Are Durable Goods Consumers Forward Looking?
Evidence from College Textbooks

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Abstract:

Popular wisdom holds that publishers repeatedly revise college textbooks in order to kill off the secondary market for used books. However, many neo-classical authors argue that, if consumers are forward-looking, such behavior should not be profitable; consumers' willingness to pay for new books will fall if they know that they can't resell their used books. Using a large new dataset on all textbooks sold in psychology, biology and economics in the 10 semesters from 1997 to 2001, we estimate a demand system for textbooks by college students and test whether textbook consumers are forward looking. Our estimates strongly support the view that students are forward looking and that, when they buy their textbooks, they take into account the probability that they will not be able to resell their books at the end of the semester due to a new edition release. The demand estimates do suggest, however, that students are overly optimistic in their forecasts and that there are also some important frictions in the market for used books that can affect publisher revision decisions. Simulation results suggest that students are sufficiently forward-looking that publishers cannot raise revenues by accelerating current revision cycles, even if revising were costless to the authors.

INTRODUCTION

The pricing and design of durable goods products has been the focus of enormous literatures in economics. Frequently, however, theoretical results contradict popularly-held views of durable goods industries on issues such as whether producers have an incentive to eliminate resale markets for their used products. One of the central tenets of the neoclassical economic approach to durable goods industries that frequently generates the differences is the assumption that consumers are rational and forward-looking. Popular wisdom and some research in behavioral economics question this assumption and thus question the results of the neoclassical durable goods literature.

The market for textbooks provides a textbook example, if you will, of the extreme difference between the popular and the neoclassical view. Publishers revise textbooks frequently and when they do, college bookstores almost immediately stop selling older editions. The popular view holds that publishers exploit students by introducing these new editions because they are trying simply to eliminate competition from inexpensive used books.[1] Traditional economic reasoning, as described in Friedman (1962) or Miller (1974) claims that this argument does not make sense ; forward looking consumers will pay less for new books if they cannot sell them back at the end of the year.[2] Indeed, under some standard assumptions about the market, the economists show that publisher revenues are invariant to the expected life of a college textbook so revisions must be driven by some other factor like updated content.[3] .

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 how forward-looking the buyers of college textbook are and the implications for publishers. Despite its status as a classic example of a durable good, the textbook industry has seldom been studied empirically.[4] We start by noting the many ways that the textbook market provides an ideal empirical setting to examine forward-looking behavior and other frictions in durable goods markets because it lacks many of the

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[1] See, for example, Fairchild (2004).

[2] For durable goods papers citing textbooks, see, for example, Miller (1974), Rust (1986), Waldman (1993), Fudenberg and Tirole (1998), and Waldman (2003).

[3] The important assumptions are that books do not change quality when they get revised, that books do not fall apart over time, that students do not want to keep their textbooks at the end of the course, that the used textbook market has no frictions, and that students are rational and forward-looking with the same rate of time preference as the textbook publishers.

[4] We have learned of one recent paper that examines textbooks as a durable good (Iizuka, 2004). This paper takes student myopia as a starting point, and examines the relationship between textbook characteristics and new edition time.

complicating factors found in other such industries. Then, we establish three basic results.

First, we show that the prices of new and used books remain fairly constant over the life of an edition, while the probability that the edition is revised (thus rendering the book unable to be resold to the campus bookstore) varies rather dramatically over the life of the edition and across fields. This means that the behavior of a forward looking consumer should change over the life of the edition in a way that the behavior of a myopic consumer should not.

Second, we estimate a demand system and show rather clear evidence that consumers are, in fact, forward looking. They take into account the probability that the publisher will revise a book later during the semester when deciding whether to buy books at the start of the semester and are more elastic in their new book purchases the higher is the probability that they will not be able to resell it.

Third, although they document forward-looking consumers, our estimates also reject the perfect environment modeled in Miller(1974) (and implicit in other models of durable goods) as the consumers seem to be overly optimistic about the likelihood of resale. Still, when we use our estimates of student demand to simulate the revenue effects of adjusting the revision cycle, our estimates suggest that students are sufficiently forward-looking that biology publisher revenues would fall if publishers tried to accelerate the revision cycle. Our simulations also suggest that the relative speed of revision cycles across fields (economics versus biology) correspond with our estimates of differences in demand parameters across the fields. They also suggest that publisher revenues do not vary dramatically with revision time regime (in the range of our data), in keeping with the neoclassical model.

The paper proceeds as follows. Section 1 explains why textbooks provide an ideal environment to test for forward-looking behavior among durable goods customers. Section 2 provides a description of the data. Section 3 examines new prices and new edition introductions in the college textbook market and the implications for the true price of textbooks. Section 4 explains the methodology and shows the empirical results about consumer demand. Section 5 examines presents our simulation estimates of publisher revision time strategies. Section 6 concludes.

I. Textbooks as a Durable Good: Industry Background and Previous Literature

A. Textbooks as a Durable Good: Theoretical Advantages

There are several theoretical and practical advantages to the textbook industry that make it an attractive place to test for forward-looking behavior of consumers. The theoretical advantages arise because textbook markets are exempt from some of the durable goods issues that arise in most other durable goods markets.

First, because each semester brings a new generation of students to the market to buy books and these students, essentially, decide at the beginning of the semester whether or not to purchase the assigned textbook for their class, there is little scope for delaying purchase of the good until the next semester. A significant literature in macroeconomics and industrial organization, including, for example, Caballero (1990; 1993) and Eberly (1994), focuses on consumers' transactions costs and S-s considerations in decisions regarding the timing of when to purchase or replace a durable product. As long as a students purchase their textbooks only at the beginning of the semester in which it is assigned, and only sell them at the end of the semester, we avoid the complications entirely.

Second, we can also reasonably ignore the standard time-inconsistency problems of the durable goods producer outlined in Coase (1972), Stokey (1981), Bulow (1982) or Gul et al. (1986) because it seems very unlikely that students would delay taking a class or purchasing a book in order to exploit expected future changes in the price of the textbook. Similarly, it seems safe to assume that students do not base a decision on when to take a class on forecasts of changes in the future quality of the textbook, eliminating the dynamic issues outlined in Melnikov (2000) or Carranza (2004).

