EXPIRATION DATES AND STIGMA: WHY DON'T WE OBSERVE HEDONIC MARKETS FOR PERISHABLE PRODUCTS?

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Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29, 2008.

Introduction

Two of the most important characteristics influencing consumers' preferences for perishable foods are price and freshness (International Food Information Council (IFIC) Foundation 2007). It is reasonable to assume that consumers prefer low over high prices, and fresh over less fresh food. However, if this is a reasonable postulate, then it raises a puzzling question (Rosen 1974): why don't we observe hedonic markets for perishable food in the marketplace? For example, retailers do not sell meats in different display cases with several different prices based on time since butchering, nor do retailers sell milk differentiated by the date it was produced or pasteurized.[1]

Why is it that we do not observe hedonic markets for perishable food characterized by age and price? We contend this occurs because expiration dates on products fundamentally change the preferences of consumers, who in the absence of an expiration date would devalue the food based on age. The addition of an expiration date may lead consumers to consider perishable food as having a consistent level of freshness until the expiration date in contrast to them assuming a more linear decline. In this way, expiration dates would dichotomize or stigmatize consumer preferences so that food before the expiration date is viewed as acceptable and food that is past the expiration date is viewed as unacceptable. Psychologists describe situations where certain unacceptable behaviors, such as drinking expired milk, generate disgust and are viewed as examples of stigma (Rozin 2001). This can lead to profound biases in sensory evaluation (Wansink 2003; Wansink and Park 2002) and lead to avoiding consumption altogether. In the words of Fischhoff (2001, p. 361), "(S)tigma is demonstrated by *principled refusal to engage in an act that would otherwise be acceptable.* It happens when an individual feels that the act is *just not done*."

Expiration dates can be viewed as a means to assist consumers to avoid tasting soured milk or to avoid opening cottage cheese only to find it moldy. Yet food retailers have long used expirations dates as a means to convey a positive message about product quality and to lessen consumer concerns over food safety (Wansink and Wright 2006). However, spoiled food is rarely a food safety issue. Indeed, perishable food products often carry expiration dates even though there are no federal laws requiring food retailers to publish them. While some states require retail outlets to sell perishable food products by their expiration date, the Food and Drug Administration and the U.S. Department of Agriculture only place this requirement on infant formula because it loses its nutritional value over time.

While food scientists have conducted volumes of research on the impact of expiration dating on food quality and nutrient content, the economic impacts of expiration dates are not well understood.[2] Within the food psychology literature, there is also little published research in this area. One exception is a study by Wansink and Wright (2006), who investigated how freshness dating influences consumer perceptions about the quality of yogurt. In this study, a group of subjects tasted similar yogurt products, which had different expiration dates printed on their packages ranging from 30-days prior to 30-days past the expiration date. In reality, all of the yogurts were one month prior to their expiration date. The authors found that consumer acceptance and perceptions about the healthiness and freshness of the yogurt declined (compared to the no freshness dated yogurt) as the freshness date varied between 30-days prior and one-day prior to the expiration date. Once the expiration date was passed, however, a much sharper decline in consumer perceptions occurred for the yogurt with freshness dating than for the yogurt without freshness dating. Dating had no impact on the perceptions about food safety or risk.

Our goal is to investigate the economic impacts of expiration dating on perishable products. The focus is on how expiration dates affect consumers' preferences for perishable food products. In the next section, a theoretical model is developed to illustrate the nature of perishable food product markets in the absence of expiration dates. This model shows how consumers with different preferences and firms with different cost structures optimally choose to consume and produce perishable products with differing price and freshness attributes. The theory is then examined using experimental economics to elicit willingness to accept (WTA) measures to consume milk of different known true ages under two different treatments: (1) a treatment wherein subjects are not given the expiration date and (2) a treatment wherein subjects are given the expiration date. Our findings indicate that expiration dating substantially alters consumers' beliefs on milks' freshness and potentially enhances firms' profits. The addition of an expiration date may lead consumers to consider a perishable product to have a consistent level of freshness until the expiration date has passed.

