How do consumers make durable goods purchase decisions? Demand for college textbooks

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Very preliminary and incomplete!

Abstract:

This paper examines durable goods issues in the college textbook industry. College textbooks have frequently been cited as an example of a market in which firms attempt to "kill off" the secondary market for their products by introducing new editions. We examine new edition introduction behavior, showing that much of the college textbook industry is on a fairly reliable 3-year revision cycle. We show that, contrary to the predictions of asset pricing theory, prices of new and used textbooks do not fall over the life of the book as the implicit asset value of the textbook falls. We estimate demand for textbooks by college students. Our estimates suggest that college students partially, but not fully, take into account the asset value of the textbook when making purchase decisions. Furthermore, our estimates suggest that students are sufficiently forward-looking that speeding up the revision cycle would not increase publisher revenues.

There is an extensive theoretical literature in Industrial Organization, Law, and Macroeconomics considering both producer and consumer behavior in the presence of secondary markets for used goods. Secondary markets have become increasingly important, as the Internet has lowered the transaction costs of matching buyers and sellers for second-hand goods. Traditionally, in the literature, textbooks are frequently cited as the canonical example of a durable good product in which producers may try to "kill off" the used good market.[1] Despite this theoretical interest in textbooks as an example of a durable product with active used markets, empirical studies of textbooks are scant.[2]

The question of how students should make a decision regarding a college textbook purchase is quite simple, and is laid out in detail in Miller (1974), as well as in other papers. Miller recognizes that students should, in making a new or used textbook purchase decision, recognize the existence of the used textbook market. Thus, for example, if a student were not liquidity constrained and a textbook was known to be infinitely lived, then, in principle, the student would purchase a textbook as long as the student's willingness to pay was greater than the forgone interest on his investment in the book plus the book's expected depreciation during the student's holding period. Of course, in reality, textbooks are not infinitely-lived due to edition changes. As we show later, when a publisher releases a new edition of a textbook, the new edition typically "kills off" the older editions, as college bookstores generally refuse to carry stale editions of textbooks and faculty are essentially forced to assign the newer edition. In that case, (again described in Miller, 1974), if there is full information about the life of the textbook and if the perceived quality of the book does not degrade over the life of the book, then prices and student behavior should adjust such that each successive generation of students pays the same effective per-period price for the book. Thus, the price of both new and used books should steadily fall over the life of the textbook as the new edition introduction approaches.

The approach described in Miller (1974) and implicit in much of the other durable goods literature presupposes perfect foresight on the part of consumers. This contrasts with much popular writing about college textbooks, where it is presupposed that "killing off" an older textbook with a newer edition is a

[1] For durable goods papers citing textbooks, see, for example, Miller (1974), Rust (1986), Waldman (1993), Fudenberg and Tirole (1998), and Waldman (2003).
[2] We have just become aware of one paper, Iizuka(2004).

profitable strategy due to the imperfect foresight of students.[3] Clearly, some level of myopia on the part of students may have implications for strategic behavior by textbook publishers.

In this paper, we use a new dataset of college textbook assignments and new and used college textbook purchases in the disciplines of economics, psychology, and biology to study the behavior of college textbook buyers, suppliers, and retailers. First, we characterize new edition introduction behavior for college textbooks. We show that new editions are introduced frequently, particularly for costly and introductory textbooks. Second, we ask whether consumers, producers, and retailers behave according to basic predictions of durable goods theory. In particular, theory predicts that consumers (students) base purchasing decisions on the full asset value price of a book. If students are basing purchase decisions entirely on the asset value of the book and the expected lifespan of a textbook edition is not infinite, then the "sticker" price of a book should be adjusted over its life to reflect the book's declining asset value. We show that this prediction does not hold in the data. Third, we estimate demand for new textbooks and use the estimated parameter values to predict the revenue effects of alternative revision time policies.

We show in this paper that basic asset price durable good theory does not appear fully consistent with student and bookseller behavior. In particular, we find that posted prices for both new and used textbooks stay largely constant over the life of a textbook edition. Indeed, we document that, overall, students are somewhat asset price sensitive, but that our estimates suggest that they may underestimate the probability that new editions will prevent them from selling back their textbooks. We assess the implications for students and textbook retailers of this partial asset price sensitivity. Our simulations suggest that student foresight does discipline book publishers' revision time strategies; for example, we show that biology textbook publishers' would fall if they were to speed up their revision cycle to the faster speed observed for economics textbooks.

The paper proceeds as follows. Section 1 provides background on the structure of the college textbook industry and its relationship to the durable goods literature. Section 2 provides a description of the data. Section 3 examines new edition introductions in the college textbook market. Section 4 explains the methodology and shows the empirical results about consumer behavior. Section 5 concludes.

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[3] See, for example, Fairchild (2004) or Galbraith (1958).

1. Industry background and durable goods literature

The textbook industry has several features that make it an attractive empirical setting for examining durable goods issues. First, textbooks are an important expenditure category for college students. The Book Industry Study Group estimates that, in 2002, wholesale sales of college textbooks totaled $4 billion, making the market approximately the same size in dollar volume as wholesales sales of textbooks for elementary through high school students. Fairchild (2004) surveys students throughout the University of California system estimates that the typical college student spends $898 on textbook purchases each year.[4] Because of the importance of college textbooks in the budget of the typical college student, and because of the transitory need for a particular book, it is not surprising that a well-developed market exists for used college textbooks. Indeed, the National Association of College Stores webpage estimates that used materials accounted for 28.5% of course material revenues at college bookstores in 2003.

A second feature of the textbook industry that is useful for data collection is that, despite the growth in online buying opportunities, the majority of new textbook transactions still appear to be mediated by campus college bookstores. A survey by the National Association of College Stores estimates that 6% of college textbooks were sold online in 2000. Our survey of 203 Yale College students enrolled in Econ 115a in 2004 showed that, of the 178 students who owned the required course textbook, 130 had purchased it at the campus bookstore.

Finally, the most attractive feature of college textbooks is that, while the market contains several features common to other durable goods markets, and therefore, of interest, the college textbook market is, in many ways, less complicated than other durable goods markets. That is, some but not all of the issues raised in the durable goods literature apply to college textbook market.

From our perspective, the most important distinguishing feature of the college textbook market is that each semester brings a new generation of students and these students essentially must decide at the beginning of the semester whether or not to purchase the assigned textbook for their class. At the end of the semester, they effectively decide whether or not to sell it back. Because of this

[4] A similar study conducted by the staff of Sen. Charles Schumer (2004) estimates the costs of textbooks at New York Universities to have been $922 per in 2003.

market structure, many of the issues considered in the durable goods literature seem irrelevant to this market. For example, a significant literature in macroeconomics and industrial organization (see for example, Caballero (1990, 1993) and Eberly (1994))) has focused on S-s considerations and consumers' decisions regarding the timing of when to purchase or replace a durable product. Clearly, if a student purchases a textbook, s/he is likely to do so at the beginning of the semester in which it was assigned, and if s/he sells it, that will occur at the end of that semester.

Furthermore, the time-inconsistency problems modeled in Coase (1972) and Bulow (1982) seem largely irrelevant to this particular market; the idea that the student might delay taking a class or purchasing a book in order to exploit expected future changes in the price of the textbook seems extremely far-fetched.

Additionally, because any quality differences between a new copy of a given textbook and a used copy of that textbook are readily observable, an empirical analysis of the textbook industry need not concern itself with the lemons issues raised in Akerlof (1970), although these issues would be of paramount importance in many other used good settings.