Third, because quality differences between a new copy of a given textbook and a used copy of that textbook are readily observable at the time of purchase, adverse selection and the "lemons" problem of Akerlof (1970) are not especially relevant.

Fourth, when a new edition of a textbook is introduced, the consumer's decision of whether to upgrade to the new edition is fairly simple. Textbooks are frequently revised and the new edition kills off the old one almost immediately. In our data from college bookstores, we find that, after a single transitional semester, college bookstores simply do not sell used older editions of a textbook once the new edition has been published.[5] Most college bookstores claim this as a policy, arguing that faculty are frustrated when students rely upon editions other than the one assigned.[6] This, combined with the aforementioned fact that each consumer is effectively a potential user of a given textbook for only a single semester, implies that we can avoid considering consumer decisions of whether to consume the older or newer version of the product. These issues are

[5] This situation is beginning to change with the growth of used book sales on the Internet, a topic to which we return later.

[6] 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.

paramount for example, for consumers in the market for software and are discussed in work such as Levinthal and Purohit (1989), Fudenberg and Tirole (1998) and Viard (2004).

B. Textbooks as a durable good: Practical Advantages

In addition to the simplified theoretical setting of textbooks as a durable good, there are several factors that make textbooks an attractive place to do empirical testing, arising mainly from factors that simplify the estimation problem or facilitate data collection.

The first such practical advantage is that the purchase decision process for textbooks is done in two separate stages and that seriously limits the importance of cross-price elasticities between textbooks. Typically, the instructor decides what book to assign for a course. Next, the students decide whether to buy the assigned book (or a used copy of the assigned book). Students are unlikely to buy an alternative book, no matter what its price may be. In our estimation, we will examine student demand conditional on instructor assignment. This restricts the choice set for our estimation to something quite tractable.[7] In contrast, for many other durable products, one would ideally need to consider the substitution between *each* 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 order to estimate demand for new and used cars.[8] Copeland and Stevens (2004) face similar issues in their study of new and used highway rollers.

The second practical advantage of textbooks is that, despite the growth in online buying, the majority of new textbook transactions still happen at college bookstores. A survey by the National Association of College Stores estimates that only 6% of college textbooks were sold online in 2000 (our data will be for the 1997-2001 period). Our survey of 203 Yale College students enrolled in Econ 115a in 2003 showed that, of the 178 students who owned the required course

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[7] This feature of the textbook industry is, in principle, shared with some other industries, such as, for example, pharmaceuticals, where consumers have limited choice of which drug to purchase once a prescription has been written or Cable television where customers in a market can choose only between cable and satellite in their market not the cable system from a different geographic location.

[8] A 2004 Civic, for example, could have a different cross-price elasticity with respect to the 2003 Civic, the 2002 Civic, the 2001 Civic, and so on, as well as to the 2004 Corolla, the 2003 Corolla, the 2002 Corolla, etc. The difficulties of estimating such a model without extensive restrictions should be clear.

textbook, 130 had purchased it at the campus bookstore (and among those that had not, friends were the most likely source).[9]

A final practical advantage of the textbook market is that textbooks are an important category of spending by students. The Book Industry Study Group estimates that, in 2002, wholesale sales of college textbooks totaled some $4 billion. Fairchild (2004) surveys students throughout the University of California system and estimates that the typical college student spends $898 on textbook purchases each year, a non-negligible fraction of the typical student's annual expenses.[10] Indeed, because of the cost of textbooks and the transitory nature of demand by the students, it is not surprising that a well-developed used market exists. The National Association of College Stores webpage estimates that used materials accounted for 28.5% of course material revenues at college bookstores in 2003.

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), among others. The idea that textbook revisions might be motivated by an attempt to kill the market for used goods, has been discussed extensively, starting at least with Galbraith (1958). The idea has been criticized as inconsistent with rational forward-looking consumers by Friedman (1962) and Miller (1974) but defended in more recent models of obsolescence such as Waldman (1993).[11] A key point, however, is that if students are not forward looking, the publishers will have a much easier time of fooling them by constantly issuing new revisions.

II. Data

Our data come from the foremost data source in the industry—Monument Information Resources (MIR), a consulting company that collects data from college bookstores, creates databases and sells them to textbook publishers. We have access to a sample including all textbooks in the fields of economics, biology and psychology. Our sample includes semester level information from

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[9] One might ask why the campus bookstore remains so important. One reason is that the bookstore allows students to obtain the book quickly. Another is that bookstores generally allowed books to be returned (as new) several weeks after purchase if the students show proof of dropping the assigning course.

[10] 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 year in 2003.

[11] 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 choices made at the time of production.

1997 to 2001 (10 consecutive semesters). Over the whole time period, a total of 1698 schools are included in the data.[12]

The main limitation of our dataset is that it covers college bookstore sales, but not sales through other channels. As discussed above, fortunately Internet retailers were negligible during this period. However, when examining used books, it is important to keep in mind that informal sales of used textbooks between students may be important. In our survey of Economics 115 students at Yale in 2003, 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: the semester and year of the course, the course number at the school, the name of the course, the instructor's name, MIR's course category classification, and, crucial for our purposes, the number of students estimated to be enrolled in the course when the instructor places his or her book order, and the actual enrollment in the course.[13] The assignment data contain the textbook(s) assigned for each course as well as an indicator that defines whether each assigned book is required for the course or optional. These data gives us an estimate of how many students were assigned a given textbook in a semester.

We merge the assignment data with the second MIR database, the sales data. The sales data sums, for each semester, the sales of each textbook across all schools. MIR does not provide us data on sales at the individual school level. Importantly, however, the bookstores surveyed for assignments each semester are the same ones in the sales records for that semester. So to the extent that we can sum the assignments over all of those schools, we can compare sales to assignments. In practice, we cleaned the sales and assignment data to fix any obvious coding errors such as enrollments 10 times larger than the entire student body of a school, and so on.

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[12] 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.

[13] 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.

When considering the propensity of students to purchase assigned textbooks, we will also consider student characteristics at schools that assign the book. To estimate these characteristics, we use data from the 2000 College Board survey and match them by name and location to the MIR data. For this study, we use information from the College Board on the size of each university or college, the mean SAT scores, and the fraction of students commuting to the college or university rather than living in university housing.[14]

We do need to do two types of interpolation to match up all these data sets comprehensively. First, 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, though, 575 still had no data. For all schools, though, the College Board data categorizes the school by selectivity and 2- year versus 4-year status. The schools missing SAT scores were mainly open admission 2-year community or junior colleges. For these schools we assigned the mean SAT score of other schools in that category.

