

# An Empirical Analysis of Planned Obsolescence\*

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## Abstract

This paper examines planned obsolescence using new data from the textbook market. The conventional view suggests textbook publishers periodically revise editions to kill-off used textbooks. However, economists have also argued that it is not necessary because initial price alone can capture the present value of all future transactions. I find that publishers revise editions more frequently when competition from used textbooks increases. However, hazard rates increase as textbooks become older, suggesting that publishers may also revise editions to keep the content up-to-date. These two factors are important in magnitude, indicating publishers' frequent revisions cannot be attributed to planned obsolescence alone.

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# 1 Introduction

Durable goods producers face potential competition from used units because of the long-lasting nature of the products. To avoid such competition, firms may “kill-off” used units by introducing a new version of the product, which makes the used units economically obsolete. Such behavior is referred to “planned obsolescence.” Often cited examples include auto manufacturers and textbook publishers, both of which periodically introduce new products. On the other hand, economists have also argued that used units do not compete with new goods since the price of new goods reflect the present value of all future services of a product (e.g., Swan (1980)). This suggests that manufacturers have no incentive to kill-off used units, and the periodic introductions of new models may be motivated by other reasons. For example, firms may need to introduce new products periodically, because, otherwise, the demand for their products may decline as technology and/or information content becomes outdated.

In contrast to a large theoretical literature on planned obsolescence, empirical examination on the same has been very limited. This is primarily due to a lack of data on used markets. Using a new data set containing information on new and used textbook transactions, this paper attempts to fill this gap by examining the extent to which textbook publishers introduce new editions to kill-off used units. The textbook publishing market is ideal for examining planned obsolescence due to the following reasons. First, as often appear in the popular press, conventional views suggest that textbook publishers periodically introduce new editions to kill-off used textbooks.<sup>1</sup> Second, it is reasonable to treat used textbooks of the same title-edition as homogeneous, which substantially reduces the dimensionality of the analysis.<sup>2</sup> The same treatment would be difficult, say, for used cars where prices for the same model-year would vary substantially depending on the condition of the vehicle.<sup>3</sup> Third, and more important, new data on the used textbook market have become available recently.

The data for this study come from a scanner data set collected from college bookshops, containing semi-annual textbook-level data for 1996-2000. A unit of observation

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<sup>1</sup>See, for example, a recent article by Erwin V. Cohen, “Same Book, New Look,” *The Wall Street Journal*, December 3, 2003.

<sup>2</sup>The assumption is reasonable because used textbooks of the same edition are commonly sold at the same price regardless of their exact conditions. Part of the reason for this is college bookshops do not buy back used textbooks of poor conditions.

<sup>3</sup>See, Esteban and Shum (2002) for more discussion.

is title-edition-semester. For this study, I examined only data on textbooks used in economics courses. More than 2,500 observations are included in the estimation. For each period, I observe, among other variables, average retail prices (new vs. used), quantity sold (new vs. used), ISBN, and the edition revision information.

Empirically, I analyze the revision decisions of textbook publishers using reduced-form, discrete-time duration models with time-varying covariates. I construct a variable that captures the extent of competition between used and new units and examine how this affects the timing of textbook revision. Various product attributes including textbook categories, physical characteristics of textbooks, market size, and market structure are included as controls in the estimation. In order to capture the heterogeneity across textbook categories, base-line hazard rates are allowed to vary across the categories. A split-population model that accounts for unobserved individual heterogeneity is also estimated.

I find that textbook publishers revise editions more frequently when the share of used textbooks increases, holding time trends and other factors constant. The result is robust across various specifications, with or without unobserved individual heterogeneity. This result is consistent with the view that publishers introduce new editions to kill-off used units. Estimation results suggest that if used textbook share increases by 10%, the probability of edition revision goes up by 15%, holding all other factors constant. At the same time, I find that hazard rates increase as textbooks become older, suggesting that publishers revise editions in order to keep the content up-to-date. If we compare a typical textbook at five and six semesters old, the probability of a publisher revising an edition in the sixth semester goes up by 17%. Both of these factors are important in magnitude, indicating that publishers' frequent revisions cannot be explained by planned obsolescence alone.

To my knowledge, this is the first paper that empirically examines durable goods producers' decisions to introduce new models to kill-off used units. However, several empirical papers are related to the current paper. Porter and Sattler (1999) construct a model in which heterogeneous consumers specialize in different types of used automobiles and show that the patterns of trade are consistent with their model but not with that of adverse selection. Esteban and Shum (2002) constructed a dynamic structural model to examine the effects of durability and secondary markets on equilibrium firm behavior in the automobile market. Purohit (1992) examined how the prices for used cars are affected by the introduction of new models and found that old car prices fall more than propor-

tionally when new models are introduced. Suslow (1986) examined whether competition from the recycling sector affected the market power of a monopolist in the primary sector, using Alcoa as an example. While these papers are related to the current paper, they do not address durable goods producers' decisions to introduce new products to avoid potential competition from used units, the main objective of this paper.

A recent study by Greenstein and Wade (1998) is also related to the current paper. They examined the determinants of exit and entry of models in the commercial mainframe computer market. Using duration models similar to this paper, they find, among other things, that the degree of competition, firm attributes, and vintage of product affect firms' exit and entry decisions. Their paper, however, does not address how competition from used units affects the decision to introduce new models.

The rest of the paper is organized as follows. Section 2 briefly reviews related literature. Section 3 describes the data set. Section 4 discusses the empirical model and related econometric issues, and Section 5 report results. Section 6 discusses alternative explanations and the following section concludes the paper.