Having carved away many durable goods issues that are irrelevant to this particular market, we can consider a smaller set of issues. We focus here on examining the consumer's purchase decision and its effect on the publisher's new edition introduction decision. The disciplinary effect of used goods on a new good producer's market power has been discussed in Carlton and Gertner (1989), Swan (1980), and Suslow (1986). The idea that the edition changes might be motivated by an attempt to "kill the market for used goods", has been discussed extensively, starting at least with Galbraith (1958). However, this idea has been criticized as inconsistent with rational forward-looking consumers by Miller (1974), but has been more recently resurrected in formal models of obsolescence such as Waldman (1993).[5]

We demonstrate that the availability of used books clearly crowds out sales of new ones. However, if students incorporate the asset value of the book in their purchase decision, this competition from used textbooks may not diminish

[5] Rust (1986), Swan (1970, 1972), and Sieper and Swan (1973) consider the closely related issue of optimal durability decisions. However, these papers focus exclusively on durability "built-in" at the time of production.

publisher profits. We examine the extent to which students appear to consider the asset value of the book in making a purchase decision. We provide rough calculations of how the measured student behavior would affect a publishers' revenues from lengthening or shortening the new edition introduction cycle.

Given that new edition changes have been frequently cited as attempts to "kill off" the market for used goods, this raises the important issue of whether and why edition changes actually do "kill" the market for used goods. After all, if one takes the cynical view that edition changes are mostly cosmetic, then why don't students simply use older editions of assigned textbooks? Various pieces of evidence do suggest that new editions do, for the most part, render older editions obsolete. Unlike software, where "old" users have to make a decision of whether or when to upgrade when new versions appear, for textbooks, the total users of a textbook in any semester are effectively just those students who have arrived in the market in that particular period.[6] Thus, the important issue for textbooks is whether sales channels make older editions of textbooks available to students. In our data from college bookstores, we find that, after a transitional semester, college bookstores do not appear to sell used older editions of a book once the new edition has been published. Most college bookstores claim this as a policy, arguing that faculty are frustrated when students rely upon editions other than the one assigned.[7]

A last useful feature of college textbooks is the two-step nature of the purchasing decision. College students are generally assigned required or optional textbooks for a course by the instructor. For a required textbook, the student, then, has essentially no significant cross-book decision to make. The student must decide whether to purchase the assigned book new, purchase it used, or not purchase it at all. This restriction of the choice set for students makes empirical estimation of their behavior much more tractable.[8] In contrast, for many other durable products, one would ideally need to consider the substitution between *each*

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[6] This makes the problem of software upgrades considerable more complicated then the problem of textbook edition changes, since the software firm has to consider the attractiveness of the overall upgraded package to new consumers while considering whether and how to induce older users to purchase the upgrade. For treatments of problems of this type, see Levinthal and Purohit (1989) and Viard (2004).

[7] The website of the National Association of College Stores (www.nacs.org) suggests, in their "FAQs on used textbooks" that carrying only current editions is a universal college bookstore policy.

[8] This feature of the textbook industry is, in principle, shared with other industries, for example, pharmaceuticals, where consumers have no choice of which drug to purchase once a prescription has been written. However, our paper is distinct from empirical treatments of the pharmaceutical purchase decision of which we are aware (see, for example Ellison, Cockburn, Griliches and Hausman (1997)), in that we separately have data on textbook assignments and student purchases. Thus, we can examine purchases conditional on assignments.

possible new product with *each* available vintage of each product's used goods. For example, Esteban and Shum (2004) must make many restrictions on the matrix of substitution possibilities in his examination of new and used cars. Copeland and Stevens (2004) face similar issues in their study of highway rollers. Thus, a useful feature of college textbooks as an empirical setting is that college textbooks isolate some interesting durable goods issues, while allowing some important but difficult durable goods issues to be set aside.

As described above, college bookstores sell both new and used copies of college textbooks. One might at first think that the relative prices of new and used textbooks would be determined by the number of semesters that the new book has been assigned, the elasticity of student supply of used books across various subjects, and the condition of the used books supplied. All of these intuitions for how the college bookstore might work are incorrect. We randomly selected one-tenth of the college bookstores in our sample to survey about their college textbook selling policies. All of our respondents informed us that their bookstore either sold used textbooks at a price equal to 75% of the textbook list price or sold used textbooks at a price equal to 75% of the price that the charge for new books. Most college bookstores charge 100% of the list price for college textbooks, making these policies essentially identical, but a handful charge less.[9] Furthermore, we visited the websites of many college bookstores that offer pre-ordering of college textbooks online (for in-store pickup). These bookstores all priced used books at 75% of the new book price.

An interesting partial explanation of this behavior was offered to us in a confidential interview with executives from a chain that operates hundreds of college bookstores in the U.S.[10] The executives from this company suggested that frequently, in renting university space to a college bookstore operator, many universities obtain an agreement with the bookstore operator to set used book prices at 75% of the new book price. In our dataset, we find that a regression of the used textbook price on the new textbook price produces a coefficient of 0.74 with an R-squared of 0.99. Thus, our empirical strategy will explicitly avoid estimating cross-price elasticities between new and used books.

Our interview with executives of the large bookstore chain also suggests that, at the 75% industry standard price, college bookstores generally stock out of used

[9] For example, the Stanford bookstore webpage announces that textbooks are sold at 7% off of the list price. A comparison to other ordering systems suggests that this is a fairly unusual policy.
[10] This interview was conducted in August of 2004.

textbooks. In the analysis below, we consider mechanisms for modeling the rationing of used books.

Given the price inflexibility in used book selling policies, it is not, perhaps, surprising that college bookstore used book buyback policies have fairly rigid institutional characteristics. Our surveys and interviews suggest that most larger college bookstores offer to buy back any book that is being used on campus in the subsequent semester for either 50% of the current list price or 50% of the new price posted by the college bookstore in the previous semester. Empirically, these policies will be identical for a large fraction of books at a large fraction of bookstores. Generally, most end-of-semester sellback events also have a table at which representatives of one of the three major used college textbook wholesalers are represented. If a book has not been reordered for the subsequent semester at that campus, students are referred to the wholesaler for a buyback price. These wholesalers generally offer prices in the range of 25% of the new price. These books will be sold at the beginning of the next semester to college bookstores at universities and colleges where the book has been assigned. Textbook wholesalers generally charge retailers a price of approximately 50% of the new book price. The large textbook retailer that we interviewed suggested that, at this fixed price, the book wholesalers generally resort to rationing the used textbooks resold to retailers, who in turn sell them at 75% of the new book price, a price that leads to stock-outs at the retail level.[11]

2. Data

Our data comes from Monument Information Resources (MIR), a consulting company that collects data from college bookstores and sells it to textbook publishers. While MIR collects data for every field of study, we currently have available to us datasets covering economics, biology and psychology. All of our results will be for textbooks in these three fields for the 1997 through 2001 period. Over the whole time period, a total of 1698 schools are included in the

[11] Given the fixed pricing regime, one might ask whether the marginal profitability of an additional new book and an additional used book are equated. The National Association of College Stores (NACS 2004) reports that gross margins on used books are approximately 34.4% and gross margins on new books are approximately 22.9%. The 34% figure almost exactly matches what one would expect when buying a book at 50% of the new price and selling it at 75% of the new price. Since used books are sold for 75% of the new book price, this implies that gross dollar margins are slightly higher for used books. However, handling costs for used books are slightly higher, leading true dollar margins to be close to equated. As one industry source pointed out, however, most retail leases provide for payments from the tenant to the owner as a function of revenues (not profits). Under the current regime, then, the rationing by the wholesaler may constrain the retailer, as retailers offering the "standard" pricing policies and a revenue-based lease would, at the margin, prefer to sell more used books over new ones.

data. The number of college bookstores surveyed by MIR increases over the time period. MIR estimates that their survey represents 31% of college bookstore sales in 1996 and 58% of college bookstore sales by 2001. We will adjust for the shifting sample where appropriate.