The second interpolation relates to the assignment data. The data provide enrollments but the *actual* enrollments are quite frequently missing so we will instead use the estimated enrollment (which is estimated by the instructor at the time the book is ordered by the bookstore). Even this estimated enrollment is occasionally missing. In those cases, we know the book assigned, but not the number of students. Since we are summing the assignments across schools and compare the total assignments each semester to the aggregated MIR data on total sales across all the schools, we cannot simply drop schools from study for which the instructor estimated enrollment data is missing. So, for courses for which estimated enrollment is missing, we impute it using school-level predictors of enrollment for each of the 121 unique courses in the three disciplines under study identified by MIR. For each of the 121 courses, we regress school-level total enrollment (using all the schools for which we have the enrollment data) on the university's total enrollment, squared total enrollment, female enrollment, the school's mean SAT score and its square, dummies for the type of institution in the College Board classification system, and interactions of those dummies

[14] In principle, the College Board data also contain more detailed information about each university, such as distribution of students across majors, financial aid, etc. These data are often missing, however, so we will only use them sparingly.

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.

For the analyses in this paper, we examine new and used sales for a textbook in a given semester relative 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”. We have information for each school-course whether the book is required or optional and we use it to compute a "fraction required" variable. 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 with increasing frequency, 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 textbook alone do not have the same product code identifier (ISBN number), they are effectively the same book. Thus, we hand-identify such books as being in the same book family. The second complication 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” measure, 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.

Finally, we make some effort to distinguish between true textbooks and trade books that are frequently assigned as textbooks—a popular book that gets assigned to a class but whose primary market is not students. Publishers are clearly going to behave differently in those cases since there is a wider market they must consider. Because of this limitation, we will often examine the robustness of our results to including only the sample to books whose new price is $40 or more. This rules out virtually all trade books. This is a crude correction but there is no better way to solve the problem given the nature of the data. Of course, this problem would likely be much more of an issue in a field like English or history, where there are many trade books assigned as textbooks.

We also collect data about the format of the textbook: paperback, hardcover, spiral bound, etc. We do this by searching on Amazon.com by ISBN number. For this analysis, we use these data to form a dummy variable which takes the value one when a book is paperback and zero otherwise.

We present summary statistics for the variables in our sample in Table 1.

III. Implications of Prices and New Edition Introductions for Forward-Looking Consumers

Our goal is to determine how forward looking durable goods consumers are in this market. The basic idea is that the true price of a new textbook embodies two components. The first is the purchase price. The second is the amount the book can be resold for at the end of the semester. Thus, the true price of a new book is:

$$P_{TRUE} = P_{NEW} - dP_{RESALE}$$

where d is the student's discount factor. We will see that in the textbook market, the relative importance of those two components change rather dramatically over the life of the book, even though the first component, the new price, changes very little, if at all. A myopic consumer will only be looking at the purchase price while the forward looking consumer should be taking into account the amount for which they can resell the book at the end of the semester.

A. Purchase Prices of Textbooks

The approach one might at first consider taking in estimating demand in such a market would be to examine changes in the relative prices of new and used books over the life of the edition. However, in reality this is not possible as prices are, for the most part, fixed over time.

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 sold used textbooks at a price equal to exactly 75% of their new textbook price.[15] We also visited the websites of many college bookstores that offer pre-ordering of college textbooks online (for in-store pickup) and these stores all priced used books at 75% of the new book price.

It is not clear why this should be true, though an interview with executives from a chain that operates hundreds of college bookstores in the U.S. indicated that many universities that contract out their bookstore actually require

[15] For almost all bookstores this is just the list price though there are a few, such as the Stanford bookstore, where new textbooks are sold at a small discount.

the store to set used book prices at 75% of the bookstore's new book price.[16] In our dataset, a basic regression of the used textbook price on the new textbook price yields a coefficient of 0.74 with an R-squared of 0.99. Given this pricing rule, there is no practical way to estimate a cross-price elasticity of demand between new and used books. Further, our interview with executives at the large bookstore chain also suggests that college bookstores *generally* sell out of used textbooks at the 75% price. In order to cope with the institutional features of this market, in the analysis below, we consider mechanisms for modeling the rationing of used books.

Given the fixed relative prices, the ratio of used books to book assignments creeps up over the life of the book, while the ratio of new book sales to assignments falls over the life of the book, as the supply of available used books rises. Figure 1 shows this pattern over the life of the book for the sample of introductory textbooks over $40.

The buyback price of bookstores is similarly inflexible. Our surveys and interviews suggest that most large college bookstores will buy back any book that is being used on campus in the subsequent semester for 50% of either the current or previous new price. Generally, most end-of-semester sellback events also have a table with representatives from one of the three major used college textbook wholesalers. If a book has not been reordered for the subsequent semester at that campus, students are referred to the wholesaler for a buyback price.[17] These wholesalers generally offer prices in the range of 25% of the new price, although this price can be lower, if the wholesaler has "enough" of a given textbook in stock.

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 the pricing rule is such that book wholesalers almost always ration the used textbooks resold to retailers. The textbook retailers in turn sell the used books at 75% of the new book price, creating used book stock-outs at the retail level.[18]

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[16] This interview was conducted in August of 2004 but the company prefers to remain confidential.

[17] Many of the smaller college bookstores have a buyback in which the bookstore is not involved at all. Students simply sell their books to one of the textbook wholesalers.

[18] Given the fixed pricing regime, one might ask whether the marginal profitability of an additional new book and an additional used book are equal. 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

Almost no one in the college bookstore supply chain is willing to buy or sell a used book for an outdated edition beyond one transitional semester.