Hedonic Markets for Perishables

It would seem that hedonic markets for perishable foods, where fresher products would sell for higher prices, would be the natural market outcome as it is for many other commodities and attributes. For example, studies have shown that the hedonic model describes the relationship between price and attributes for the real estate market (e.g., Witte, Sumka, and Erekson 1979), the automobile market (e.g., Andersson 2005), and the labor market (e.g., Brown 1980), and in each of these markets, age or quality (of the home, of the car, or of the worker) plays a significant role in explaining price. Thus, it is logical to suppose that the age of perishable products would provide the basis for hedonic markets for fresh food. In this section we develop a simple theoretical hedonic model for fresh produce such as dairy products, vegetables, meat, fish, poultry, etc. This model provides the basis for interpreting the experiment described in the next section that obtains the willingness to accept to consume milk of increasing age and reduced freshness in two treatments, one with and one without, information on the expiration date of the milk. Note, the true age of the milk was known by participants in both treatments.

Define t as the number of days since a perishable product, like milk, was purchased by the consumer, A^0 as the age of the product when it was purchased, and A_t as the age of the purchased product at the point of consumption where $A_t = A^0 + t$. Thus, in a hedonic market, the consumer must decide on the age of the product to purchase, A^0, at a price that depends on the age at purchase, $P(A^0)$, the hedonic price function. The consumer's household is assumed to derive daily utility from the daily consumption of the product, Q_t, but utility is reduced by increases in the age of the product at the time of consumption, A_t. Utility also increases in the consumption of a composite good, C_t. We set the price of the composite good equal to one. Thus, daily utility takes the form, $U(Q_t, A_t, C_t)$, where $U_Q > 0$, $U_A < 0$, and $U_C > 0$ (U_{QQ}, U_{AA}, $U_{CC} < 0$), so utility increases in the consumption of the product, decreases in the age of the product at the time of consumption, and increases in the consumption of all other goods with the conventional curvatures in each variable. Households are assumed to maximize the sum of the daily utilities over the day of the shopping trip (day t = 0) and the subsequent days between shopping trips, T days, where it is assumed that T is small enough that discounting can be ignored.[3] Thus, if the household has a shopping period budget of M dollars over T + 1 days, it maximizes

$$(1) \qquad \sum_{t=0}^{T} U(Q_t, A^0 + t, C_t)$$

subject to

$$(2) \qquad M - \sum_{t=0}^{T}(P(A^0)Q_t + C_t) \geq 0$$

with respect to choice of Q_t, A^0, and C_t. Assuming that the resulting Kuhn-Tucker conditions hold with equality, the condition optimizing the choice of A^0 can be written as

$$(3) \qquad P'(A^0) = \frac{\sum_{t=0}^{T} U_A(Q_t, A^0 + t, C_t) / U_C(Q_t, A^0 + t, C_t)}{\sum_{t=0}^{T} Q_t},$$

where the marginal utility of consumption of the composite good is equal over all periods. So the optimal age of the product at the time of purchase is found where the slope of the hedonic price gradient is equal to the slope of an indifference curve that trades off the purchase of a less fresh product of greater age over the shopping period against the value of additional consumption of the composite commodity, per unit of the product consumed over the period. Note that the numerator on the right hand side of (3) is the sum over the shopping period of the daily marginal WTA monetary compensation to consume an older, less fresh, product, and the denominator is the total consumption of the perishable product over the shopping period. $P'(A^0)$ must be negative since $U_A < 0$ and the other terms in the right-hand-side of (3) are positive, which verifies our previous conjecture. Condition (3) is shown graphically in figure 1 for two different households, where the tangency of the indifference curves denoted I^1 and I^2 to the hedonic price function determines the optimal levels of A^0 for the two households with different preferences. Note that the direction of increased utility is towards the origin since consumers prefer a cheaper price and a fresher, less aged, product, at the time of purchase.