The main limitation of our dataset is that it covers college bookstore sales, but not sales through other channels. As discussed above, the time period of our sample is fortunate, in that Internet retailers had not captured a very large fraction of total textbook sales during this time period. However, when examining used books, it is important to keep in mind that informal "handing down" of used textbooks or informal sales of used textbooks between students may be important. In our survey of Econ 115, we found that, while virtually all of the students who bought new textbooks acquired them from the campus bookstore, only about half of the students who bought a used textbook bought it through the campus bookstore. Any examination of used textbook purchases must be considered in light of undercounting of used textbook transactions.

We merge together two different datasets from MIR, MIR's database of textbook assignments and MIR's database of textbook sales. The database of textbook assignments lists, for each course at each university in the sample, semester and year of the course, the name of the course, the instructor for the course, the number of students estimated to be enrolled in the course when the instructor places his or her book order, the actual enrollment in the course, the course number at the individual school, and MIR's definition of the topic of the course. MIR's definition of the topic area of the course represents MIR's attempt to code all "introductory microeconomics" or "intermediate microeconomics" courses with a common course number across schools, so that enrollments in a similar course across schools can be matched. Most importantly, the MIR data also contains the assigned textbook(s) for the course, and a field that defines whether each assigned book is required for the course or optional.

The assignment data is merged with the second MIR database, the sales data. The sales data sums, for each semester, the sales of each textbook. Thus, we do not have data on sales at the individual school level. This is an important constraint of the data and limits our analysis. Importantly, however, the bookstores surveyed for assignments each semester are exactly those for which sales records are obtained for that semester. We "clean" these data extensively to fix obvious coding errors.

When considering the propensity of students to purchase assigned textbooks, it will be useful to consider student characteristics. To estimate the characteristics of students assigned to books, we use data from the 2000 College Board survey. We match school names and locations from the MIR data to the College Board data to obtain information about the size of each university or college in our database, and the mean SAT scores at each university or college in our database. The College Board data also, in principle, contains more detailed information about each university, such as distribution of students across majors, financial aid and commuting characteristics of students, etc. However, we have found these data to often be missing.

The first data issue to be tackled is that not every school reports SAT scores to the College Board. Of these, a large fraction (mostly in the Midwest and South) report ACT scores in lieu of SAT scores. We convert ACT scores to SAT score equivalents using the methodology described in Dorans (1999). For some other schools missing SAT scores, we were able to find SAT or ACT scores from the 1999 or 2001 College Board surveys or on school web pages. Of the 1698 unique schools in our dataset, these methodologies failed to generate an SAT score for 575 of them. The College Board provides categorizations of universities by selectivity and 2- year versus 4-year status. The schools missing SAT scores were mostly "open admission" 2-year community or junior colleges. We assigned these schools the mean SAT score for schools that reported SAT scores in their College Board category.

The main complication with the assignment data is that actual enrollment is frequently missing, and that estimated enrollment is occasionally missing for a particular course. For this reason, our analysis focuses on estimated enrollments. For those schools with missing estimated enrollments, we know the book assigned, but not the number of students for whom the book has been assigned. Because these schools' sales of those textbooks will be counted in the MIR sales data, we cannot simply drop schools from study for which the instructor estimated enrollment data is missing. Thus, for schools for which estimated enrollments are missing, we fill in our estimates of instructor's estimated enrollments. To do this, we estimate school-level predictors of enrollment for each of the 121 unique courses in the three disciplines under study identified by MIR. Thus, for each of the 121 courses, for schools for which we had enrollments we regress school-level total enrollment on the university's total enrollment, squared total enrollment, female enrollment, the school's mean SAT score and its square, College Board "institution type" dummies, and those dummies interacted with enrollment, a spring dummy, and year dummies for each year of

our sample. We use the predicted values from these regressions to predict course level enrollments for the schools that were missing enrollments. These predicted enrollments were then allocated to the actual textbooks that the school assigned.

For the analyses in this paper, we examine new and used sales for a textbook in a given semester to assignments of that textbook in that semester. Throughout our analysis, we remove lab manuals and student study guides from consideration, focusing only on textbooks. The estimated enrollments in all courses in all schools assigning a given textbook in a given semester are added together to produce "total assignments". Data on whether each school-course assigned a textbook as "required" or "optional" is used to calculate the fraction of assignments that are required. Characteristics of these schools and their enrollments are used to calculate the SAT and other characteristics of students assigned the books. In order to sum up assignments and sales of a textbook, we used all available information in the MIR data on author, title, etc. (as well as frequent double-checking on the Internet) to match up different "versions" of the same textbook. This involved tracing a book through edition changes, but also aggregating different packages involving the same textbook.

Occasionally, and increasingly frequently, study guides, dictionaries, CD-ROMs or other ancillary material are shrink-wrapped to the textbook and sold as a unit. This presents two complications. First, while the "wrapped" textbook and the "unwrapped" textbook do not have the same product code identifier (ISBN number), they are effectively the same book. Thus, we hand-identify that such books as being in the same "book family." The second issue is that these bundles will bear a different price from the main textbook. We identify such bundled units, and assign the assignment and sale of such a bundle to the textbook in the bundle. For all textbook-semesters in the dataset, we generate a "fraction bundled" is the fraction of sales accounted for by bundled units. Again, the time period of our data is fortunate, in that the "bundling" phenomenon appears to have escalated between the end time of our data and today.

Lastly, in an ideal dataset, we would like to distinguish between true "textbooks" and trade books that are frequently assigned as textbooks. For example, many universities assign popular economics, psychology, and biology books to students as assigned textbooks. We might expect such books to behave differently from true "textbooks" in that the publisher is optimizing its behavior considering both non-student demand for the book and student demand for the

book. Because of this limitation, we will often analyze separately the subsample of books that cost an average of $40 or more new. These books are essentially always textbooks, and appear not to have much of an "outside" audience. This is a crude correction for the "trade paperback" problem, but, unfortunately, our data do not give us other satisfactory means of separating out true textbooks from non-textbooks that happened to be assigned as required reading. Of course, this problem might be much more dramatic in subject fields such as English than in psychology, biology, or economics.

We also harvest from Amazon.com data about the format of the textbook: paperback, hardcover, spiral bound, etc. In most of the analysis, we use these data to form a dummy variable which takes the value one when a book is paperback.

Summary statistics for the variables described below are found in Table 1.

Table 1

		Mean	St. Dev.
Price	11464	57.69	24.13
ECON	11464	0.28	0.45
BIO	11464	0.20	0.40
INTRO	11464	0.25	0.43
AVSHRINK	11464	0.47	40.64
SPRING	11464	0.52	0.50
AVSAT	11464	1052.42	59.12
FRACREQ	11464	0.92	0.16
EDAGE	11464	2.60	3.26
PAPERBACK	11464	0.48	0.50
Fraction assignees buying book new	11464	0.30	0.18
Fraction assignees buying book overall	11464	0.50	0.18

3. New edition introduction behavior

Before considering the path of prices and sales of books that would be predicted by a durable goods model, it is useful to illustrate the new edition behavior of college textbooks. In order to illustrate this for a fairly homogeneous set of

books, we first focus on textbooks in our dataset designed for introductory courses. Figure 1 shows the CDF of new edition introduction for biology, economics, and psychology introductory textbooks with a new price of over $40 in our dataset. The database includes only books for which the book was designated as "required" for at least 70% of assignees and excludes lab manuals and student study guides. The CDF is calculated using a Kaplan-Meier survival function accounting for the right-censoring and left-censoring in our dataset. Figure 1 shows that, in all three disciplines, the majority of textbooks have introduced a new edition in the third year. This accords well with casual empiricism, which suggests that publishers usually offer 3-year revision contracts to authors. By the fifth year, essentially all economics textbooks have introduced a new edition. Thus, even if students have some uncertainty about the exact time at which a particular textbook will be revised, it seems reasonable to expect an alert student to understand that the expected lifespan of an edition of an introductory college textbook is less than 5 years.

