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Durable Goods Price Cycles: Theory and Evidence from the Textbook Market*

Eric W. Bond and Toshiaki Iizuka

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Abstract:

We study the pricing of a durable-goods monopolist who faces heterogeneous buyers. Our durable good has the features of a textbook: each period new consumers enter the market, and the introduction of a new edition kills off used goods. We show that, unlike the traditional Swan-type models where all consumers resell the good, the monopolist's optimal policy could be to increase the price over the life of an edition. Our empirical analysis supports this model: textbook prices increase as the share of used textbooks increases. Moreover, textbook prices tend to increase as the end of the current edition approaches.

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In this paper, we develop a model of monopoly pricing of a durable good when there are heterogeneous buyers. We examine a market in which the durable good has the features of a textbook: each period, new consumers enter the market with a demand for the use of the good during that period. At the end of the period, purchasers have the option of continuing to hold the good or selling it in the used market. Our emphasis is on how the price of the good varies over the life of an "edition" of the good, where it is assumed that the introduction of a new edition will kill off the used market value of a previous edition. We then test the implications of the model for the pricing of economics textbooks over the life of an edition.

Our analysis is motivated by the observation that the price of an edition of a textbook does not seem to decline over the life of the edition, as would be suggested by the standard model of durable goods pricing where consumers are homogeneous. Following the seminal work of Swan (1970), it is normally assumed that consumers factor the expected resale value of a durable good into their willingness to pay for a new good. This model would predict that the value of the new good should decline as the end of an edition approaches because the expected resale value would be lower. If consumers know with certainty when the edition will end, and a book can only be resold once, then it is only the one period ahead resale value that matters and the model would suggest a significant drop in consumer valuation of a new edition in the last period of its life. If a good can be resold more than once or the end date of the edition is uncertain, then the decline in the valuation of a new good by a representative consumer would be spread over the life of the edition. However, data on pricing of new textbooks at college bookstores do not provide evidence of such a decline with the age of an edition or a dramatic reduction in price in the last period of the life of an edition.

Our theoretical model assumes that there are two types of consumers. One type is a Swan-type

consumer who will purchase a good for current use and then resell the good on the used market. For these consumers, the willingness to pay will decline as the anticipated end of the edition approaches. The other type of consumer will buy and hold onto a good. For these consumers, the valuation of a new good is unaffected by the existence of a used market and is constant over the life of an edition. We then examine the optimal pricing policy of a monopoly seller in a stationary model in which a fixed number of buyers of each type enter the period to buy a textbook, and each edition of the textbook has an exogenously given life of two periods. Under the assumption that those who plan to keep the textbook place the highest value on the new good in the last period, we show that the price of a new textbook may fall, remain constant, or rise over the life of an edition. Not surprisingly, a falling (constant) price over the life of the edition occurs when the consumers who plan to sell (keep) the book after its use dominate the market. The most interesting case is that of the rising price of a textbook that occurs when the monopolist finds it optimal to sell to all consumers in the first period but only to high valuation buyers who will keep the good in the second period.[1,2]

Our results also contrast with those obtained in the literature on the Coase conjecture for a durable good monopolist (eg, Bulow (1981), Bond and Samuelson (1984)), where prices of a durable good fall over time if the monopoly seller is unable to commit to an output policy. As the stock of existing durables increases, the monopolist's incentive to cut price increases due to the fact that part

[1] The price discrimination story we develop in this paper resembles to the pricing pattern and market segmentation in the pharmaceutical market after patent expiration. When the patent expires, generic drugs enter the market and the incumbent brand-name drugs face competition from these cheaper drugs. Frank and Salkever (1992) develop a model in which prices of branded goods rise after patent expiration because brand name producers sell only to brand loyal, price insensitive consumers. Frank and Salkever (1997) find evidence that brand prices increase after patent expiration.

[2] Stokey (1979) and Conlisk Gerstner, and Sobel (1987) develop models in which a monopolist chooses prices that vary over time. The cycles in these models are based on the ability of consumers to engage in intertemporal substitution and the absence of resale markets, assumptions that do not fit well with the textbook markets.

of the losses from price reduction fall on consumers who have already purchased the durable. Although we also assume that sellers are unable to commit to a pricing policy, our results differ due to the entry of new consumers and the imperfect substitutability between new and used goods due to consumer heterogeneity.[3]

Our empirical analysis tests whether increases in the supply of the used books and reaching the end of the edition create an incentive for the seller to raise the price to sell only to the high valuation buyers. We obtained a panel data set from college bookshops that contain price and quantity information for economics textbooks for each semester between 1997 and 2003. We estimate simple pricing equations with textbook fixed effects. Instrumental variables are also used to account for the potential endogeneity of a regressor. We find that textbook prices increase as the share of used textbooks increases and, in some regressions, as the last period of the current edition arrives. In contrast, we find no evidence that the textbook prices fall over the life of the edition. Thus, our results suggest that textbook pricing cycles are consistent with the prediction of the price discrimination model with heterogeneous consumers but not with that of the traditional Swan-type models with homogeneous consumers.

This paper contributes to the growing empirical literature on the durable goods market. In contrast to the large theoretical literature on durable goods monopolists, empirical analysis on the durable goods market has been fairly limited until recently due to the limitations of the data. In

[3]We maintain the assumption that the life of an edition is exogenously determined throughout this paper. Another question that has been addressed in the literature on durable goods is whether a monopolist has an incentive to alter the life of the good from the socially optimal level in order to kill off the used market. Waldman (1996) provides a good discussion of the issues. This question of whether the monopolist would choose the socially optimal life of an edition with our specification of consumer demands is beyond the scope of this paper, and is addressed in a companion paper (Bond and Iizuka, 2004). As noted below, Iizuka (2007) also empirically analyzes whether textbook publishers introduce new textbook editions to avoid competition with previous units.

particular, two recent papers on the textbook market are most closely related to the current paper.[4] Iizuka (2007) considered the supply side of the textbook market and examined whether the textbook publisher engaged in planned obsolescence. He found that publishers are more likely to introduce new textbook editions when competition from used textbooks is high. Chevalier and Goolsbee (2009) examined consumer behavior in the textbook market and found that consumers are forward-looking and have rational expectations about publishers' revision behavior. The current paper focuses on the pricing policy of durable goods producers and complements these two papers. Additionally, while the above references were purely empirical exercises, this paper develops a theoretical model of durable goods pricing and applies the model to empirical data.

The college textbook market is important because it is a stylized market from which to examine the behavior of durable goods producers and because the textbook pricing has attracted a lot of public attention. There has been a concern that textbook prices have increased much faster than other goods and services,[5] which led the U.S. Congress to ask the Government Accounting Office (GAO) to investigate the rising prices of college textbooks in recent years.[6] We expect that the theory and evidence in this paper will help the understanding of pricing behavior in the textbook publishing market.

The rest of the paper is organized as follows: we introduce our model in Section I, we

[4]Recent empirical literature on the durable goods market outside of textbooks includes Adda and Cooper (2000), Esteban and Shum (2007), Gordon (2009), Yin et al. (2010), Schiraldi (2011), and Chen et al. (2011).

[5]See, for example, "Textbook Prices on the Rise," Washingtonpost.com, September 18, 2004.

[6]The GAO(2005) found that college textbook prices have increased at an average of 6% per year, which is twice the rate of inflation. As a result, textbook prices nearly tripled from December 1986 to December 2004. The GAO notes that "the increasing costs associated with developing products designed to accompany textbooks, such as CD-ROMs and other instructional supplements, best explain price increases in recent years."

describe the empirical analysis in Section II, and we conclude the paper in Section III.

I. The Model

We examine a model of a monopoly producer of a durable good that has the basic features of a textbook. Each period a new cohort of buyers enters the market with a demand for the services of the durable good to be consumed in that period. At the end of the period, the owner can choose to sell the good in the used market or to keep it. However, the introduction of a new version of the durable drives the used market value of the previous version to 0, so a purchaser in the last period of the current version's life will have no resale option. We examine the optimal pricing over the life of a durable good that has an exogenously given life of two periods and a constant marginal cost of production, c.[7] Similar results can be obtained when we extend the model to three periods (please see section I-B below.)

We assume that there are two types of consumers, denoted by K and S, that are potential consumers of the good. Each period an exogenously given number N_i of type $i \in \{K, S\}$ consumers enter the market. Type K consumers will buy and keep the durable, with V_K^N (V_K^U) denoting the present value of returns that the type K consumer earns from purchasing the new (used) good. In the

[7]Our model treats the seller of textbooks as being a monopoly seller to students given the decision of a faculty member to adopt the book. We therefore abstract from the competition between publishers for course adoption. The responsiveness of student demand to the price of new goods will thus result from the availability of used goods or the possibility of sharing or not buying the text. We follow this approach because we believe that the price of a text plays a minor role in the decision of a faculty member to adopt. This view is supported by casual empiricism. The authors have heard a number of arguments from textbook representatives over the years as to why a particular book should be adopted, but argument that a particular good is cheaper than a competitor has never been encountered.

This issue is potentially important, because one might argue that the dynamics of pricing over an edition might reflect more aggressive pricing in the early stages of an edition to encourage adoptions of a new book. While it is clear that obtaining adoptions is important to the publisher in the early stage of an edition, we believe that adoptions are encourage primarily by more aggressive advertising and the provision of a higher level of service from the publisher.

textbook case, type K consumers are those who hold onto the book after the class is completed. These could be students who major in the subject and use the text as a reference in the future, or students for whom the transactions costs of going to the used market to sell the good are high.