Thus, used prices and sell-back prices are, to a first approximation, a constant share of the new price. In table 2, we go further and show that the new price itself is essentially constant over the life of the edition. Intuitively, one might expect that the used price and new price would vary depending on how long the current edition has been available (both because of the declining asset value of the book and because of the growing stock of used books available). This does not work out to be the case. We estimate a regression of the form:

$$\ln(P_{jt}) = \sum_{k=1}^{8+} g_k I_k + \Gamma\, Time_{jt} + k_1 Spring_t + k_2\, Avshrink_{jt} + \sum_{m=1}^{J} B_m + u_{jt} \quad (1)$$

where $\ln(P_{jt})$ is the natural log of the new price of book j at time t, Spring is a dummy for the spring semester, and Avshrink is the share of books shrink wrapped with something else such as CD-ROMs, study guides, etc. The I_k dummies index the age of the edition for a given book. 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 will 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 (i.e., new) is the omitted category. Importantly, we also include book fixed effects denoted by the B variables.

We can include time controls in two ways. First, as in column (1), we can simply allow a linear time trend to allow prices to drift up or down in average prices of all books over time. Second, as in column (2), we can allow a different dummy for every time period (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 together books for which more than 8 periods

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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. An industry source pointed out to us that most retail leases involve payments as a function of gross revenues (i.e., not profit) so under the current pricing regime, 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 than new ones.

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 seldom-revised books such as the *Marx-Engels Reader* or the *Selfish Gene*.

In both of these cases, we see that the price of a new book is essentially unchanged over the life of the edition. There is certainly no evidence that prices fall for new textbooks (as one might expect given the rising competition from used books, for example), and the increases in prices over the four years of about 4 to 5 percent is, basically, at the level of inflation. Finally, in column (3) we restrict attention to books costing more than $40 in their first year (as a crude mechanism to eliminate trade books). Again, we find prices essentially constant over the life of the edition. Given the fixed relationship of used to new prices, this same regression on used prices gives almost identical results so we do not report it here. These results are all robust to alternative specifications of the timing, such as including a continuous variable for edition age, or including the probability of book death.

This pricing behavior is potentially puzzling. Publishers we have spoken to claim that the professors assigning the textbooks get upset when they see the price of a book they have assigned declining over time since they required their students to buy it at the higher price and express fear of upsetting the professors choosing what book to assign. We will not attempt to explain the pricing behavior here but will instead just take the prices as given for the students choosing whether to buy the book. Even if one does not believe the sotry put forward by the publishers, it is worth noting that others have found similar pricing behavior for information based durable goods like software (e.g., the price of windows does not change much in the periods prior to a new windows edition being released).

B. Future Resale Value of Textbooks.

Demand estimation may seem particularly daunting in that we have shown that, over the life of an edition, the price of new textbooks do not much vary, that prices of used textbooks and the buyback prices of textbooks basically do not vary. However, one thing that does vary greatly over the life of an edition is the probability that the edition will be made obsolete by a revision. If that happens, the buyback price for students holding the obsolete book essentially falls to zero. If students are forward looking, they should certainly consider whether or not they are likely to be able to resell their textbooks.

To illustrate the likelihood of revision given the age of the edition, we first focus on textbooks in our dataset designed for introductory courses—the most homogenous set of textbooks we have. Figure 2 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 a required book for at least 70% of its assignments 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 2 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 introductory 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.[19]

The survival data show interesting patterns in the characteristics of textbook new edition introduction behavior. Table 3 reports a Cox proportional hazard model on the book survival data. The form of the hazard is assumed to be:

$$h(t) = h_0(t)\exp[(Intro_j)f_1 + (Econ_j)f_2 + (BIOj)f_3] \qquad (2)$$

Where $h_0(t)$ is the baseline hazard. The explanatory variables included in equation (2) 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 3.

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

[19] 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 killthe 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 not the primary determinant of the timing of new edition introductions.

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 3 adds an additional variable to the specification in Equation (2). This variable, $EXPENSIVE_i$ 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 choose 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 is possible 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 for each textbook of the mean SAT scores of students at the institutions assigning that textbook. Contrary to the hypothesis however, it appears that books designed for higher SAT students have slower revision times, although the effect is not statistically different from zero.

Given the changing hazard for a book throughout its revision life, it is clear that true price of buying a book will be changing over time, as the probability that the book will not be resellable is rising sharply over the first few year's of a book's existence. For a book that costs $100, say and can normally be resold for $50, the forward-looking price is something like $100-$50=$50 (assuming no discount factor for the moment). In a semester in which the book will be revised and cannot be resold, the price will effectively double to $100. It is this change in the price that affects forward-looking consumers that we will use to identify whether and how accurately consumers consider the probability of new editions in making textbook purchasing decisions.

One might worry that competition from used books and the probability of a new edition are both increasing over the life of the book; both of these factors might lead to consumers' becoming more elastic in their new book purchase decisions, over the life of the edition. This would make it difficult to disentangle the extent to which consumers are forward-looking. However, as we explore in more detail later, the effect of the new edition probability on demand is likely to be separately identifiable from the competition from used books because the time pattern of the availability of used books does not resemble the revision hazard. The availability of used books grows steadily over time, while the revision hazard peaks sharply at around three years, especially for introductory books.

IV. Demand Relationship

An important feature of our data is that we separately observe 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:

$$u_{ij} = x_{jt} b - a r_{jt} + x_{jt} + e_{ijt} \qquad (3)$$

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

Of course, we do not directly observe the rental price of the book but only the selling price. Both the selling price and the expected resale price together determine the rental price of the book. However, we do observe measures of the probability that a student in a given semester will or will not be able to sell back the book from our hazard estimates above. Using the probability that the books survives and thus it is feasible to sell it back, we can construct a proxy for the expected future price of the book. Call DIEj to be the probability that the book cannot be sold back because the book gets revised. Let the expected sell back price be a fraction m of the purchase price and let d be the student's discount factor.

Then the student's utility can be written:

$$u_{ijt} = x_{jt} b - a(p_{jt} - dm((1 - DIE_{jt}) p_{jt})) + x_{jt} + e_{ijt} \qquad (4)$$

or

$$u_{ijt} = x_{jt} b - a p_{jt} + a dm(1 - DIE_{jt}) p_{jt} + x_{jt} + e_{ijt} \qquad (5)$$

There are two complications that may lead to concern that the model above does not fully capture the utility of college textbook buyers. First, 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). One specification of this is to alter (5) to be:

$$u_{ijt} = x_{jt}b - ap_{jt} + adml(1-DIE_{jt})p_{jt} + x_{jt} + e_{ijt} \qquad (6)$$

where l 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.

