effect of Durability

As we discussed in the model section, the durability of the car represents how well the car holds up with usage. We previously made the realistic assumption that $n(\gamma) \geq u(\gamma)$; that is, the value of a new car (for a fixed level of durability) is greater than or equal to the used car value. Moreover, by definition, the valuations are equal only when $\gamma = 1$. These assumptions are compatible with the assumption that $u'(\gamma) > n'(\gamma)$, i.e., the used car valuation function increases faster than the new car valuation function, resulting in equality when $\gamma = 1$. In other words, this means that small changes in durability have a greater impact on the changes in valuation of a used car than a new car.[9] In the subsequent development, we assume a somewhat more stringent condition concerning the durability parameter's effect on changes in the new and used car valuations. Specifically, we assume that

$$(C1) \quad u'(\gamma) \geq n'(\gamma)\left[1 + \frac{\tau(n(\gamma) - u(\gamma))}{\tau n(\gamma) - kR}\right].$$

(C1) is a sufficient condition for our proofs and is stronger than a necessary condition. In other words, our following results may hold even when the condition stated in (C1) is not satisfied. However, for the remainder of this section, we assume that the condition in (C1) holds and show the following two propositions.

PROPOSITION 3. *The range of parameter values for which $R^* > 0$, and therefore the likelihood that the manufacturer will give a cash rebate, decreases when the durability of the car, γ increases.*

PROPOSITION 4. $\partial R^*/\partial\gamma < 0$.

Propositions 3 and 4 state that a manufacturer with a more durable (and thus a higher quality) product is less likely to give a rebate, and when it does it, provides a smaller rebate than a manufacturer with a less durable product. The reason for this can be traced back to the competition between new and used cars. In the demand function of new cars (Equation (7)), the coefficient for p_u is $1/(n(\gamma) - u(\gamma))$, which increases with γ because the difference in valuation of a new car and used car decreases with γ. Therefore, as γ increases, new cars and used cars become closer substitutes. Consequently, holding on to the existing car becomes a more attractive option for consumers who already have used cars and are contemplating replacing their used car with a new car. This means the number of consumers willing to trade in their used car and purchase a new car decreases with γ.

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[9] As an illustration, $n(\gamma) = \gamma$ and $u(\gamma) = \gamma^2$, where $1/2 < \gamma \leq 1$. Then, $u'(\gamma) = 2\gamma$ and $n'(\gamma) = 1$ and $u'(\gamma) > n'(\gamma)$.

Because the purpose of cash rebates is to enable consumers who are willing (but unable) to replace their used car and buy a new car, the rebate becomes less effective. Said differently, because the low durability manufacturer does not experience as much competition from its used car as does the high durability firm, it is able to get a bigger bang for its rebate buck.

As we noted earlier, the condition in (C1) is a strong sufficient condition. We say this because it is easy to find parameters for which our results are valid even when (C1) doesn't hold. In the next section, we empirically test Propositions 3 and 4 to ascertain its external validity. To do so, we need to reconcile the fact that our model assumes that the firm gives a rebate throughout the period, yet empirically firms seem to offer rebates periodically. Other models (e.g., Lal 1990, Rao 1991, etc.) address this issue by allowing the firm to use a mixed strategy, i.e., promote only with some specified probability. Our approach is somewhat different, but still captures the spirit of periodic rebates. We assume that the manufacturer determines the proportion of nonliquid consumers that it wants to make liquid through the cash rebate, and we capture this proportion via our parameter $f(R)$. We suspect that there exists some psychological threshold in terms of the size of the rebate that will cause consumers to notice and respond to the rebate offer. For example, we suspect that an offer given constantly during the full year of a \$75 cash rebate for a \$20,000 car would not attract much attention. However, an offer of an \$865 ($=75 * 12$) rebate offered only during 1 month out of a 12-month period will be noticed. Moreover, both offers yield the same effect as predicted by our model, assuming the response is linear, because 1 month at \$865 is equivalent to 12 months at \$75. Thus, although our model assumes a continuous promotion and a depth rate R^*/p_n that occurs throughout our one-period model, we would not be surprised to find empirically that firms using a depth rate R^{**}/p_n that is set purposefully to catch consumers' attention (and get the desired response) but they alter the length of time that they promote.[10] Therefore the effective average rebate rate, R^*/p_n, is R^{**}/p_n multiplied by the proportion of time the firm promotes. We use this effective average rebate rate when we test Proposition 4.

4. Empirical Analysis

Our theory offers several testable hypotheses. In this section, we test three of them as well as our underlying assumption that consumer rebates are given throughout the model year. They are:

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[10] In effect, we assume that there may be a threshold below, which the response to R, i.e., $f(R)$, is not weakly concave. However, as long as empirically manufacturers operate above this threshold, we believe it is logical to assume that $f(R)$ is concave.

HYPOTHESIS 1. *The probability that consumer rebates are given decreases with the durability of the product.*

HYPOTHESIS 2. *The depth of consumer rebates, averaged over the model year, is higher for products with lower durability.*

HYPOTHESIS 3. *The retail price of a new car increases with the depth of the consumer rebates and the durability of the car.*

Hypothesis 1 comes directly from Proposition 3, whereas Hypothesis 2 comes from Proposition 4 and our interpretation that it is equivalent for a firm to give a promotion of \$x for the entire analysis period or \$nx for $(1/n)$th of the period. Hypothesis 3 comes from the results in Table 1 for p_n^*, which increases with deal size, R^* and durability, $n(\gamma)$.

4.1. Empirical Model

We note that Hypothesis 2 is conditional on the manufacturer giving a consumer rebate in a given model year. Consequently, we jointly test Hypotheses 1 and 2 using a random effects variant of the widely applied sample selection model (see, for example, Verbeek 1990, Verbeek and Nijman 1992, Zabel 1992).