Type S consumers are those who value the good primarily for its service flow in the current period, and will sell the good with probability $\alpha \in (0, 1)$ in the used market in the subsequent period if it has value. A type S consumer will receive a piece of information with probability $(1 - \alpha)$ which results in the good not being sold in the used market. Examples of such information might be damage to the good that prevents its resale, high transactions costs in the used market, or a change in preferences that result in a preference for keeping the good. All type S consumers are identical ex ante, and correctly anticipate that the good will be resold with probability α. The expected surplus of a type S consumer of buying a new good will be $V_S^N + \alpha\beta p_2^U$, where V_S^N is the expected value placed by a type S consumer on the flow of service from a new good, β is the discount factor, and p_2^U is the price of a used good in the second period. It is assumed that used goods have no value following the second period, so the value to a type S consumer of the new good in the second period is simply V_S^N. The value of a used good to an S consumer in the second period is denoted V_S^U.[8]

The preference parameters of the respective types can be used to characterize the demand for new and used goods in each period. In the second period, a type $i \in \{K, S\}$ consumer will buy used goods if the surplus from buying a used good is non-negative ($V_i^U \geq p_2^U$) and exceeds that available from purchasing a new good ($V_i^U - p_2^U \geq V_i^N - p_2^N$). Similarly, a new good will be purchased if V_i^N

[8]We can decompose the value of a new good to type K into its current service flow, S_K^N, and its future value value when the good is kept, F_K^N, so that $V_K^N = S_K^N + \beta F_K^N$. Our assumption on type K preferences is that the value of its service use exceeds its used market value net of used market transactions costs of type K, t_K, for all used prices, so that $F_K^N > p_2^U - t$. This assumption simplifies the analysis by ensuring that type K buyers of new goods never enter the used market as sellers, and would be satisfied if $F_K^N > V_S^U$ or if t_K is sufficiently high.

$\geq p_2^N$ and $V_i^N - p_2^N \geq V_i^U - p_2^U$. Combining these results, we obtain the reservation price for a used (new) good by type i in period 2, R_{i2}^U (R_{i2}^N), to be

$$R_{i2}^U = \min\left[V_i^U, V_i^U - V_i^N + p_2^N\right] \qquad R_{i2}^N = \min\left[V_i^N, V_i^N - V_i^U + p_2^U\right] \qquad \textbf{(1)}$$

We will impose two restrictions on the taste parameters of the two types. The first gives type K the greatest valuation on new goods and type S the greatest valuation on used goods:

(A.1) $V_K^N > V_S^N + \alpha\beta V_S^U$ and $V_S^U > V_K^U \geq 0$

Note that the value of a new good to S buyers includes the expected return from being able to sell the good to a type S buyer in the used market in the future. Assumption (A.1) ensures that type S will always be the high valuation buyers in the used market, since it implies $R_{S2}^U > R_{K2}^U$ for all p_2^N. This assumption seems plausible for the case of textbooks, since a student planning to hold on to the book will place a higher valuation on having a high quality copy and making careful use of the book. On the other hand a student wanting the book only for the purpose of getting through the course is likely to find the used book to be a much better substitute for the new good.

The second assumption relates the taste parameters of the S buyers to the marginal cost of production

(A.2) $V_S^N > c > V_S^N - V_S^U$

The left hand inequality restricts attention to cases in which type S buyers have a sufficiently large willingness to pay for the services of the good that they would purchase a new good in the second period if it was priced at marginal cost. Utilizing the right hand inequality in (A.2), we have $R_{S2}^U > 0$ for all $p_2^N \geq c$. Since sellers will only choose prices that are no less than marginal cost, there will

be a positive price in the second period as long as supply is less than N_S. An implication of this assumption is that it is not socially efficient to kill off the used market, since the used market would exist under a seller pricing at marginal cost.

Letting X_2 denote the stock of used goods in the second period, this analysis yields

Lemma 1: If $X_2 \leq N_S$, $p_2^N \geq c$, *and assumptions (A.1) - (A.2) hold,* $p_2^U = R_{2S}^U = \min [V_S^U, V_S^U - V_S^N + p_2^N] > 0$.

Under the assumption that type K buyers always keep their goods and that the number of consumers is constant in each period, this is the relevant case for consideration here since the maximum possible second period supply is αN_S. For the benchmark case of a durable being supplied by perfectly competitive sellers, $N_K + N_S$ units of the good would be sold in the first period and $N_K + N_S(1 - \alpha)$ units in the second period. Used market sales in period 2 would be αN_S units at a price of $V_S^U - V_S^N + c > 0$.

I-A. Monopoly Pricing of the Durable Good

We now turn to the analysis of the optimal pricing policy for a monopoly seller of the durable good. Since the first period valuations of type S buyers depend on the seller's second period pricing policy, we solve the problem using backward induction. In period 2, the seller chooses the price for a new good given a stock X_2 of used goods resulting from sales in the previous period. If $p_2^N \leq V_S^N$, then it follows from (1) and Lemma 1 that type S buyers will buy both new and used goods and type K buyers will purchase new goods. If $p_2^N \in (V_S^N, V_K^N]$, then type K buyers will receive non-negative surplus from new goods and type S buyers will purchase only used goods. This indicates that the monopolist will choose between two pricing strategies: selling to only type K buyers at a price of V_K^N and selling to both types at a price of V_S^N. The former strategy yields a profit of $(V_K^N - c)N_K$, while

the latter yields a profit of $(V_S^N - c)(N_K + N_S - X_2)$. Letting $\lambda_K \equiv N_K/N_S$ and $x_2 \equiv X_2/N_S$, the strategy of selling only to type K will be more profitable if $\lambda_K \geq (V_S^N - c)(1 - x_2)/(V_K^N - V_S^N)$.

This comparison yields the following result:

Lemma 2: Under (A.1) and (A.2), the optimal policy of the monopolist in the last period of the editions is:

(a) $p_2^N = V_K^N$ *and* $\pi_2^*(x_2) = (V_K^N - c)\lambda_K$ *for* $x_2 \geq \tilde{\mathbf{x}}$

(b) $p_2^N = V_S^N$ *and* $\pi_2^*(x_2) = (V_S^N - c)\,(1+\lambda_K - x_2)$ *for* $x_2 < \tilde{\mathbf{x}}$.

$$\text{where} \quad \tilde{\mathbf{x}} \equiv \max\left[1 - \lambda_K\left(\frac{V_K^N - V_S^N}{V_S^N - c}\right), 0\right] \tag{2}$$

In either case, $p_2^U = V_S^U$.

The seller will sell only to type K buyers if the normalized stock of used goods exceeds $\tilde{\mathbf{x}}$. This result establishes a non-decreasing relationship between the stock of used goods and the price that a monopoly seller charges for new goods in period 2, since a larger used stock makes it more attractive to sell only to the high valuation buyers.

The profit function and used price solution from Lemma 2 can now be used to solve for the first period optimization problem for the seller. Since the monopolist's pricing strategy will depend only on the relative abundance of type K buyers, as in Lemma 2, we can simplify the notation by normalizing all quantities by the number of type S buyers. The discounted normalized profits of the firm over the life of the good will be

$$\Pi = (p_1^N - c)\, y_1(p_1^N) + \beta\pi_2^*(x_2(p_1^N)) \tag{3}$$

where $y(p_1^N)$ is the normalized first period demand and $x_2(p_1^N)$ is the second period stock resulting

from the firm's first period price choice. The normalized second period stock will equal α if type S consumers buy in period 1 and 0 otherwise, which from Lemma 2 yields

$$x_2(p_1^N) \quad \begin{array}{ll} 0 & \text{for } p_1^N > V_S^N + \alpha\beta V_S^U \\ \alpha & \text{otherwise} \end{array} \qquad (4)$$

The firm's first period choice can be simplified to choosing between setting a price of V_K^N and selling λ_K units or setting a price of $V_S^N + \alpha\beta V_S^U$ and selling $(1 + \lambda_K)$ units.[9] If the seller chooses to serve only high valuation buyers in the first period, there will be no second period stock of used goods and normalized profits will be $(V_K^N - c)\lambda_K + \beta\pi_2^*(0)$. If the seller chooses to sell lower the price to sell to both types, the profits will be $(V_S^N + \alpha\beta V_S^U - c)(1 + \lambda_K) + \beta\pi_2^*(\alpha)$.

Comparing the payoffs from these strategies, we can obtain the critical values of λ_K for which the respective strategies will be optimal.

Proposition 1: Under (A.1), the optimal strategy for the monopolist will be:

a. sell to type K consumers only in both periods at $p_1^N = p_2^N = V_K^N$ *if* $\lambda_K > \dfrac{V_S^N + \alpha\beta V_S^U - c}{V_K^N - V_S^N - \alpha\beta V_2^U}$.

[9] It is straightforward to show that if it is profitable for the monopolist to sell to some consumers of type i, then it is profitable to sell to all consumers of type i. This holds for type K buyers because if $y_1 < \lambda_K$, marginal revenue from type K buyers is $V_K^N - c > 0$. In the case of sales to type S buyers, marginal revenue will depend on whether first period sales affect the quantity of second period sales. For $y_1 < \lambda_K + \tilde{x}/\alpha$, additional period 1 sales will reduce period 2 sales to type S and marginal revenue is $(1 - \alpha\beta)(V_S^N - c) + \alpha\beta V_S^U > 0$. For $y_1 > \lambda_K + \tilde{x}/\alpha$, additional period 1 sales have no impact on period 2 sales and marginal revenue is $V_S^N + \alpha\beta V_S^U - c > 0$. Thus, it is sufficient to compare the profitability of selling to all of type K with that of selling to all of both types.

b. sell to both types in period 1 but sell only to type K in period 2, $p_1^N = V_S^N + \alpha\beta V_S^U < p_2^N$

$$= V_K^N \text{ if } \lambda_K \in \left(\frac{(V_S^N - c)(1-\alpha)}{V_K^N - V_S^N}, \frac{V_S^N + \alpha\beta V_S^U - c}{V_K^N - V_S^N - \alpha\beta V_S^U}, \right).$$

c. sell to both types in both periods, $p_1^N = V_S^N + \alpha\beta V_S^U > p_2^N = V_S^N$, *if* $\lambda_K < \dfrac{V_S^N - c}{V_K^N - V_S^U}$.

