Who Can See the Future?
Information and Consumer Reactions to Future Price Discounts

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Abstract

This paper extends the literature on consumer reactions to future price changes to a new context – markets with substantial repeat purchase behavior – where the efficacy of common dynamic pricing strategies turns on the strength of these reactions. Utilizing the unique discount structure in automobile insurance, I am able to measure the extent to which consumers react to changes in the future price path, holding current prices fixed. In the aggregate, the answer is not at all. However, there is a well-defined set of "informed" consumers, who are less likely to depart as they approach discounts. And these consumers are also the most responsive to current prices from firms in the external market, suggesting that they truly have more information about "hard to know" prices. Limiting attention to these informed consumers, I also examine the pattern of discount factors, finding support for quasi-hyperbolic discounting, rather than either standard models or more general hyperbolic discounting models.

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JEL Classifications: D91, D83, D84, D12, G22.

I. Introduction

An active line of empirical work in both economics and marketing measures consumer reactions to anticipated future price changes. In economics, the focus is on durable goods, testing the well-known predictions that consumers adjust purchase timing in response to falling prices and that demand for new goods responds to expected resale prices (Prince, 2004; Erdem, Keane, and Strebel, 2004; Chevalier and Goolsbee, 2005; Gowrisankaran and Rysman, 2005). In marketing, work centers on retail promotions, asking whether consumers stock up during sales in anticipation of higher future prices (Hendel and Nevo, 2002; Erdem, Imai, and Keane, 2003). In both branches, the bulk of papers have concluded that consumers are sensitive to future prices, but that they may discount them heavily and rely on faulty expectations concerning future price paths.

This paper examines the issue in a different context – markets with important repeat purchase behavior – where many firms base prices on consumer purchase histories (see Rossi, McCulloch, and Allenby, 1996, for a nice study of this practice). For example, frequent flyer and other loyalty programs are effectively future price discounts, while credit cards often raise prices following an initial teaser rate. The critical issue for the efficacy of such strategies is the strength of consumer reactions to these future price changes. So that is my primary question -- holding current prices fixed, to what extent do consumers react to changes in the future price path?

A distinct feature of these markets is that the price paths are individual specific, as opposed to the market-wide price variation for durable goods or storewide promotions for retail products. This suggests identification strategies built on individuals' reactions to their own future prices. But this is difficult because expected future prices are generally functions of tenure with a firm, so reactions to them may be confounded with other explanations for tenure dependence in demand. What's more, the predictions for the path of consumer purchases over tenure are not clear – at any point in time, flying on an airline other than one's primary carrier simply delays rewards by one purchase. As a result, previous work on consumer reactions to loyalty programs, while very creative, has been forced to rely on unique situations, such as changes in the value of future rewards or the introduction of reward coupons redeemable at specific future dates (Lederman, 2004; and Hartmann, 2004, respectively).

I overcome these challenges by studying the unique loyalty program used in automobile insurance, where firms provide a discount after enough *consecutive* years with the firm *with no chargeable (basically at-fault) claims.* Crucially, this set-up means that switching to another insurer eliminates any accrued tenure. So the larger the claims free tenure, the closer a consumer is to the price discount, and the more accrued tenure he gives up by switching firms. Also, this setup means that any chargeable claim resets the accrued tenure to 0, so that this claims-free tenure is distinct from overall tenure with firm. Putting these features together yields this paper's main empirical question: does the probability that a consumer departs her current firm fall as she approaches discounts, controlling for both *the overall tenure with the firm* and all other "rating-class" variables?

I implement this strategy on the departure decisions of 25,414 consumers of one auto insurer in Illinois. The panel runs from 1992 – 2002. The firm offered 10% discounts after every 3 years of chargeable claims-free tenure (up to 30%) until the start of 1998, after which it increased the first discount to 15% (and thus the maximum to 35%). My main finding is that, in the aggregate, *there is no statistically significant evidence for consumer reactions to the future price discounts*. The departure probability in the 6-month policy period just prior to a discount is not significantly lower than the departure probability in previous periods; and overall, there is no detectable pattern in the periods leading up to the discount.

The obvious question is why. In general, the firm's agents do not remind consumers that they are approaching a discount. So while consumers are told about the discounts at their initial purchase, it is certainly possible that they forget about them or at least don't realize how close they are to the next one. Note that this connection between the strength of reactions to future prices and the quality of information about those prices is implicit in much of the previous literature. Nearly all papers have struggled with the correct form for consumer expectations, with most assuming rational expectations, implemented by assuming that consumers use the mathematical expectation of the particular stochastic process that the authors specify. Obviously this assumption can be questioned. Even if one accepts it, there remain questions about what information consumers have and thus what conditional expectation they actually compute.

I argue that these informational limitations explain the lack of observed reactions to price discounts. To this end, one advantage of studying automobile insurance is that the price schedule is fully specified. There is a price discount each time the consumer goes 3 years without a chargeable claim. Consumers are told about this upfront. So there is no debate about what the expectation should be and no possibility that consumers don't appear to react to expected future prices simply because the econometrician specified the wrong stochastic process.

Note that once I admit the possibility that consumers have bad information about future prices, I also need to allow for heterogeneity – some consumers surely have better information than others. My approach is built on that heterogeneity. Representatives of the study firm suggest that some consumers are well informed, and that these consumers tend to be older, to buy more than just the legally mandated liability insurance, and to make frequent changes to their insurance policies. So I define a class of "informed consumers" (admittedly a leading name, which I'll have to justify) as the 19.8% of consumers who are over 40, buy more than the legal limits, and have made a change to their policy terms in the last 2 years.

Crucially, *this group of consumers has a statistically detectable, declining path of departure probabilities as they approach a discount*. But it is swamped by the departure probabilities among the much larger group of uninformed consumers, who follow no such path. What's more, the informed consumers' path of departure probabilities declines more steeply following the 1998 pricing change, strongly suggesting that they are sensitive to future prices.