The second complication is somewhat trickier to deal with and that is the fact that some students may value their books enough that they do not want to resell them. For these students, it is rational not to consider resale of the books when making a purchase decision. To keep things simple (and due to various practical limitations in our data) we consider a scenario with two types of students. The typical student has the utility as specified in (6). These are type 1 students. Type 2 students, the bibliophiles, have utility:

$$u_{ijt} = x_{jt}b - ap_{jt} + x_{jt} + e_{ijt} \qquad (7)$$

Note that, in constructing (7) we assume that the pragmatists and bibliophiles value other characteristics of books identically.[20]

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 e_{ijt} has an extreme value distribution). Consider first a scenario in which all students are the mercenary type 1s. Then, following the standard Berry (1994) inversion for aggregate data, this provides the following equation determining

[20] Some readers might note a similarity between this setup and the setup in Berry, Carnall, and Spiller (1997), where they examine discrete types of airline travelers, "leisure" and "business". We are similar to them in that we are limiting our attention to two types, rather than a continuum of types. However, their framework is very different in that their two types of travelers actually pay different prices for their tickets That is, high priced tickets and low priced tickets both appear in the data, and the high-priced tickets presumably have fewer unobservable (to the econometrician) restrictions. They allow the different type consumers to have different preferences for all of the characteristics. Given our data, this would be infeasible.

the share, s_j, of students who buy the book and the share, s_0, of students who consume the outside good:

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt} b - a p_{jt} + a d m l (1 - DIE_{jt}) p_{jt} + x_{jt} \qquad (8)$$

In a scenario in which a fraction t of students are of the type described in (6) and a fraction 1- t are as described in (7), then the market shares are an appropriately weighted average of the market shares given in (8) and the market shares given by:

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt} b - a p_{jt} + x_{jt} \qquad (9)$$

Given that we assume that the ß's, a's, and x_{jt}'s at the same across both consumer types, this collapse down to:

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt} b - a p_{jt} + t a d m l (1 - DIE_{jt}) p_{jt} + x_{jt} \qquad (10)$$

Of course, while this demand equation can be easily estimated, we obviously cannot separately identify t,d , m, or l . However, as we will show below, market data give us decent empirical proxies for t,d , and m, and we will thus be able to roughly calibrate the magnitude of l which will suggest how accurately forward looking the students are.

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 with other things, editions bundled with study guides or other ancillary material. Students may or may not value the ancillary material.

As proxies for the difficulty 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.[21]

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 (10) 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 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 “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 (10) 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 (10) for new books 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.

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[21] 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.

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 b 's) and demand elasticities (a) 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.[22] 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 (10) above can be estimated, but the share s_j is calculated as (total new sales + total used sales)/total assignments. We estimate Equation (10) 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.

The last hurdle to estimation is the familiar endogeneity of price, and thus also the interaction of price with the probability of revision. In the absence of rationing, we would jointly estimate supply and demand. Given the complications posed by rationing, however, we must settle for estimating demand alone using 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

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

interactions between the basic instruments and the years since revision (elapsed time).

GMM estimation results for (10) 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. 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.

The estimated value of dml t is the ratio of the coefficient on the interaction term to the coefficient on the price term. Her it is about 0.80. There are two things to note about this coefficient. First, the canonical Miller (1974) model assumes publishers have the same discount rate as the students. In reality, the publishers semester level discount rate is likely to be close to one so our demand estimates suggest that, in effect, the resale value of the book is undervalued relative to the Miller environment (and suggest that optimal book lifespans will we be shorter here).

Second, although we cannot separately identify the parameters, we can reasonably assume that students expect to sell back the book for somewhere between 50% and 75% of the new price (i.e., that m is between 0.5 and 0.75) since that is the bookstore used book buyback and used book sale price. 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). Estimates of t (the share of people that want to keep their books at the end of the semester) are harder to come by. We can generally bound it, though. First, if we look at the sales of used books in an editions' second full semester (so there is only one previous semester's worth of used books available), we find used book sales through bookstores were about 48% of the previous semester's sales.[23] Given that many of used books are also sold informally, this provides a lower bound for t. Second, an executive at a leading textbook publisher estimated for us that in extreme circumstances like required math courses, the share of people selling their books can be 75% or more so this provides something of an upper bound.[24] These values imply the product dmt in the range of .25 to .5625. Since the implied product of all the terms was .8, the implied ? is between 1.4 and 3.2. Perfect foresight would put ? at one so our results suggest that students are

[23] We excluded lab manuals and any books whose fraction required was lass than 90% in order to be sure we had traditional textbooks for this computation.
[24] Estimated by Craig Bleyer of Bedford, Freeman and Worth, correspondence on January 5, 2004

forward looking but are, perhaps, overly optimistic about the expected future resale price of the book or the probability that they will be able to resell their books at the end of the semester. They are clearly not myopic, however.

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). Column (2) 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.

The results in column (3) present the efficient rationing specification. Notice the small elasticities implied by the coefficients in Column (3). 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. The coefficients imply again that students are definitely forward looking but overly optimistic about the expected future resale price or survival probability of the book .

In columns (4) and (5) we include book dummies. Here we are explicitly looking at the same book across time rather than looking across books in the same sub-market. The interaction of price with the survival probability is still identified without a problem in the data. To the extent that the price of the new book is literally constant over the edition life, the price coefficient would not be separately identifiable from the book dummy. In column (4) we do not include the own price. The coefficient on the interaction continues to show significant evidence of forward looking behavior on the part of the consumers. In column (5) we include the price term separately. We are a bit leery of this given that the price changes outlined above are small and that most of our instruments are constant for a book across time but using the small amount of variation we have shows results remarkably similar to the results without the book dummies. Here the ratio of the two coefficients is .54 so the implied ? is between .96 and 2.16. Once again the consumers are forward looking and perhaps a bit over-optimistic, though here even closer to perfectly foresighted, and certainly not myopic.

Table 5 considers alternative ways of specifying the probability of book death, and also shows that the rising elasticity is probably not caused from a rising stock of competing 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.

The second column of Table 5 shows a specification in which a proxy for the stock 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. The coefficient on the survival probability terms remains positive and significant.