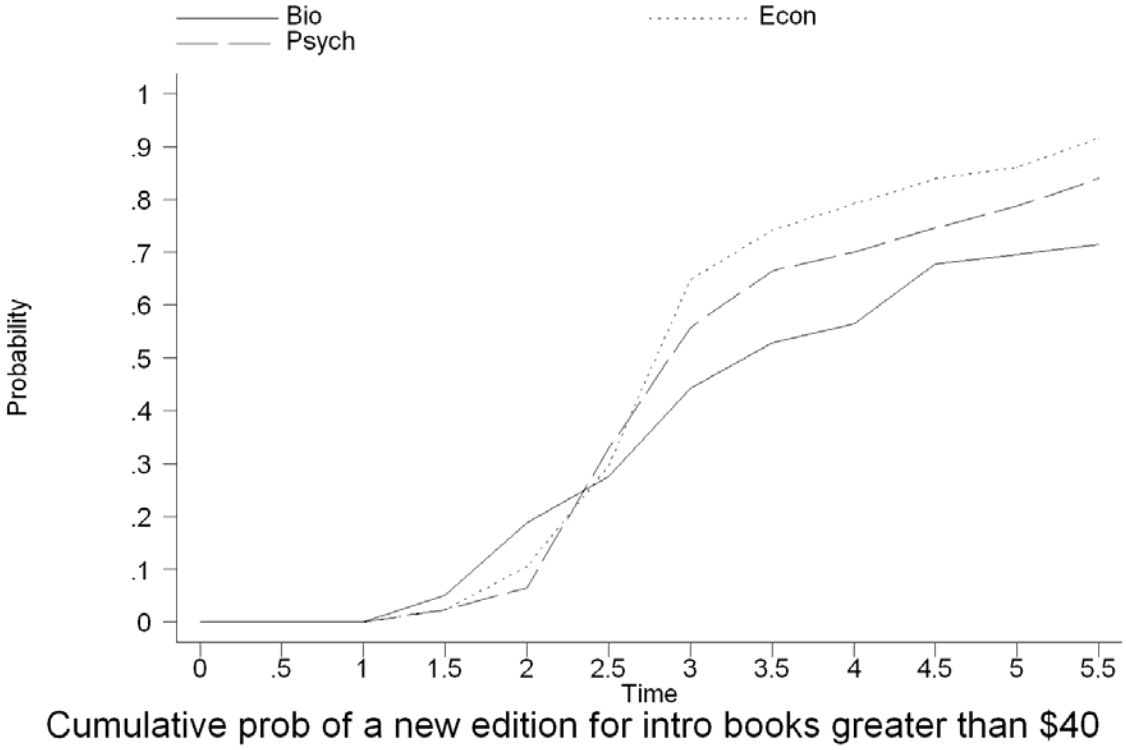

FIGURE 1

The survival data show interesting patterns in the characteristics of textbook new edition introduction behavior. Table 2 reports a Cox proportional

hazard model on the book survival data. The form of the hazard is assumed to be:

$$h(t) = h_0(t)\exp[(Intro_j)\phi_1 + (Econ_j)\phi_2 + (BIOj)\phi_3] \qquad (1)$$

Where $h_0(t)$ is the baseline hazard. The explanatory variables included in equation (1) are INTROj – an indicator variable that takes the value one for introductory textbooks , ECONj – an indicator variable that takes the value of one for economics textbooks, and BIOj – an indicator variable that takes the value of one for biology books. The results are shown in Column 1 of Table 2.

Table 2

Independent Variables	(1) Hazard Ratio	(2) Hazard Ratio	(3) Hazard Ratio
INTROj	1.562	1.524	1.350
	(0.131)	(0.128)	(0.143)
	5.33	*5.02*	*2.84*
ECONj	1.345	1.312	1.371
	(0.125)	(0.122)	(0.154)
	3.19	*2.92*	*2.81*
BIOj	0.886	0.873	0.819
	(0.083)	(0.081)	(0.087)
	-1.30	*-1.46*	*-1.89*
EXPENSIVEj		1.596	1.507
		(0.169)	(0.186)
		4.42	*3.32*
MEAN SATj			0.999
			(0.001)
			-1.46
Number of obs	7107	7107	5830
Number of subjects	2160	2160	1819
Number of failures	748	748	592
Log Likelihood	-4659	-4648	-3571

Table 2: Cox hazard estimates of time to new edition as a function of book characteristics. Standard errors in parentheses. Z-statistics in italics.

These results show that introductory books have a shorter survival time than non-introductory books. The results also confirm what we saw for introductory

books in Figure 1; economics books have a shorter and biology books a longer lifespan than the omitted category, psychology textbooks. Later, we will confirm that demand characteristics in economics and biology are such that it is optimal from a revenue perspective for biology to have a slower revision cycle than economics.

Column (2) in Table 2 adds an additional variable to the specification in Equation (1). This variable, $EXPENSIVE_j$ is an indicator variable that takes the value of one for books greater than $40. We do not include this variable in the main specification due to obvious endogeneity problems. However, the results for pricing are particularly strong and interesting. Certainly, we do not mean to imply causality in either direction, as the new introduction behavior and pricing strategy are clearly jointly chosen. The data are consistent with a setting in which, if publishers expect students to keep the book, they charge a low price and a long life-span. If publishers expect students to sell back books to the used book markets, they charge a high price and a short life-span.

It has been suggested that students at elite universities might demand more up-to-date content. To investigate this, in Column 3, we augment our specification in Column 2 to include the mean of the mean SAT scores of students at the institutions assigning each textbook. Contrary to the hypothesis that "elite" universities would demand more current books, it appears that books designed for higher SAT students have slower revision times, although effect is not statistically different from zero.

Iizuka (2004) addresses the issue of textbook durability using MIR data on sales of economics textbooks. He hypothesizes that publishers introduce new editions for two reasons: to "kill off" the used market when used textbook sales build up in the market and to freshen book content. Given the spike in the "death" of textbook editions at exactly three years, and given the standard three-year author contract proposed by most major publishing houses, we would argue that *ex post* realized used textbook sales are unlikely to play much role in determining new edition introductions. Clearly expectations do play a role, and we explore that later.

4. Does textbook pricing follow the patterns predicted by asset values?

Most basic models of producer/consumer behavior in this market would lead to the prediction that prices for new and used textbooks should fall over the life of

the edition.[12] The literature on planned obsolescence and optimal durability has taken as its starting point, forward-looking consumers who form rational expectations about the path of future prices/production levels. In keeping with this, consider a world of forward-looking consumers, perfect information, no pricing frictions, and a perfectly liquid used good market. Assume also, for simplicity, that the used product doesn't deteriorate in quality until it is rendered totally obsolete by the introduction of a new product.

The price at which the good could be sold in period t is then:

$$p_t = r_t + \sum_{j=1}^{T} \delta^j p_j \qquad (2)$$

where r_t is the per-period rental rate, δ is the per-period discount factor and period T is the last period before the introduction of the new product that will render this good obsolete.

For further simplicity, we consider the example of a product that will exogenously become obsolete after two periods of use. In this case, we have $p_1 = r_1 + \delta r_2$ and $p_2 = r_2$.