Additional evidence supports the information-based distinction between the two groups. The overall departure rates are quite similar across the groups, as are the reactions to the discounts when they are actually received. So, perhaps surprisingly, it is not that the "informed" consumers are simply more likely to depart and thus more responsive to prices or other stimuli. It is specifically that they are more responsive to the future price changes.

So, what is it about those future prices? I see two possibilities – either the paper's hypothesis that they are harder to know than current prices, or the fact that they are in the future, which the uninformed group may discount more heavily than the informed group. One piece of evidence strongly suggests the former. I have a measure of the average market price by consumer rating class. A long line of research on insurance markets suggests that consumers may not have good information about these market prices (Joskow, 1973). And, in fact, controlling for price at the study firm, the uninformed group shows no significant reaction to this market average price. But the informed group shows the expected significant, negative effect – holding price at the study firm fixed, those in classifications with higher market average prices are significantly less likely to depart. These are current prices, so this can't reflect the groups' relative discount factors. Rather, the informed consumers truly appear to be more aware of the full price distribution, both in the broader market and from their own firm in future periods.

Having pinned down a group of consumers that is aware of and responsive to the future price changes, this pricing structure presents a unique opportunity to study consumer discount rates. That is, I can see consumer reactions to price breaks that are one period away, two periods away, and so on. Using this, I ask both how heavily consumers discount the future, and whether there is one discount rate across all future periods, or different discount rates for comparisons of today and tomorrow relative to comparisons of more distant future periods. My findings support the idea of quasi-hyperbolic discounting – consumers sharply discount future price changes, but only slightly discount more distant price changes relative to those in the near future.[1]

The remainder of the paper proceeds as follows. Section II describes the dataset and the relevant institutional details. Section III presents the basic empirical framework and aggregate results. Section IV contrasts informed and uninformed consumers. Section V discusses the discount factors for informed consumers. Section VI concludes.

II. Data and Pricing Structure

A. Basics

All analysis relies on a panel of 25,415 consumers joining one Illinois auto insurance firm between 1992-2001. The dataset was built by adding an equal number of new consumers (2,541 or 2,542) each year. Each consumer is observed starting with her initial purchase from the firm. 42.3% of these consumers voluntarily depart the firm during the study period. 44.3% of consumers survive the entire study period with the firm, and thus are right censored. The remaining 13.3% of consumers randomly fall off the dataset without leaving the firm.[2] Both random censoring and right censoring are easily accounted for in the empirical analysis.

The record for each consumer is divided into 6-month periods, the length of an auto insurance policy. The dependent variable for all analysis is a 0/1 indicator for whether the consumer departs the firm during the period, which she does in 6.9% of all observed periods.

Explanatory variables include the seven categorical variables used to determine a consumer's rating class and thus her price:

1. Demographic Class: 9 categories defining the consumer's age, gender, and marital status.
2. Vehicle Usage: 6 categories defining how the vehicle is used: high or low mileage; personal, commuting, or work.
3. Insurance Discounts: 4 categories defining whether the consumer gets good student and/or multiple insured car discounts.
4. Claim History: 6 categories for number of chargeable claims in the past 3 years, ranging from 0-5.[3] A chargeable claim is basically any claim for which the consumer

[1] It's crucial that I'm able to limit this analysis to the informed consumers. Including the uninformed consumers would not only bias the discount factor downward, but would also flatten the path of discount factors across periods, making it more difficult to detect quasi-hyperbolic discounting.

[2] Consumers randomly fall off the sample if they move to another state, get married and cancel one policy, or for a variety of administrative reasons that lead them to be assigned a new policy number.

[3] This is technically unbounded, but five is the highest observable value.

is at fault, including either damage to her own vehicle or damage to another's vehicle or person.
5. Territory: 15 geographic territories.
6. Vehicle Price: 20 categories for vehicle list price.
7. Model Year: 12 categories for vehicle age.

These categories determine the price at the study firm in a given year and are very similar to those used at other firms in the state. So, all analysis includes an additive function of these seven categorical variables, plus a categorical variable for year (with 11 values for 1992 through 2002), as controls, basically establishing the baseline departure probability.

As explained below, analysis also utilizes a single measure of each consumer's claims risk, formed by estimating the model:

$$\Pr(Chgclm) = \Phi(\sum_{i=1}^{7} \theta_i (RC_i) + \theta_8 (year)) \tag{2.1}$$

where Φ(.) is the standard normal CDF, *Chgclm* is an indicator for one or more chargeable claims in a period, RC_i (i = 1,…,7) are the 7 categorical rating class variables discussed above, and *year* is a categorical variable for the calendar year. The fitted value from this equation for each consumer-period is defined as *clm_risk*.[4]

B. Discount Structure

While the categorical rating class variables determine the base price at the study firm, plus the price a given consumer can get from a potential new firm, the actual price a consumer pays is modified by the chargeable-claims-free discount. As noted above, any time the consumer goes 3 consecutive years (6 consecutive policy periods) with no chargeable claims she receives a discount equal to 10% of the base price (15% for the first discount from 1998 on), up to a maximum discount of 30% after 9 years (35% from 1998 on).[5]

The critical implication of this structure is that as consumers accrue chargeable-claims-free tenure (hereafter referred to as tennc) they move closer to these discounts, which should make the current firm increasingly attractive vs. potential alternatives. Consider a consumer paying the sample average 6-month policy price, $297.31, yielding (pre 1998) discounts of $29.73. After accruing 1 period of chargeable-claims-free-tenure, he is 6 periods away from the

[4] The estimated parameters for equation 2.1 are available from the author on request.
[5] A very similar structure is used at many firms.

first discount, 12 away from the second, and 18 away from the third, rather than 7, 13, and 19 with no accrued tenure.