One possible source of concern with our estimates is the possibility that there identifiable subgroups of consumers that are more or less price elastic, more or less inclined to resell books, or more or less forward-looking. We examine the robustness of our estimates to three kinds of consumer heterogeneity. First, we consider the possibility that richer students might behave differently than poorer ones and might be more price elastic. The College Board data provide an estimate of the fraction of students at each school in our college bookstore sample who are commuters. Commuters may be different from other students in that they may be more likely to be paying for their own textbooks (versus their parents) and have generally shown a propensity to save costs by commuting to school.[25] We generate a variable CommuterDev for each textbook. Since our data on sales is aggregated to the book level, we must translate the College Board data on fraction commuters at each school into a characteristic of the assigned textbook. Our variable CommuterDev is the weighted fraction of commuters at the schools assigning each textbook (with the number of assignees as the weights) minus the overall mean fraction of commuters for assigned textbooks in the dataset. We subtract the overall mean in order to give CommuterDev a mean of zero.

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[25] We contemplated other measures, but the commuting ratio is reported by the College Board for almost all schools. Various measures of financial aid provision are more sparsely reported. We considered tuition charges as a proxy for income, but it is not obvious to us, given both the selection and the actual tuition costs whether the families of students at cheaper schools generally have more or less discretionary income available for books after tuition charges are paid.

We reestimate the basic logit specification of Equation 10, including commuter effects. The new specification contains all of the variables included in the basic logit specification of Equation 10, but also includes an interaction between CommuterDev and Price, and CommuterDev and Price x (1-DIEPROB). The results are shown in Column 1 of Table 6. In the interest of space, we display only the coefficients for Price, Price x (1-DIEPROB), and those variables interacted with CommuterDev.

The results suggest, perhaps unsurprisingly, that demand is, indeed, more elastic for books assigned to commuters versus non-commuters (although the effect is statistically significant at only the 12% confidence level). However, there is no significant difference between the commuters and non-commuters in sensitivity to the sellback probability. They appear to be equally forward looking.

We secondly examine the robustness of our results to differences in elasticities across high and low SAT students. Some people argue that more advanced students are also more likely to keep their books rather than selling them back at the end of the semester or that they are likely to be more forward looking. Again, we rely on school characteristics from the College Board, but convert them to textbook characteristics. The variable SATDEV is defined for each textbook as the mean SAT score of schools assigning the textbook (weighted by the number of assignees) minus the overall sample mean SAT score of assignee schools in the dataset. Thus, SATDEV has a mean of zero.

Once again, we reestimate the basic logit specification of Equation 10, including SAT interaction effects. The new specification contains all of the variables included in the basic logit specification of Equation 10, but also includes an interaction between SATDev and Price and an interaction between SATDev and Price x (1-DIEPROB). The results for the price coefficients are shown in Column 2 of Table 6. There is no significant difference as SAT scores vary in either the price or the sellback probability coefficient. The simplest explanation is that the tau and the forward lookingness are the same across schools.

Finally, we investigate the possibility that sellback probabilities differ substantially across fields. The received wisdom in the publishing industry is that students are less likely to resell books in biology, in part because students use the books later to study for premedical examinations. To examine this, we reestimate the basic logit specifications in Equation 10, but interact the price variable and the Price x (1-DIEPROB) variable with each of the three field indicator variables. The results for the price coefficients are shown in Table 7. The results suggest that biology and psychology students are somewhat more price-sensitive than economics students. The ratio of the coefficients on sellback probability and on price are .71 in biology, .75 in psychology and 1 in economics. Thus if the other parameters are constant across fields (the relative sellback price of the book, m, the discount rate, d, and the forward lookingness, ?) then the share of students trying to sell back their books at the end of the semester are about 30-40% higher in economics than in the other fields. The standard errors on these coefficients, however, mean that we cannot reject the hypothesis that they are all the same.

V. Implications for Publisher Behavior

Our results, then, show that students are definitely forward-looking when they buy their textbooks but that they are, perhaps, overly optimistic on the probability that they will be able to sell back their books at the end of the semester. Given this behavior, an important question is whether they are sufficiently mistaken in their beliefs that publishers could take advantage. Using the estimates from Section IV, plus some 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 assignment behavior is affected by the age of an edition. Teachers may prefer newer material, for example, irrespective of the economic considerations. For the purposes of our calculations below, however, we will assume that edition age has no impact on faculty assignment behavior, leaving that issue for examination somewhere else.

Remember that in the canonical forward looking model of Miller (1974), the rationality of the students means that the publisher's revenue does not vary with the length of the revision cycle. To illustrate the point, take an example where the students' willingness to pay for a semesters' worth of use of a textbook is $10 and their discount rate is r. If new books were issued every semester (making reselling of old books impossible), publishers could sell new textbooks for $10 each period. If instead, books were never revised and could be resold forever, new textbooks could be sold for a price of $10/r. The present discounted value of revenues will be $10/r either way. This is quite different than in a purely myopic model where the publisher stands to gain a great deal by accelerating the revision cycle.

In this section, we consider a representative 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 III, we estimated the new edition hazard for textbooks with those characteristics. Using the demand estimates in Section IV, 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.[26] First, if new editions are introduced more frequently, then the sales of used books drop to zero more frequently. If the age of the edition directly impacts students' propensity to buy the assigned book (as in the demand results above), then the frequency of new editions will directly impact sales of the new book. Finally, if students are forward-looking and understand the change in the revision hazard, the change in the sellback probability will affect their demand for the new book. In the case of a faster new edition hazar d, the first two effects will tend to increase publisher sales of new books, while the third will tend to decrease them.

For this calculation, we examine compare 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 (10). 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 simple regression specification. We estimate r and ? in the specifications:

$$(s^{used}{}_{jt}) = ETIME_{jt}\, r + \sum_{k=1}^{J} I_k q_k + e_{jt} \qquad (11)$$

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 an d the I_k's are book fixed effects. Because the fields potentially differ in the desire of students to keep the books, we estimate (11) separately for economics and biology textbooks. Our estimate of r for

[26] We model the revision cycle as a hazard function rather than a specific number mainly because that is how we estimated things above but also because any publisher will tell you that although one can demand that a faculty author to produce a book by a specific date, the actual arrival time is uncertain.

economics textbooks is 1.6 times our estimate of r for biology textbooks. As expected, used book sales build up more slowly in biology than in economics. Using our estimates of r for biology textbooks and economics textbooks and our example of a book that is assigned to 7000 students each semester, we can then generate a predicted number of used book sales for each book age.