We do this as follows. First, we define z_{it}^* to be the latent propensity of a manufacturer to offer rebate for nameplate i (Toyota Camry, Ford Escort, etc.) in a model year t. We next define z_{it}^* to be a function of the vector composed of durability and other explanatory variables, denoted as w_{it}, a nameplate specific effect, η_i and a idiosyncratic disturbance term u_{it}. We acknowledge that we do not observe z_{it}^* but only z_{it}, which is 1 if the manufacturer gives a rebate for the nameplate i in the model year t and is zero otherwise. Finally, we model the average depth of the consumer rebate (y_{it}) for a nameplate i in year t as a function of the vector of explanatory variables (one of which is durability), denoted as x_{it}, a nameplate-specific effect, α_i and a disturbance term ε_{it}.

To estimate the system of equations, we need to make several distributional assumptions. We use the standard assumption that the idiosyncratic error terms $(\varepsilon_{it}, u_{it})$ follow bivariate normal distributions with mean vector zero and covariance matrix, Σ and that the conditional distribution $(\varepsilon_{it} \mid u_{it})$ is also normal. Because we do not observe the fixed nameplate effects (α_i, η_i), we assume that these effects are random and are distributed bivariate normal, with zero means, standard deviations (σ_α and σ_η), and cumulative distribution function $G(\alpha_i, \eta_i)$. We also assume that these effects are uncorrelated with the random errors, i.e., $\alpha_{it}, \eta_{it} \perp \varepsilon_{it}, u_{it}$. Finally, we let the disturbance components, ε_{it} and u_i, be correlated and

denote this correlation by the parameter ρ. We operationalize the above discussion with the following set of equations:

$$\left.\begin{array}{l} z_{it}^* = \lambda' w_{it} + \eta_i + u_{it} \\ z_{it} = 1 \quad (z_{it}^* > 0), \\ \quad\;\; = 0 \quad \text{otherwise} \end{array}\right\} \quad (12)$$

$$y_{it} = \beta' x_{it} + \alpha_i + \varepsilon_{it}, \quad (13)$$

where y_{it} and x_{it} are observed if, and only if, $z_{it} = 1$,

$$(\varepsilon_{it}, u_{it}) \sim N[0, \Sigma], \quad \text{where } \Sigma = \begin{bmatrix} \sigma_\varepsilon^2 & \rho\sigma_\varepsilon \\ \rho\sigma_\varepsilon & 1 \end{bmatrix}, \quad (14)$$

and thus

$$u_{it} \,|\, \varepsilon_{it} \sim N\left[\frac{\rho\varepsilon_{it}}{\sigma_\varepsilon}, (1 - \rho^2)\right].$$

The parameters to be estimated in our model are the slope and intercept parameters contained in vectors β and λ, the variance parameters σ_ε, σ_α, and σ_η, and the correlation parameter, ρ. To ensure the system is identified, we make the nonrestrictive assumption that $\sigma_u = 1$.

Our approach is to obtain estimates of our model parameters by maximizing the theoretical unconditional likelihood of the ith nameplate. We derive this likelihood function by first stating the contribution of the ith nameplate in year t to the likelihood conditional on the unobserved random effects. We then integrate out these unobserved variables. This conditional likelihood comprises three expressions: (1) the conditional probability that a manufacturer offers a consumer rebate, (2) the distribution of the consumer rebate depth, and (3) the probability that the manufacturer does not offer a consumer rebate. Thus the theoretical unconditional likelihood of the ith nameplate is

$$L_i(\beta, \lambda, \Sigma)$$

$$= \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \left[\prod_{i=1}^{T_i} f(\varepsilon_{it}, u_{it} \,|\, \alpha_i, \eta_i) \right] dG(\alpha_i, \eta_i), \quad (15)$$

where T_i is the number of years of data. We estimate the parameters using the maximum simulated likelihood routine found in LIMDEP 8.0.

We test Hypothesis 3 using another system of equations. This time our dependent variable of interest is retail price. Specifically, we estimate the following system:

$$\text{Rebate Amount} = a_0 + a_1 \, \text{durability} + \text{error}, \quad (16)$$

$$\begin{aligned} \text{Retail Price} = {} & b_0 + b_1 \, \text{durability} + b_2 \, \text{rebate amount} \\ & + b_3 \, \text{control dummies} + \text{error}. \end{aligned} \quad (17)$$

From Hypothesis 2, we hypothesize that a_1 will be negative, while Hypothesis 3 implies that b_2 and b_3 will be positive. We estimate this system of equations using three-stage least squares.[11]

4.2. Data Description and Measures

Our primary data source comes from a proprietary database that lists every consumer rebate program offered by the big three U.S. automobile manufacturers (Daimler-Chrysler, Ford, General Motors) and the major Japanese automobile manufacturers (Honda, Mazda, Nissan, and Toyota) during 1992–1997. Specifically, every consumer rebate program is associated with a make and model year, the start and end date of the promotion and the size of the rebate. In all, 69 nameplates sold by these firms during the time period are included in the database. These data were augmented with data that came from the following public sources: *Automotive News Market Data Book*, *Consumer Reports* magazine, and *Automotive Lease Guide*. Not every nameplate was sold in all six years. Therefore we have a total of 317 nameplate-year observations. For each observation, we obtained the following measures.

Consumer Rebate. Our dependent measure for Hypothesis 1 is the indicator variable, z_{it}, denoting whether or not a nameplate was on rebate in a given model year. We define a model year to be 16 months long. Because we are able to attach the time periods for a specific promotion with a specific nameplate, there is no confusion in those periods in which multiple model years are available (normally September–December).

Retail Price. We acknowledge that most retail transactions in the automobile industry are negotiated, and thus are unique to the individual customer. Consequently, determining the actual average retail price is extremely difficult. We follow the lead of other researchers and use the manufacturer's suggested retail price (MSRP) as a proxy for the average retail price, our dependent variable used in our analysis of Hypothesis 3.