## 2 A Brief Review of Literature

There are two streams of theoretical literature on planned obsolescence.<sup>4</sup> The first group of literature examines whether the producers faced with competition from used units reduce durability of a product below the socially-optimal level. This includes, for example, Swan (1970, 1972), Bulow (1982), Rust (1986), and Waldman (1996a). Swan shows that such planned obsolescence is not optimal since durable goods producers can maximize profits by setting the productivity level to the socially-optimal level. Rust (1986) shows, however, that this well known "independence result" does not hold if the monopolist can change the durability of the product endogenously. The second group of literature, in contrast, examines the decisions of producers to introduce new models over time. This includes for example Miller (1974), Benjamin and Kormendi (1974), Waldman (1993), and Fishman and Rob (2000). Since the focus of this paper is to examine textbook publishers' decisions to revise textbook editions, I focus my discussion on the second, more closely-related strand of literature.

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<sup>4</sup>See Waldman (2003) for a broad overview of the durable goods literature.

Within the second stream of literature, there are two distinctive views on firms' product introduction decisions. On the one hand, it has been argued that the price for a new product incorporates all future transactions, and thus used units do not compete with new units. For example, Swan (1980) argues:

“the pure monopolist selling such a durable item as an automobile services to possibly a whole host of future owners. Competitive secondhand auto dealers (or scrap merchants and recyclers in the case of aluminum) can then buy and sell the item indefinitely without in any way restricting the power of the monopolist as the original seller” (page 78).

This suggests that durable goods producers have no incentive to “kill-off” used units. In turn, according to this argument, periodic introductions of new models should be explained by other factors. For example, the demand for the durable good may decline over time as the product becomes outdated and obsolete.

On the other hand, others have argued that durable goods producers have incentives to eliminate the secondhand goods market in order to increase their profits. Earlier theoretical papers partially support this view. For example, Benjamin and Kormendi (1974) find that, under certain conditions, a monopolist can increase profitability by eliminating the used goods market, but this relation can be reversed under other conditions. Similarly, Miller (1974) specifically examines the textbook market and find that a monopolist may or may not increase profits by killing off the secondhand market. More recently, Waldman (1993) shows that, in the presence of network externality, a monopolist faces “too high” an incentive to introduce a technology in the second period that is not compatible with the product sold during period one. This happens because the seller does not internalize the loss of values for the previously sold units due to the introduction of new goods.

In sum, theoretical models of planned obsolescence suggest that, under some specific conditions, firms may be able to increase profits by reducing the availability of used units.<sup>5</sup> It remains to be seen empirically, therefore, whether manufacturers try to kill-off used units, and if so, to what extent the phenomenon is important in specific sectors of the economy. Now I turn to the discussion of the data used in the analysis.

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<sup>5</sup>Other theoretical papers on planned obsolescence include Bulow (1986), Choi (1994), Waldman (1996b), and Fudenberg and Tirole (1998).

## 3 Data

### 3.1 Describing the Data

The data used in this study are collected from college textbook shops. For each semester, Monument Information Resource (MIR) collects information on the number of textbooks sold (new vs. used), average prices (new vs. used), edition number, year and month of publication, author name, textbook categories, publisher name, and the ISBN code. For this study, I use only economics textbooks that appear in the MIR database between 1996 and 2000. MIR collects data twice a year, and this gives me at most ten semesters' observations for each textbook.<sup>6</sup> I refer to these semesters as fall and spring semesters. MIR estimates that their data cover approximately 46 per cent of the total college textbook market in the U.S. in 2000.<sup>7</sup> Physical characteristics of textbooks, such as number of pages, color illustration, type of paper, and size of textbook, are collected from the Library of Congress web site, Amazon.com, and Barnesandnobles.com using the ISBN code.

For the ten semesters between 1996 and 2000, I have a total of 2,472 observations. An observation is a title-edition-semester. It is common for publishers to revise textbook editions over time, using almost identical names for the textbooks. A "title" refers to the name of a textbook. There are 406 unique textbook titles in the data set. On average, each title has 1.7 editions in the data set, and I observe a total of 291 edition revisions or "failures." Because of the relatively short panel, many title-editions are either right censored or delayed entry (or left truncated). I will discuss how I deal with these issues in the estimation section. Study guides, custom textbooks, government publications, and Canadian editions were excluded from the analysis.<sup>8</sup>

When I observe multiple ISBNs for the same title-edition in one semester, I combine

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<sup>6</sup>The textbook sales during summer are combined with the spring sessions. Ideally, one would like to observe the "summer" period separately from the spring semester. Unfortunately, MIR does not collect data separately for spring and summer sessions.

<sup>7</sup>MIR's data coverage increased between 1996 and 2000. I used these coverage rates to recover the number of total used and new textbooks sold for each title in each semester.

<sup>8</sup>I do not include study guides since their revision decisions are primarily determined by the revision decisions of accompanied textbooks. Custom textbooks usually do not have used markets, and thus are excluded. Canadian editions of a textbook were not included. I do not observe many of these editions since MIR does not cover much of the Canadian market.

these and treat them as one observation.<sup>9</sup> The multiple ISBNs per edition typically happens with textbook “packages,” in which textbooks are bundled with additional materials, such as a study guide, CD-Rom, and *The Wall Street Journal*.<sup>10</sup> I choose to combine these different versions of the same edition because textbooks originally sold as part of packages are likely to be sold separately in the used textbook market as a stand-alone textbook.<sup>11</sup> Combining all observations of the same title-edition allows me to compare the quantity of used and new units sold over a given time period.

In order to analyze the revision decisions of textbook publishers, one has to define the timing of a revision. I identify the entry of a new edition when I observe a new edition of a textbook in the MIR data. For those textbooks introduced before spring 1996, the month of the new edition entry was identified using the MIR data, Amazon.com, and Barnesandnobles.com. I also searched the latter two databases to find out whether a new edition of a title was introduced immediately after the fall 2000 semester, when my data set is truncated.<sup>12</sup> Sometimes, an old edition of a title is sold even after a new edition of the same title is introduced. I dropped these “overlapping” observations when analyzing publishers’ decisions to revise editions.