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 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 new introductory economics textbook book, a 1-semester old book, etc.

In order to calculate revenue effects, we consider a hypothetical economics hardcover book and a hypothetical biology hardcover book that start out in the new (zero-semester-old) state. Each book ages but may return to the zero-semester old state at age. The probability of that varies with the edition age following the hazard functions we estimated above. 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, we can add up the predicted level of books sold in each period for each of the transition matrices.

Table 8 shows these results. The upper panel compares sales of a biology textbook following the actual biology revision hazard to sales of a biology textbook following the faster economics revision hazard. The lower panel compares sales of an 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 8, 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.

The simulation in Table 8 suggests that present discounted revenues are fairly similar under both revision hazards. That is, for this relatively small change in expected revision times, expected revenues are relatively flat, consistent with the prediction of the canonical model. Further, to the extent that there are the differences in revenues across the two, the revenues are higher for biology textbooks under the actual biology schedule, and for economics textbooks under the actual economics schedule. This stems largely from the fact that our estimates in Equation (11) suggest that used books build up more quickly in economics than in biology. Remember that the optimal revision time balances the falling new book sales over the edition life against the effective increase in elasticity 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 suggest that publishers are, perhaps, following the correct course in their revision schedules. The idea that publishers of biology books might not increase revenues by speeding up their revision cycles may be somewhat surprising to some industry observers (including college bookstore owners that we interviewed). These observers have suggested that only thing preventing publishers from adopting faster revision times is resistance from the authors to doing the extra work. Our estimates suggest that students are sufficiently forward looking that speeding up revision cycles would lower revenues for biology textbooks, even if authors faced no costs of revising their work.

Our results for economics publishers suggest however, that, even ignoring from any faculty taste for updated material, and ignoring revision costs, the optimal lifespan of the college textbook is not infinite. This is consistent with survey evidence (see Fairchild 2004), which suggests that faculty members believe that revision cycles are too fast to be justified by demand for new material.

VI. Conclusions

In this paper, we examine durable goods production and consumption in the empirical setting of college textbooks to test for forward looking behavior. We find clear evidence that college students are forward-looking and consider their ability to sell-back textbooks at the end of a semester when they are buying the book at the beginning of the semester. The clarity of their forward looking behavior, however, is not perfect and they seem to overestimate the likelihood of being able to sell back their books. Our estimates suggest, though, that the students are sufficiently forward looking that college textbook publishers' could not increase revenues by speeding up their current revision cycles to take advantage of the student errors. Our simulations show, for example, that students are sufficiently forward-looking that if publishers accelerated the longer revision cycle of biology textbooks to the shorter revision cycle of economics textbooks, they would lose money.

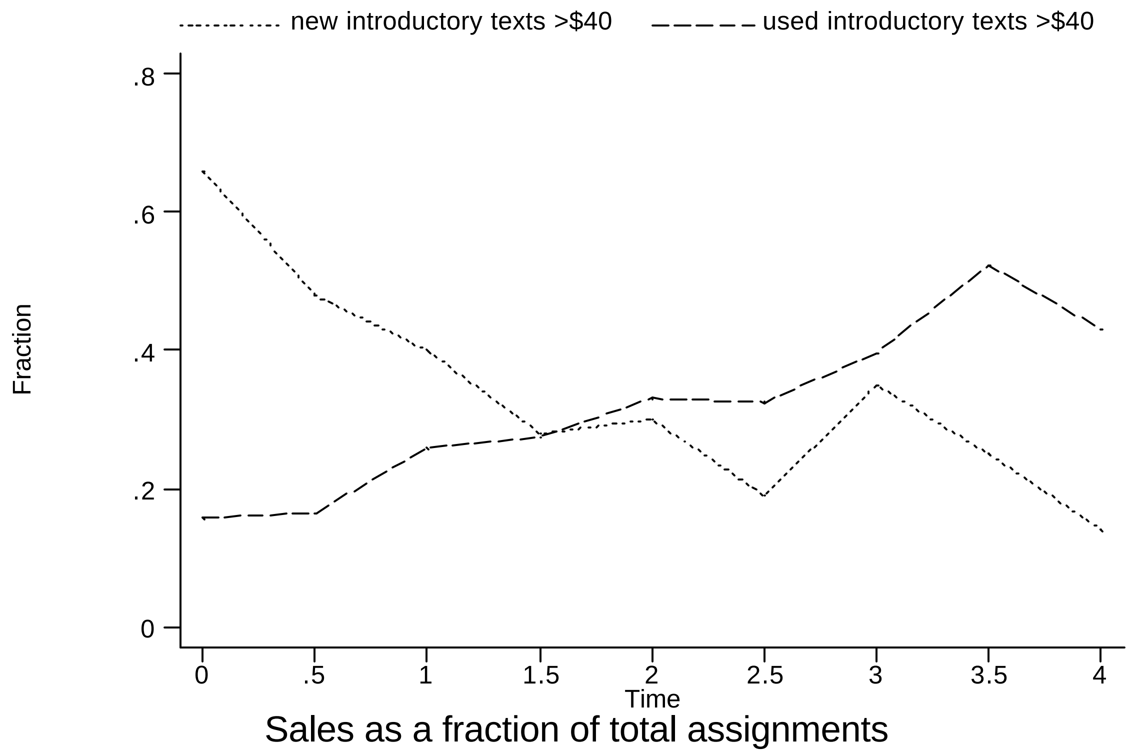

Figure 1: Figure one shows the path of new book sales divided by assignments and used book sales divided by assignments over the life of a book. Time measures the age of a book in years (with each semester representing a half year). The sample is introductory economics, psychology, and biology textbooks that cost more than $40 (on average over the life of the book).