Average Consumer Rebate Depth. For every consumer rebate promotion for a nameplate in a given year, we weight the per car value of the promotion by the fraction of the year that the car was on promotion and divide the result by the car's MSRP to

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[11] We use a slightly different measure for rebate depth in this analysis. (Thus the notation rebate amount.) As detailed subsequently, we use MSRP as our dependent variable measure in Equation (17). Consequently, we did not want to include this measure on the right-hand side of the equation to control for different levels of retail price. Thus we did not divide the rebate amount by our measure of price. Instead, we included as independent variables a number of measures pertaining to the type of car being sold, i.e., luxury, SUV, etc., to capture the fact that rebate depth may be related to the initial price of the car.

adjust for different average retail prices.[12] If there were multiple promotions per year, we then used the sum of these duration-weighted measures. Because we assume consumer depth is normally distributed (and thus varies conceptually from minus infinite to plus infinite), we rescale this weighted average proportion by taking the log odds of the weighted average.

Average Consumer Rebate Amount. The measure is the rebate amount weighted by the fraction of the year that the rebate was offered. If there are multiple rebate events in a year, we use the sum of the duration-weighted measures.

Durability. As in Desai and Purohit (1999), we use the predicted annual reliabilities from *Consumer Reports* magazine as our measure of durability. Consumer Reports base their predicted reliabilities on the frequency of repair data for earlier vintages of the same model as well as their assessment of the durability of the current year's model. Thus it is a measure of durability that is (1) available to consumers when making the buying decision and (2) based on both new car and used car durability. We convert predicted reliabilities from *Consumer Reports* into a 5-point scale.

One might postulate other factors that could influence the frequency and depth of consumer rebates as well as the retail price of the car. To control for such factors, we include several variables in our analysis, which are described below.

Degree of Concentration. We control for any competitive effects by including a measure that captures the extent to which market shares are concentrated within the nameplate car segment. We divide the automobile market into segments using the scheme adopted by *Automotive News Market Data Book*. We calculate the *Herfindahl Index* for each segment as $\sum_i m_{it}^2$, where m_{it} is the market share of nameplate i in the given segment in the year t. Because this index increases as the market becomes more concentrated, we believe this index is a good proxy for product differentiation. Basic economic theory predicts that the need to promote and the depth of promotions will decrease when products are more differentiated. Thus we expect a negative coefficient.

Average Monthly Excess Inventory. One alternative explanation for consumer rebates is that they are because of inventory backlogs. We do not have a measure of such backlogs. However, we are able to calculate monthly changes in inventory levels. Specifically, for month t, we define

$$\Delta I_{it} = \frac{EI_{it-1} - BI_{it-1}}{S_{it}},$$

where EI_{it-1} and BI_{it-1} are ending and beginning inventories in month $t - 1$ and S_{it} is the sales in the next month for nameplate i. Note that this is mathematically equivalent to the difference in last period's production and sales divided by S_{it}. We use this obtainable measure to reflect the industry practice of thinking about inventory in terms of number of days of sales (referred to as *days supply* by the trade). Because only positive values of ΔI_{it} lead to excess inventory levels, we use as our measure of excess inventory the sum of positive values of ΔI_{it}, where the summation is taken over a model year for a given nameplate. Model years with higher values of our measure indicate the model year had (at least at times) higher (excess) inventory levels compared to model years with lower values of our measure. The production and sales data for all calendar years in this study are available in the *Automotive News Market Data Book*. Our conjecture is that if inventory levels are high for a nameplate, the firm would be more likely to promote and would give deeper discounts.

Car vs. Truck. To control for the possibility that consumer rebate policies depend partly on whether the nameplate is a car or a truck, we include a dummy variable to reflect the fact that the rebate was for a car.

Foreign vs. Domestic. Finally, we created a dummy variable to indicate if the nameplate was a foreign car. We note that Japanese nameplates have, on average, higher predicted durability than the domestic nameplates. Therefore, by including this variable along with our durability measure, we are able to control for other factors associated with foreign cars such as management policy and longer supply channels, that may serve as alternate explanations.

Table 2 provides a summary of our measures.

4.3. Results

The results of our analysis pertaining to Hypotheses 1 and 2 along with the list of the explanatory variables used in our analysis are provided in Table 3. As predicted, the durability coefficients in the rebate likelihood and depth equations are statistically significant and negative; that is, the likelihood of consumer rebate decreases with durability (Hypothesis 1) and the average depth of consumer rebate decreases with durability (Hypothesis 2). In addition, the coefficient on product differentiation is negative and significant in the rebate likelihood equation, suggesting that consumer rebates are more likely to occur when markets are more competitive, i.e., less differentiated. Note, however, that product differentiation does not affect the average depth of the consumer rebate.

The foreign car indicator is insignificant in both equations. We previously noted that the American nameplates on average have a lower durability level

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[12] We have estimated a model in which MSRP was replaced with the dealer's invoice price, but this did not change our results.

Table 2   Definitions of Variables Used in the Empirical Analysis

Variable	Description	Source
Degree of product differentiation	*Herfindahl Index* calculated for automobile segment in each year. (SUVs, vans, etc.)	*Automotive News Market Data Book*
Durability	Predicted annual reliabilities from *Consumer Reports*. Predicted reliabilities are measured on a 5-point scale for each nameplate.	*Consumer Reports*
Rebate depth for nameplate used to test Hypotheses 1 and 2	Rebate depth is the value of a promotion for each nameplate in a model year divided by its MSRP. Each promotion in a model year was weighted by the fraction of the model year the nameplate was on promotion. The value of the promotion for a nameplate in a model year was taken to be the sum of these weighted measures for that nameplate.	Rebate amount and duration: Proprietary data MSRP: *Automotive Lease Guide*
Rebate amount used to test Hypotheses 2 and 3	The amount of the rebate for each nameplate in a model year weighted by the fraction of the model year for which the rebate was offered.	Rebate amount and duration: Proprietary data
Foreign/domestic	Dummy variables: 1 = Foreign manufacturer 0 = Domestic manufacturer	
Excess inventory	Monthly excess inventory. For each nameplate, we divide the difference in production and sales in the prior month by the sales in the current month to obtain a measure of inventory change. For a measure of excess inventory, we use the sum of all positive changes over the model year.	*Automotive News Market Data Book*
Vehicle type	Dummy variable: 1 = Cars 0 = SUVs, truck, minivan	
Duration of promotion	Duration in days	Proprietary data

than the Japanese nameplates. By including the foreign car indicator, we are able to rule out the possibility that our durability results are entirely because of differences in the management practices of the Japanese and American carmakers. Said more directly,