To compute a simple measure of the net present value of this period of tenure, I ignore the possibility that the individual switches firms, assume a 6-month discount factor of 0.97, and use the sample average probability of having 0 chargeable claims in a period, 0.951, which enters the expected NPV exactly like the discount factor The NPV of moving from *tennc = 0* to *tennc = 1* is given by: $(0.97*0.951)^{6}*29.73 + (0.97*0.951)^{12}*29.73 + (0.97*0.951)^{18}*29.73$ = $36.37. A similar computation can be done for *tennc = 2* and so on.

Table 1 contains these net present values (all relative to *tennc =0)* through *tennc = 7*, computed both before and after the 1998 increase in the first discount. It demonstrates that the benefit of chargeable-claims-free tenure can be quite large, reaching a peak of $411.81 for *tennc = 7* after 1998.   So the remainder of the paper examines consumer responsiveness to these future price breaks, measuring the impact of *tennc* or, equivalently, the number of periods remaining before the next discount (*per_disc*) on the probability that a consumer departs the firm.

C. Departure Patterns over Tenure

To accurately measure the impact of tennc, I need to control for the underlying impact of tenure (defined throughout as number of policy periods with the firm). To see why, consider Table 2, which reports the observed departure probability by tenure, defined as the number of consumers who voluntarily depart at a given tenure divided by the number who either voluntarily depart or survive the full period with the firm. As is typical in continuously provided services like insurance, the departure probability falls with tenure, from over 10% in the first two periods, to below 2% by the end.

As noted above, because tennc resets to zero with each chargeable claim, its impact can be separately identified from these tenure effects. Table 3 provides a count of observations by tenure and chargeable-claims-free tenure (through 12 for each), to demonstrate that there is in fact substantial independent variation. Also note that because the relevant term for discounts is the *time* since the most recent chargeable claim, the impact of tennc can also be separated from the basic claims-risk term used in pricing – the *number* of chargeable claims in the past three years.

Table 4 provides an initial look at departure probabilities as a function of tennc (through 13). The first column provides the raw data, with no controls. The dominant pattern that emerges is falling departure probabilities, but this surely reflects the underlying tenure effects documented above. Of more interest is the lack of a pattern leading up to the discounts. While the departure probability falls from tennc 5 to 6 (the last period before a discount), it only returns to its level at tennc 4. And it rises substantially from tennc 11 to tennc 12.

The second column of the table looks only at consumers with tenure = 9 to control for the tenure effects.[6] In this case, there is no pattern leading up to the first discount. In particular, the departure probability rises substantially from tennc 3 to 4, and then stays flat through tennc 6. However, there is a notable and persistent drop in the departure pattern from tennc 7 on. Together, these patterns suggest that consumers do not react to future price discounts, but do value the discount once it is actually received. The next section builds on these basic patterns with a more formal empirical model.

III. Aggregate Results

A. Basic Empirical Setup

All analysis starts with a period-specific probit departure function of the form:

$$\Pr(Depart) = \Phi\left(\sum_{i=1}^{7} a_i(RC_i) + \alpha_8(year) + \delta(tenure) + \gamma_1 discount + F(future\_discount)\right) \tag{3.1}$$

The δ(*(tenure)* function controls for tenure categories 1, 2,…, through a final category of 12 or more. The variable *discount* is the dollar value of any claims free discount currently being received (10% of the base price after 6 periods, etc.).[7] Of most importance, though is the function *F(future_discount)*, which will take various forms in what follows, each of which is designed to capture the impact of expected future price discounts.

Estimation proceeds by maximizing the likelihood of all observed departure decisions. Note that with a period-specific departure function, right or randomly censored periods are simply excluded from the likelihood function.

[6] Tenure 9 is chosen so that we can see a wide-range of tennc values, including both sides of the first discount, without losing too many observations to departures or censoring.
[7] While I include a simple linear function of the discount amount, I tried many other forms – categorical variables for the discount percentage, higher order polynomials of the discount amount, etc., with no substantive change in the results.

B. Main Results

The base model specifies *F(future_discount)* as a trend in reactions to the expected value of the next discount, *ex_disc*.[8] The expected value of the next discount is given by the dollar value of that discount (10% of the current policy price for all observations, except for consumers approaching their first discount after 1998, when it increases to 15%) times the probability of reaching the discount with no chargeable claims, $(1\text{-}clm\_risk)^{per\_disc}$.[9] The impact of this expected discount is allowed to vary flexibly by how far away it is:

$$F(\,future\_discount) = \gamma_2(\,per\_disc) * ex\_disc \tag{3.2}$$

Note that in a standard, dynamic model, the change in the γ_2 term with *per_disc* would simply reflect the discount factor being raised to a higher power as the price change gets farther away. Here, I do not impose that structure, but rather estimates $\gamma_2(1)$, $\gamma_2(2)$, $\gamma_2(3)$, $\gamma_2(4)$, and $\gamma_2(5)$. I stop at 5, meaning that all results are relative to 6 or 7 periods away from a discount.[10]

Table 5 reports the results from the base model.[11] Before looking at the future price effects, note the large impact of the discount when it is actually received, as measured by the parameter γ_1. Based on the point estimate of -0.00261, a 10% price reduction off the sample average 6-month policy price of $297.31 (evaluating all other variables at their sample averages) reduces the departure probability by 1.1 percentage points, from 6.9% to 5.8%.

Now consider the estimates for $\gamma_2(\,per\_disc)$ in the last section of the table. There is simply no evidence that consumers react to future price discounts. None of the estimated parameters is close to significant. Even more importantly, there is no trend toward larger effects as the discount draws nearer. In particular, contrast the parameter in the last period before the discount with the parameter on the discount itself. Consumers clearly do not want to eliminate a *current* discount by switching to another firm. However, they seem quite willing to eliminate

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[8] In most periods, there is more than 1 future discount (since consumers can receive up to 3). However, the time remaining until the discount is received, the size of the later discounts, and the probability that a consumer has no claims before the discount all vary monotonically with the expected value of the next discount, so this can be viewed as a summary measure for all future discounts.