Of course, producers must be willing to supply perishable products of different ages at the time of sale. How and why might this occur? The delivered cost of perishable products clearly increases with increased freshness and decreases with increased age. It is reasonable to suppose that production and delivery costs increase at an increasing rate with the level of firm production, X, and decrease at a decreasing rate with the age at the time of sale, A^0. Thus, firm costs will take the form $C(X, A^0)$ where $C_X > 0$ and $C_A < 0$ (C_{XX}, $C_{AA} > 0$). The firm will then maximize profit

$$(4) \qquad P(A^0)X - C(X, A^0)$$

with respect to X and A^0. The condition for the choice of A^0 takes the form

$$(5) \qquad P'(A^0) = C_A/X.$$

Assuming that the firm optimally chooses X implies that the iso-profit curves between P and A^0 have a slope equal to the right-hand-side of (5). Iso-profit (or iso-earnings) curves for two different potential firms are shown by E^1 and E^2 in figure 1. In this case, the direction of increasing profits for producers is up and to the right, implying that a higher price and a less fresh product increases profits. Note that Firm 2 may, for example, be located further away from an urban market, which implies greater transportation costs but possibly cheaper land costs, and so they choose to sell a less fresh product. Firm 1 may be located closer to an urban market, which has lower transportation costs and much higher land prices, and so they choose to sell a fresher product at a higher price. Depending on such cost differences, producers may have very different iso-profit curves and choose different levels of freshness as is shown in figure 1.

It is clear that, without expiration dates, hedonic markets for perishable products are likely to arise, similar to those described in the model developed here. To see how the practice of expiration dating changes this natural outcome, the hedonic market depicted here is contrasted in the following experiment, which elicits willingness to accept (WTA) for less fresh, older milk, with a market where expiration dates are introduced.

Experiment Design

Two experimental sessions where held at XXXX using undergraduate student participants. Subjects were recruited via e-mail, and they signed up for individual sessions online. Session 1 had 23 participants, and session 2 had 24 participants. Participants earned an average of $29.63 and $23.23 in Sessions 1 and 2, respectively. Once the subjects entered the laboratory, they were randomly assigned to computer terminals that were covered with privacy shields. Cups of fresh milk were placed on each computer terminal. The participants were told that they could drink as much of this milk as they desired and if they wanted more milk they should notify one of the administrators, who would be happy to give them more. It was also stressed that this milk had been bought in a local grocery store the same morning as the experiment. These procedures were done to isolate the effect of the age of the milk by making the marginal benefit of drinking an additional incremental amount of fresh milk later in the experiment equal to zero. The experiment administrators were also drinking the milk for the duration of the experiment. Both this milk and other milk with varying expiration dates were visibly stored in their original cartons in coolers containing ice at the front of the laboratory.

Each participant was told they would receive $5 as a show-up fee. After filling out Institutional Review Board and other forms, participants were given written instructions for Part A of the experiment. Sample instructions can be found in the Appendix, where the expiration date information was deleted for those in Session 1. The written instructions were followed by an oral Power Point presentation of the instructions. Part A of the experiment included five, low-incentive training rounds where the participants learned to use the Becker-Degroot-Marshack (BDM) mechanism (1964) with induced losses in a WTA scenarios.

Every participant had the same induced value in each round. Following similar procedures as Noussair, Robin, and Ruffieux (2004), after all of the participants had indicated the minimum amount of compensation (or request) that was necessary for them to be willing to lose their induced loss amount, all of the offers for the round were anonymously posted on a screen at the front of the room. Participants were then asked, when applicable:

1) Can you identify your request?
2) Which subjects lost their loss amount?
3) How much will these subjects be compensated and how much will they earn in this round?
4) How much will the subjects who did not lose their loss amounts earn in this round?
5) Did anyone see a request that someone might regret and why?

The administrator also explained that submitting offers equal to their induced value was the best strategy.