The per-period rental prices chosen by the monopolist, r_1 and r_2 depend on the marginal cost of production in each period, c_1 and c_2, and whether or not the monopolist can precommit to the path of prices. If $c_1=c_2=c$ and the monopolist can precommit, then monopolist's problem is equivalent to choosing the optimal rental price period by period. It is easy to show that $r_1=r_2=r$. Thus,

$p_1 = r_1(1 + \delta)$
and $p_2 = r_2=r_1 < p_1$. (3)

If the monopolist cannot precommit to a price schedule, then both p_1 and p_2 are less than in the commitment case, but the path of prices still falls, because the monopolist charges a lower rental rate in the second period, $r_2<r_1$.

One could imagine various extensions to this model which would leave the falling price path intact. For example, in a model with more than 2 periods, used books could be resold into the used book market, and we would see their values

[12] The treatment here resembles Levinthal and Purohit (1989).

fall as the end of the edition approached. One could incorporate some disutility for having a used book, creating a discount of the used book relative to the new, as appears in the data, but this would have no effect on the price path. One could alter the model so that the book is not fully obsolete at the terminal date, but as long as the book is rendered discretely less valuable, the falling price path of the book remains.

Thus, the falling price path of both the new copies of the book and of the used copies of the book is a robust feature of many models. For that reason, our first empirical test examines whether new and used book prices fall over the life of the edition. We explore this question in a relatively simple manner. We consider two specifications. First, we estimate regressions:

$$\ln(P_{jt}) = \sum_{k=1}^{8+} \gamma_k I_k + \Gamma\, Time_{jt} + \kappa_1 Spring_t + \kappa_2\, Avshrink_{jt} + \sum_{m=1}^{J} B_m + u_{jt} \quad (4a)$$

and:

$$\ln(P_{jt}) = \gamma_1 DIE_{jt} + \gamma_2 AGE_{jt} + \Gamma\, Time_{jt} + \kappa_1 Spring_t + \kappa_2 Avshrink_{jt} + \sum_{m=1}^{J} B_m + u_{jt} \quad (4b)$$

where $\ln(P_{jt})$ is the natural log of the new price of book j at time t.

The first specification (4a), examines the path of prices using an indicator variable approach. There, the variables of interest are the I_k indicator variables. The indicator variable indicates the number of semesters since book j's current edition was released. That is, if a book was released in the first semester of 1998, and then a new edition was released in the first semester of 2000, there were be observations for the two semesters of 1998 and the two semesters of 1999, and the semester since edition change would move from zero to three. In the first semester of 2000, the time since edition change would return to zero. Since a constant is included in the regressions, in the new book regressions, elapsed time of zero periods is the omitted category.

The second specification, in (4b), examines the path of prices by examining whether the new book price is a function of the probability that the book will enter a new edition in the following period (so that the student will not be able to sell back the book). The DIE proxy is estimated simply as the empirical

probability in the data that a book of book j's age, discipline (psych, bio, or econ), and introductory/non-introductory status will undertake a new edition in the next period. The AGE variable allows the price of book to move linearly with the time since the edition change. Note that the AGE and DIE variables are not collinear due to the spike in the DIE probability at an age of 3 years.

Importantly, in both specifications we include other controls for factors that might affect book prices. We include the book fixed effects, denoted B. Two "versions" of a book within the same edition are considered the same book, but each new edition receives a different book fixed effect. $Spring_t$ is a dummy variable that equals one in all Spring terms and zero in all Fall terms. We also include in our specification $Avshrink_{jt}$. This variable measures the fraction of all assignments in that semester that were of "bundled packages" of books. Bundle packages generally increase the price of the textbook by bundling in CD-ROMs, study guides, etc. Ideally, our dataset would allow a finer hedonic pricing model of the bundle, but this is impossible, since we can ascertain from our data that the textbook is shrink-wrapped with other elements, but the data do not always allow us to determine what those elements are.

We can include time controls in two ways. First, we can simply allow a linear time trend to allow prices to drift up or down on average over time. Second, we can, more flexibly, allow a different time intercept for each of the 10 semesters in the data (in doing so, we omit $Spring_t$ as redundant). Note that estimation of this vector of time indicator parameters would not be possible if we also included the full complement of book age indicator variables. However, our specification groups books for which more than 8 periods have elapsed since the revision change. Given the indicator variable scheme we have used, it is clear that the time indicator parameters are effectively identified in the data by using the price changes from books that have not revised in over 8 periods. That is, the time indicators essentially reflect the price paths of "old standbys" like the Marx-Engels reader.

Finally, to restrict attention to primary course textbooks, rather than trade paperbacks assigned as texts, we present the results separately for all books and for books whose average selling price new is greater than $40. We also present some results separately for introductory and non-introductory textbooks.

The results are found in Table 3. The first column of Table 3 estimates (4a) for the full sample of books. Column 2 shows the same specification as Column 1, replacing the continuous time variable with time indicators. Column 3 estimates

(4b) for the full sample of books. The fourth column estimates (4a) for the subsample of books greater than $40. All of the specifications suggest that books experience a modest but statistically significant increase in price after semester zero and price does not fall as the edition ages or as the probability of edition "death" increases. This increase is consistent with discussions with major college textbook retailers who suggest that book publishers increase prices of existing textbooks slightly over time. For books greater than $40, the coefficients imply a price increase over the period zero price of approximately 2%. Whatever the explanation for the modest price increases, it is clear that the books do not follow the declining path predicted by the theory in Equation (2).

Again, because used book prices appear to be set mechanically with respect to new book prices, unreported regressions replacing new book prices with used book prices in (4a) and (4b) generate results that are almost identical to the regressions shown in Table 2. One might consider attributing the price path of new books to some kind of menu costs, though it is troubling that the book prices do rise through time. Menu costs also seem difficult to reconcile from the used book price behavior. Used book prices are divorced from the price imprinted on the book, so changing them shouldn't be that difficult.

Table 3

Independent variables	(1)	(2)	(3)	(4)
Elapsed time - 1	0.00266	0.0034		0.00446
	(0.003)	(0.003)		(0.003)
Elapsed time - 2	0.009234	0.00974		0.0091
	(0.003)	(0.003)		(0.003)
Elapsed time - 3	0.01733	0.01658		0.01353
	(0.003)	(0.003)		(0.003)
Elapsed time - 4	0.0226	0.023		0.0146
	(0.004)	(0.004)		(0.004)
Elapsed time - 5	0.0351	0.03517		0.02078
	(0.004)	(0.004)		(0.005)
Elapsed time - 6	0.0415	0.0409		0.02709
	(0.005)	(0.005)		(0.005)
Elapsed time - 7	0.0501	0.05055		0.0309
	(0.006)	(0.006)		(0.006)
Elapsed time - 8	0.0479	0.04664		0.0297
	(0.007)	(0.007)		(0.007)
Elapsed time > 8	0.047	0.04635		0.0241
	(0.007)	(0.007)		(0.008)
DIE Prob			0.1159	
			(0.018)	
Elapsed time			0.060	
			(0.001)	
SPRING	-0.0072			-0.0059
	(0.0017)			(0.0019)
SHRINK %	0.031	0.030	0.032	0.036
	(0.007)	(0.007)	(0.007)	(0.007)
TIME_ID	0.053			0.063
	(0.001)			(0.001)
Constant	3.692	3.981	3.740	3.967
	(0.005)	(0.006)	(0.005)	(0.006)
Book fixed effects?	Yes	Yes	Yes	Yes
Time fixed effects?	No	Yes	Yes	No
Sample	All	All	All	>$40
N	11733	11733	11478	8793
R-squared	0.989	0.989	0.988	0.927

Table 3: The dependent variable is ln(new price). Standard errors are in parentheses.