Figure 1 shows the pattern of edition revisions and the quantity share of new textbooks in two textbook categories. Panel A and B presents selected textbooks in the Macroeconomics-Principles and Advanced Microeconomics categories, respectively. The four textbooks in Panel A show a remarkably similar pattern: following an introduction of a new edition, the share of new textbooks drops to 60 to 70% in the next semester. The share continues to decline up to 10 to 20% afterwards, and a new edition is introduced after five or six semesters, when the market share for new textbooks goes back to approximately 100%. Panel B shows a slightly different pattern. For example, the share of new books for the title “E” continues to be high during the sample period, and in fact the publisher did not revise the edition. Similarly the share of new books for the title “F” does not go down as low as 10%, which was typically the case in Panel A. These differences between Panel A and B suggest that publishers’ revision decisions may vary substantially across textbook categories.

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<sup>9</sup>Different ISBN codes are assigned not only for different editions of the same title, but also for different packages of the same edition.

<sup>10</sup>For example, Mankiew’s *Principles of Economics* has more than five different packages for its second edition sold in spring 2000.

<sup>11</sup>There are many “new” packages in the data, but I observe very few “used” packages.

<sup>12</sup>That is, if a new edition was introduced in spring 2001, I code revision decision=1 for fall 2000 (discussed in detail below).

Figure 2 shows the hazard rate using the life table estimators, pooling all observations in the data set. A unit of observation is textbook-title-edition.<sup>13</sup> The vertical line associated with each observation shows the 95% confidence intervals. When a confidence interval cannot be calculated because no revision is observed during a given period, the figure shows a hazard equal to zero and provides no confidence interval. In the following, I focus the discussion on observations with confidence intervals. Note that there is an outlier that revised an edition after 60 semesters since publication. As I will discuss later, estimation results are robust with or without this observation.

Figure 2 indicates that many textbook editions complete their publication cycles after five, six, and seven semesters. This is consistent with the popular perception that textbooks revise editions every two to three years. In contrast, very few textbooks revise editions within three semesters. Note that no obvious time trend emerged for the entire sample; it appears that the hazard rate peaks at six semesters and gradually declines, but it goes up again later. One explanation for the non-monotonic hazard rate is that decisions to revise textbooks are heterogeneous across different groups. For example, if “movers” revise editions every four to five years and “stayers” do so later, the observed “failure” pattern may emerge in the aggregate but treating the population as homogeneous will lead to a miss-specification.

To further examine this possibility, Figure 3, Panels A-D separately shows the hazard rates for 16 textbook categories. These textbook categories are created in reference to the MIR’s original textbook categories. Appendix A shows all textbook categories used in this paper. A striking finding in Figure 3 is that, by partitioning the textbook categories, the probability of revising editions increases in most of the book categories as textbooks get older. This suggests that it is important to allow each category to have a different base-line hazard rate, and, conditional on the textbook categories, hazard rates tend to increase monotonically over time. I also note that few categories have textbooks that last more than 15 semesters without a revision. Notable exceptions include “History (category=2),” “Micro Other (category=15),” and “All Other (category=16).” I include these 15 textbook category dummies in the estimation so that I can account for the heterogeneity across textbook categories.

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<sup>13</sup>That is, if there is more than one edition of the same title, all editions are included in constructing the estimator. Alternatively, one can construct the estimator by including only one observation for each textbook title. Using this treatment, the distribution of hazard function slightly shifts to the right, although the shape of the distribution changes little.

Figure 4 shows the survival function for the population using the life table analysis. The figure shows that median survival age is about seven semesters, indicating that half of the textbooks get revised within four years. The survival function becomes flat after around 20 semesters. This suggests the possibility that those textbooks that do not revise editions within ten years or so may never revise editions at all. In fact, Figure 4 appears to indicate as much as 20% of the textbooks in the sample may never revise editions at all.

## 4 The Empirical Analysis

### 4.1 The Model

This section discusses discrete-time survival models in order to “explain” publishers’ decisions to introduce new editions of textbooks. Corresponding to the nature of the data, I consider that there are two mutually exclusive periods in each year, i.e., fall and spring semesters. In each period, publishers observe the extent of competition from used textbooks, among other variables, and decide whether to introduce a new edition in the next semester. I count the duration until the transition of a state (or censoring) by the number of semesters using the positive integers, i.e., 1, 2, 3, etc. Specifically, I estimate the following discrete-time duration model:

$$Rev_{it} = \alpha \cdot Usedshare_{it} + \beta \cdot \ln(Age_{it}) + \psi \cdot Comp_{it} + \gamma \cdot Size_{it} + Cost_{it} \cdot \delta \\ + Category_k \cdot \tau + Firm_j \cdot \eta + Year_t \cdot \lambda + \phi \cdot Fall + \epsilon_{it}$$

where:

- $Rev_{it}$ : a revision indicator for the textbook title  $i$  during semester  $t$ , which equals 1 if the publisher introduces a new edition of the title in the *next* semester, and 0 if otherwise.
- $Usedshare_{it}$ : quantity share of used textbooks for each title-edition in each semester. This captures the extent of competition from used textbooks, the variable of our main interest.
- $\ln(Age_{it})$ : a natural logarithm of the number of semesters since publication for textbook title  $i$  during semester  $t$  (base-line hazard).

- $Comp_{it}$ : the number of textbooks within each textbook category defined by MIR, which captures the extent of competition in each category. Waldman (1996a) argues that planned obsolescence is more likely when firms have substantial market power.
- $Category_k$ : a vector of 15 textbook category dummies such as “history,” “international economics,” and “microeconomics-principles.” I aggregate MIR’s original textbook categories into 16 categories. Appendix A shows all categories included in the estimation and how they correspond to MIR’s original categories.
- $Cost_{it}$ : a vector of cost variables that reflect the level of textbook revision costs and marginal production costs, including number of pages, color vs. no color illustration, special paper vs. standard paper, hard vs. soft cover, and size of the textbook. I collected this information from the Library of Congress web site.
- $Size_{it}$ : Market size of textbook  $i$  during semester  $t$ . As a measure of market size, I use the sum of new and used textbooks sold in each semester.
- $Firm_j$ : I included seven major publishers as dummy variables to account for publisher fixed effects. Firms may employ different policies in terms of revision decisions of textbooks and may have different cost structures.<sup>14</sup>
- $Year_t, Fall$ : Year and Fall semester dummies

## 4.2 Estimation

In this section, I discuss the basic estimation approach. The next subsection discusses three additional estimation issues relevant for the data and questions.