After the training rounds, the milk the participants were initially given was removed from their desks and they were handed written instructions for Part B. After the participants had finished reading, the instructions were also presented orally in a Power Point presentation. Session 1 participants were presented with decisions on four different types of milk, which varied only by the number of days since each type of milk had been pasteurized. Participants were informed that the different types of milk had been pasteurized 7, 15, 17, and 21 days ago. Participants were then asked, one type of milk at a time, how much compensation they would need to drink a 3-ounce cup of each of the types of milk using the BDM mechanism. Session 2 participants made the same exact decisions, except that they additionally knew that the expiration date of the milk was 16 days after the pasteurization date. They were also explicitly told for each type of milk exactly how many days it was before or after its expiration date. After all of the WTA offers for the four milks were collected, one of the four types of milk was randomly selected for actual drinking and compensation at the end of the experiment by pulling a labeled poker chip out of a bag.[4] Participants were then called up to the front of the laboratory one at a time, allowing for all drinking and payment to be done privately behind a privacy screen so that the rest of the participants could not see whether or not someone drank the milk.

Results

The average amount of compensation the participants require to drink each type of milk per session is shown in figure 2. For those who are not told the expiration date, the average amount of compensation required to drink a 3-ounce cup of milk increases from \$5.74 to \$8.74 as the days past pasteurization increases from 7 to 15 days. This difference is significant at the 1% level, t-value = 3.09, using a two-sided paired t-test. Note that there were a number of participants who either disliked milk or were lactose intolerant who required substantial compensation to drink milk of any age. It is also possible that, in spite of the training participants received in the use of the BDM, some might have provided positive offers even if their true value was zero. Thus, we focus on the changes in compensation required for drinking milk of differing ages or freshness.

For those who know the expiration date, increasing the days past pasteurization from 7 days to 15 days has no statistical effect on the amount of compensation the participants require to drink a cup of milk, as the average value goes from \$4.03 to \$4.01, where a paired two-sided t-test yields a t-statistic of 0.03. Participants who know the expiration date only have a statistically significant increase in the amount of compensation they require to drink a cup of the milk once the milk has passed the expiration date. When the milk increases from 15 to 17 days past the pasteurization date, and also passes the expiration date, the average amount of compensation necessary to drink the milk jumps from \$4.01 to \$7.68. This difference is significant at the 1% level with a t-stat of 2.86 using a 2-tailed paired t-test.

In testing if the existence of an expiration date changes people's WTA milk of varying freshness, we analyze how preferences change with the addition of an expiration date and how behavior changes around the expiration date. We assume that the marginal compensation an individual needs to drink milk of decreasing freshness is constant in the days past pasteurization unless the information the participant has changes. Let V_{iq} be the amount of compensation person i needs to drink milk q, where q represents one of the types of milk the participant was presented. Let D_{iqrs},{7,15,17,21} be the number of days that passed since the milk was pasteurized, where r = Y if individual i knows the expiration date and r = N if they do not know the expiration date and s = B if the milk is before its expiration date and s = P if the milk has passed its expiration date.

First, we want to analyze the behavior of the individuals who do not know the expiration date. We are primarily interested in how the freshness of the milk and the expiration date affect behavior. So we estimate

$$(6) \qquad V_{iq} = \alpha_N + \sum_{s=\{B,P\}} \beta_{Ns} D_{iqNs} + u_i + v_{iq} \ \ \forall q, i$$

using a random effects Tobit analysis since participants' offers were truncated at $0 and $30, where we cluster over the individual.[5] If a given number of days since pasteurization and the subscripts do not match, such as if s = B and days are equal to 17, we code this as a 0 for the D_{iqrs} variable. The results can be found in table 1. When regressing the minimum WTA on the varying days since pasteurization when the participants did not know the expiration date, we find that the slope on days since pasteurization is positive and significant both before and after the expiration date, at the five percent and one percent level, respectively. When conducting a $\Pi^2(1)$ test to see if the coefficient on the days past pasteurization before the expiration date is different than the coefficient on the days past pasteurization after the expiration date, we get a $\Pi^2(1)$ = 1.30. So we cannot reject that the coefficients on the days since pasteurization are the same, p=0.255. This indicates that we cannot reject the conjecture that when individuals do not know the expiration date, they devalue drinking older milk at the same rate both before and after the unknown expiration date.