Table 3   Estimates of Empirical Models for Hypotheses 1 and 2

Models	Estimate	Standard error	*t*-stat
Rebate likelihood:			
Constant	1.1659*	0.0941	9.523
Durability	−0.2912*	0.0726	−4.010
Herfindahl Index	−3.7705*	1.0414	−3.620
Foreign/domestic	−0.1898	0.1803	−1.084
Excess inventory	1.3528*	0.5223	2.590
Vehicle type	−0.3727*	0.1803	−2.068
σ_η	1.1659*	0.0940	12.399
Average consumer rebate depth:			
Constant	−0.5106*	0.0607	−8.261
Durability	−0.0991*	0.0190	−5.226
Herfindahl Index	−0.0519	0.1729	−0.300
Foreign/domestic	0.0408	0.0310	1.318
Excess inventory	0.0052	0.0286	0.183
σ_α	0.1473*	0.0124	11.866
σ_ε	0.5556*	0.0149	37.329
ρ	−0.9700*	0.0047	−207.717
LL	−278.62		

Sample size ($N = 317$)
Panels (69 nameplates)

*Significant at 1% significance level.
**Significant at 5% significance level.

we find that the hypothesized durability effects exist even after controlling for any differences in managerial practices. This finding provides us with more confidence concerning our assertion that lower durability causes manufacturers to use consumer rebates and gives deeper average rebates.

Another possible explanation for cash rebates is that the rebates are a way to manage inventory levels. Table 3 results provide some support for this belief, at least in terms of the likelihood that a firm offers consumer rebates during the 16-month period. However, we find no impact of excess inventory levels on the depth of the rebate.

We further explore the impact of inventory levels on consumer promotions by looking at the frequency of consumer promotions by month over the 16 months associated with a given model year by aggregating the data across models and model years. Our analytic model assumes that consumer promotions are offered throughout the period to solve consumers' upside-down problem. In contrast, if consumer promotions are used to clear inventories, a different pattern should show because excess inventories historically exist at the end of the model year.

The results shown in Tables 4 and 5 reveal two important observations. First, consumer rebates are offered throughout the total model year. Second, the promotion frequency for foreign manufacturers is somewhat higher in the latter part of the model year.

Table 4 Aggregate Frequency Distribution of Consumer Promotion Over the Model Year (16-Month Period)

		Domestic cars		
Month in the model year	Frequency	Percent	Cumulative frequency	Cumulative percent
1	184	5.68	184	5.68
2	200	6.18	384	11.86
3	203	6.27	587	18.13
4	203	6.27	790	24.41
5	201	6.21	991	30.61
6	204	6.30	1,195	36.92
7	204	6.30	1,399	43.22
8	208	6.43	1,607	49.64
9	207	6.39	1,814	56.04
10	207	6.39	2,021	62.43
11	208	6.43	2,229	68.86
12	207	6.39	2,436	75.25
13	208	6.43	2,644	81.68
14	197	6.09	2,841	87.77
15	198	6.12	3,039	93.88
16	198	6.12	3,237	100.00

We infer from this latter finding that inventory management might play a greater role in foreign firms' decisions to offer consumer promotions. This inference is also compatible with the observation that foreign firms' supply chain is longer (i.e., most Japanese cars are shipped from Japan). In summary, though firms are more likely to use consumer promotions if an inventory imbalance exists (especially among foreign nameplates), we find strong evidence that these promotions are used throughout the model year. This, in turn, supports our underlying model assumption, and thus our Table 3 results.

Table 5 Aggregate Frequency Distribution of Consumer Promotion Over the Model Year (16-Month Period)

		Foreign cars		
Month in the model year	Frequency	Percent	Cumulative frequency	Cumulative percent
1	12	1.94	12	1.94
2	28	4.52	40	6.45
3	36	5.81	76	12.26
4	38	6.13	114	18.39
5	36	5.81	150	24.19
6	37	5.97	187	30.16
7	37	5.97	224	36.13
8	44	7.10	268	43.23
9	46	7.42	314	50.65
10	48	7.74	362	58.39
11	47	7.58	409	65.97
12	51	8.23	460	74.19
13	47	7.58	507	81.77
14	38	6.13	545	87.9
15	36	5.81	581	93.71
16	39	6.29	620	100.00

Table 6 Three-Stage Least Square Results, Model for Hypothesis 3

Models	Estimate	Standard error	t-stat
Dependent variable: log(price):			
Constant	4.4928*	0.9043	4.968
Durability	0.1082*	0.0411	2.632
Log(average rebate amount)	0.7479*	0.1168	6.400
Full-size van	1.0244*	0.3487	2.938
Midsize van	−0.2879*	0.0843	−3.413
Full-size pickup	−0.6170*	0.1756	−3.514
SUV	0.0474	0.1042	0.455
Midsize cars	−0.1454	0.0936	−1.555
Small cars	−0.4067*	0.0951	−4.279
Std. dev. = 0.719			
RSS = 127.605			
Dependent variable: log(rebate amount):			
Constant	7.6845*	0.1455	52.828
Durability	−0.2088*	0.0505	−4.135
Std. dev. = 0.821			
RSS = 171.16			
Sample size (N = 256)			

*Significant at 1% significance level.
**Significant at 5% significance level.