If the population consists of a sufficiently large fraction of type K buyers, the optimal pricing policy is to set a constant price for new goods in each period that extracts all surplus from type K buyers. In this case there will be no used market and type S obtain zero surplus. When the fraction of type K is sufficiently low, the optimal price for new goods declines over time to extract all surplus from type S buyers. Used markets are active in each case, and type K buyers earn a positive surplus in each period on purchases of new goods. The interesting case arises for intermediate values of λ_K, in which the price of new goods rises in the last period of the good's life. In this case, a sufficiently large fraction of type S buyers purchase goods in the used market that the seller writes off that segment of the market and sells only to type K buyers.

I-B. Extensions of the Model

Proposition 1 established conditions under which the price of a new durable good would be higher in the second period than in the first period of an edition under the assumption that (A.1) holds. A natural question to ask is to how this possibility is affected by extending the life of the durable good to three periods. Is the rising price necessarily a "last period effect," or could it arise in the second period of the life of the good as well? It is straightforward to show that either of these possibilities

can arise in the three period model. A rising price of new goods between the first and second periods arises when the monopolist's optimal policy is to sell to both types in period 1, but to sell only to K types in subsequent periods. The price rises in the last period when the optimal policy results in sales to both types in the first two periods, but only to the K types in the last period. Since S type buyers will have a higher reservation for new goods the greater is the remaining life of the good, the threshold stock for selling only to type K buyers in the second period is higher than that in the last period.

A second extension is to consider the case in which type K buyers place a higher valuation on both new and used goods. Such a case might arise if type K are high income, high transaction cost buyers. A high income would be associated with a relatively higher valuation for all goods, but a high time cost might prevent them from selling goods in the used market. It can be shown in this case a rising price of new goods might arise if we modify (A.1) to

(A.1') $V_K^N > V_S^N + \alpha\beta V_S^U$, $V_K^U > V_S^U$, and $V_K^N - V_K^U > V_S^N + (\alpha\beta - 1)V_S^U$.

Assumption (A.1') captures the case in which the K buyers value both new and used goods more highly, but have a relative preference for new goods.

As in the case where (A.1) held, a rising price of new goods over the life of the edition will be observed for parameter values such that the monopolist finds it optimal to sell new goods to both types in the first period, but only to type K in the second period. Establishing this possibility under (A.1') is slightly more complicated because of the possibility that type K buyers can outbid type S buyers for used goods in period 2. It is shown in Appendix I that if $\lambda_K < (V_S^N - c)/(V_K^N - V_S^N)$. This restriction requires that the type S be sufficiently abundant in the market that it never pays for the monopolist to set the price of new goods so high that type S are driven out of both the new and used

markets. It is shown in Appendix I that the monopolist will choose to sell only to type K in the second period if $\lambda_K < (V_S^N - c)/(V_K^N - V_S^N)$ and $x_2 > 1 - (V_K^N - V_K^U + V_S^U - V_S^N)/(V_S^U - c)$. Since the former condition also ensures that it will be optimal to sell to both types in the first period, we obtain the following result:

Proposition 2: If (A.1') and (A.2) hold and $\lambda_K < (V_S^N - c)/(V_K^N - V_S^N)$, the optimal first period policy is to sell to both consumer types. The optimal second period policy is to sell only to type K if $\alpha > 1 - (V_K^N - V_K^U + V_S^U - V_S^N)/(V_S^U - c)$, which results in a rising price of new goods over the life of the edition.

Proposition 2 shows that the threshold effect of the used stock and the rising price of new goods over time can both be observed in the model in which type K buyers have an absolute preference for new and used goods, although the upper bound on λ_K for which this holds is lower than that in Proposition 1b.[10]

II. An Empirical Analysis of the Textbook Market

In this section, we use data from the sales of new economics textbooks to test hypotheses regarding the pricing of textbooks over the life of an edition. We first describe the data and then discuss the empirical model to examine the firm's price setting behavior.

[10] If $\lambda_K > (V_S^N - c)/(V_K^N - V_S^N)$, then the seller will find it optimal to set a price of V_K^N when the supply of used goods is quite small under assumption (A.1'). When the share of type K buyers is sufficiently large, the seller will find it optimal to price type S out of both new and used markets. As the stock of used goods rises, it will become profitable to lower the price of new goods to prevent type K buyers from purchasing used goods. This example generates a difference from the previous case, in that it results in a negative relationship between the price of stock of used goods and the price of new goods.

II-A. Data

Our textbook pricing data come from college bookshops and are collected by Monument Information Resource (MIR). Each semester, MIR collects textbook sales and adoption information for each school. Our sales data are aggregated at the national level and contain the number of textbooks sold (new vs. used), average prices (new vs. used), edition number, year and month of publication, author name, textbook category, publisher name, and the ISBN code. In contrast, adoption data are at the school level and contain the name, location, and ID of the school, the course name, estimated enrollments, and detailed information on the adopted textbook, including the ISBN code. If multiple sections or courses are offered in a school in the same semester, we observe the textbook adoption information separately. For this study, we focus our attention on economics textbooks that appear in the MIR database between 1997 and 2003. MIR collects data twice a year, and this gives us 14 semester of observations, at most, for each textbook.[11] We refer to these semesters as fall and spring semesters. MIR estimates that their 2003 data covered approximately 50.4 per cent of the total college textbook market in the U.S.[12]

The main limitation of the data is that the MIR only covers the transactions that take place through college bookstores. For example, buying and selling textbooks through online bookstores are not captured in the data. We are fortunate, however, that during the data period (1997 to 2003), the online sales of textbooks appear to be relatively small. According to the estimate by the National Association of College Stores, online textbook sales accounts for only 7% in 2002. Nonetheless, the

[11] Summer textbook sales are combined with the spring sessions. Ideally, one would observe the "summer" period separately from the spring semester. Unfortunately, MIR does not collect data separately for spring and summer sessions.

[12] MIR's data coverage increased between 1997 and 2003. We used these coverage rates to recover the number of total textbooks sold for each title in each semester.

results should be viewed with care because the data also do not contain other transactions, such as transactions among students.

For the 14 semesters between 1997 and 2003, we have a total of 4,708 observations for the sales data. An observation is a title-edition-semester. Publishers commonly revise textbook editions over time with almost identical names. A "title" refers to the name of a textbook. There are 483 unique textbook titles in the data set, and each title has an average of 1.6 editions; we observe a total of 440 edition revisions. We limit our attention to the textbooks that cost more than $40 in 2003 dollars, averaged across the semesters in the data. We exclude textbooks that did not revise editions during our data period and textbooks with no edition information assigned by MIR, Amazon, or Barnes & Noble. Therefore, we do not to include popular press books that are sometimes assigned to economics classes, for which publishers are likely to have different pricing problems. Study guides, custom textbooks, government publications, and Canadian editions are excluded from the analysis.

As a measure of textbook price, we focus our analysis on the price of the textbook as a stand-alone textbook. That is, we do not use the "package" price of a textbook in our estimation, which contains supplementary materials, such as study guides, software, and CD-ROMs. Various types of these supplementary materials exist especially for popular textbooks, and controlling for these product attributes is difficult. Thus, comparing the prices of stand-alone textbooks is more reliable for examining the textbook pricing cycles.[13] In our preliminary analysis, however, we also estimated the model with average textbook prices of packages and stand-alone textbooks. The qualitative results changed little for this sample.

[13] In rare cases, different versions of stand-alone textbooks are available in a given semester. We compute a weighted average of prices for these cases.

To examine how prices change over the life of an edition, we need to know when an edition was launched. If we observe multiple editions of the same title, we identify the entry of a new edition when we observe a new edition of a textbook in the MIR data.[14] For those textbook-editions that appear in the MIR data for the first time, the month of the new edition entry is identified using the MIR data, Amazon.com, and Barnesandnoble.com. Sometimes, an old edition of a title is sold even after a new edition of the same title is introduced. These "overlapping" observations were dropped from the data set.

Table I presents summary statistics. An average price for a new textbook in our sample is $91.5 in 2003 dollars, and the average quantity share of used textbooks (UsedRatio) is 40%. There is substantial variation in both textbook prices and used market shares, as shown in the table (see Figure 1 for the distribution of textbook prices in the data.) The average age of the textbooks is 6.9 semesters. In Figure 2, we look at the textbooks that experienced a revision between 1997 and 2003 and show the distribution of the age of the textbook in semester when a new edition is introduced. Although textbooks are thought to follow a pre-determined "3-year revision cycle," the data show that there is substantial variation in the timing of textbook revision; while 35% of the textbooks in this sample revise editions within 6 semesters (or 3 years), as indicated by the highest bar in the graph, 33% of the textbooks introduce new editions in 7 semesters or longer. Additionally, 32% of the textbooks revise editions in 5 or fewer semesters.[15]

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[14] Sometimes, even after a new edition is introduced in the data, an old edition dominates the market. This may happen, for example, if the new edition was published very close to the beginning of a semester; most schools had alreday adopted the old edition of the textbook. In such cases, the introduction of a new edition is effectively delayed. Thus, when the quantity of a new edition is less than 10% of the total quantity sold in the semester, we treat the new edition as being introduced in the next semester. Qualitative results do not change as a result of this treatment.

[15] Note that only the textbooks with revised editions between 1997-2003 are included in this figure. Thus, textbooks that revise editions infrequently are under-represented in the data.

II-B. Empirical Model

We now turn to the estimation of the firm's price setting behavior derived from the theoretical model. The theoretical model in the previous section suggests estimating a relationship of the following form:

$$\mathbf{p}_\tau^{\mathbf{N}} = \mathbf{f}(\mathbf{X}_\tau, \mathbf{T} - \tau) \qquad \textbf{(5)}$$

where $\mathbf{p}_\tau^{\mathbf{N}}$ is the price of a new textbook in the τth period of the current edition, $\mathbf{X}_\tau$ is the stock of used goods for the edition at age τ, and T is the expected life of the current edition. If the textbook market consists of homogeneous buyers who plan to sell the books, such as the type-S buyers of the theoretical model, then the primary determinant of the price of the book should be the remaining life of the edition, i.e., T- τ. As in Proposition 1c, the price of the book will fall as the remaining life of the edition becomes shorter because the expected value of the good in resale will be lower. However, the price discrimination model with heterogenous buyers in Proposition 1b suggests a positive relationship between the stock of used goods and the price of new goods; the policy of raising the price of new goods to sell only to the high valuation buyers of new goods becomes more attractive as the number of low valuation buyers purchasing in the used market rises. In addition, raising the price will be more attractive with the shorter remaining life of the edition.