Suppose  $T_i$  is a discrete-time random variable with probabilities

$$f_{ij} = \Pr(T_i = j)$$

where  $j \in \{1, 2, 3, \dots\}$ , the set of positive integers. I observe a textbook  $i$ ’s spell from semester  $k=1$  through to the end of semester  $T_i$  at which point spell is either complete ( $c_i=1$ ), or right censored ( $c_i=0$ ). The discrete hazard is given by:

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<sup>14</sup>The firms included as fixed effects are: Worth Publishers, Houghton Mifflin, John Wiley & Sons, McGraw-Hill, Pearson Education, Thomson Learning, and W. W. Norton & Company.

$$h_{ij} = \Pr(T_i = j | T_i \geq j)$$

Ignoring delayed entry for the moment, the likelihood function is given by:

$$L = \prod_{i=1}^n [\Pr(T_i = j)]^{c_i} [\Pr(T_i > j)]^{1-c_i}$$

where a completed spell contributes for the first part of the likelihood function, while a censored spell contributes for the second part. I can rewrite the likelihood function as:

$$L = \prod_{i=1}^n \left[ h_{ij} \cdot \prod_{k=1}^{j-1} (1 - h_{ik}) \right]^{c_i} \left[ \prod_{k=1}^j (1 - h_{ik}) \right]^{1-c_i} = \prod_{i=1}^n \left[ \left( \frac{h_{ij}}{1 - h_{ij}} \right)^{c_i} \cdot \prod_{k=1}^j (1 - h_{ik}) \right]$$

Log likelihood is

$$\log L = \sum_{i=1}^n c_i \log \left( \frac{h_{ij}}{1 - h_{ij}} \right) + \sum_{i=1}^n \sum_{k=1}^j \log(1 - h_{ik})$$

Now, I can further rewrite this by defining a new binary variable  $y_{ik}$ , which equals 1 if the  $i$ th textbook has decided to revise an edition at  $T_i=j$ , and 0 if otherwise.

$$\log L = \sum_{i=1}^n \sum_{k=1}^j [y_{ik} \log(h_{ik}) + (1 - y_{ik}) \log(1 - h_{ik})]$$

Note that the likelihood  $L$  is the same form for the standard likelihood function for a binary regression model with event probabilities  $h_{ik}$ . If I assume the hazard function follows the discrete proportional hazard model, the hazard ratio is given by:<sup>15</sup>

$$h_{ik} = 1 - \exp[-\exp(\beta' X_{ik} + f(k))]$$

where  $x_{ik}$  is time-varying covariates, and  $f(k)$  is baseline hazard during semester  $k$ .

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<sup>15</sup>An alternative to the proportional hazard model is the proportional odds model, i.e., the logistic model. Estimation results change little when this model is used.

For the basic specification, I specify the baseline hazard as a monotone increasing (or decreasing) function of time  $t$ , i.e.,  $\ln(t)$ , which is a discrete time analogue to a continuous-time Weibull model. I use this specification because I anticipate that the contents of textbooks become outdated over time, and thus the hazard rate increases as the book gets older.<sup>16</sup> I allow these time trends to be different across textbook categories since the extent to which each category is outdated may vary from category to category.

## 4.3 Additional Estimation Issues

### 4.3.1 Multiple Editions Per Title

In the data, I often observe multiple editions of the same title. For example, I observe both the second and third editions of *Industrial Organization* by Carlton and Perloff in my data. Ideally, one would like to estimate a textbook fixed-effects model to control for unobserved product attributes that might be correlated with the variables of our interest.<sup>17</sup> Unfortunately, this strategy does not work in this case since I still have many titles that do not revise editions during the five years I observe. If I estimate a fixed-effects model, then I have to drop these titles from the estimation since there is no change in the dependent variables (which equals to zero) for these observations. This will reduce the number of observations in half. Moreover, analyzing this selected sample is problematic since this ignores a large number of textbooks that revise editions infrequently. As a result, estimated coefficients will be biased due to the sample selection problem. Because of this difficulty, I do not estimate a fixed-effects model. Instead, I include a number of variables including category dummies in the estimation to control at least partially for the potential endogeneity.

Another challenge is that revision decisions of the same textbook-title are likely to be correlated across editions. I address this issue by computing robust standard errors that take into account the clustering at the title level. Note that this treatment assumes that, if there is more than one edition of the same title, the “failure” events (i.e., revision decisions) are of the same type and unordered within the different editions of the same title. Alternatively, one can consider a learning model in which publishers learn from the previous publishing cycle and update their beliefs over editions. This, in turn, requires

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<sup>16</sup>I also examine a “mover-stayer” model later in which I allow some proportion of textbooks to never be revised.

<sup>17</sup>I can estimate, for example, Chamberlain’s conditional logit model.

one to treat the edition decisions as “ordered.” This is certainly an interesting issue but one which requires more sophisticated modelling, and I will leave it for future study.