Finally, we note in Table 3 the highly significant negative estimate of ρ. We find this interesting because it suggests that when consumer rebates are given for causes not included in our model (by assumption these causes are random), the resulting promotion has a smaller average depth. Although we have little evidence about why this occurs, it is consistent with the conjecture that if a firm offers an unplanned promotion, the average consumer depth will be lower than if the consumer promotions were planned.

The results of our test of Hypothesis 3 are found in Table 6 along with a list of control variables. As can be seen from these results, the coefficients for durability and average rebate depth are positive and significant even after adjusting for car type in the new car retail price equation. Thus, compatible with Table 1 results, we find our proxy for dealers' retail price increases when the manufacturer gives deeper consumer rebates and when the car is more durable. As predicted from Hypothesis 2, we find (again) that durability has a negative and significant effect on rebate amount. We find these results encouraging, because they provide one more test of our model predictions.[13]

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[13] We again call attention to the fact that we use two slightly different measures for deal depth. One might argue that the first set of results were because of, at least in part, the fact that we divided the per car promotion value by the retail price. Because retail price is lower for lower durability cars, this would lead to higher deal depth for lower durability products. We choose to divide through with retail price so as to better compare deal depth across the dif-

5. Conclusions

The overarching goal of this paper is to explain why durable manufacturers might want to give rebates directly to consumers even when they cannot set the retail price. We center our attention on the automobile industry for which there is considerable evidence that a significant percentage of the car-owning population is in a negative equity position with respect to their current car. We were not able to find any trade journal articles that discussed both the negative equity issue and consumer rebates in other industries. However, either one or the other issues were discussed for such major durables as recreational boats and farm equipment (see, for example, Griffin 2004, Shepard 1992). Thus our results might generalize to other expensive durables that are (1) financed and (2) have an active used market.

5.1. Assumptions

We note that our model makes a few limiting assumptions. First, it is a one-period model, and therefore does not reflect the possible interplay between cash rebates offers and the proportion of consumers who may be unable to pay. One of the major reasons consumers become upside down is that their car depreciates faster than their equity accumulation through their monthly payments. We find that cash rebates lead to lower used car prices, i.e., cause the car to depreciate (but not deteriorate) faster. This finding implies a linkage between the rebate size, R, and the future proportion of consumers who are upside down, something not reflected in our model. We believe that including this linkage would just increase the frequency of subsequent promotions. However, it should not alter our results qualitatively.

Second, we do not model interbrand competition. We believe this decision should not affect the qualitative aspects of our conclusions. Interbrand competition in itself does not change a consumer's level of negative equity. Therefore, even in the presence of interbrand competition, rebates would serve the purpose of mitigating consumers' negative equity problem. It is also very likely that our result showing low durability firms benefit more from giving consumer rebates will hold in the presence of interbrand competition. Consider, for example, two Brands L and H such that Brand L has lower durability than Brand H. Brands L and H can also be differentiated on taste (i.e., horizontal) attributes and quality (i.e., vertical) attributes other than durability. At any point in time, each brand would have a pool of existing owners of their brand cars with the negative equity problem.

ferent categories of cars. Our latter analysis, however, indicates that we still find a negative relationship without such an adjustment (although we do control for average segment prices).

If both brands focus their rebate programs toward their own pool of negative equity customers, then the central intuition of our paper, that the low durability firm gains more from a given rebate than a high durability firm, is applicable with interbrand competition as well. It is also possible that each firm may try to attract the negative equity customers of the other firm. However, customers who own Brand L cars purchased that car in the past because they preferred the bundle of attributes that Brand L cars provide. Therefore, Brand H will need a bigger rebate amount than Brand L to attract the negative equity customers holding Brand L cars. By a similar logic, Brand L would need a bigger rebate amount than Brand H to attract the negative equity customers holding Brand H cars. Thus the primary emphasis of the rebate program will be on own-brand customers with negative equity problems rather than competing-brand customers with negative equity problems. This suggests that expanding the model to include interbrand competition would preserve our insight that the lower durability firm has more to gain from offering rebates.

Third, our results are driven in large part by our (unverified) assumption that used car valuation is a faster increasing function than is new car valuation. Although we provide no empirical evidence to support this assumption, we feel justified in making such an assumption because it is consistent with the concepts that (1) new car valuation (for a fixed level of durability) is greater than used car valuation and (2) the two valuations are equal only when the new car never deteriorates, i.e., γ approaches its upper limit.

Fourth, we note that we assumed an individual's willingness to pay is independent from his ability to pay for the durable. One might make the argument that the two constructs are positively correlated although we know of no evidence supporting this conjecture. In any case, we believe our results will go through, at least qualitatively, as long as the correlation is not perfect. In this regard, we observe that (1) cars are often viewed as conspicuous consumption and (2) there is a major industry associated with repossessing new cars. Both point to the less-than-perfect correlation between willingness and ability to pay constructs.

Fifth, because our model (by design) is parsimonious, it ignores a multitude of other factors that might affect consumers', retailers', and manufacturers' behavior. For example, we do not include any fixed or variable selling and manufacturing costs, nor do we have any fixed costs associated with the rebates. Likewise, we assume that the retailer does not get any margins when he resells the used car. We acknowledge that these factors may have main effects

on our variables of interest, i.e., prices, quantities, etc. However, we do not believe they will have any major interaction effects with durability, and thus our four propositions will still hold.