We next examine the results from the experiment where the individuals were told the expiration date. We conduct the same analysis on the data, but this time with those who knew the expiration date,

$$(7) \qquad V_{iq} = \alpha_Y + \sum_{s=\{B,P\}} \beta_{Ys} D_{iqYs} + u_i + v_{iq} \;\; \forall q,i \,.$$

This time the coefficient on the days past pasteurization before the expiration date is insignificant at all commonly accepted levels, p=0.368 level. This shows that we cannot reject the hypothesis that individuals consider a product to have a consistent level of freshness any day before the expiration date, when they are told what it is. After the expiration date, the coefficient on the days past pasteurization is positive and significant at the one percent level. This shows that individuals need more compensation to consume the product after the expiration date has passed since they consider it is less fresh. When conducting a $\Pi^2(1)$ test to see if the coefficient on the days past pasteurization is the same before and after the expiration date, we find a $\Pi^2(1)$=9.37, p-value of 0.002. This is in contrast to the previous result where we could not reject that the coefficients on the days past pasteurization were the same both before and after the expiration date. Now, we can reject at the one percent level the hypothesis that the marginal compensation needed to consume the milk as freshness decreases is the same before and after the expiration date.

Finally, we combine all of the data into one grand regression to compare the marginal compensation an individual needs to accept the milk both before and after the expiration date, both when they know the actual expiration date and when they do not. We estimate

$$(8) \qquad V_{iq} = \alpha + \alpha_{Yonly} + \sum_{r=\{N,Y\}} \sum_{s=\{B,P\}} \beta_{rs} D_{iqrs} + u_i + v_{iq} \;\; \forall q,i \,,$$

where $\forall$ is the overall intercept and $\forall_{Yonly}$ is the change in the intercept from knowing the expiration date. The magnitudes of the coefficients are extremely similar to the results we previously found.

Once individuals know the product is older than the expiration date, they eventually (by day 21) appear to put the same value on the freshness of the product as they would if they did not have the expiration date. When the milk is 21-days old, a t-test of the difference between the means of the participants who knew the expiration date versus those who did not know the expiration date yields a t-statistic of 0.603 and a p-value of .275. Therefore, we cannot reject the idea that once a product is well past the expiration date at day 21, the addition of the expiration date does not change individuals' perceptions of the product.

Discussion

An examination of figure 2 suggests that the introduction of an expiration date provides information that dramatically alters consumer preferences. Consumption of an expired product is stigmatized to the degree that, for most consumers, the compensation needed to consume it increases rapidly with time after the expiration date, such that the compensation required would imply a negative price for the product to be acceptable. The implications for the potential hedonic market for perishable products are shown in figure 3. Given that the marginal compensation required to consume an older product is likely to be zero on each day up to the expiration date, the likely slope of an indifference curve between price and age at the time of purchase will shift from the continuously downward sloping curve (with no expiration date information) to a flat curve up to an age equal to the expiration date, E, minus the shopping period (E –T), where a sharp kink is likely to be present since the compensating differential to consume the product even one day beyond the expiration date is so large. This suggests that the kink introduced into the average indifference curve for households creates a vertex solution for producers at the expiration date minus the shopping period so that producers choose to set $A^0 = E - T$, making it is unlikely that any hedonic market will form. Put more intuitively, expiration dates cause consumers to not differentiate the values of various aged perishable products as long as the age is below the expiration date. Note that the advantage to producers is that the price buyers will pay increases with the introduction of an expiration date relative to the price buyers would pay without an expiration date. In a more sophisticated model of producer behavior, firms will likely choose both E and A^0 to attempt to keep consumers on the horizontal portion of their indifference curves since price will drop precipitously if $A^0 > E - T$ for consumers. Again these arguments are only meant to be suggestive since the purpose of this article is to show the surprising role of expiration dates. In any case, the fact that daily values do not decline in age up to the expiration date prevents what might be viewed as the formation of a natural hedonic market.