### 4.3.2 Delayed Entry or Left Truncation

The next issue is delayed entry or left truncation. For example, for all textbooks that were published before spring 1996, I cannot observe their history before fall 1995. Thus, these observations exhibit the delayed entry (or left truncation) problem. Fortunately, I do observe in the data when these textbooks were introduced before 1996, and thus can assign the semester age for the delayed entry observations. This age information allows us to include these observations in the estimation without much difficulty.<sup>18</sup>

### 4.3.3 Unobserved Heterogeneity

Standard survival models assume that all observations eventually “fail.” In the current context, this implies that all textbook titles revise editions with probability one. However,

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<sup>18</sup>To see this, recall that the likelihood function for observation  $i$  without delayed entry is given by:

$$L_i = \left( \frac{h_{ij}}{1 - h_{ij}} \right)^{c_i} \cdot \prod_{k=1}^j (1 - h_{ik})$$

Suppose I do not observe  $i$  until time  $e_i$  in the data set, i.e. delayed entry. In this case, since I observe these textbooks conditional on the survival up to  $e_i$ , I have to adjust their likelihood contributions by taking this into account. The likelihood contribution for  $i$  is given by:

$$L_i = \frac{\left( \frac{h_{ij}}{1 - h_{ij}} \right)^{c_i} \prod_{k=1}^j (1 - h_{ik})}{S(e_i)}$$

Note, however, the survivor function for this observation up to  $e_i$  is given by:

$$S(e_i) = \prod_{k=1}^{e_i} (1 - h_{ik})$$

and this leads to a “convenient canceling” result (Jenkins, 1995):

$$L_i = \left( \frac{h_{ij}}{1 - h_{ij}} \right)^{c_i} \left[ \frac{\prod_{k=1}^j (1 - h_{ik})}{\prod_{k=1}^{e_i} (1 - h_{ik})} \right] = \left( \frac{h_{ij}}{1 - h_{ij}} \right)^{c_i} \prod_{k=e_i}^j (1 - h_{ik})$$

That is, I can correctly incorporate the delayed entry observations by including only the periods after they entered the data set.

it is plausible that some textbooks covering “classic” contents, such as Adam Smith’s *The Wealth of Nations* or basic mathematical techniques, may never revise editions perhaps because they may never become obsolete. If so, this implies that I have two types of textbooks in the population, i.e., “mover” and “stayer.” This is a relevant concern for my data since, as shown in Figure 4, many textbook publishers did not revise editions during the period I observed. Lancaster (1979) showed that, if such unobserved heterogeneity exists, treating the population as a homogeneous one may lead to erroneous conclusions on duration dependence and bias coefficients.

Note that I have already addressed this issue at least partially by including category specific dummy variables. If the distinction between “movers” and “stayers” are determined primarily by textbook categories, the textbook category dummies should be able to account for the problem. If, however, “movers” and “stayers” exist in the population even after controlling for the textbook categories, then allowing unobserved heterogeneity would further improve the estimation results.

I deal with this potential problem by estimating a simple model that assumes a fraction  $p$  of the population to be “stayers” who never introduce a new edition. Now, censored observations consist of two cases: 1) those who eventually revise editions, but haven’t yet done so, and 2) those who never revise editions. Thus the likelihood function can be written as:

$$L = \prod_{i=1}^n [(1 - p) \cdot \Pr(T_i = j)]^{c_i} [p + (1 - p) \cdot \Pr(T_i > j)]^{1 - c_i}$$

If we find  $p=0$ , it implies that all textbooks eventually revise editions, and this reduces to the standard survival model without population heterogeneity. I test this hypothesis by using the likelihood ratio test.

## 5 Results

### 5.1 Basic Results

Table 1 Model 1 shows the results when I use the natural logarithm of semester-age,  $\ln(t)$ , as the base line hazard function. This model includes 15 book category dummies (the

omitted category is “History”). I report robust standard errors that take into account the clustering at the textbook title level.

I find that the coefficient for the used market share is positive and statistically different from zero, suggesting that publishers are more likely to revise editions as the market share of used books increases, holding all other factors constant. This is consistent with the view that textbook publishers introduce new editions to kill-off used textbooks. The coefficient for the natural logarithm of age is also positive and significant, suggesting that, on average, textbooks are more likely to be revised as they become older, conditional on their “ages.” These initial findings indicate that the competition from used textbooks as well as the “aging” of the textbook accelerate publishers’ revision decisions.

Other estimated coefficients also provide insights into publishers’ revision decisions. First, the coefficient for market size is positive and significant, suggesting that publishers revise editions more frequently in large markets as expected. In contrast, the extent of competition within each textbook category does not seem to affect the frequency of revision. This is an interesting finding in reference to Waldman’s (1996a) argument that planned obsolescence is likely to be present in markets where firms have substantial market power. The finding is not surprising, however, given that textbook publishers are likely to maintain market power even in crowded markets because, once a textbook is chosen by instructor, students do not have much choice in choosing alternative textbooks.<sup>19</sup>

Nor do various cost variables have much explanatory power (not reported individually). For example, the coefficient for hard-cover textbooks is negative as expected but not statistically significant. The coefficient for the fall semester dummy is negative and significant, indicating that publishers are less likely to introduce a new textbook in the *spring* (i.e., next) semester. The coefficients for about half of the book categories are positive and significant, suggesting that textbook categories, including “Intermediate Macro” and “International Economics,” revise editions more often than “History” textbooks.

I also estimate the model by using a flexible base-line hazard function, i.e., the cubic polynomial specification. This hazard function was motivated by the time trend observed in Figure 2. The results are similar to the previous model and not reported. In particular, the coefficient for used ratio continues to be positive and significant with a comparable point estimate. The coefficients for the three time-trend variables are all significant with expected signs.

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<sup>19</sup>Waldman discusses this point by explicitly referring to the textbook market.

One can compute the hazard ratios associated with various coefficients and interpret them and compare their magnitudes. For example, the coefficient for used share suggests that, in a typical book category, a 10% change in used share increases the probability of revision by 15%. I obtain this by multiplying the coefficient from Model 1 by 0.1 and taking the exponential, i.e.,  $\exp(1.40*0.1)=1.15$ . Similarly, the coefficient for  $\ln(t)$  implies that if we compare a typical textbook at semester five and semester six, the probability that the textbook publisher revises an edition in the sixth semester goes up by 17%.<sup>20</sup> Using these results, it can be shown that, if there are two textbooks with five and six semesters after publication, and the latter's used market share is 11% lower than the former, then the probability of introducing a new edition in the next semester is about the same for the two books, holding all other factors constant.

So far, I have assumed that the base-line hazard rate is the same across all textbook categories. This means that all textbook categories follow the same “aging” pattern. It may well be the case, however, that the advances of each economics category may be different, and thus some textbooks may become obsolete more quickly than others. In this case, as I discussed in the Data section, it is important that I allow for heterogeneity across textbook categories in the base-line hazard rates.