Finally, there is the issue of the effects of leasing on rebate programs. We noted earlier that there are two ways for a consumer to obtain a new car without paying for it outright, via a loan or a lease. When a consumer uses the latter method, she gets the right to use the car for a limited time (e.g., three years), and hence needs only to finance a fraction of the price of the car. Therefore, leasing may involve smaller monthly installments and a smaller down payment compared to buying a car on loan of the *same duration*. A consumer who wants to replace her negative equity car needs cash to meet two obligations: (1) to pay off the old loan and (2) pay the down payment for the new car. Leasing a car instead of financing it with a loan can reduce the down payment requirements. However, for several reasons, leasing a car does not eliminate the role of cash rebates in addressing the negative equity problem. We first note that negative equity consumers need extra cash *inflow* to pay off the old loan to be able to get out of the old car. In contrast to rebates, leasing does not provide any additional cash inflow to the lessees. Therefore, a consumer who is in a serious negative equity situation cannot be helped by leasing alone, but can be helped by cash rebates. In fact, cash rebates are almost always available to lessees as well as buyers. Second, in our conversations with auto industry insiders, we also found that leasing tends to require higher credit rating than loans.[14] Finally, in Table 7, we give the data on the percentage of consumers who had negative equity and the percentage of consumers who leased their vehicles. We find that the percentage of upside-down consumers is much higher than the percentage of consumers who lease. For example, 32% of the consumers of a domestic midsize car had negative equity in 2003. However, only 13% of the consumers of that car chose to lease their cars in that year even though most customer rebates can be applied to the down payment of the lease. These data are consistent with the idea that leasing may be useful for a consumer who has a small amount of negative equity but it is not an effective solution for consumers who have a significant amount of negative equity problems.

[14] This is also supported by leasing advice on http://www.bcsalliance.com/autoloans10.html, which asks consumers to make sure that their Fair Isaac Corporation (FICO) credit score is at least 700 before applying for a lease. The leasing guide on http://www.safecarguide.com/gui/lea/leasing.htm states that consumers with an A rating can qualify for "most leases" and consumers with B and C ratings cannot get leasing without "a very large down payment."

Table 7   **Comparison of Negative Equity and Leasing Proportions for Selected Vehicles in 2003**

Vehicle	Percentage of transactions with negative equity (%)	Percentage of transactions with leasing (%)
A domestic midsize car	32.41	12.61
A foreign midsize car	20.73	10.31
A domestic truck	38.11	6.27
A foreign truck	33.77	8.92

Note. The above data are based on a sample of 201,907 purchase transactions.
Source. Data provided by Power Information Network.

5.2. Findings

Our general approach is to develop a model that has the consumer rebate shift the demand curve outward (as well as allow the firm to slide down the demand curve). We do this by relaxing the standard assumption that consumers always have the ability to pay for a product, and thus only consumers' willingness to pay for a product matters.

Our model makes an explicit link between the amount of cash rebate given (which can be used for the down payment) and the number of consumers who will ultimately be able to buy. It also reflects the fact that new and used cars are partial substitutes. Thus, increases in new car sales to current owners result in an increased supply of used cars and ultimately lower used car prices. Because used cars are partial substitutes for new cars, the lower used car prices put a downward pressure on new car prices.

We show analytically that there are situations where manufacturers find it profitable to provide the consumer with a cash rebate and the incidence of these situations increases for low durability manufacturers, i.e., manufacturers whose car deteriorates faster than average. Moreover, the depth of these promotions is larger for these lower durability manufacturers. We test these two findings along with our Table 1 result for new car prices using a large data set of customer promotions given over the years 1992–1997. In each case, the empirical results are consistent with our model predictions. We note that our analytic model makes a number of other predictions. Four of the most interesting are that retail and wholesale margins decrease with the rebate, retail profits increase when the rebates are given and the effective price paid by consumers increases with the rebate.[15]

[15] Busse et al. (2006) provide empirical evidence that the transaction price net of the rebate *decreases* holding fixed the wholesale price. At first blush, this would seem to be counter to our results on net price. However, our model assumes that the manufacturer knows it will be offering a rebate, and therefore sets a wholesale price that is increased by more than the rebate amount relative to the wholesale

We end this discussion with an excerpt from a recent *Dallas Morning News* (May 29, 2004) article that provides strong anecdotal support to our argument: "As incentives go up, so do the prices of cars and trucks," said Jerry Reynolds, managing partner of Prestige Ford and owner of Prestige Lincoln Mercury and Prestige Madza in Dallas. "If you put this before a bunch of Harvard MBAs they'd say why not cut the prices $3,500 and get rid of the incentives? But consumers need that money to put with their trade. Without incentives, we can't trade with anybody."

5.3. Future Research

Our findings suggest that the practice of providing customer rebates is related to the consumers negative equity problem. Thus, if all consumers have the ability to pay, we would not expect durable manufacturers to offer customer rebates. (They might, however, offer promotions through the trade.) Likewise, if the percentage of consumers who are upside down rises, we would expect the incidence of rebate to increase. An interesting avenue for future research is to examine the link between the extent of the negative equity problem and the incidence of consumer rebates in a longitudinal study. Another interesting area for research is to determine if manufacturers' and retailers' marketing actions, such as trade and consumer promotions, contribute to the existence of the negative equity problems. Other factors that could affect our results, and thus merit exploration are competition, the inclusion of a product line, and the coexistence of leasing and trade promotions.

Acknowledgments

Appendix

PROOF OF LEMMA 1. After substituting for p_u^*, the new car demand function is given by

$$q_n = \frac{(1-\alpha)(1-\alpha+c_0\alpha+(1-c_0)\alpha f(R))(\tau n(\gamma)-p_n+R)}{(1-\alpha)n(\gamma)+\alpha(c_0+(1-c_0)f(R))u(\gamma)},$$

where $0 < f(R) < 1$, $f'(R) > 0$, and $f''(R) < 0$; $n(\gamma) \geq u(\gamma)$, $n'(\gamma) > 0$, and $u'(\gamma) > 0$. We can now determine both

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price it would have set absent of the rebate. Because this latter wholesale price is never actually charged to dealers in the market, Busse et al. (2006) are not able to measure such an increase from their transaction data. Assuming that the manufacturer did increase its wholesale price before the launch of a vehicle in anticipation of giving rebates, the Busse et al. (2006) results are compatible with ours, because they find the consumer pays more (before netting out the rebate) when the car is on promotion.