To examine the textbook publisher's price setting behavior, we estimate the following price equation:

$$\ln p_{it} = \mathbf{A}_\tau + \mathbf{B}_i + \alpha UsedRatio_{it} + \sum_{N=1}^{4} \beta_N RmnLifeN_{it} + \gamma \ln Q_{it} + \varepsilon_{it} \qquad (6)$$

where the dependent variable is the natural logarithm of the new price of a textbook title-edition *i* during semester *t*. $\mathbf{A}_t$ and $\mathbf{B}_i$ are semester and textbook title-edition dummy variables, respectively. As noted, one of the key factors that would affect the pricing policy is the stock of used goods. To adjust

the stock for the size of the market, we define $UsedRatio_{it}$ to be the quantity share of used textbooks for title-edition *i* during semester *t*.[16] Another key factor that would affect the price of a new textbook is its remaining life. We capture this effect by including a series of four dummy variables that indicate the remaining life of the edition: $RmnLife1_{it}$, $RmnLife2_{it}$, $RmnLife3_{it}$, and $RmnLife4_{it}$. For example, $RmnLife1_{it}$ equals 1 if a new edition of the same title will be introduced at t+1 and 0 otherwise. Note that the impact of these dummy variables are identified compared to the textbooks whose remaining life are five or more semesters. Homogeneous consumer models, in which consumers capitalize the used market value of the goods market into their demand for a new good, would predict a negative coefficient for these dummies. In contrast, the model with price discrimination and heterogeneous buyers raises the possibility of a rising price of a textbook - particularly in the last periods of the edition. Because we already have textbook title-edition and semester dummies, note that these "remaining life" dummies are identified with the assumption that the coefficients are constant for periods of remaining-life greater than four. We explore the validity of this assumption later. To construct the remaining-life dummies, we obtained additional sales data for 2004 and 2005 for the textbook titles that existed at the end of 2003.

In addition to the explanatory variables suggested by (6), we also include Q_{it} in the regression, which is the quantity of new textbook sales for title-edition *i* in semester *t* and is a natural regressor in a supply relationship. All prices are deflated by the Consumer Price Index (CPI) for "educational books and supplies," which includes college textbooks, and in 2003 dollars. Standard errors are corrected for clustering at the title level. That is, we allow the error terms for different editions of the

[16] All textbooks, including textbooks sold as packages, are included when computing this variable.Textbooks originally sold as packages are commonly sold separately in the used textbook market as stand-alone textbooks. In fact, while we observe many "new" packages in the data, there are few "used" packages. Combining all observations of the same title-edition allows us to compare the quantity of used and new units sold over a given time period.

same title to be arbitrary correlated across semesters. In addition to the log-log specification, we also estimate a model with the linear-linear specification with respect to price and quantity.

In addition to the fixed effects model discussed above, we also estimate a model that takes into account the potential endogeneity of $Q_{it,}$ and $UsedRatio_{it}$ in Equation (6). $Q_{it,}$ is endogenous because new book price and quantity are jointly determined. $UsedRatio_{it}$ is also endogenous, because it is a function of new and used textbook quantities for title-edition *i* at *t*, both of which are influenced by the new textbook price. We address the endogeneity problem by constructing instrumental variables that utilize the school-level, textbook adoption data. As we are interested in the supply relationship, a natural place to look for instruments is the demand side. In particular, the number of students enrolled in the courses that use title-edition *i* at semester *t*, i.e., $Enrollment_{it}$, is a good candidate because it shifts the demand for textbook *i* but does not affect the marginal cost of producing a new textbook. MRI reports the estimated enrollments for the school-sections that adopted a textbook, and we construct $Enrollment_{it}$ by aggregating school sections up to the title-edition level.[17]

The second instrument, $PrevUsed_{it}$, also exploits the school level data and computes the *proportion* of the schools that used title-edition *i* in both *t* and *t*-1 from the schools that used *i* at *t*. For example, suppose that four schools used title-edition *i* at *t*. If three of these schools used the same title-edition *i* at *t*-1, $PrevUsed_{it}$ becomes 0.75. Typically, college bookshops "buy back" used textbooks from students at the end of a semester if the same textbook will be used in following semester. We naturally

[17] About 6.8 % of the enrollment data (out of more than 250,000 observations) are missing, and they are sometimes unreasonably high; in one case, the data indicated that more than 500,000 students are enrolled in a school-section in a semester. When estimated enrollments are missing or "unreasonably high," we replace them with the average enrollment number for the textbook title in the same semester. We define the estimated enrollments as are "unreasonable" when the enrollments are greater than or equal to 5,000 for a school-section per semester. There were 21 such observations. In a preliminary analysis, we estimated the same model without making any adjustments to the enrollment number and obtained similar results.

expect that the supply of used textbooks will be higher at *t* if more schools "buy back" the textbook at the end of *t*-1. This suggests that PrevUsed, is positively correlated with UsedRatio. Conversely, after UsedRatio and other regressors are controlled for, there is no strong reason to believe that PrevUsed directly affects new textbook prices.[18] This makes PrevUsed another candidate for the instrumental variable.

As shown in Figure 3, PrevUsed substantially varies across title editions and semesters. Additionally, as shown in Table I, the average number for PrevUsed is 0.34, which indicates that the same title edition is used at the same school in the previous year 34% of the time. However, if we focus on "principles" textbooks, this number goes up to 0.46.[19] Such variation helps us identify UsedRatio in regression models.

II-C. Empirical Results

II-C1 New textbook prices

Figures 4a-c show the relationship between new textbook prices and UsedRatio for the six most popular textbooks. Utilizing MIR's textbook categories, we divide the sample into three categories: "principles," "intermediate," and "applied." We pick the two most frequently used textbooks within each respective category.[20] In each graph, new textbook prices are indicated by bar charts, while

[18] One concern is that PrevUsed may be correlated with the popularity of the textbook and thus may affect textbook pricing. However, we include more direct measures of the popularity of the textbook in the regression, such as with textbook title-edition dummies and the quantity of new textbooks , Q, sold at *t*. Thus, after these factors are controlled for, it is less likely that PrevUsed directly affects new textbook prices.

[19] The principles category includes textbooks used in introductory classes, with the subcategories "introductory", "principles", "micro principles," and "macro principles" as defined by MIR.

[20] The "principles" category is defined in the same way as in footnote 28. The "intermediate" category includes "micro-intermediate" and "macro-intermediate" subcategories. The remaining textbooks are categorized as "applied." These three categories consist of 36%, 7%, and 57% of the entire sample, respectively.

UsedRatios are represented by dot charts. An arrow in the figure indicates the semester in which a new edition of the textbook was introduced.

These figures consistently show a strong positive relationship between new textbook prices and UsedRatios. In addition, it appears that the new textbook prices often jump up immediately before the introduction of a new edition. For example, on the left-hand side of the "principles" textbooks (Figure 4a), there is a price hike in semesters 3 and 9, both of which precede the introduction of a new edition. On the right-hand side of the same graph, similar price hikes occur in semesters 3 and 9, although the latter is smaller than the other cases. Similar price hikes are also observed in other textbooks. These pricing patterns are consistent with the price discrimination theory developed in the theory section. Please note that new textbook prices are already deflated by CPI for "educational books and supplies," and thus, the general price trend in this industry alone may not explain the correlation. Nonetheless, the correlation may be spurious; we examine the relationship more carefully in the regression models below.

Table II presents the estimation results for the fixed-effects model without instrumental variables. In all cases, we estimate models using both the log-log and linear-linear specifications in terms of price and quantity. Standard errors are corrected for clustering at the book title level.

In the first two columns, we report the results when we include only remaining-life dummy variables aside from textbook title-edition fixed effects and semester dummy variables. We find that all of the coefficients for the remaining-life dummies are positive and significant and the coefficients become larger as the end of the life of an edition approaches. This indicates that textbook prices go up as the remaining life becomes shorter, which is consistent with our price discrimination model with heterogenous buyers but not with Swan-type consumers. Estimated coefficients indicate, for example,

that in the last period of an edition, textbook prices increase by about 5 %, or $4.7 relative to the base period.

The next two columns check whether the results change if fewer remaining-life dummies are included in the regression. The results do not change substantially; we continue to see an increase in textbook prices toward the end of an edition, and these effects are statistically significant. Columns 5 and 6 add UsedRatio and Q to the models shown in Columns 1 and 2. In these regressions, the remaining-life dummies continue to show the same pattern as in the previous results. The coefficient for UsedRatio is positive and significant, which indicates that UsedRatio and textbook price are positively correlated; the estimated coefficients imply that textbook prices increase by an average of 3.1%, or $2.2, as the share of used books within a title-edition increases from 0 to 1. The coefficient for Q is small and statistically insignificant in both regressions, which suggests that the quantity of new textbooks has relatively little impact on its price.

In Table III, we present the results that take into account the endogeneity of UsedRatio and Q. In the first two columns, we estimate the same model as in Table II, Columns 5 and 6, except that UsedRatio and Q are treated as endogenous. These two columns represent our preferred specifications. First, as before, the coefficients for the remaining-life dummies are all positive and become larger as the end of an edition approaches. Again, this pricing pattern is consistent with the price discrimination model but not with the traditional Swan-type model. However, these coefficients are statistically significant (or weakly significant) only immediately before the introduction of a new edition, which suggests that the price rise is largely a "last period effect" (see section I-B for the distinction). The results also indicate that UsedRatio continues to affect textbook prices positively and significantly, and the estimated coefficients imply that new textbook prices increase by an average of 8.0%, or $8.9, as

the share of used books within a title-edition increases from 0 to 1. The coefficient for the quantity of new textbooks, Q, continues to be very small in magnitude and statistically insignificant. Cragg-Donald Wald F-statistics for the two excluded instruments are 109.9 and 18.6 for the two regressions, suggesting that the instruments have good explanatory power.