5. Demand Relationship

Note that, given the failure of books to follow a declining price path, the implied rental price of a textbook is far from constant over the life of the textbook. Given the considerable variance in the prices faced by students both across time and across books, we are able to estimate student demand behavior.

An interesting and convenient feature of our data is that we separately have data on student book assignments and student purchases. Thus, when we estimate student demand for book j, we estimate demand *conditional* on the student having been assigned book j by their instructor. Thus, while the instructor chooses a textbook to assign given the characteristics and possibly prices of a range of possibly appropriate textbooks, the student faces no cross-book decision. The student simply decides whether or not to buy the assigned book (and whether to buy it new or used, a decision we return to later). Consider a student i, whose utility u_{ijt} from purchasing an assigned textbook j at time t is given by:

$$u_{ij} = x_{jt}\beta - \alpha r_{jt} + \xi_{jt} + \varepsilon_{ijt} \qquad (5)$$

Where is the r_{jt} is the rental price of book j, x_{jt} are observed characteristics of book j, ξ_{jt} are unobserved characteristics of book j (which may be correlated with r_{jt}). Individual and book specific taste shocks are given by ε_{ijt}, which is assumed to be i.i.d extreme value.

Of course, the data that we observe are not the rental price of the book, but rather, the selling price. We also observe measures of the probability that a student in a given semester will or will not be able to sell back the book. Allow DIEj to be the probability that the book cannot be sold back. Let the expected sell back price be a fraction μ of the purchase price and let δ be the student's discount factor.

Then the student's utility can be written:

$$u_{ijt} = x_{jt}\beta - \alpha(p_{jt} - \delta\mu((1 - DIE_{jt})p_{jt})) + \xi_{jt} + \varepsilon_{ijt} \qquad (6)$$

or

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} - \alpha\delta\mu(1 - DIE_{jt})p_{jt} + \xi_{jt} + \varepsilon_{ijt} \quad (7)$$

Implicit in many discussions of new edition introductions is the hypothesis that students do not fully understand the probability that their book will not be resellable at the end of the semester. (That is, they are myopic and do not always recognize that new introductions will prevent them from selling back their books). We can consider a very specific specification of this by altering (7) above to be:

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} - \alpha\delta\mu\lambda(1 - DIE_{jt})p_{jt} + \xi_{jt} + \varepsilon_{ijt} \quad (8)$$

Where λ is a factor which accounts for a student scaling up (or down) the probability of resale. Of course, by specifying the equation in this way, we impose the shape of the new edition arrival hazard, and consider only the possibility of the student scaling up (or down) the probability of resale.

Student i will purchase book j if purchasing book j provides higher utility than not purchasing the book (and hopefully going to the library to do the assigned reading). We normalize the utility of the outside good to be zero.

We first consider a simple logit demand framework. (That is, we assume that ε_{ijt} has an extreme value distribution). Following the standard Berry (1994) inversion for aggregate data, this provides the following equation determining the share, s_j, of students who buy the book and the share, s_0, of students who consume the outside good:

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt}\beta - \alpha p_{jt} - \alpha\delta\mu\lambda(1 - DIE_{jt})p_{jt} + \xi_{jt} \quad (9)$$

We use the following book characteristics x_{jt} in the specification: $Econ_j$ and BIO_j, indicator variables for the book discipline; $INTRO_j$, an indicator for an introductory book; $AVSHRINK_{jt}$, the fraction of assignments of the book that are "shrink wrapped editions", editions bundled with study guides or other ancillary material. Students may or may not value the ancillary material.

As proxies for the "level" of the book, we include SAT_{jt}, the average composite SAT score of students assigned book j in semester t. When specifying the relationship between product characteristics and shares, it is always difficult to disentangle characteristics of the goods with characteristics of the buyers. This

issue is particularly the case here, where we cannot tell the difference between the hypothesis that low SAT students are less likely to buy their books and that books written for low SAT students are less likely to be bought.

We also include "$FRACREQ_{jt}$", the fraction of assignments of the book that are required. Students may get less utility from purchasing and buying a recommended book than a required book. All books in the included sample have a $FRACREQ_{jt}$ greater than 0.90, but the actual level of $FRACREQ_{jt}$ is still included as a control.

We also include a dummy variable $SPRING_t$, which equals one in the spring semester. Students may systematically be more or less interested in purchasing course materials in the spring semester.

We also include a dummy variable that equals one for paperback books. Holding price constant, students might be more or less likely to buy a paperback book than a hardcover one.[13]

Finally, while the age of an edition may enter utility through the probability that a book can be sold back, it may also enter utility directly. Thus, we include $EDAGE_{jt}$, the age of the current edition of book j at time t.

Three issues remain before (9) can be estimated. First, we have thus far ignored the issue that students may purchase either new or used textbooks. Second, we must address possible specifications of DIE_{jt}, since DIE_{jt} is not directly observed in the data. Third, we must address the endogeneity of the p_{jt} and $DIE_{jt}p_{jt}$ terms in the equation above and describe appropriate instruments.

As described before, students often can choose between new and used books. At first, one might imagine handling this issue straightforwardly, expanding the choice set to include three products: new books, used books, and the outside good. However, there are three impediments to taking this approach. First, there is considerable evidence that used books are rationed, as described above, and second, used book prices generally do not vary from 75% of the new book price. Thus, the price elasticity of demand for used books cannot be estimated using the available data. Thirdly, an additional complication is that, other than

[13] We also considered specifications that included measures of the "size" of the book, such as length times width times height or number of pages. These variables did not appear to be important in demand specifications. They were not available for all books, and thus limited our sample size, so we chose not to include them.

"newness" itself, all measurable characteristics of the new book and used books are identical (subject, number of pages, etc.). Thus, we consider two alternative approaches.

First, note that rationing used books can be thought of as sometimes removing used books from the choice set. One familiar limitation/feature of the logit demand model in (9) is the independence of irrelevant alternatives property of the logit. If used books are (sometimes) removed from the choice set, logit substitution patterns imply that (9) is still correctly specified. The share s_{jt} is calculated as students buying the new book divided by all students assigned the book. The share s_{0t} is calculated as students buying neither the new or used book divided by all students assigned the book.

An alternative approach relaxes the assumption of logit substitution patterns between new and used books, but imposes alternative restrictive assumptions. As in the specification above, we assume that preferences over characteristics (the β's) and demand elasticities (α) are the same for all students. Assume also that r_j^{new} and r_j^{used} are set such that the used book is always rationed, and that efficient rationing takes place (a fairly heroic assumption). Efficient rationing in this circumstance means that the students with the biggest logit error draws end up purchasing the books. In this circumstance, then, we can view the buyers of the used book as strictly inframarginal.[14] Under these circumstances, the share of students buying the book (new plus used) is set at the margin by a new book buyer and thus, by the new book price. Equation (9) above can be estimated, but the share s_j is calculated as (total new sales + total used sales)/total assignments. We estimate Equation (9) using both alternative sets of assumptions about new and used substitution patterns.

The second specification hurdle mentioned above is that we do not directly observe DIE_{jt}, the probability that book j will be revised between period t and period t+1, and thus not be resellable by the student at the end of period t. We specify DIE_{jt} as we specified DIE_{jt} above—the probability that book j will not survive from t to t+1 as estimated using the hazard model from Section 3 (which considers the discipline, age, and introductory nature of the book). We will consider some robustness checks to this specification.

[14] Note that this assumption is implicit in other treatments of new and used goods. See, for example, Suslow (1986).