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the retailer's and manufacturer's optimal decisions when rebates are offered.

The retailer's profit, π_r, is given by $\pi_r = (p_n - w_n)q_n$. Solving the retailer's optimization problem, we get

$$p_n^* = \frac{R + n(\gamma)\tau + w_n}{2}.$$

The manufacturer's profit is then given by

$$\pi_m = \big[(1-\alpha)(w_n - R - kR)(n(\gamma)\tau + R - w_n)$$
$$\cdot (1-\alpha+\alpha(c_0+(1-c_0)f(R)))\big]$$
$$\cdot \big[2((1-\alpha)n(\gamma)+\alpha(c_0+(1-c_0)f(R))u(\gamma))\big]^{-1}.$$

The first-order condition for w_n is

$$(1-\alpha)((2+k)R - 2w_n + n(\gamma)\tau)$$
$$\cdot \big(1-\alpha+\alpha(c_0+(1-c_0)f(R))\big) = 0,$$

giving

$$w_n^* = \frac{(2+k)R + n(\gamma)\tau}{2}.$$

Similarly, the first-order condition for rebate R, evaluated at the optimal wholesale w_n^* price, is

$$\frac{\partial \pi_m}{\partial R}\Big|_{w=w_n^*} = \big(-2k(1-\alpha+x_1)((1-\alpha)n(\gamma)+x_1 u(\gamma))$$
$$+ x_2(\tau n(\gamma) - kR)(n(\gamma) - u(\gamma))f'(R)\big) \cdot A^{-1} = 0,$$

where

$$x_1 = \alpha c_0 + \alpha(1-c_0)f(R),$$
$$x_2 = \alpha(1-\alpha)(1-c_0), \quad \text{and}$$
$$A = \frac{8((1-\alpha)n(\gamma)+x_1 u(\gamma))^2}{(1-\alpha)(\tau n(\gamma) - kR)} > 0.$$

Note that if $R^* > 0$, then $\partial \pi_m/\partial R|_{w=w_n^*}$ evaluated at $R = 0$ must be positive, i.e., the profit function must be increasing in R. This leads to the expression stated in Lemma 1. Moreover, assuming that the manufacturer's profit is positive over some values of R, we are assured that R^* provides positive profits. Finally, the partial derivative $\partial \pi_m/\partial R|_{w=w_n^*}$ evaluated at $R = 0$ is negative for $\{\tau = 2, f(R) = 0.2R, c_0 = 0.2, \alpha = 0.25, k = 0.0125, n(\gamma) = \gamma, u(\gamma) = \gamma^2, \gamma = 0.6\}$ and is positive for $\{\tau = 2, f(R) = 0.2R, c_0 = 0.2, \alpha = 0.25, k = 0.01, n(\gamma) = \gamma, u(\gamma) = \gamma^2, \gamma = 0.55\}$. Thus, there exist parameter values for which the firm will give a rebate and other parameter values for which the firm will not give a rebate. $\square$

PROOF OF PROPOSITION 1. We denote the case when the manufacturer does not offer a rebate with the superscript $**$. The retail price when the manufacturer does not offer a rebate, (i.e., when $R = 0$) is $p_n^{**} = 3\tau n(\gamma)/4$. Thus, from Table 1, we see that $p_n^* - p_n^{**} = R^* + kR^*/4$ and $p_n^* - R^* - p_n^{**} = kR^*/4$. That is, new car price, p_n^*, and the effective price, $(p_n^* - R^*)$, with rebate are greater than those without a rebate. We confirm that new car sales (q_n^*) increase and used

car prices (p_u^*) decrease with the rebate by first obtaining the following derivatives:

$$\frac{\partial q_n^*}{\partial R} = (-k(1 - \alpha + x_1)((1 - \alpha)n(\gamma) + x_1 u(\gamma))$$
$$+ x_2(\tau n(\gamma) - kR)(n(\gamma) - u(\gamma))f'(R)) \cdot B^{-1},$$

$$\frac{\partial p_u^*}{\partial R} = (u(\gamma)[k(1 - \alpha + x_1)((1 - \alpha)n(\gamma) + x_1 u(\gamma))$$
$$- x_2(\tau n(\gamma) - kR)(n(\gamma) - u(\gamma))f'(R)]) \cdot C^{-1},$$

where x_1 and x_2 are as defined in the proof of Lemma 1,

$$B = \frac{4((1 - \alpha)n(\gamma) + x_1 u(\gamma))^2}{(1 - \alpha)} > 0 \quad \text{and}$$

$$C = 4((1 - \alpha)n(\gamma) + x_1 u(\gamma))^2 > 0.$$

We note that at the optimal rebate,

$$R^* > 0, \quad \frac{\partial \pi_m}{\partial R}\bigg|_{R=R^*,\, w=w_n^*} = 0.$$

This implies that

$$-2k(1 - \alpha + x_1)((1 - \alpha)n(\gamma) + x_1 u(\gamma))$$
$$+ x_2(\tau n(\gamma) - kR)(n(\gamma) - u(\gamma))f'(R^*) = 0.$$

Thus it is easy to see that $\partial q_n^*/\partial R > 0$ and $\partial p_u^*/\partial R < 0$ at $R^* > 0$. □

PROOF OF PROPOSITION 2. The manufacturer's wholesale price when $R = 0$ is $w_n^{**} = \tau n(\gamma)/2$. Thus the increase in wholesale prices because of the rebate is

$$w_n^* - w_n^{**} = R^* + \frac{kR^*}{2} > R^*.$$

It is easy to see that the manufacturer's margin with the rebate is

$$w_n^* - R^*(1 + k) = \frac{\tau n(\gamma)}{2} - \frac{kR^*}{2},$$

which is less than the manufacturer's margin without the rebate, $w_n^{**} = \tau n(\gamma)/2$.