As we discussed in section I-B, the remaining-life dummies are identified based on the assumption that the coefficients for the remaining life of greater than four are constant. While we cannot directly test this assumption, the results reported in Columns 7 and 8 indicate that, with the exception of periods immediately before the introduction of a new edition, the remaining-life dummies are not significantly different from those of the base period, which supports the assumption. Columns 9 and 10 further check the robustness of the results by reducing the number of the remaining-life dummies included in the regression. As reported in Columns 9 and 10, the results change little with the elimination of a remaining-life dummy variable.

II-C2 Additional Analysis

Semester-age dummy variables

The results thus far have been based on the assumption that consumers know exactly when a new edition is coming out. Under this assumption, it was appropriate to include the remaining-life dummies in the regression and examine the price path immediately before the introduction of a new edition. This assumption is supported by Chevalier and Goolsbee (2009), who examined the same textbook data and found that students are forward-looking and behave as if they have rational expectations of publishers' revision decisions. However, to check the robustness of the results, we estimate an alternative model in this section in which consumers are assumed to respond to the "age" of the textbook when they

make purchase decisions.

To capture this idea, we include the semester-age dummies (instead of the remaining-life dummies) in the regression. Specifically, we include a series of dummy variables that correspond to the semester(s) between 4 and 6, 7 and 9, 10 and 12, and 13 and above since the introduction of the current edition.[21] All of the remaining variables and the estimation approach are the same as our preferred specification presented in Table III, Columns 7 and 8.

We report the results in Table IV, Columns 11 and 12. The results change little with the use of the semester-age dummy variables; we continue to see that UsedRatio positively affects new textbook prices, and the estimated coefficients are comparable to the previous results. The coefficients for the semester-age dummies are all positive and become larger as the textbook gets older. Consistent with the price discrimination theory, this indicates that textbook prices go up as the textbook becomes older and the revision of the textbook nears. However, except for a few cases corresponding to the semesters between 4 and 6 and between 7 and 9, the coefficients for the age dummies are not statistically significant. This may be because we observe relatively few textbook revisions beyond the ninth semester, as can be seen in Figure 2. The coefficient for Q is still positive and insignificant in these regressions. We have also experimented with various constructions of the semester-age dummies, finding that the results are not sensitive to how semesters are grouped. As an example, Columns 13 and 14 present the results when the first four semesters since the introduction of an edition are considered as the base period. The results are qualitatively the same as before.

[21] Again, because we already have textbook title-edition dummies and semester dummies, we cannot include semester age in the linear form.

Quantity of new and used textbooks

Thus far, our empirical analysis has focused on whether textbook prices change over the life of an edition as our price discrimination model predicts. Additionally, our price discrimination model predicts that the quantity of new (used) textbooks decreases (increases) over the life of an edition. In Appendix II, we check these predictions by estimating simple fixed effects models of textbook quantity on time trends. We find that the quantity of new (and used) textbooks changes as the model predicts, which provides additional support for the price discrimination model.

III. Conclusion

This paper attempted to provide a new perspective on durable goods pricing. Since Swan (1970), durable goods literature has primarily analyzed one type of buyer who purchases goods for current use and then resells them in the used market. In this setup, if durable goods producers periodically introduce new models, the prices of new goods will decline over time as the end of the economic life of the product approaches. While the declining price over its life is commonly observed in various durable goods theories, it is not clear whether the price cycle is sustained when there is heterogeneity in buyers preferences.

In this paper, we developed a model of monopoly pricing of a durable good when there are heterogeneous buyers. If some buyers continue to place value on the old durable good after a new model is introduced, we showed that durable goods prices could increase over the life of the product. Using a panel data set that contains economics textbooks, we tested the prediction of the model. We found that new textbook prices increase overtime as the share of used books increases. In contrast, we found no evidence that textbook prices decline as the end of the current edition approaches.

A general lesson of the paper is that price discrimination can lead to a rising price of a durable good over its life cycle. While our analysis is specific to the textbook market, we expect that a similar pricing pattern can emerge when a used market is active and grows over time. In such markets, "writing off" the low valuation buyers can become optimal as used products accumulate. An analysis of such markets will become more complex because an optimal pricing policy should not only reflect buyer heterogeneity, but also the possibility of intertemporal substitution, from which we could abstract away because of the nature of the textbook market.

References

Adda, Jerome and Russell Cooper (2000), "Balladurette and Juppette: A Discrete Analysis of Scrapping Subsidies", Journal of Political Economy, 108(4), 778-806

Bond, Eric W. and Larry Samuelson (1984), "Durable Goods Monopolists with Rational Expectations and Replacement Sales," Rand Journal of Economics, 15, 336-45.

Bulow, Jeremy (1982), "Durable Goods Monopolists," Journal of Political Economy, 90, 314-332.

Chen, Jiawei, Susanna Esteban, and Matthew Shum (2011) "How Much Competition is a Secondary Market?" working paper

Chevalier, Judith and Austan Goolsbee (2009), "Are Durable Goods Consumers Forward Looking? Evidence from College Textbooks," Quarterly Journal of Economics, 124(4), 1853-1884

Conlisk, John, Eitan Gerstner and Joel Sobel (1984), "Cyclic Pricing by a Durable Goods Monopolist," Quarterly Journal of Economics, 99. 489-505.

Esteban, S. and M. Shum (2007), "Durable-goods oligopoly with secondary markets: The case of automobiles," RAND Journal of Economics, 38, 332-354.

Frank, Richard G., David S. Salkever (1992) "Pricing, Patent Loss and the Market for Pharmaceuticals", Southern Economic Journal, 59, 165-179.

Frank, Richard G., David S. Salkever (1997), "Generic Entry and the Pricing for Pharmaceuticals," Journal of Economics and Management Strategy, 6(1), 75-90.

Gordon, Brett R. (2009) "A Dynamic Model of Consumer Replacement Cycles in the PC Processor Industry", Marketing Science, 28(5), 846-867.

Iizuka, Toshiaki (2007), "An Empirical Analysis of Planned Obsolescence," Journal of Economics and Management Strategy, 16(1), 191-226.

Stokey, Nancy (1979), "Intertemporal Price Discrimination," Quarterly Journal of Economics,

Schiraldi, Pasquale (2011) "Automobile Replacement: a Dynamic Structural Approach," Rand Journal of Economics, forthcoming.

Swan, Peter (1970), "Durability of Consumption Goods," American Economic Review, 60, 884-94.

United States Government Accountability Office (2005), *College Textbooks: Enhanced Offerings Appear to Drive Recent Price Increases*, GAO-05-806.

Waldman, Michael (1996), "Durable Goods Pricing when Quality Matters," Journal of Business, 69, 489- 510.

Wooldridge, J. M. (2002), *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

Yin, S., S. Ray, H. Gurnani, and A. Animesh (2010) "Durable Products with Multiple Used Goods Markets: Product Upgrade and Retail Pricing Implications," Marketing Science 29(3): 540-560

Appendix I

Proof of Proposition 1: First suppose that $\tilde{\mathbf{x}} \leq 0$, which from (1) requires $\lambda_K \geq (V_S^N - c)/(V_{K1}^N - V_S^N)$. With $\tilde{\mathbf{x}} \leq 0$ the monopolist sells only to type K in period 2 regardless of the first period sales policy, the desirability of selling to type S in the first period depends only on first period profits. Selling to type K only in the first period gives $(V_K^N - c)\lambda_K$ and selling to both types in the first period gives $(V_S^N + \alpha\beta V_S^U - c)(1+\lambda_K)$. It follows that selling to type K only is preferred if $\lambda_K > (V_S^N + \alpha\beta V_S^U - c)/(V_K^N - V_S^N - \alpha\beta V_S^U)$, which establishes part (a) of the proposition. Selling to both types will be optimal for $\lambda_K \in [\ (V_S^N - c)/(V_{K1}^N - V_S^N),\ (V_S^N + \alpha\beta V_S^U - c)/(V_K^N - V_S^N - \alpha\beta V_S^U))$. Now suppose that $\tilde{\mathbf{x}} \in (0, \alpha)$, which requires that $\lambda_K \in [\ (V_S^N - c)(1 - \alpha)/(V_{K1}^N - V_S^N), (V_S^N - c)/(V_{K1}^N - V_S^N))$. If the firm sells to type S buyers in period 1, the supply of used goods in period 2 is αN_2. This exceeds the critical value for period 2, so that the firm sells only to type K buyers in period 2 and earns a discounted profit of $(V_S^N + \alpha\beta V_S^U - c)(1+\lambda_K) + \beta(V_K^N - c)\lambda_K$. If the firm sells only to type K buyers in period 1, the second period stock will be 0 and the firm will sell to both types in period 2. This yields a discounted profit of $(V_K^N - c)\lambda_K + \beta(V_S^N - c)(1+\lambda_K)$. Comparing these expressions, the monopolist will find it profitable to sell only to type K buyers in the first period if $[(V_K^N - V_S^N)(1 - \beta) - \alpha\beta V_S^U]\lambda_K > ((V_S^N - c)(1 - \beta) + \alpha\beta V_S^U)$. However, this inequality cannot be satisfied for any feasible values of λ_K. If $(V_K^N - V_S^N)(1 - \beta) - \alpha\beta V_S^U < 0$, this inequality cannot be satisfied for $N_1, N_2 \geq 0$. If $(V_K^N - V_S^N)(1 - \beta) - \alpha\beta V_S^U > 0$, the inequality requires $\lambda_K > (V_S^N - c)/(V_K^N - V_S^N)$ which lies outside the required range. Therefore, the seller will sell to both types in period 1 and only to type K in period 2 for λ_K in this range. Combining this result with that of the previous paragraph yields part b.