Model 2 shows the results when each textbook category follows its own base-line hazard rate. The main results change little due to the inclusion of the interaction terms between textbook categories and  $\ln(t)$ . In particular, we continue to find textbook publishers revise editions more frequently as used market share increases. The coefficients for the interaction terms vary across the textbook categories. In particular, the coefficient corresponding to “International Economics” is the largest, followed by “Intermediate Micro,” “Introductory Economics,” and “Econometrics.” One can test whether these category specific hazard rates are different from each other. For example, the coefficients for “History” and “International” are statistically different from each other at the 5% confidence level, suggesting that “History” textbooks are less likely to revise editions at a given age compared to some other categories. One interpretation for this difference is that textbook content becomes outdated more quickly in some categories than others, and thus publishers need to revise editions more frequently in the former case. The fact that the textbooks in “History” tend to be revised less frequently than others appears to be consistent with this view.

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<sup>20</sup>To obtain this, first, note that  $\ln(t)$  increases by 0.182 between semesters five and six. The corresponding hazard rate is given by  $\exp(0.8829*0.182)=1.17$ .

## 5.2 Split Population Model

Table 1, Model 3 reports the results from the split population model. Here a fixed proportion of population  $p$  is assumed not to revise editions at all and  $p$  is estimated empirically. As before, I allow each textbook category to have a different base-line hazard rate. The qualitative results found in this model are almost identical to that of the previous model. Most importantly, publishers revise editions more frequently as the share of used textbooks increases. Also, the coefficients for the interaction terms between textbook categories and  $\ln(Age)$  are positive in most cases, indicating that hazard rates increase over time conditional on categories. Most of the estimated coefficients are larger in absolute terms compared to that of Model 2. This is expected because the “stayers,” which do not revise editions at all, are separated from the “movers” in this estimation, and thus do not draw the estimated coefficients down to zero. The proportion  $p$  corresponding to the “stayers” is estimated to be 0.15, suggesting 15% of all textbooks used in economics courses never revise editions. The estimated proportion of non-revising textbooks is in agreement with the prior observation obtained from the survival function shown in Figure 4. I can reject the null hypothesis that  $p=0$  at the 1% confidence level.

## 5.3 Robustness Check

To check the robustness of the results, I also estimated the models using a logistic hazard specification and dropping the outlier that revised edition during semesters 60 (see Figure 2). The results are robust to these specifications (not reported).

Up to now, I have presented results using the semester-level data. However, some concerns may exist for using the semester-level data since demand for textbooks may be seasonal. For example, some textbooks may be used only in the spring semesters and the class size may substantially vary between the fall and the spring semesters. These differences may affect the number of used textbooks available on the market, and in turn this may affect the estimates. Because of these concerns, I also estimate the previous models using annual data by aggregating two semesters of data since publication. As shown in Appendix B, qualitative results are very similar to the previous results, and thus I do not repeat the discussion here.

## 6 Discussion: Buyer's Expectation

One issue that I haven't addressed so far is buyers' expectations on the timing of textbook revisions. If buyers correctly foresee the introduction of a new edition and change their purchasing decisions, this may lead to an endogeneity problem. Specifically, if buyers correctly expect a revision in the next period, and this increases the purchase of used textbooks relative to new ones, this will lead to the same positive correlation between used-ratio and revision as I showed in the previous section. This section aims at addressing this issue by focusing on two major buyers in this market i.e., students and college bookshops.

Arguably, college bookshops have more experience in dealing with used textbooks and have more information on the timing of textbook revisions. Generally, college bookshops learn about the introduction of a new edition four to five months prior to its launch. It is less likely, however, that this information affects a bookshop's choice between carrying used vs. new textbooks because college bookshops usually do not take an inventory risk for both new and used textbooks. For most textbook titles, both used and new, college bookshops can return unsold units to publishers and/or wholesalers after the initial period of each semester. Since carrying used textbooks is not necessarily riskier even in the semester before a revision, the choice between carrying new vs. used textbooks is not necessarily affected by the timing of textbook revisions. Managers of college bookshops I interviewed agree on this point.

Unfortunately, consumers' expectations are more difficult to address. Although students may not be well informed about the timing of a revision for each textbook, it is difficult to completely eliminate the concern that students may foresee the introduction of a new textbook. Ideally, one would like to instrument for used-ratio, but this is not an easy task since an instrument that is correlated with the used ratio and does not enter the estimated equation is difficult to find. Because of this difficulty, I address this issue indirectly. First, as discussed in Section 3-2, textbook prices do not go down immediately before the introduction of a new edition, and this is not consistent with the view that students correctly foresee the timing of a revision. Second, I argue in the following that the endogeneity problem, even if it exists, would likely to bias estimates downwards and thus would not lead to a false positive conclusion.

To see the last point, consider two types of students, those who intend to keep a textbook after a class (i.e., economics majors) and those who intend to sell it after the class (i.e., non-economics majors). Suppose that the latter students are more likely to

buy used textbooks compared to the former since the latter would tend to place a lower value on the textbook. In fact, managers of college bookshops observe a similar purchasing pattern: graduate students—who are likely to use textbooks in the future—tend to buy new books compared to undergraduates who tend to use textbooks only during the class.<sup>21</sup> In this context, if non-economics majors foresee a revision in the next period, used book sales are likely to go down more than that of new books since used book buyers will have difficulty in selling back the book at the end of the semester. Knowing that they will keep the books after the class, new book purchases will be less affected by the introduction of a new edition. This possible negative correlation between used-share and revision decision would bias the coefficient for used market share downwards, leading to a possible false negative conclusion but not a false positive one. Thus, qualitative results discussed before should still hold in this case, although the effect of competition from used textbooks may be understated.