[9] Any of the price, the value of *clm_risk*, or the discount percentage may change before the discount is actually received, but I use the current values to compute *ex_disc,* for simplicity.

[10] Because the function γ_2(per_disc) is interacted with ex_disc, I don't really need to exclude any categories. But the estimates for $\gamma_2(6)$ and $\gamma_2(7)$ would basically measure the effect of price (since the discount is just a function of the price) on those consumers far from a discount. The rating class variables are already included to control for price. So, instead, this function should be thought of a trend in departures as the discount draws nearer, with the slope of the trend allowed to vary with the size of the discount.

[11] Because they are only included as controls, I do not report estimates for the α parameters. They are available on request. I do report the β (tenure) parameters, which show the expected falling departure probability.

next period's discount by departing when *per_disc = 1*. Future price discounts simply do not impact aggregate departure probabilities.

C. Alternative Specifications

These aggregate results are robust to a wide number of specifications. To demonstrate this, I report two alternative specifications for *F(future_discount)* here.

Table 6 reports the simplest specification, which simply measures the trend in departures as consumers approach the discount. That is:

$$F(future\_discount) = \gamma_2 (per\_disc) \tag{3.3}$$

The table just reports the γ_2 parameters, which again show no evidence of declining departures as consumers approach the discount.

An alternative is to impose a discount factor and then compute the expected present value of the future discounts, similar to the computation shown in Table 1. To do this, I again impose a discount factor of 0.97. Then, the expected net present value of all future discounts, *npv_disc*, for $tennc = t \leq 6$ is given by:

$$\begin{aligned} npv\_disc = & \sum_{j=7-t}^{\infty} (0.97*(1-clm\_risk))^j * disc1 \\ & + \sum_{j=13-t}^{\infty} (0.97*(1-clm\_risk))^j * disc2 \\ & + \sum_{j=19-t}^{\infty} (0.97*(1-clm\_risk))^j * disc3 \end{aligned} \tag{3.4}$$

where disc1, disc2, and disc3 are the dollar values of the discounts, based on the current price (10% of the current price for all 3 before 1998, with disc1 increasing to 15% of the current price in 1998). For *tennc* between 6 and 12, the first discount is being received, so the first term is gone from the future value, and so on for later periods. With this calculation, I then re-estimate 3.1 with:

$$F(future\_discount) = \gamma_2 * npv\_disc \tag{3.5}$$

This yields an estimate for γ_2 of -0.000504, with a standard error of 0.00073. So, again, I can not reject the hypothesis that future price discounts have no effect at any reasonable level of significance.

IV. Informed vs. Uninformed Consumers

A. Definition

Given the size of the discounts in NPV terms, demonstrated in Section II, the lack of a measurable reaction requires some explanation. The obvious one, which is also consistent with introspection, is that many consumers are either completely unaware of the upcoming price discount or at least unaware of how close they are to receiving it. This is supported by conversations with company officials, who indicate that (for whatever reason), agents generally do not remind consumers that they are approaching a discount.

Those company officials, however, believe that there are informed consumers, whom they identify internally as consumers meeting the following three conditions:

1. The consumer is age 40 or older.

2. She purchases more than the legally mandated liability insurance. Basically, Illinois law requires a minimum amount of liability insurance for injury to another person or damage to his vehicle. Roughly 1/3 of the company's clients purchase only this coverage. These consumers may view insurance as a "driving tax" and not pay much attention to the details of the policy.

3. She has made a change to her policy in the last 2 years. A change includes any change to policy terms – adding cars, adding coverages, changing deductibles, increasing or decreasing liability limits. Only 35% of consumers meet this criterion, but this is the group that appears to be paying active attention to their insurance policy.[12]

I adopt this definition, and using it, classify 30,739 (19.8% of the 155,246 non-censored consumer-periods on the sample) as informed. I then run the base empirical model separately for informed and uniformed consumer periods.

B. Basic Findings

Table 7 contains the results of interest, with *F(future_discount)* defined according to (3.2). The estimates for the uninformed bulk of consumer-periods closely mimic those for the overall sample. But, based on the γ_2 parameters, *the informed consumers show a clear, declining path of*

[12] Note that this implies that one consumer can be defined as informed in some periods but not others. This seems reasonable – consumers can change, and may be paying attention in some periods but not others. While I cannot capture this perfectly, defining informed consumer-periods in this way seems a reasonable approach. Most importantly, I stick to the definition provided by the firm, meaning that I do not fish for a result.

departures as they approach a discount. The estimates of $\gamma_2(1)$, $\gamma_2(2)$, and $\gamma_2(3)$ are significantly different from 0, and I can easily reject the hypothesis that the γ_2 parameters jointly equal 0.

To get an idea of the magnitudes, consider a sample average informed consumer (before 1998) who has a 95.1% chance of making it to the next period claims free, at which point she'll receive a $29.73 discount, which implies that *ex_disc* = 28.27. Using the estimated value of $\gamma_2(1)$, -0.00190, this yields a 0.6 percentage point decline in the departure rate, from the sample average of 6.9% to 6.3%. Two periods in advance, she has a $(0.951)^2 = 0.904$ chance of getting to the discount, which implies that *ex_disc=$26.88*. So the estimated value of $\gamma_2(2)$, -0.00169, implies a 0.5 point reduction in the departure probability.