Finally, consider the case where $\tilde{\mathbf{x}} > \alpha$, which requires that $\lambda_K < (V_S^N - c)(1 - \alpha)/(V_{K1}^N - V_S^N)$. If the firm sells to type S in the first period it will also sell to both types in the second period, yielding a return of $(V_S^N + \alpha\beta V_S^U - c)(1+\lambda_K) + \beta(V_S^N - c)(1 + \lambda_K - \alpha)$. If the firm sells only to type K in the first period, it $(V_K^N - c)\lambda_K + \beta(V_S^N - c)(1+\lambda_K)$. Selling to both types in period 1 is preferred if $(V_K^N - V_S^N - \alpha\beta V_S^U)\lambda_K > ((v_2 - c)(1 - \beta) + \alpha\beta\theta_2)N_2$. This condition will always be satisfied when Assumption 1 holds, which yields part d of the Lemma.‖

Proof of Proposition 2: Under Assumption (A.1'), Lemma 1 no longer applies because $R_{2K}^U > R_{2S}^U$ for $p_2^N > V_K^N - V_K^U + V_S^U$. Therefore, the demand curve for new goods has three regions in period 2. For $p_2^N \in (V_K^N - V_K^U + V_S^U, V_K^N)$, type S are priced out of the used market and the sales of new goods will be $(\lambda_K - x_2)$. The maximum profit in this region is $(V_K^N - c)(\lambda_K - x_2)$. For $p_2^N \in (V_S^N, V_K^N - V_K^U + V_S^U]$, type K buy new goods and S buy used goods, yielding new sales of λ_K. The maximum profit in this region is $(V_K^N - V_K^U + V_S^U - c)\lambda_K$. For $p_2^N \leq V_S^N$, both types buy new goods and the monopolist sells $(\lambda_K + 1 - x_2)$ units. The maximum

profit from this strategy is $(V_S^N - c)(1 + \lambda_K - x_2)$. Comparing the profits from the first option (K indifferent between new and used) with the third (S indifferent between new and used), it follows that the latter option will be preferred for all $x_2 \in [0,1]$ if $\lambda_K < (V_S^N - c)/(V_K^N - V_S^N)$. This restriction requires that the type S be sufficiently abundant in the market that it never pays for the monopolist to set the price of new goods so high that type S are driven out of both the new and used markets. Comparing the profits form the second option (selling only to K in the second period) with that of the third option, we again obtain a threshold result that the monopolist sells only to type K in the second period if $x_2 > \hat{x}_2' = 1 - (V_K^N - V_K^U + V_S^U - V_S^N)/(V_S^U - c)$. This result is similar to that in Lemma 2, in that the firm will switch from selling to both types to selling only to the high valuation buyers in period 2 if the stock of used goods is sufficiently high. One difference in this case is that the monopolist must leave some surplus to the high valuation buyers of new goods when $x_2 > \hat{x}_2'$ because they are also the high valuation buyers of new goods.

The optimal second period profits can then be expressed as $\pi_2^*(x_2) = (V_K^N - V_K^U + V_S^U - c)\lambda$ for $x_2 < \hat{x}$ and $\pi_2^*(x_2) = (V_S^N - c)(1 + \lambda_K - x_2)$ for $x_2 > \hat{x}_2'$. We can then define the profit differential between selling only to type K in period 1 and selling to both types in period 1(assuming $V_K^N > V_S^N + \alpha\beta V_S^U$) to be

$$\Gamma(\alpha) = (V_K^N - c)\lambda_K + \beta\pi_2^*(0) - (V_S^N + \alpha\beta V_S^U - c)(1+\lambda_K) - \beta\pi_2^*(\alpha)$$

Using the definition of π_2^*, it can be shown that this expression is strictly decreasing in α. Evaluating at $\alpha = 0$, we have $\Gamma(0) = (V_K^N - V_S^N - \alpha\beta V_S^U)\lambda_K - (V_S^N + \alpha\beta V_S^U - c) < -\alpha\beta V_S^U(1 + \lambda_K) < 0$ for $\lambda_K < (V_S^N - c)/(V_K^N - V_S^N)$. This establishes that the optimal policy will be to sell to both types in period 1 for all α, establishing Proposition 2.

Appendix II

To examine how textbook quantities change over the life of an edition, we estimate simple regression models with textbook title-edition fixed effects. The number of semesters since the introduction of an edition and its squared and cubic terms are also included as regressors. Table A-1 reports the results. The first two columns indicate that new textbook quantity decreases by an average of 12.7%, or 53 units, in each semester after the introduction of a new edition. The next two columns add the squared and cubic terms of the time trend variable and indicate that new textbook quantity sharply declines, especially in the initial periods after the introduction of a new edition.

Columns 5 through 8 of the same table show used textbook quantity. Columns 5 and 6 show that used textbook quantity increases by an average of 7.3%, or 57 units, per semester after the

introduction of a new edition. Models 7 and 8 include the squared and cubic terms of the age variable and indicate that the relationship is non-linear; used textbook quantity quickly increases in the initial periods after the introduction of a new edition and levels off after several semesters. These results are consistent with the prediction of the price discrimination model, although alternative theoretical models may also lead to similar time trends.

Figure 1: Distribution of New Textbook Prices (n=4708)

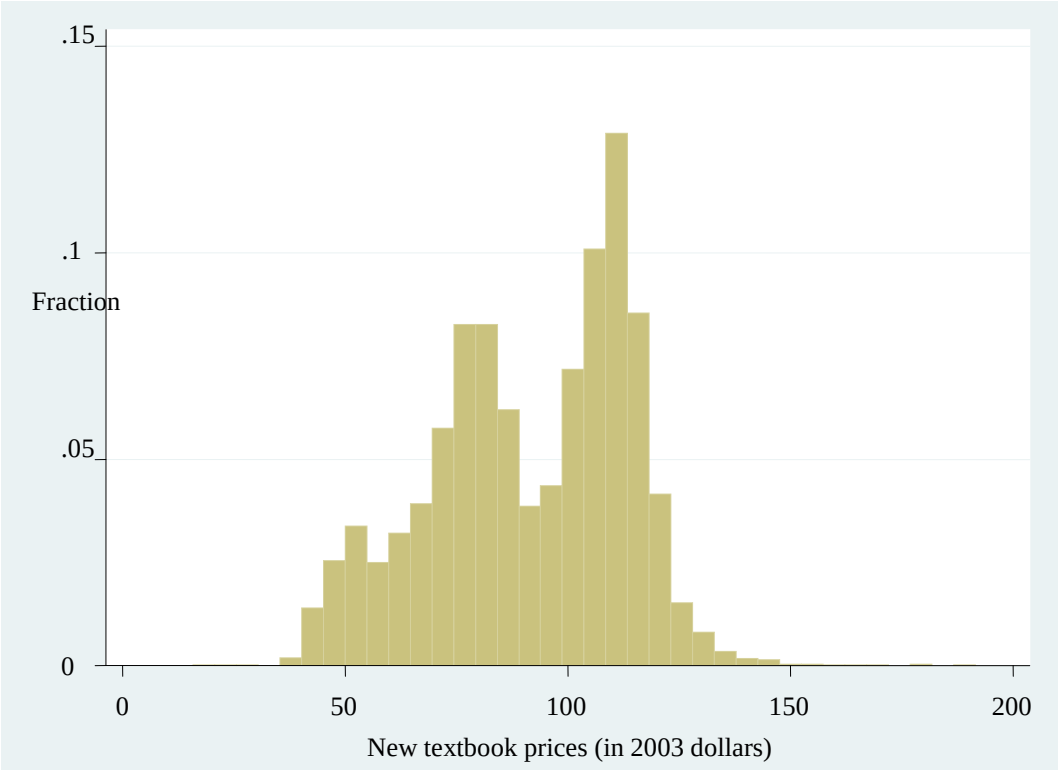

Figure 2: Distribution of the age of textbooks when revised (n=382)

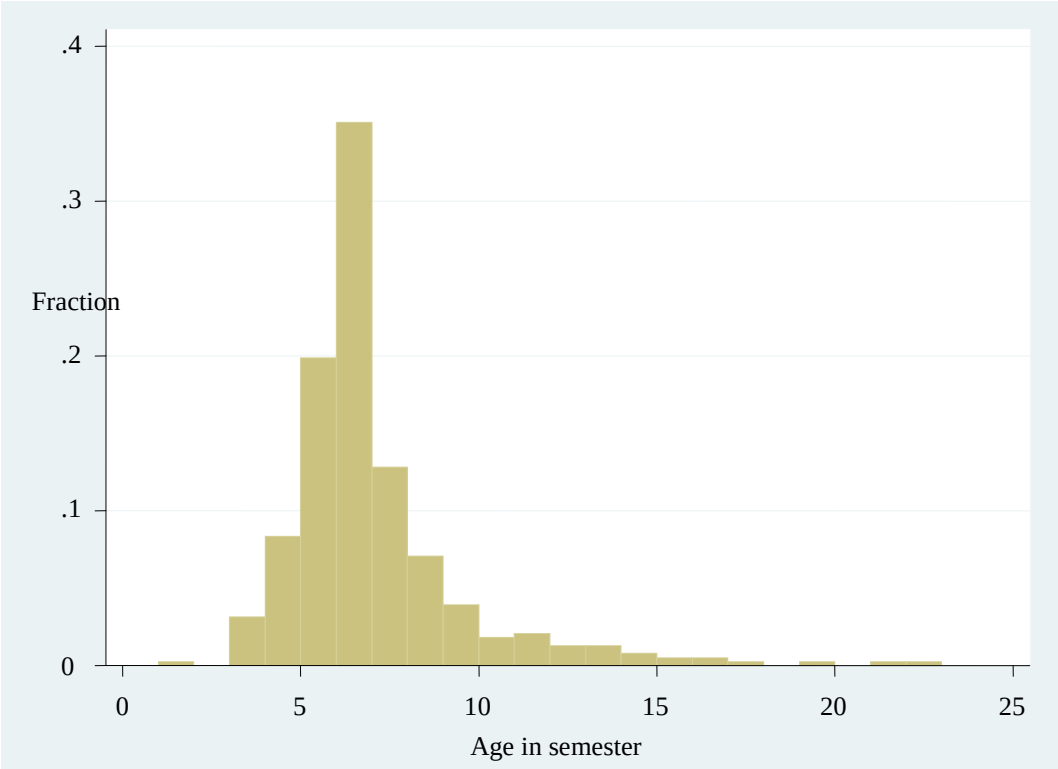

Figure 3 : Distribution of PrevUsed (n=4312)