The last hurdle to estimation to be discussed is the familiar endogeneity of price, and thus also the price-probability of revision interaction term. In the absence of the observed book rationing, we would be more eager to jointly estimate demand and supply specifications. Given the complications posed by rationing, we settle for the solution of introducing instruments for price and the price-new edition revision interactions.

We include several instruments. First, we include a dummy that equals one if a book is published by a non-profit publisher. Our data suggest that non-profit publishers (such as most University presses) charge systematically lower prices. We also include the share of non-profit publishers among textbooks designed for the same course as the textbook in question in the year in which the textbook was published. We also include the herfindahl index for publishers for the course in the year in which the textbook was published. Because we are instrumenting for price and the price-die probability interaction, we include the die probability as an instrument and also include as instruments, interactions between the other instruments and the die probability. Finally, we include interactions between the basic instruments and the years since revision (elapsed time).

GMM estimation results for (9) assuming standard logit substitution patterns are contained in Table 4, Column 1. The results suggest that, if students believed that they could not sell back their books with probability one, the elasticity of demand would equal -3.5 at the current mean book price. At first, this elasticity might seem inconsistent with the profit maximization on the part of the bookseller. However, this elasticity does not take into account the fact that students *do* understand that they are likely to be able to sell back the book. Indeed, if students expect to be able to sell back the book with probability one, then the implied elasticity overall elasticity of demand in Table 4, Column 1 is -0.70.

Independent variables	(1)	(2)	(3)
Price	-0.0622	-0.0063	-0.0595
	(0.0048)	(0.0029)	(0.008)
P x (1-DIEPROB)	0.0499	0.0075	0.0425
	(0.0046)	(0.002)	(0.004)
ECON	-0.046	-0.245	-0.071
	(0.058)	(0.044)	(0.071)
BIO	-0.044	-0.138	-0.061
	(0.075)	(0.048)	(0.091)
INTRO	-0.090	-0.067	-0.087
	(0.067)	(0.038)	(0.079)
AVSHRINK	0.0008	0.0006	0.0008
	(0.00002)	(0.00002)	(0.00003)
SPRING	-0.072	-0.208	-0.0628
	(0.045)	(0.027)	(0.044)
AVSAT	0.0008	0.0004	0.001
	(0.0003)	(0.0002)	(0.0004)
FRACREQ	1.656	1.706	1.301
	(0.201)	(0.145)	(0.182)
EDAGE	-0.049	0.0012	-0.092
	(0.007)	(0.004)	(0.0136)
PAPERBACK	-0.251	0.101	-0.263
	(0.141)	(0.105)	(0.154)
Constant	-1.823	-1.851	-1.239
	(0.401)	(0.328)	(0.624)
Sample	All	All	>$40
Model	Logit	eff ration	logit
N	11464	11464	8612

Table 4: Logit demand specifications estimated using GMM.

The estimated value of $\delta\mu\lambda$ is 0.80. Of course, we cannot separately identify δ, μ, or λ. However, it is probably reasonable to assume that students expect to sell back the book for the college bookstore industry-standard 50% of the new price (μ=0.5). Another reasonable assumption is that the discount factor is close to 1 (given that the waiting period for the book buyback is only one semester, and many students probably keep their cash in low or no interest-bearing checking accounts). Taking those as given, this implies that λ is about 1.6.

Taking 1-DIEj as the "true" probability of sellback, the results are consistent with students overestimating the probability of sellback by 60%. We can reject at standard confidence levels the hypothesis that the coefficient for P x (1-DIEPROB) equals -0.5 times the coefficient for price. That is, if we accept that the discount rate is 1 and the sell-back price is 50% of the purchase price, we can reject the hypothesis that λ=1 at standard confidence levels.

Other coefficients mostly accord with intuition. The share of students buying the book conditional on assignment does not vary dramatically for introductory (versus intermediate and advanced courses), nor across fields. The probability of purchase is significantly higher for books assigned to high-SAT students and for books that are assigned as "required" more frequently. There appears to be a somewhat lower propensity for students to purchase paperback books (of course, holding price constant).

The results in column (2) present the efficient rationing specification. Notice the unreasonably small elasticities implied by the coefficients in Column (2). The implied price elasticity of demand varies from approximately 0 for a book with a zero probability of sell-back to –0.41 for a book with a sell-back probability of one. Cleanly interpreting $\delta\mu\lambda$ is more difficult. New good buyers and used good buyers are mixed in this specification. It isn't clear whether the marginal buyer expects to receive a buyback price equal to 50% of the purchase price (applicable for new textbook buyers), or 67% of the purchase price (applicable for used textbook buyers). In either case, the coefficients imply that students overestimate the book sell-back probability. Column (3) reproduces the results in Column (1) for the subset of books costing greater than $40 (again, a crude sort for "real textbooks"). The qualitative results are stable.

Table 5 considers alternative ways of specifying the probability of book death, and also tries to proxy for the effect of "overhang" of used books. Column 1 of Table 5 repeats the specification Column 1 of Table 4, but adds an additional term to the specification, an interaction between price and book age. Suppose that, instead of considering the new edition hazard similar to the estimated one, students assumed that the new edition hazard was smoothly increasing in the age of the book. Under those circumstances, we would find a significant negative coefficient for Price x Book age, and a zero coefficient for Price x (1-DIEj). The estimated coefficient for Price x Book age and is negative, it is not statistically different from zero at standard confidence levels. Furthermore, the coefficient for Price x (1-DIEj) is not substantially altered by this inclusion.

Independent variables	(1)	(2)
Price	-0.074	-0.032
	(0.012)	(0.013)
Price x (1- DIEPROB)	0.056	0.028
	(0.009)	(0.010)
Price x Elapsed time	0.0016	
	(0.0017)	
Price x (Past asg/cur asg)		-0.0013
		(0.001)
ECON	-0.048	-0.053
	(0.062)	(0.051)
BIO	-0.023	-0.103
	(0.082)	(0.072)
INTRO	-0.073	-0.089
	(0.074)	(0.055)
AVSHRINK	0.0009	0.00071
	(0.00003)	(0.00006)
SPRING	-0.093	-0.224
	(0.048)	(0.057)
AVSAT	0.0009	0.0004
	(0.0003)	(0.0004)
FRACREQ	1.762	1.739
	(0.209)	(0.192)
Elapsed time	-0.098	-0.015
	(0.047)	(0.014)
PAPERBACK	-0.290	-0.099
	(0.147)	(0.144)
Constant	-1.675	-1.775
	(0.441)	(0.409)
Sample	All	All
Model	Logit	Logit
N	11464	11464

Table 5: GMM estimation of logit specifications. Standard errors, robust to clustering on course, are in parentheses.

The second column of Table 5 shows a specification in which a proxy for the overhang of used books is interacted with price as a regressor. We construct the number of total assignments of book i prior to the current semester divided by

the total assignments of book i in this semester as a rough proxy for the probability that used books are available. Of course, if this measure of the availability of used books effects the price elasticity of demand for the new book, the logit assumption is clearly violated. This coefficient is negative, which would be consistent with demand being more elastic in the presence of greater used book availability, but it is not statistically different from zero at standard confidence levels.

6. Implications for Publisher Behavior

In section 5, we measured how student purchases of new textbooks is affected by forward-looking behavior on the part of students. This raises the question: how is new edition introduction behavior affected by the students' estimation of the probability of sell-back? Using the estimates from Section 5, plus additional assumptions, we can provide rough estimates of the revenue implications of a regime change in which publishers adopt longer or shorter revision cycles.