The pattern of coefficients is also suggestive about how consumers discount the future. In particular, while $\gamma_2(1)$ is well below γ_1, suggesting that consumers greatly prefer dollars today to dollars 6-months from now, the path from $\gamma_2(2)$ through $\gamma_2(5)$ is much flatter, suggesting that they do not discount periods in the distant future that much more heavily than periods in the near future. This is exactly the pattern suggested by models of quasi-hyperbolic discounting, something I explore more formally in Section V.

C. Reaction to 1998 Price Change

If the informed consumers are truly sensitive to future prices, their path of departures leading up the first discount should fall more sharply following the 1998 pricing change, which increased this discount from 10% to 15%. To test this, I again use the basic formulation of *F(future_discount)* given in 3.2, but I redefine *ex_disc*, using a discount equal to 10% of the policy price *for all consumer periods*. I then define a new variable, *1stdisc_post98*, which is an indicator for consumers who are approaching their first discount after 1998, and interact this with *ex_disc* to see if that declining path of departures gets steeper after 1998. That is, I define:

$$F(future\_discount) = \gamma_2(per\_disc) * ex\_disc + \gamma_3(per\_disc) * ex\_disc * 1stdisc\_post98 \quad (4.1)$$

Table 8 contains the results. Not surprisingly, I find no reaction to this change for the uninformed consumers – I can not reject the joint hypothesis that all of their γ_3 parameters equal 0 at any reasonable level of significance. In contrast, for the informed consumers the path of departures approaching the first discount does decline more steeply after 1998. While the individual estimates are not significant, most likely because there are not enough observations after 1998, I can reject the joint hypothesis that all of their γ_3 parameters equal 0 at the 5% level.

D. Additional Comparisons/Contrasts

While I have labeled the two groups as informed and uninformed consumers, more evidence is required to demonstrate that information is the key distinction. An obvious alternative is that the so-called uninformed consumers are really just consumers who prefer to stay with one firm, so their departure probability will be quite low and they'll appear unresponsive no matter what information they have. However, the relative departure rates belie this claim – the uninformed consumers voluntarily depart in 7.1% of all non-censored consumer-periods, while for informed consumers, the corresponding figure is only 6.2%.

Another possibility is that the so-called informed consumers are just more price sensitive in general, and thus react more strongly to the potential future discounts. However, this is contradicted by the estimates of γ_1, which indicate that the uninformed consumers actually respond slightly more strongly to the price discount when it is actually received.

Given that the so-called informed and uninformed consumers are actually quite *similar* in overall departure rates and price sensitivity, the difference is something specific about their reaction to future prices. I see two possibilities. First, it may be the fact that the prices are in the future, which the uninformed consumers discount more heavily. Or, it may be that the discount structure is harder to know than the current price – as time passes from initial purchase, consumers (particularly those who haven't been actively managing their policies) may forget about the upcoming discounts, or at least how close they are to receiving one.

The distinct feature of the information story, which I use to separate these explanations, is that it should apply not just to future prices, but also to any current prices that are difficult to observe. In particular, a long history of work on automobile insurance argues that it is difficult to get price quotes, so that the price a specific consumer will pay at another firm may be hard for her to observe (Joskow, 1973). Analyzing reactions to these market prices is made easier by three other features of auto insurance prices (Israel, 2005):

1. As noted above, firms use similar rating class variables, so that the observed rating class variables at the study firm effectively determine the price he can get from other firms.

2. The price for a given consumer in a given rating class varies substantially across firms, with the standard deviation on the order of 25% of the mean price.

3. The study firm's position in the market distribution of prices varies from class to class – the firm's price is higher than average for some classes and lower than average for others.

Putting these together means that there is real variation across observable rating classes in the price available from firms in the market, even holding the price at the current firm fixed. While full menus of prices from all market firms are very difficult to obtain, I have constructed a measure of the average market price by rating class and year, which incorporates firms comprising about 55% of the non-study-firm Illinois market share.[13] This measure is admittedly imperfect, but if anything, this should make it harder to find a difference between the reaction of informed and uninformed consumers.

Table 9 reports the results of a model incorporating these market prices. To do this, I replace all the rating class variables (along with the current discount), with two summary measures – price at the study firm and market average price. That is, I estimate the following model:

$$\Pr(Depart) = \Phi(\beta(tenure) + \gamma_2(per\_disc) * ex\_disc + \lambda_1 own\_price + \lambda_2 mkt\_price) \tag{4.2}$$

The results are quite clear. Both groups show the expected, significant positive reaction to own price – a consumer paying a higher price is more likely to depart.[14] But while the informed consumers show the expected significant negative reaction to higher market prices, the uninformed consumers show no detectable response. Since these are current prices, this cannot reflect the relative discounting of future periods. Rather, it seems that uninformed consumers simply do not react to "hard-to-know" prices, whether future prices from their own firm or current prices from other firms in the market.

The obvious remaining question is: how can we reconcile the findings that uninformed consumers do depart and do react to prices at their own firm, but don't react to future or external, market prices? How do they decide to depart? This is an interesting avenue for future research.

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[13] While the data supporting these calculations are largely proprietary, I can provide more details on the computation and some summary statistics on request.

[14] The magnitude of this effect is smaller than for the discount or price change terms in previous specifications. But this is not surprising, both because the market price control is imperfectly measured (so that a higher own price may also suggest a higher than measured market price), and because the price reflects a wide array of individual characteristics that could have their own impact on departure probabilities.

Two possibilities were raised in discussions with company officials. First, young consumers who purchase only the legal minimums are the most likely to go without insurance altogether, in violation of the law. Consumers may be more likely to drop insurance when they price gets high, without thinking about more complex parts of the pricing scheme. Second, this set of consumers is generally considered to be less loyal and more impulsive. So they'll switch insurers if they move or if prices go up or if they get an advertisement in the mail from another firm. Again, these departures surely reflect current prices and perhaps the price from a specific alternative firm, but may not reflect future prices or the full distribution of prices in the market.