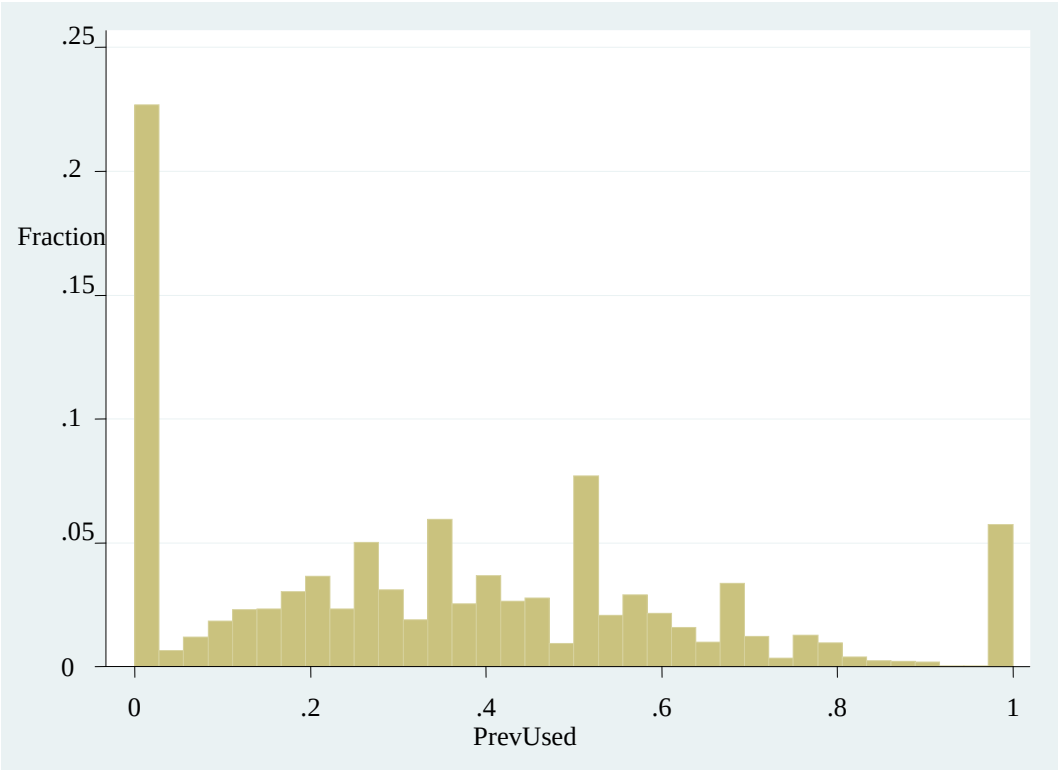

Figure 4a: The relationship between new textbook prices and UsedRatios: "Principles" textbooks