Conclusion

Expiration or "sell-by" dates are printed on labels for many retail foods and beverages. A primary reason why expiration dates are included on labels is to inform consumers about the potential risk that the product is no longer suitable to consume; however, there might be unintended consequences to such labels.

Our experimental results suggest that expiration date labeling changes perceptions, so that by stigmatizing the expired product, the price of the good no longer necessarily decreases as the product ages since consumers do not devalue the food based on age. Instead, they behave as if the perishable product has a consistent level of freshness any time before the expiration date. Thus, consumers no longer require a lower price to buy in equilibrium as long as the age of the product is before the expiration date. This phenomenon would thus give firms an incentive to add an expiration date to help enhance their profits.

Footnotes

[1] A potential exception is fresh-baked bread, which frequently has an age-based hedonic market, such as the discount offered with "day-old bread." However, few other perishable foods have similar markets, and one might argue that the effective expiration date for fresh bread is one-day.

[2] Indeed, a search on EconLit of "food expiration dates," "food expiration dating," "food sell by dates," and "best if used by dates for food" revealed that there have been no economic studies published to date on this topic.

[3] We take T as exogenous; although, obviously, it is a choice variable. The inclusion of the choice of T would add considerable complexity to the model since it involves the trade-off between transaction costs of time and transportation against freshness and storage capacity for many products, a topic that is beyond the scope of this study.

[4] The randomly chosen cup of milk was determined with five other decisions that were made in Part C of the experiment. We do not use this data in this analysis. During Part B of the experiment, the participants were only told that they would make five other decisions in the experiment. They did not know what they were.

[5] We also conducted the analysis using a Tobit model that was only truncated at $30 and a random effects linear model to check for robustness, and as expected, the results are almost identical.

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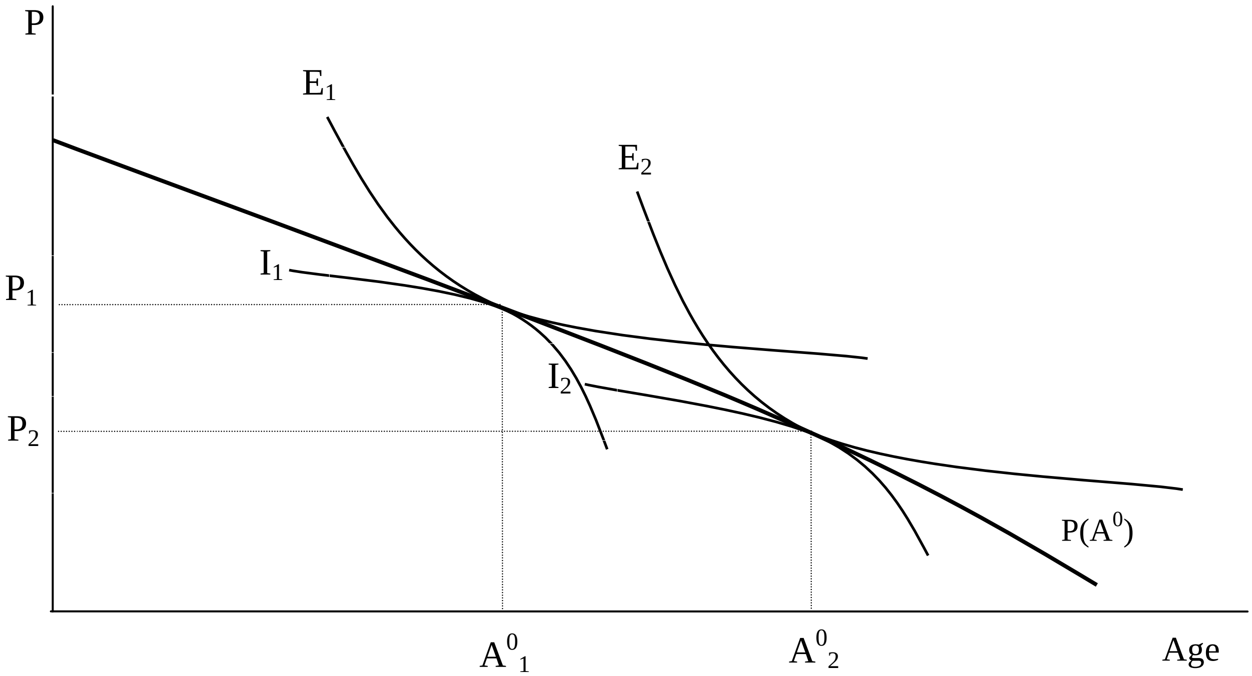