V. Discount Factors for Informed Consumers

Relying just on the informed consumers, the pricing structure provides a unique opportunity to look at the pattern of consumer discount factors. That is, I see consumers who are getting a price break, are one period away from a break, 2 periods away, etc., and by comparing the relative departure rates can measure the value they put on price breaks of varying proximities.

I implement this with a version of the *npv_disc* calculation used in 3.4 and 3.5, modified in several ways. First, I include both current and future price breaks in one measure. Second, I denote the breaks by $disc_{t+j}$, meaning the full break the consumer will be receiving in j periods, if he stays with the current firm and remains chargeable claims free.

Finally, and most importantly, rather than fix the discount factor, I leave it free in estimation. And because the results thus far suggest that consumers discount price changes one periods ahead heavily, but do not discount more distant future periods that much relative to more proximate future periods, I use a version of the quasi-hyperbolic discounting model introduced by Laibson (1997). To be quite flexible, I actually include three discount factors – a 1-period ahead factor, β_1, a 2-period ahead factor, β_2, and the factor for all more distant periods, β. With this, I re-specify *npv_disc* as:[15]

$$npv\_disc = disc_t + \beta_1(1-clm\_risk)disc_{t+1} + \beta_1\beta_2(1-clm\_risk)^2 disc_{t+2} + \beta_1\beta_2 \sum_{j=0}^{\infty} \beta^j (1-clm\_risk)^{j+3} disc_{t+3+j} \quad (5.1)$$

Using this, I estimate the following departure probability:

[15] This specification does assume that consumers correctly compute the expected value of the discount, by using (1-clm_risk) to the appropriate power. The discount factor is the only part that takes a non-standard form.

$$\Pr(Depart) = \Phi(\sum_{i=1}^{7} a_i (RC_i) + \alpha_8 (year) + \delta(tenure) + \gamma_1 npv\_disc) \quad (5.2)$$

In this formulation, the rating class variable and year categorical variables determine the base price at the study firm and the prices available from other firms in the market and thus, together with tenure, the baseline departure probability against which the impact of discounts is measured. γ_1 determines the overall magnitude of the impact of discounts, while β_1, β_2, and β determine the path of these impacts with chargeable-claims-free tenure.

Table 10 contains the results for these 4 parameters of primary interest. Three things stand out. First, the one period ahead (6-month) discount factor is strikingly low, 0.793, suggesting that even the informed consumers heavily discount the future. Second, the results are consistent with hyperbolic discounting. The two-period ahead discount factor is 0.924, significantly higher than β_1. So, while consumers heavily discount "tomorrow" relative to today, they do not discount "the day after tomorrow" nearly as much relative to tomorrow. Third, the results are specifically consistent with quasi-hyperbolic discounting, as β, the discount factor for 3-periods and more, is 0.931, which is not significantly different from β_2. So, the key distinction appears to be today vs. tomorrow relative to more distant future periods, but there is not evidence that the rate of discounting continues to decline over more distant future periods.

One caveat -- it's certainly possible that some consumers in the informed group are not truly informed, so that the much smaller average reaction to next period's prices reflects the fact that some people aren't aware of them. Still, there are three definite lessons here. First, it's critical to consider the quality of consumer's expectations/information about future prices before estimating discount factors.[16] Second, there is no evidence for different discount factors for 2-periods-ahead and beyond. So at most, the evidence supports quasi-hyperbolic discounting, with no evidence for more general hyperbolic forms. Third, there is in fact some evidence for quasi-hyperbolic discounting, but it certainly needs to be confirmed with additional research.

VI. Conclusion

A growing body of empirical work in economics and marketing considers the dynamics of consumer product choice. Perhaps the most important advance of such work over standard, static models is that it allows consumer choices to depend not only on current prices, but on the

[16] In fact, this is a useful, general lesson – there may be a set of consumers who behave in a fully informed, rational ways, while other behavioral models are required all others consumers.

full path of expected future prices. However, due to some combination of data restrictions, modeling difficulties, and a different focus, many of the existing papers do not really measure a distinct reaction to future prices. This is unfortunate, as the strength of those reactions is a primary driver of the efficacy of teaser rates, loyalty programs, and other dynamic pricing schemes that work by varying future prices relative to current ones.

This paper takes advantage of the unique structure of future price discounts in automobile insurance to directly ask the question: how do changes in the future price path impact consumer decisions, holding current prices fixed? Consumers receive a discount after 3 consecutive years with one firm with no chargeable claims. Switching to another firm resets accrued tenure to 0, as does the occurrence of a chargeable claim. So, to the extent that consumers value future prices, they should become less likely to depart as they approach discounts, as the proximity of these discounts makes the future price path more attractive at the current firm than at alternatives.

My main finding is that, in the aggregate, there is no evidence that consumers react to future price discounts. Despite a large impact of discounts when they are actually received, consumers are just as likely to depart in the periods just before receiving the discount as in the first periods with the firm. This result is robust to a wide variety of specifications.

However, there is a group of consumers that the firm internally defines as informed – above 40, buying more than the legally required amount of insurance, and having made some change to their policy in the last 2 years – who do show a clear, detectable decline in the departure rate as they approach a discount. And these consumers, while quite similar to other consumers in average departure rate and sensitivity to current prices from the study firm, also react much more strongly to current prices from other firms in the market. Together, these relative reactions strongly suggest that the informed consumers react to "hard to know" prices, while the bulk of consumers do not.

Focusing on the informed consumers, a clear pattern of discount factors emerges. There is a sharp distinction between current and future prices, indicating that the one-period ahead discount factor is quite low. But, after this, the path of impacts for more distant future prices is much flatter, suggesting that the two-or-more period ahead discount factor is closer to 1. Together, these findings are consistent with quasi-hyperbolic discounting.