## 7 Conclusions

Two vastly different views exist on why durable goods producers periodically introduce new products. While a popular argument is that producers introduce new models to kill-off used units, others have argued that used units do not compete against new units because initial price alone can capture the net present value of all future transactions. In this paper, I attempted to sort out the alternative views empirically, using data from the textbook market. I found that textbook publishers revise editions more frequently as the market share of used textbooks increases, holding all other factors constant. This supports the view that publishers introduce new editions to kill-off used units. However, I also found that publishers are more likely to revise editions as textbooks become older. Moreover, it appears that textbook categories, such as “History,” whose contents are less likely to become obsolete over time are less frequently revised. These findings suggest that publishers’ revision decisions are also driven by the considerations to keep the contents up-to-date. In fact, both of these factors are important in magnitude, indicating that, in contrast to the popular notion, publishers’ frequent revisions cannot be attributed to planned obsolescence alone.

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<sup>21</sup>Based on my interviews with managers of college bookshops.

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Figure 1 Panel A: Percent of Textbooks Sold—New vs. Used: Selected Macroeconomics-Principles Titles

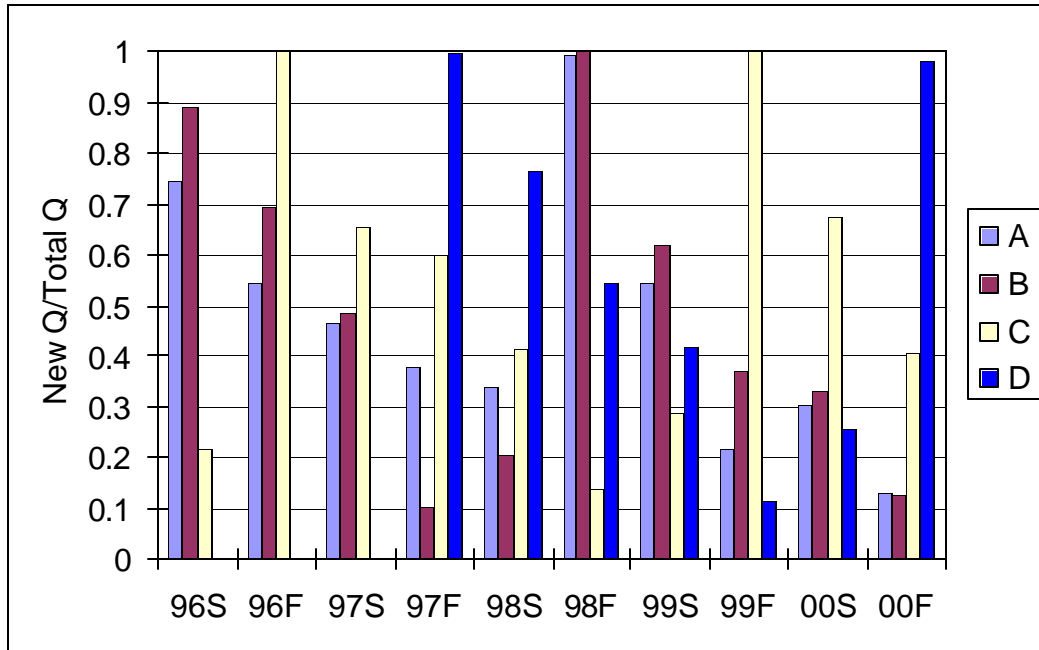


Figure 1 Panel B: Percent of Textbooks Sold—New vs. Used: Selected Advanced Microeconomics Titles