Our ability to measure the revenue implications of regime change are limited by the fact that we have not estimated how faculty behavior is affected by edition age. It may be that faculty have preferences for newer or older editions that affect their assignment behavior. For the purposes of our calculations below, we assume that faculty behavior is neutral with regard to edition age. Our intention is not to in any way suggest that this is a realistic assumption, but rather, we think that,

In this section, we consider one hypothetical example. We saw above that biology textbooks have a relatively slow revision cycle relative to economics textbooks. Consider a hardback introductory economics textbook and a hardback introductory biology textbook that is assigned to 7000 students per semester, every semester for 9 semesters. In Section 3, we estimated the new edition hazard for textbooks with those characteristics. Using the demand estimates in Section 5, we can simulate the effect of a "faster" revision cycle and a "slower" one. In particular, we ask the questions: what would be the revenue implications of moving biology textbooks onto the economics revision cycle? What would be the revenue implications of moving economics textbooks onto the biology revision cycle?

A known shift in the revision hazard has three effects. First, if new editions are introduced more (less) frequently, then the sales of used books drop to zero more

(less) frequently. If the age of the edition directly impacts students' propensity to buy the assigned book (as it does in the demand specifications above), then the frequency of new editions will directly impact sales. Finally, if new students are forward-looking, and the change in the revision hazard is well understood, then students' estimation of the probability of sell-back will change. In the case of a faster new edition hazard, the first two effects will tend to increase publisher sales of new books, while the third will tend to decrease them.

For all calculations, we examine hardcover introductory economics textbooks and hardcover introductory biology textbooks. All other book characteristics are held at their means for intro biology textbooks and intro economics textbooks (including "spring", which is set equal to ½). Coincidentally, the mean price of both hardcover introductory economics books and hardcover introductory biology books is $78. Using these characteristics, we separately estimate demand for biology books and economics books using the specification in Equation (9). From the demand specification, we generate predicted values of $\ln(s_{jt}) - \ln(s_{0t})$.

As mentioned above, we take the case of a book that is assigned to 7000 students each semester. Because used book prices are largely set administratively and used books are allocated by queuing, we estimate the share of used books using a very simple regression specification. We estimate ρ and θ in the specifications:

$$(s^{used}{}_{jt}) = ETIME_{jt}\rho + \sum_{k=1}^{J} I_k\theta_k + \varepsilon_{jt} \qquad (10)$$

where s^{used} is the number of used copies of book j sold divided by the number of students assigned book j in time t, $ETIME_{jt}$ is the number of semesters since this edition book j was released and the I_k's are book fixed effects. We estimate (10) separately for economics textbooks and biology textbooks. Our estimate of ρ for economics textbooks is 1.6 times our estimate of ρ for biology textbooks. Thus, used book sales build up more slowly in biology than in economics. Using our estimates of ρ for biology textbooks and economics textbooks and our example of a book that is assigned to 7000 students each semester, we generate a predicted number of used book sales each semester.

Given our estimates of the used book sales for each discipline, the total number of students assigned the book and $\ln(s_{jt}) - \ln(s_{0t})$, we can easily back out the predicted new book sales for each semester. That is, for our example, we generated predicted new and used book sales for a zero-semester aged

introductory economics textbook book, a 1-semester aged introductory economics textbook, etc.

In order to calculate revenue effects, we consider a hypothetical introductory economics hardcover book and a hypothetical introductory biology hardcover book that start out in the zero-semester-old state. Each book transitions to the older states, but may return to the zero-semester old state at a random time, with probabilities over transition times given by the hazard functions. We use the biology and economics transition matrices to derive the probabilities that a book following the economics hazard or that a book following the biology hazard is in each state after n semesters. Since each state is associated with a predicted level of new book sales for each book type, we can add up the predicted level of books sold in each period for each of the transition matrices.

Table 6 shows these results. The upper panel compares sales of an biology textbook following the actual biology revision hazard to sales of an biology textbook following the somewhat faster economics revision hazard. The lower panel compares sales of a economics textbook following the actual economics revision hazard to sales of a economics textbook following the slower biology revision hazard. Each row represents a number of semesters over which we are measuring expected book sales. For each semester, it shows the probability that the book has been revised at least once (that is, the probability that the age of the edition is less than the number of semesters). The expected number of new books sold reflects a probability-weighted average of all of the states that a book could be in after that number of semesters. For example, if, after 3 semesters, a book has a probability 0.95 being 3 semesters old, and a probability 0.05 of having been revised and being 0 semesters old, the expected sales reported is 0.95 x the expected sales of a 3-semester-old book plus 0.05 x the expected sales of a 0-semester old book.

The sum of new books sold after 9 semesters is shown at the bottom of each panel of Table 6, as well as an estimate of the present discounted value of revenues at the end of 9 semesters. Present discounted values are estimated assuming a discount rate of 3% per semester.

Table 6

Biology Book Estimates

Semester no (N)	Econ Speed Prob Age=N	E(books sold)	Bio Speed Prob Age=N	E(books sold)
0	1.00	2402	1.00	2402
1	1.00	2139	1.00	1985
2	0.98	1691	0.96	1454
3	0.09	1110	0.84	1683
4	0.73	965	0.77	1266
5	0.47	1923	0.63	1741
6	0.43	1902	0.58	1747
7	0.41	1730	0.55	1535
8	0.39	1543	0.50	1619
SUM		15405		15430
PDV revenues		$1,078,107		$1,080,627

Economics Book Estimates

Semester no (N)	Econ Speed Prob Age=N	E(books sold)	Bio Speed Prob Age=N	E(books sold)
0	1.00	2107	1.00	2107
1	1.00	1872	1.00	1800
2	0.98	1568	0.96	1459
3	0.09	1217	0.84	1525
4	0.73	1099	0.77	1270
5	0.47	1675	0.63	1492
6	0.43	1592	0.58	1434
7	0.41	1437	0.55	1287
8	0.39	1282	0.50	1276
SUM		13849		13650
PDV revenues		$971,214		$959,046

The simulation in Table 6 suggests that present discounted revenues are fairly similar under both revision hazards. However, revenues are higher for biology

textbooks under the slower revision schedule, and for economics textbooks under the faster revision schedule. This stems largely from the fact that our estimates in Equation (10) suggest that used books build up more quickly in economics than in finance. Remember that the optimal revision time balances the falling new book sales over the edition life against the effective increase in elasticy that results from student's rationally predicting that they may not be able to sell back their books. It appears that, were biology to shift to economics revision hazard, the gains from "killing" used books would be outweighed by the deleterious effect on student elasticities.

Our results that biology publishers could not increase revenues by speeding up revision cycles may be somewhat surprising to some industry observers. Some industry observers (including college bookstore owners that we interviewed) have suggested that revision cycles have been pushed to the technological minimum and that only the fixed cost of inducing authors to speed up revision cycles prevents publishers from adopting faster revision times. Our estimates suggest that this casual observation is not true; students are sufficiently forward looking that speeding up revision cycles would lower revenues for biology textbooks, even before considering the fixed costs of producing revisions.

7. Conclusions

In this paper, we examine durable goods production and consumption in the empirical setting of college textbooks. We find that college students are forward-looking and they consider textbook sell-back, and the possibility of not being able to sell back their textbooks, in making textbook purchase decisions. However, we reject the hypothesis that students are fully forward-looking. Our estimates suggest that college textbook publishers' current revision cycle regimes are approximately revenue maximizing. Our simulations show, for example, that students are sufficiently forward-looking that speeding up the revision cycle of biology textbooks (to match that of economics textbooks) would destroy revenues. These estimates, then, are *partially* consistent with Miller (1974) and others, who suggest that social welfare-destroying planned obsolescence strategies are limited by the forward-looking behavior of consumers.

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