One interesting implication of these findings is that future price discounts – particular those arising from complex pricing schemes – may serve to discriminate between more and less informed consumers in a fashion somewhat similar to coupons. That is, the consumers who respond to them are the same consumers who are likely to respond to competitive prices. However, unlike coupons, the price discounts are ultimately given to *all* consumers, making them less cost effective. This may be because insurance regulations require prices to be justified with cost data, making it difficult to apply them only to informed consumers. In any case, future research should consider the possibility that future price breaks perform a function similar to standard price discrimination, screening consumers based on information.

Another open question is the extent to which these findings extend to other markets. The loyalty program in auto insurance seems particularly passive. After 3 consecutive years with no chargeable claims, consumers simply see their price fall, as opposed to more active programs where consumers must enter frequent flyer or other membership numbers, track points, etc. Information is likely to be better in the more active programs. However, firms' strategic decisions depend on the margin – if we increase the ultimate discount, increase the number of purchases required to achieve it, or provide consumers with some bonus points, how will this impact their purchase decisions? Here, the informational questions seem much more relevant. Do all consumers have sufficient information to react to such marginal changes? If not, which consumers have this information and what types of changes are they most likely to react to? This paper suggests that answering these informational questions is critical to predicting the impact that such changes will have, and thus should be a key step in developing firm strategies.

References

Chevalier, J. and Goolsbee, A. (2004), "Are Durable Goods Consumers Forward Looking? Evidence from College Textbooks," mimeo.

Erdem, T. Keane, M., and Strebel, J. (2004), "Learning about Computers: An Analysis of Information Search and Technology Choice," mimeo.

Erdem, T., Imai, S., and Keane, M. (2003), "Brand and Quantity Choice Dynamics under Price Uncertainty," *Quantitative Marketing and Economics*, 1: 5-64.

Gowrisankaran, G. and Rysman, M. (2005), "Determinants of Price Declines for New Durable Consumer Goods," mimeo.

Hartmann, W. (2004), "Intertemporal Effects of Consumption and Their Implications for Demand Elasticity Estimates," mimeo.

Hendel, I. and Nevo, A. (2002), "Sales and Consumer Inventory," National Bureau of Economic Research Working Paper # 9048.

Israel, M. (2005), "Tenure Dependence in Consumer-Firm Relationships: An Empirical Analysis of Consumer Departures from Automobile Insurance Firms," *The Rand Journal of Economics*, 36: 165-192.

Joskow (1973), "Cartels, Competition, and Regulation in the Property and Liability Insurance Industry," *The Bell Journal of Economics*, 4: 375-427.

Laibson D. (1997), "Golden Eggs and Hyperbolic Discounting," *The Quarterly Journal of Economics*, 112: 443-477.

Lederman, M. (2004), "Do Enhancements to Loyalty Programs Affect Demand? The Impact of International Frequent Flyer Partnerships on Domestic Airline Demand," mimeo.

Prince, J. (2004), "Measuring the Digital Divide: Structural Estimation of the Demand for Personal Computers," mimeo.

Rossi, P, McCulloch, R., and Allenby, G. (1996), "The Value of Purchase History Data in Target Marketing," *Marketing Science*, 15: 322-340.

Table 1: Benefit of Chargeable Claims Free Tenure in Net Present Value

Chargeable-Claims-Free Tenure	NPV Before 1998 ($)	NPV After 1998 ($)
1	36.37	45.51
2	75.82	94.87
3	118.61	148.40
4	165.02	206.46
5	215.35	269.43
6	269.94	337.73
7	329.15	411.81

NPV figures give the difference between the expected net present value at the listed tenure and the value with no accrued tenure. Calculations assume consumers never switch firms, and use a 6-month discount factor of 0.97. All calculations are done at the sample average price of $297.31 and the sample average probability of no chargeable claims in a period, 0.951.

Table 2: Departure Probability by Tenure

Tenure	Observations	Departure Probability
1	24906	10.4%
2	20777	10.6%
3	17253	8.5%
4	14603	6.7%
5	12572	7.2%
6	10716	5.7%
7	9246	5.0%
8	7994	5.3%
9	6846	3.7%
10	5922	3.7%
11	5080	2.3%
12	4376	2.9%
13	3700	3.1%
14	3075	2.3%
15	2523	2.5%
16	2010	2.7%
17	1533	3.8%
18	1084	1.5%
19	698	2.7%
20	332	1.2%

"Observations" gives the number of consumers who either complete the specified tenure with the firm, or voluntarily depart. The departure probability is the percentage of this base that voluntarily departs.

Table 3: Chargeable Claims Free Tenure by Tenure

		Tennc												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Tenure	1	1103	21214											
	2	954	850	16780										
	3	775	770	673	13560									
	4	642	617	623	530	11219								
	5	580	516	497	512	441	9117							
	6	489	478	420	409	423	365	7524						
	7	424	401	393	345	350	340	303	6229					
	8	359	348	324	318	283	280	281	255	5120				
	9	313	290	286	273	259	231	229	239	215	4257			
	10	267	264	246	223	222	207	183	189	194	171	3536		
	11	236	222	211	197	185	181	163	148	152	157	137	2972	
	12	195	196	183	169	160	150	150	135	117	125	125	113	2429

Tennc is the number of consecutive periods with no chargeable claims. Any period in which a chargeable claim occurs has a value of 0.