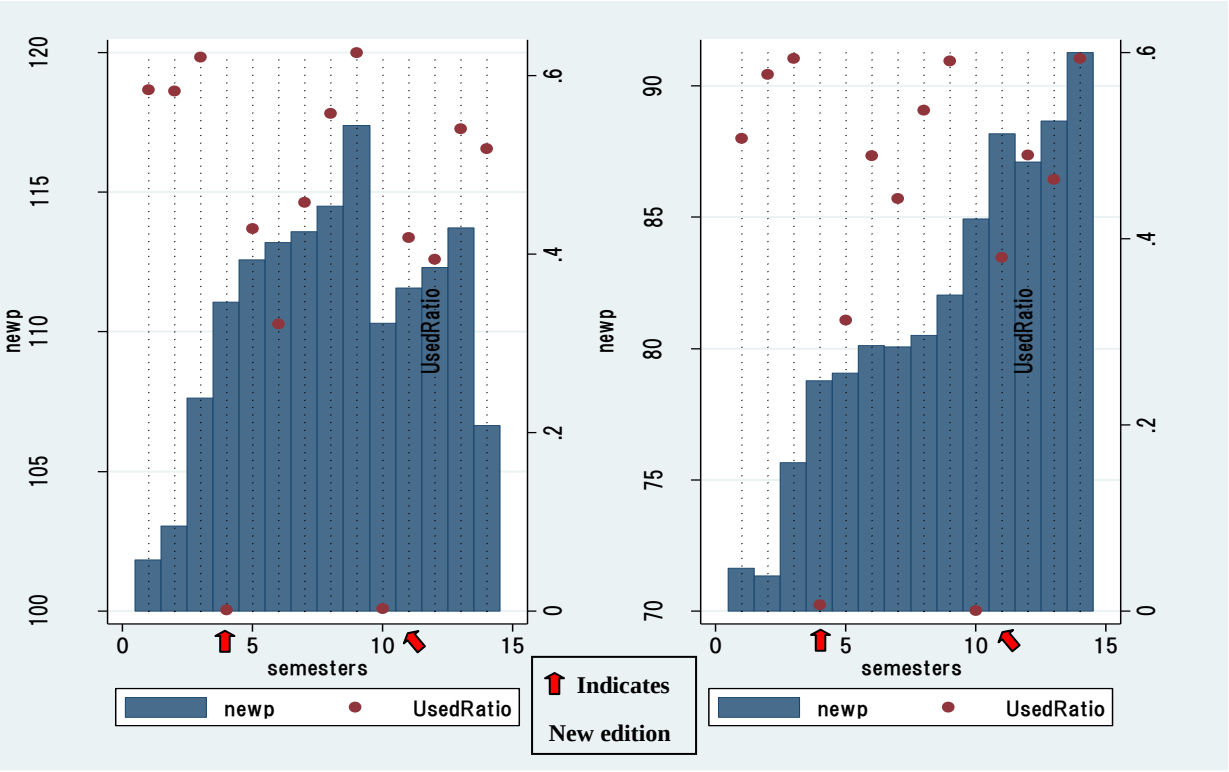

Figure 4b: "Intermediate" textbooks

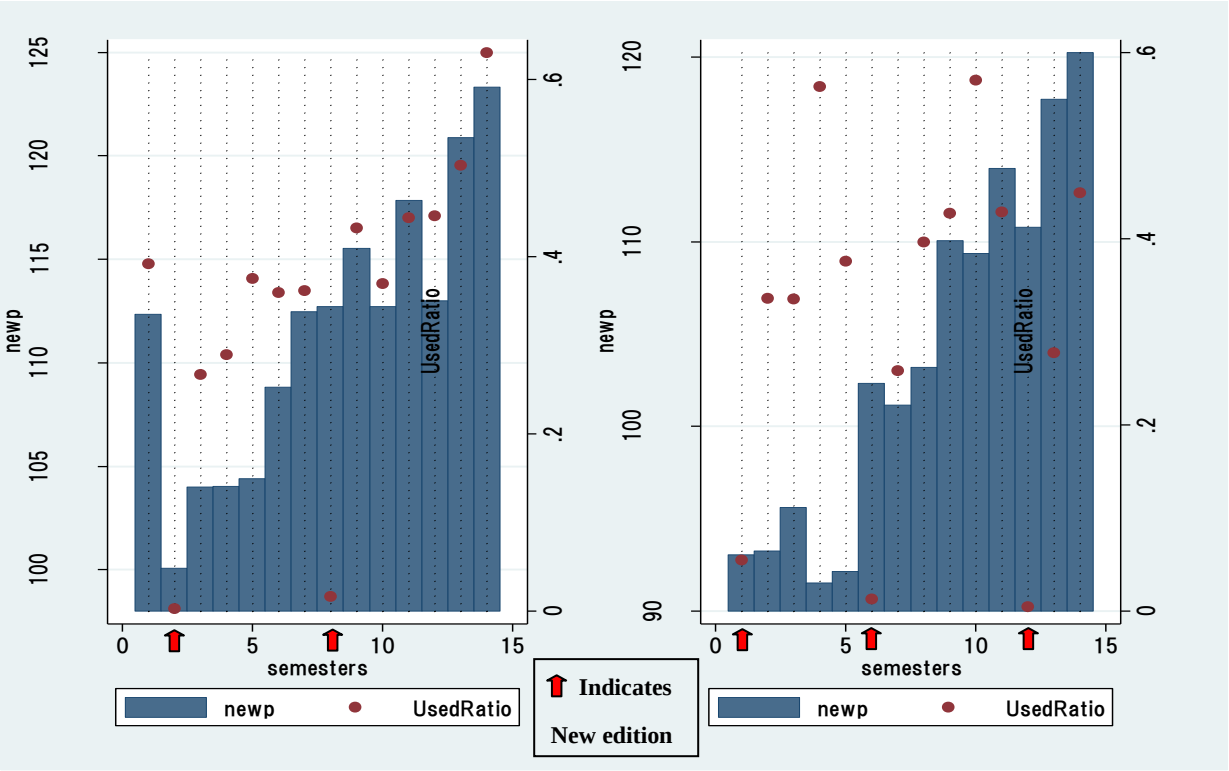

Figure 4c: "Applied" textbooks

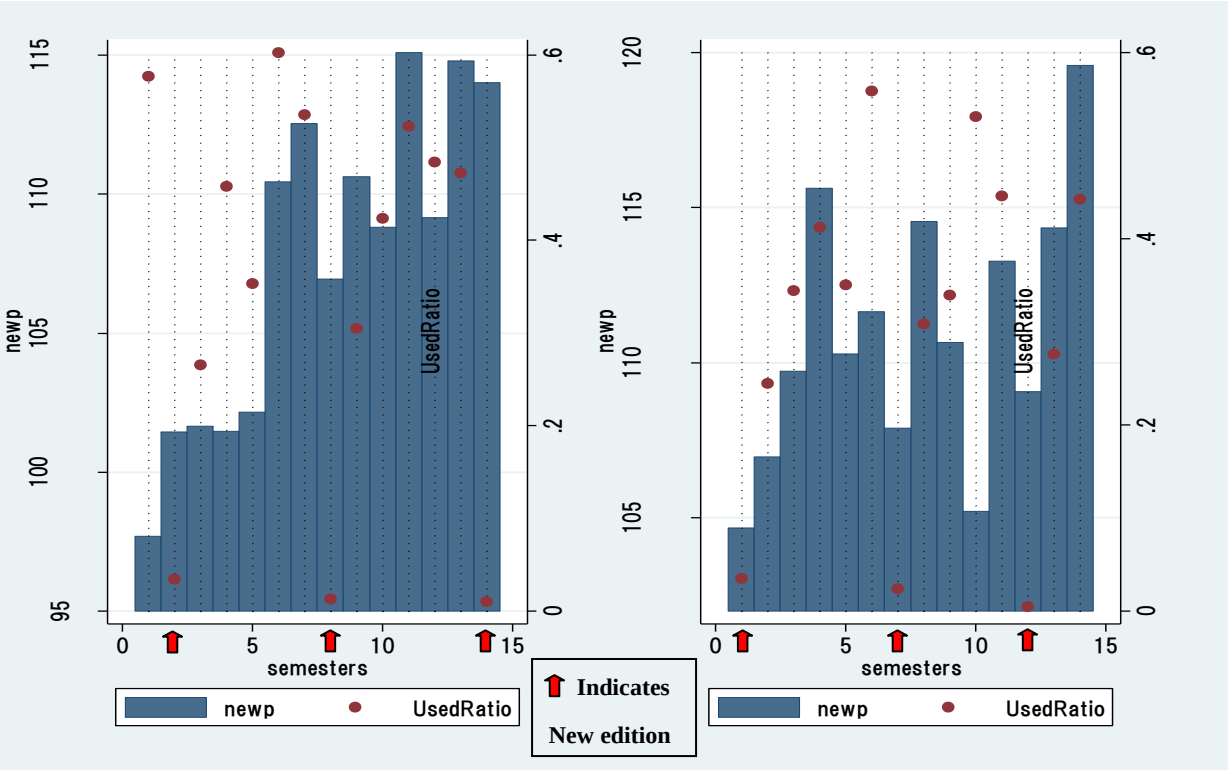

Table I: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
year	4708	2000	1.99	1997	2003
edition	4708	3.93	2.97	1	17
newp	4708	91.5	22.2	15.8	191.5
usedp	4162	68.9	15.5	29.8	125.6
newp_PK	4708	91.8	22.1	15.8	191.5
usedp_PK	4200	69.0	15.4	30.2	125.6
est_new_units (Q)	4708	1103	2322	1.98	34458
est_used_units	4708	760	1832	0	27834
UsedRatio	4708	0.401	0.283	0	0.995
PrevUsed	4312	0.342	0.283	0	1
RmnLife1	4708	0.081	0.273	0	1
RmnLife2	4708	0.085	0.278	0	1
RmnLife3	4708	0.086	0.280	0	1
RmnLife4	4708	0.084	0.277	0	1
principles	4708	0.360	0.480	0	1
intermediate	4708	0.073	0.260	0	1
applied	4708	0.568	0.495	0	1
enrollment	4613	3045	7148	0	124037
age (in semester)	4708	6.93	6.39	1	59

Table II: Estimation results for new textbook prices without instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(newp)	newp	Ln(newp)	newp	Ln(newp)	newp
VARIABLES	no IV	no IV	no IV	no IV	no IV	no IV
UsedRatio					0.0306**	2.1899**
					(0.0131)	(0.9032)
ln(est_new_units)					0.0023	
					(0.0028)	
est_new_units						-0.0000
						(0.0001)
RmnLife1	0.0513***	4.7016***	0.0442***	4.0105***	0.0422***	4.0441***
	(0.0104)	(0.8555)	(0.0088)	(0.7327)	(0.0095)	(0.7803)
RmnLife2	0.0417***	3.8127***	0.0348***	3.1495***	0.0327***	3.1562***
	(0.0086)	(0.7227)	(0.0069)	(0.5922)	(0.0080)	(0.6675)
RmnLife3	0.0291***	2.6705***	0.0226***	2.0485***	0.0220***	2.1729***
	(0.0069)	(0.5722)	(0.0052)	(0.4406)	(0.0066)	(0.5312)
RmnLife4	0.0154**	1.4863***			0.0106*	1.1670**
	(0.0062)	(0.5426)			(0.0058)	(0.4967)
Title-edition FE	yes	yes	yes	yes	yes	yes
Sem. dummies	yes	yes	yes	yes	yes	yes
Obs.	4,609	4,609	4,609	4,609	4,609	4,609
R-squared	0.9005	0.9061	0.9003	0.9059	0.9008	0.9064
N of title-edition	775	775	775	775	775	775

Standard errors, corrected for clustering at the title level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table III: Estimation results for new textbook prices with instrumental variables

	(7)	(8)	(9)	(10)
	Ln(newp)	newp	Ln(newp)	newp
VARIABLES	IV	IV	IV	IV
UsedRatio	0.0798**	8.8867***	0.0820**	9.1040***
	(0.0370)	(3.1444)	(0.0327)	(2.7509)
ln(est_new_units)	0.0004		0.0004	
	(0.0047)		(0.0047)	
est_new_units		0.0019		0.0019
		(0.0013)		(0.0013)
RmnLife1	0.0286*	3.5758**	0.0266**	3.4185***
	(0.0152)	(1.3916)	(0.0111)	(1.1704)
RmnLife2	0.0176	2.3747*	0.0157	2.2180**
	(0.0142)	(1.2433)	(0.0099)	(0.9878)
RmnLife3	0.0110	1.2103	0.0093	1.0651*
	(0.0112)	(0.9187)	(0.0073)	(0.6205)
RmnLife4	0.0031	0.2624		
	(0.0083)	(0.7276)		
Title-edition FE	yes	yes	yes	yes
Sem. dummies	yes	yes	yes	yes
Obs.	4,214	4,222	4,214	4,222
R-squared	0.9072	0.9061	0.9071	0.9058
N of title-edition	734	734	734	734

Standard errors, corrected for clustering at the title level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table IV: Estimation results with textbook age dummies

	(11)	(12)	(13)	(14)
	Ln(newp)	newp	Ln(newp)	newp
VARIABLES	IV	IV	IV	IV
UsedRatio	0.0874**	10.7956***	0.0971***	12.2566***
	(0.0377)	(3.7139)	(0.0301)	(3.5462)
ln(est_new_units)	0.0009		0.0013	
	(0.0046)		(0.0047)	
est_new_units		0.0026		0.0030
		(0.0018)		(0.0020)
4 ≤age≤ 6	0.0130	1.7073**		
	(0.0099)	(0.8617)		
7 ≤age ≤ 9	0.0190	2.4778*		
	(0.0163)	(1.3675)		
10≤ age≤12	0.0226	3.0375		
	(0.0242)	(1.9855)		
age ≥13	0.0283	3.7704		
	(0.0337)	(2.7812)		
5 ≤age≤ 6			0.0112	1.8695**
			(0.0076)	(0.7772)
7 ≤age ≤ 8			0.0127	2.0175*
			(0.0130)	(1.1218)
9 ≤age ≤ 11			0.0192	2.6807
			(0.0194)	(1.6346)
age ≥12			0.0244	3.3434
			(0.0298)	(2.5213)
Title-edition FE	yes	yes	yes	yes
Sem. dummies	yes	yes	yes	yes
Obs.	4,214	4,222	4,214	4,222
R-squared	0.9067	0.9006	0.9063	0.8970
N of title-edition	734	734	734	734

Standard errors, corrected for clustering at the title level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table V: Estimation results for new and used textbook quantities

VARIABLES	(15) Ln(New units)	(16) New units	(17) Ln(New units)	(18) New units	(19) Ln(Used units)	(20) Used units	(21) Ln(Used units)	(22) Used units
age (in semester)	-0.1272***	-53.3451***	-0.1182***	-147.6189***	0.0726***	57.5528***	0.7932***	319.7042***
	(0.0083)	(5.1972)	(0.0210)	(17.8246)	(0.0153)	(10.6123)	(0.0457)	(49.3234)
age squared			-0.0018	6.5143***			-0.0560***	-19.7234***
			(0.0018)	(1.1925)			(0.0044)	(3.8523)
age cubic			0.0001	-0.0840***			0.0009***	0.3020***
			(0.0000)	(0.0221)			(0.0001)	(0.0810)
Constant	6.4765***	1,472.9943***	6.4710***	1,695.2936***	4.8750***	360.5404***	3.1285***	-235.1040
	(0.0578)	(36.0319)	(0.0686)	(59.1645)	(0.1068)	(73.5741)	(0.1226)	(145.5916)
Title-edition FE	yes	yes	yes	yes	yes	yes	yes	yes
Sem. dummies	no	no	no	no	no	no	no	no
Obs.	4,708	4,708	4,708	4,708	4,200	4,708	4,200	4,708
R-squared	0.8100	0.8797	0.8106	0.8816	0.6191	0.7688	0.7278	0.7894
N of title-edition	874	874	874	874	804	874	804	874

Standard errors, corrected for clustering at the title level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1