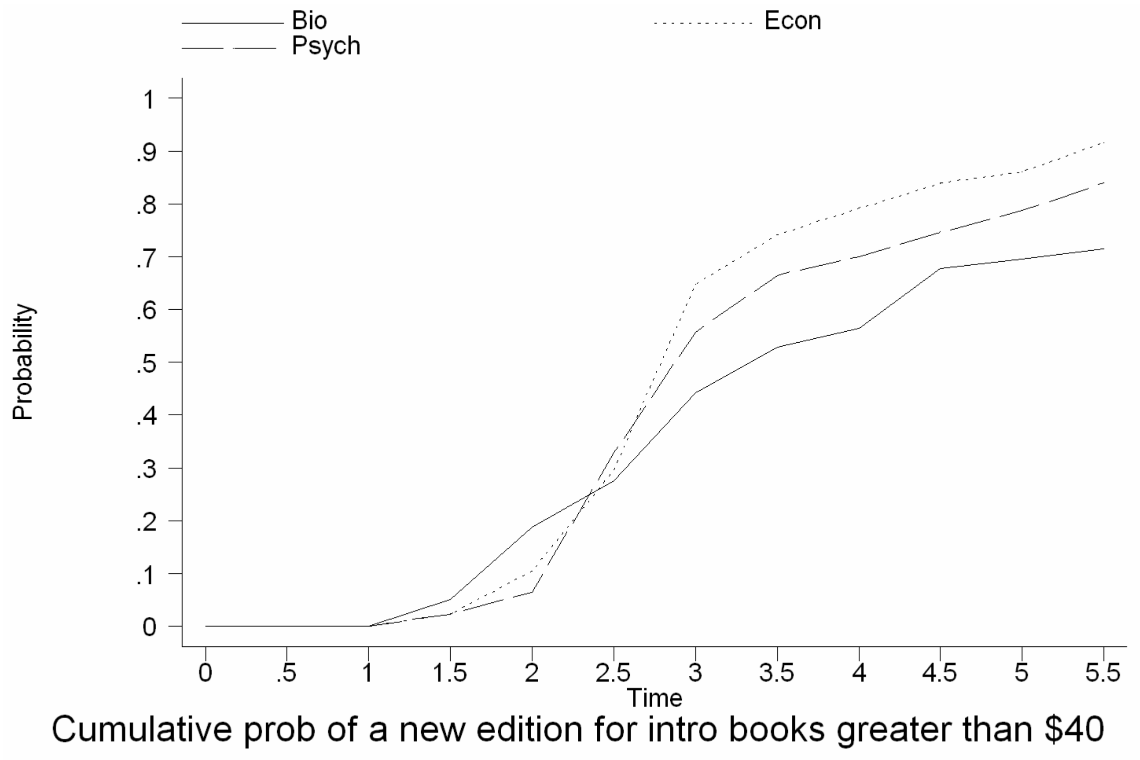

FIGURE 2: Figure two shows the cumulative probability of a new edition over the life of the edition. Time measures the age of the edition in years (where a semester represents a half year). The sample is limited to introductory textbooks in economics, psychology, and biology that cost greater than $40 (on average over the life of the book).

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

Table 2

Independent variables	(1)	(2)	(3)
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			
Elapsed time			
SPRING	-0.0072		-0.0059
	(0.0017)		(0.0019)
SHRINK %	0.031	0.030	0.036
	(0.007)	(0.007)	(0.007)
TIME_ID	0.053		0.063
	(0.001)		(0.001)
Constant	3.692	3.981	3.967
	(0.005)	(0.006)	(0.006)
Book fixed effects?	Yes	Yes	Yes
Time fixed effects?	No	Yes	No
Sample	All	All	>$40
N	11733	11733	8793
R-squared	0.989	0.989	0.927

Table 2: The dependent variable is ln(new price). Standard errors are in parentheses.

Table 3

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

Table 4

Independent variables	(1)	(2)	(3)	(4)	(5)
Price	-0.0622	-0.0063	-0.0595		-.0527
	(0.0048)	(0.0029)	(0.008)		(.0187)
P x (1-DIEPROB)	0.0499	0.0075	0.0425	.0387	.0284
	(0.0046)	(0.002)	(0.004)	(.0052)	(.0061)
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	.3598	.5429
	(0.00002)	(0.00002)	(0.00003)	(.1100)	(.1218)
SPRING	-0.072	-0.208	-0.0628	-.0388	-.0722
	(0.045)	(0.027)	(0.044)	(.0406)	(.0447)
AVSAT	0.0008	0.0004	0.001	.0027	.0028
	(0.0003)	(0.0002)	(0.0004)	(.0003)	(.0005)
FRACREQ	1.656	1.706	1.301	.6196	.6087
	(0.201)	(0.145)	(0.182)	(.1073)	(.1038)
EDAGE	-0.049	0.0012	-0.092	-.3271	-.1065
	(0.007)	(0.004)	(0.0136)	(.0130)	(.0726)
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	All	All
Model	Logit	eff ration	logit	logit	logit
N	11464	11464	8612	12391	12391

Table 4: Logit demand specifications estimated using GMM.

Table 5

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.

Table 6

Independent variables	(1)	(2)
Price	-0.066	-0.067
	(0.004)	(0.004)
Price x (1- DIEPROB)	0.046	0.047
	(0.004)	(0.004)
Price x (Frac commute-mean frac commute)	-0.0004	
	(0.0003)	
Price x (1 - DIEPROB) x (Frac commute-mean frac commute)	0.0002	
	(0.0003)	
Price x (SAT-mean SAT)		0.000025
		(0.00005)
Price x (1 - DIEPROB) x (SAT - mean SAT)		0.00006
		(0.00005)
Sample	All	All
Model	logit	Logit
N	11456	11464

Table 6: Table 6 estimates the robustness of the specifications in Table 4 to the inclusion of terms measuring consumer heterogeneity.

Table 7

Independent variables	
Price x Bio dummy	-0.083
	(0.011)
Price x Econ dummy	-0.039
	(0.007)
Price x Psychology dummy	-0.072
	(0.005)
Price x (1 - DIEPROB) x (Biology dummy)	0.059
	(0.013)
Price x (1-DIEPROB) x (Econ dummy)	0.039
	(0.006)
Price x (1 - DIEPROB) x (Psychology dummy)	0.054
	(0.007)
Sample	All
Model	logit
N	11466

Table 7: Table 7 estimates the robustness of the specifications in Table 4 to the inclusion of terms allowing for heterogeneous behavior across fields.

Table 8

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	0.90	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

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