Figure 1. Derivation of the hedonic price function for a perishable product

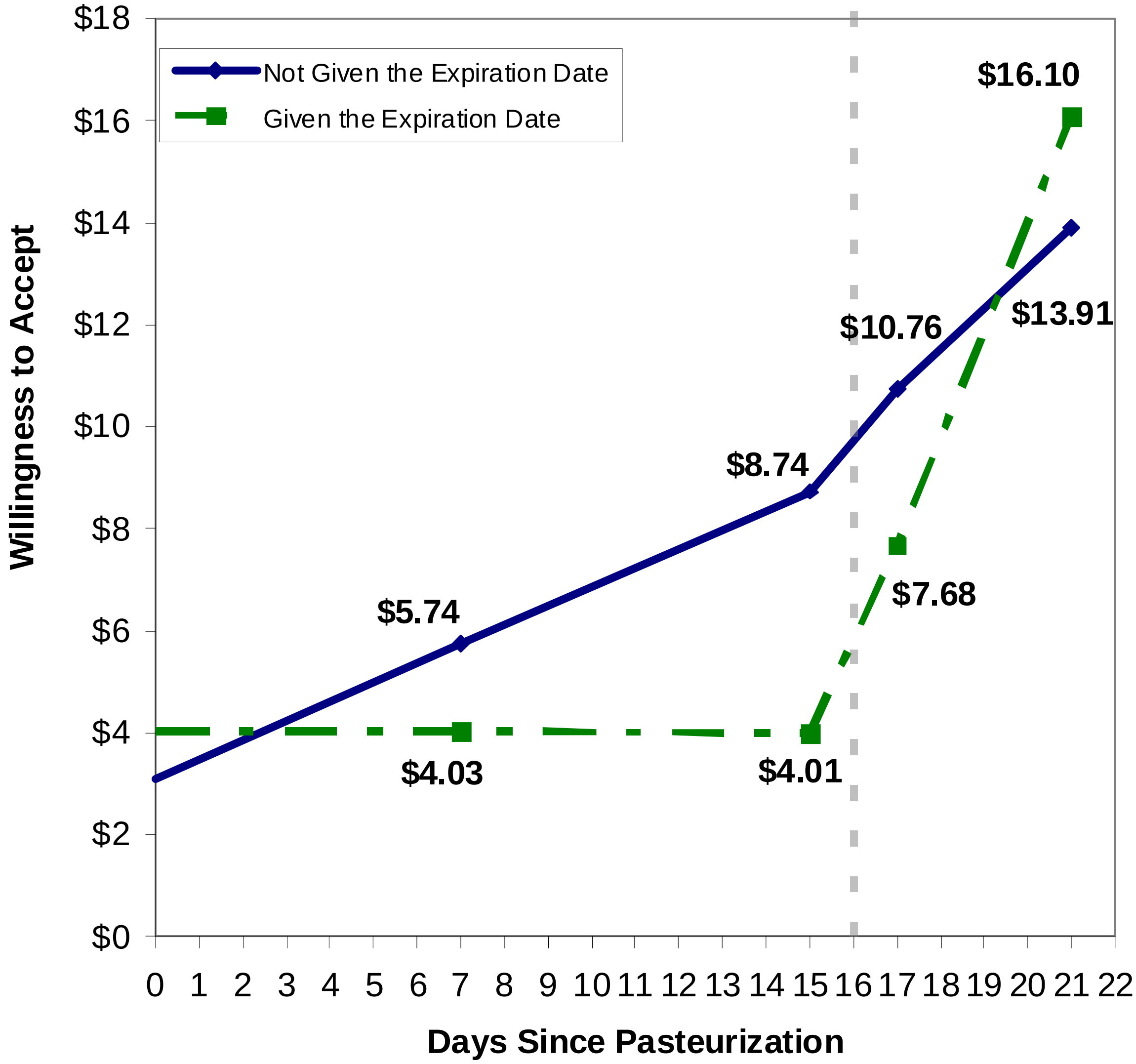
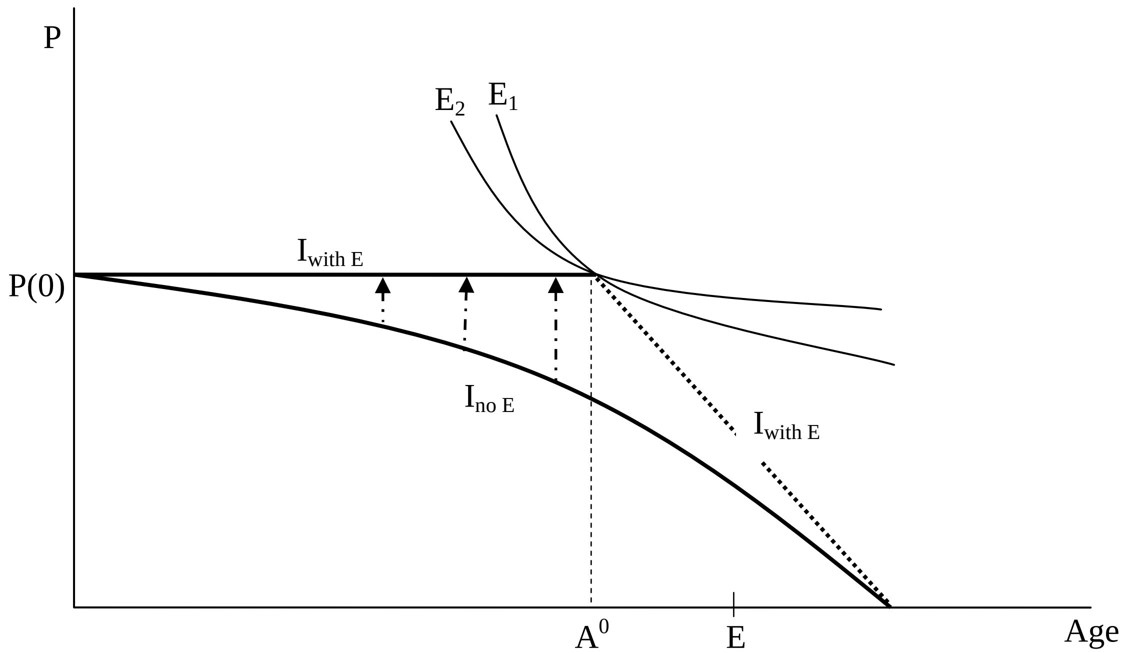


Figure 2. Experimental results



$A^0 = E - T$

Figure 3. Expiration dates change consumer preferences and producer choices

Table 1. Random-Effects Tobit Regression of Willingness to Accept to Drink the Milk of Varying Expiration Dates, Truncated at $0.00 and $30.00

	Without Expiration Date	With Expiration Date	Full Model
α			-3.4810
			(4.5184)
α_{Yonly}			-4.2615
			(6.6828)
β_{NB}	.7590**		.7567**
	(.3579)		(.3723)
β_{NP}	.9676***		.9776***
	(.2344)		(.2437)
β_{YB}		.4302	.4213
		(.4780)	(.4193)
β_{YP}		1.1972***	1.1639***
		(.3042)	(.2665)
α_N	-4.4258		
	(4.3512)		
α_Y		-8.4051	
		(5.6499)	

Note:
Total observations are 92, and 96, and 188, respectively.
The log-likelihoods are -245.21769, -206.55063, and –449.10062, respectively.
Standard errors are in parentheses.
Triple asterisk (***) and double asterisk (**) denote variables significant at 1% and 5% level, respectively.