From the proof of Proposition 1, we note that the change in retail price when the manufacturer offers a rebate is

$$p_n^* - p_n^{**} = R^* + \frac{kR^*}{4},$$

which is positive but less than the increase in the manufacturer's margins, $R^* + kR^*/2$.

Finally, note that $R^* > 0$ if and only if the manufacturer's profit increases with the rebate, i.e., $\pi_m^* > \pi_m^{**}$. To show that retailer profits are also higher when $R^* > 0$, we simply note that $\pi_r^* = \pi_m^*/2$ and $\pi_r^{**} = \pi_m^{**}/2$. Thus the retailer's profit increases compared to the case when the manufacturer does not give a rebate. □

PROOF OF PROPOSITION 3.

$$\frac{\partial \pi_m}{\partial R}\bigg|_{w=w_n^*} = (-2k(1 - \alpha + x_1)((1 - \alpha)n(\gamma) + x_1 u(\gamma))$$
$$+ x_2(\tau n(\gamma) - kR)(n(\gamma) - u(\gamma))f'(R)) \cdot A^{-1},$$

where A is as defined in the proof of Lemma 1. Let ψ_1 be the numerator of the above expression evaluated at $R = 0$. Then,

$$\psi_1 = -2k(1 - \alpha + x_1)[(1 - \alpha)n(\gamma) + x_1 u(\gamma)]$$
$$+ x_2(\tau n(\gamma))(n(\gamma) - u(\gamma))f'(R = 0).$$

As discussed in the proof of Lemma 1, $R^* > 0$ only when $\psi_1 > 0$, i.e., the profit function is increasing in R. It can be shown that

$$\frac{\partial \psi_1}{\partial \gamma} = (e_1 + e_2 + e_3),$$

where

$$e_1 = x_2 \tau(n(\gamma) - u(\gamma))f'(0)n'(\gamma) > 0,$$

$$e_2 = x_2(\tau n(\gamma))f'(0)(n'(\gamma) - u'(\gamma)) < 0 \quad \text{if } u'(\gamma) - n'(\gamma) > 0,$$

$$e_3 = -2k(1 - \alpha + c_0\alpha + (1 - c_0)\alpha f(0))$$
$$\cdot ((1 - \alpha)n'(\gamma) + \alpha(c_0 + (1 - c_0)f(0))(u'(\gamma))) < 0.$$

Note that

$$(e_1 + e_2) = x_2 \alpha f(0)[(2\tau n(\gamma) - \tau u(\gamma))n'(\gamma) - (\tau n(\gamma))u'(\gamma)] \le 0$$

if

$$\frac{u'(\gamma)}{n'(\gamma)} \ge 1 + \frac{\tau(n(\gamma) - u(\gamma))}{\tau n(\gamma) - kR^*},$$

which is our sufficient condition (C1). This implies that as γ increases, ψ_1 is more likely to be negative, and thus R^* is less likely to be positive. □

PROOF OF PROPOSITION 4. As shown in the proof of Lemma 1, after substituting for $w_n = w_n^*$, the first-order condition for R is given by

$$-2k(1 - \alpha + x_1)((1 - \alpha)n(\gamma) + x_1 u(\gamma))$$
$$+ x_2(\tau n(\gamma) - kR)(n(\gamma) - u(\gamma))f'(R) = 0.$$

We denote the left-hand side of the above equation by ψ_2. Note that R^* is implicitly defined by $\psi_2 = 0$. By the implicit function theorem,

$$\frac{\partial R^*}{\partial \gamma} = -\frac{\partial \psi_2/\partial \gamma}{\partial \psi_2/\partial R}.$$

First,

$$\frac{\partial \psi_2}{\partial R^*} = -\alpha(1 - c_0)(j_1 + j_2) < 0,$$

where

$$j_1 = kf'(R^*)\big(3(1 - \alpha)n(\gamma) + (1 - \alpha + 4c_0\alpha$$
$$+ 4(1 - c_0)\alpha f(R^*)u(\gamma))\big) > 0,$$

$$j_2 = -(1 - \alpha)(\tau n(\gamma) - kR^*)(n(\gamma) - u(\gamma))f''(R^*) > 0.$$

We can show that

$$\frac{\partial \psi_2}{\partial \gamma} = (e_4 + e_5 + e_6),$$

where

$$e_4 = x_2 \tau(n(\gamma) - u(\gamma))f'(R^*)n'(\gamma) > 0,$$

$$e_5 = x_2(\tau n(\gamma) - kR^*)f'(R^*)(n'(\gamma) - u'(\gamma)) < 0$$
$$\text{if } u'(\gamma) - n'(\gamma) > 0,$$

and

$$e_6 = -2k(1 - \alpha + c_0\alpha + (1 - c_0)\alpha f(R^*))$$
$$\cdot \big((1 - \alpha)n'(\gamma) + \alpha(c_0 + (1 - c_0)f(R^*))(u'(\gamma))\big) < 0.$$

Note that

$$(e_4 + e_5) = x_2 \alpha f(R^*) \big[(2\tau n(\gamma) - kR^* - \tau u(\gamma)) n'(\gamma)$$
$$- (\tau n(\gamma) - kR^*) u'(\gamma) \big] \le 0$$

if

$$\frac{u'(\gamma)}{n'(\gamma)} \ge 1 + \frac{\tau(n(\gamma) - u(\gamma))}{\tau n(\gamma) - kR^*},$$

which is our sufficient condition (C1). This implies that

$$\frac{\partial R^*}{\partial \gamma} = -\frac{\partial \psi_2 / \partial \gamma}{\partial \psi_2 / \partial R} < 0. \quad \square$$

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