Table 4: Departure Probability by Chargeable Claims Free Tenure

Tennc	Departure Probability Overall	Departure Probability Tenure = 9
0	6.3%	4.0%
1	9.6%	5.9%
2	9.6%	4.1%
3	7.9%	1.7%
4	5.6%	4.9%
5	7.1%	4.5%
6	5.5%	4.9%
7	4.7%	0.8%
8	5.1%	1.7%
9	3.7%	3.8%
10	3.3%	
11	1.4%	
12	2.9%	
13	1.9%	

Table 5: Base Model Parameter Estimates

Parameter	Variable	Estimate (Standard Error)
$\delta(2)$	Tenure = 2	0.0131
		(0.041)
$\delta(3)$	Tenure = 3	-0.109
		(0.043)
$\delta(4)$	Tenure = 4	-0.243
		(0.043)
$\delta(5)$	Tenure = 5	-0.199
		(0.046)
$\delta(6)$	Tenure = 6	-0.318
		(0.044)
$\delta(7)$	Tenure = 7	-0.383
		(0.050)
$\delta(8)$	Tenure = 8	-0.358
		(0.058)
$\delta(9)$	Tenure = 9	-0.515
		(0.059)
$\delta(10)$	Tenure = 10	-0.522
		(0.066)
$\delta(11)$	Tenure = 11	-0.725
		(0.074)
$\delta(12)$	Tenure ≥ 12	-0.745
		(0.051)
γ_1	Discount	-0.00261
		(0.0006)
$\gamma_2(5)$	ex_disc|per_disc = 5	-0.000414
		(0.0012)
$\gamma_2(4)$	ex_disc|per_disc = 4	0.000107
		(0.0013)
$\gamma_2(3)$	ex_disc|per_disc = 3	-0.000604
		(0.0014)
$\gamma_2(2)$	ex_disc|per_disc = 2	0.00103
		(0.0014)
$\gamma_2(1)$	ex_disc|per_disc = 1	-0.000812
		(0.0016)

Table 6: Alternate Specification for F(future_discount)

Parameter	Variable	Estimate (Standard Error)
$\gamma_2(5)$	Per_disc = 5	0.0071
		(0.029)
$\gamma_2(4)$	Per_disc = 4	-0.028
		(0.031)
$\gamma_2(3)$	Per_disc = 3	-0.032
		(0.035)
$\gamma_2(2)$	Per_disc = 2	-0.026
		(0.040)
$\gamma_2(1)$	Per_disc = 1	0.012
		(0.042)

Table 7: Informed vs. Uninformed Consumers

Parameter	Variable	Informed Consumer Estimate	Uninformed Consumer Estimate
γ_1	Discount	-0.00259	-0.00267
		(0.0008)	(0.0007)
$\gamma_2(5)$	ex_disc|per_disc =5	-0.00099	0.000111
		(0.0010)	(0.0008)
$\gamma_2(4)$	ex_disc|per_disc = 4	-0.00133	0.00051
		(0.0008)	(0.0007)
$\gamma_2(3)$	ex_disc|per_disc = 3	-0.00148	-0.000054
		(0.0007)	(0.0006)
$\gamma_2(2)$	ex_disc|per_disc = 2	-0.00169	0.00049
		(0.0008)	(0.0007)
$\gamma_2(1)$	ex_disc|per_disc = 1	-0.00190	0.00041
		(0.0009)	(0.0008)

Table 8: React to 1998 Increase in First Discount?

Parameter	Variable	Informed Consumer Estimate	Uninformed Consumer Estimate
γ_1	Discount	-0.00229	-0.00287
		(0.0009)	(0.0008)
$\gamma_2(5)$	ex_disc|per_disc ≥ 5	-0.00103	0.000211
		(0.0009)	(0.0007)
$\gamma_2(4)$	ex_disc|per_disc = 4	-0.00155	-0.00041
		(0.0010)	(0.0007)
$\gamma_2(3)$	ex_disc|per_disc = 3	-0.00164	-0.000074
		(0.0010)	(0.0008)
$\gamma_2(2)$	ex_disc|per_disc = 2	-0.00178	0.00112
		(0.0010)	(0.0009)
$\gamma_2(1)$	ex_disc|per_disc = 1	-0.00201	0.00065
		(0.0011)	(0.0010)
$\gamma_3(5)$	ex_disc|	-0.00030	0.00014
	per_disc = 5 & 1stdisc_post98=1	(0.00027)	(0.00022)
$\gamma_3(4)$	ex_disc|	-0.00039	0.00008
	per_disc = 4 & 1stdisc_post98=1	(0.00029)	(0.00022)
$\gamma_3(3)$	ex_disc|	-0.00052	-0.00015
	per_disc = 3 & 1stdisc_post98=1	(0.00033)	(0.00029)
$\gamma_3(2)$	ex_disc|	-0.00047	-0.00021
	per_disc = 2 & 1stdisc_post98=1	(0.00034)	(0.00030)
$\gamma_3(1)$	ex_disc|	-0.00061	0.00009
	per_disc = 1 & 1stdisc_post98=1	(0.00040)	(0.00032)

Table 9: Sensitivity to External Prices

Parameter	Variable	Informed Consumer Estimate	Uninformed Consumer Estimate
$\gamma_2(5)$	ex_disc|per_disc ≥ 5	-0.00107	0.000301
		(0.0008)	(0.0008)
$\gamma_2(4)$	ex_disc|per_disc = 4	-0.00142	-0.00061
		(0.0011)	(0.0009)
$\gamma_2(3)$	ex_disc|per_disc = 3	-0.00166	-0.000072
		(0.0013)	(0.0008)
$\gamma_2(2)$	ex_disc|per_disc = 2	-0.00193	0.00212
		(0.0010)	(0.0008)
$\gamma_2(1)$	ex_disc|per_disc = 1	-0.00199	0.00055
		(0.0012)	(0.0011)
θ_1	Own Price	0.00284	0.00299
		(0.0011)	(0.0008)
θ_2	Market Average Price	-0.00226	-0.00083
		(0.0012)	(0.0010)

Table 10: Discount Factors For Informed Consumers

Parameter	Estimate	Standard Error
γ_1	-0.00186	0.0010
β_1	0.793	0.0612
β_2	0.924	0.0583
β	0.931	0.0504