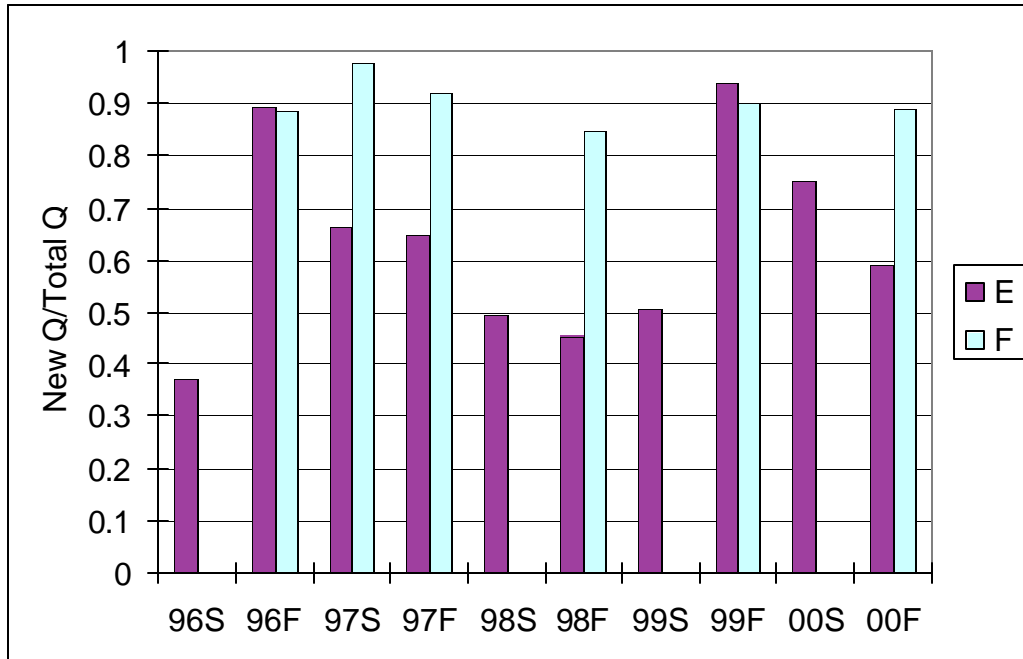


Figure 2: Hazard Rates, All Editions

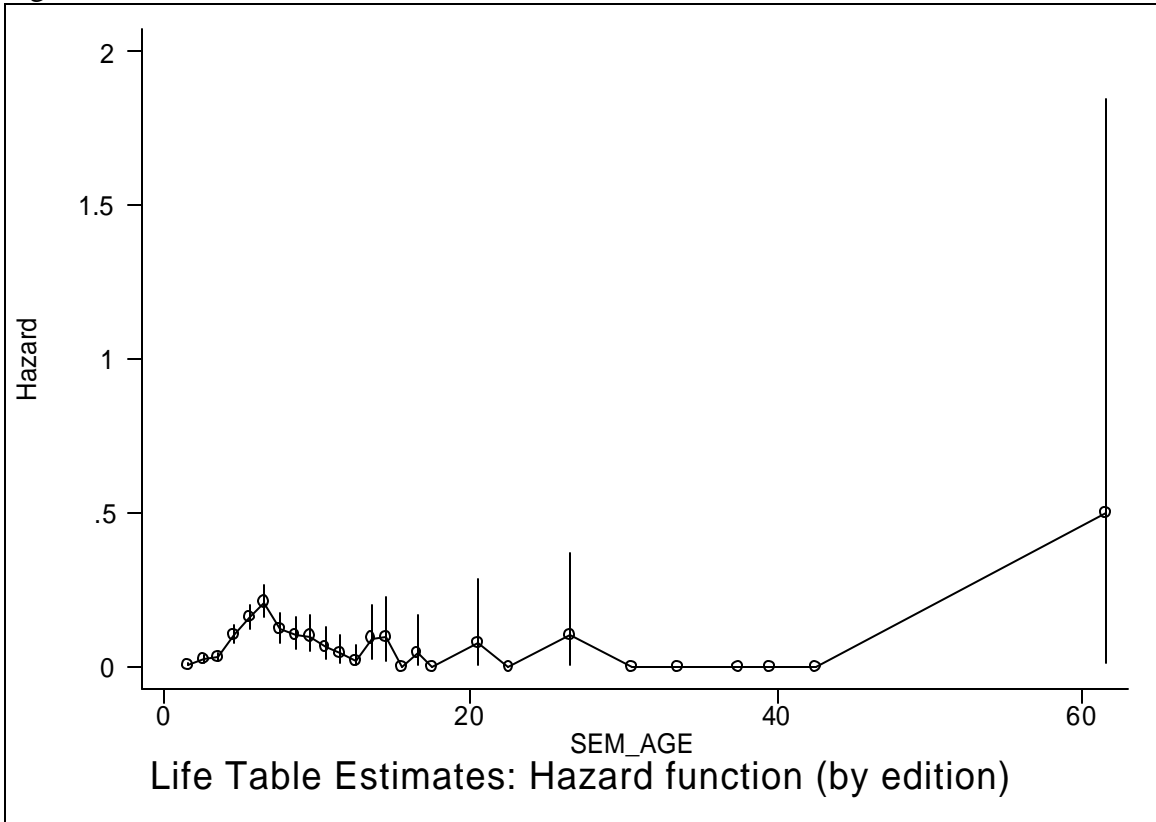
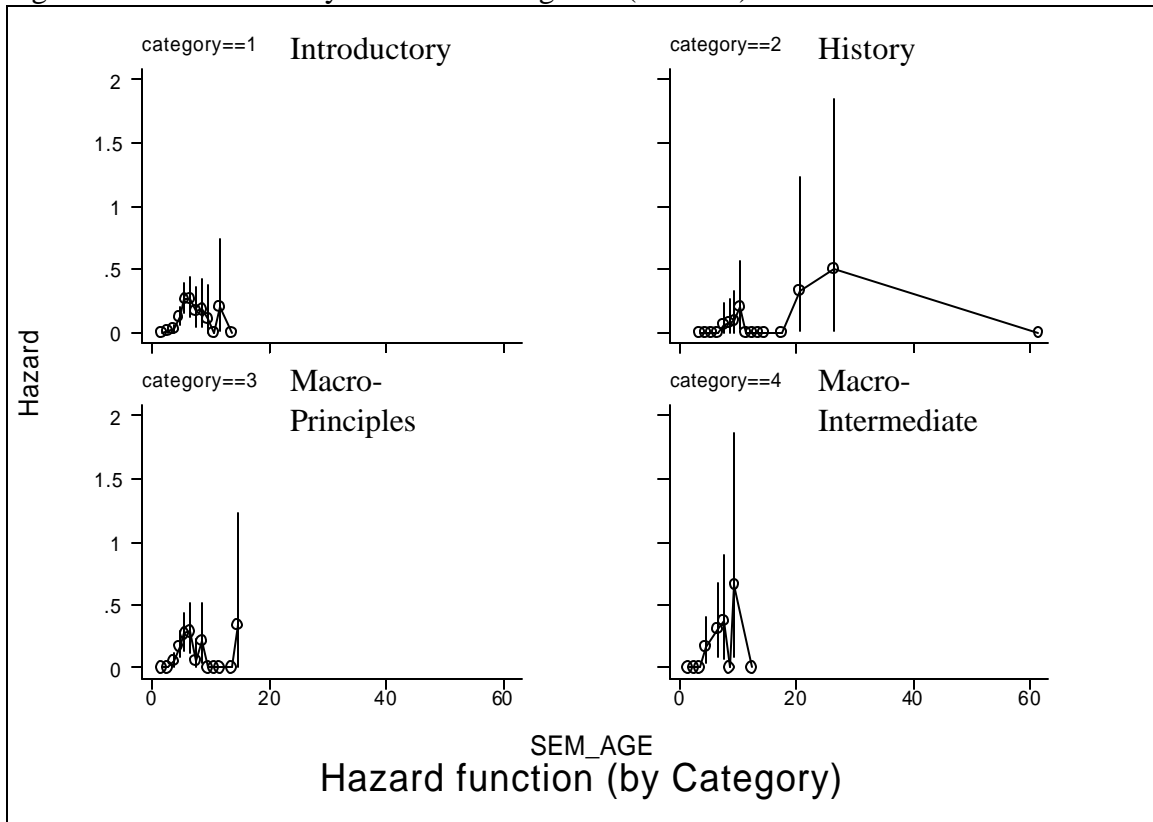
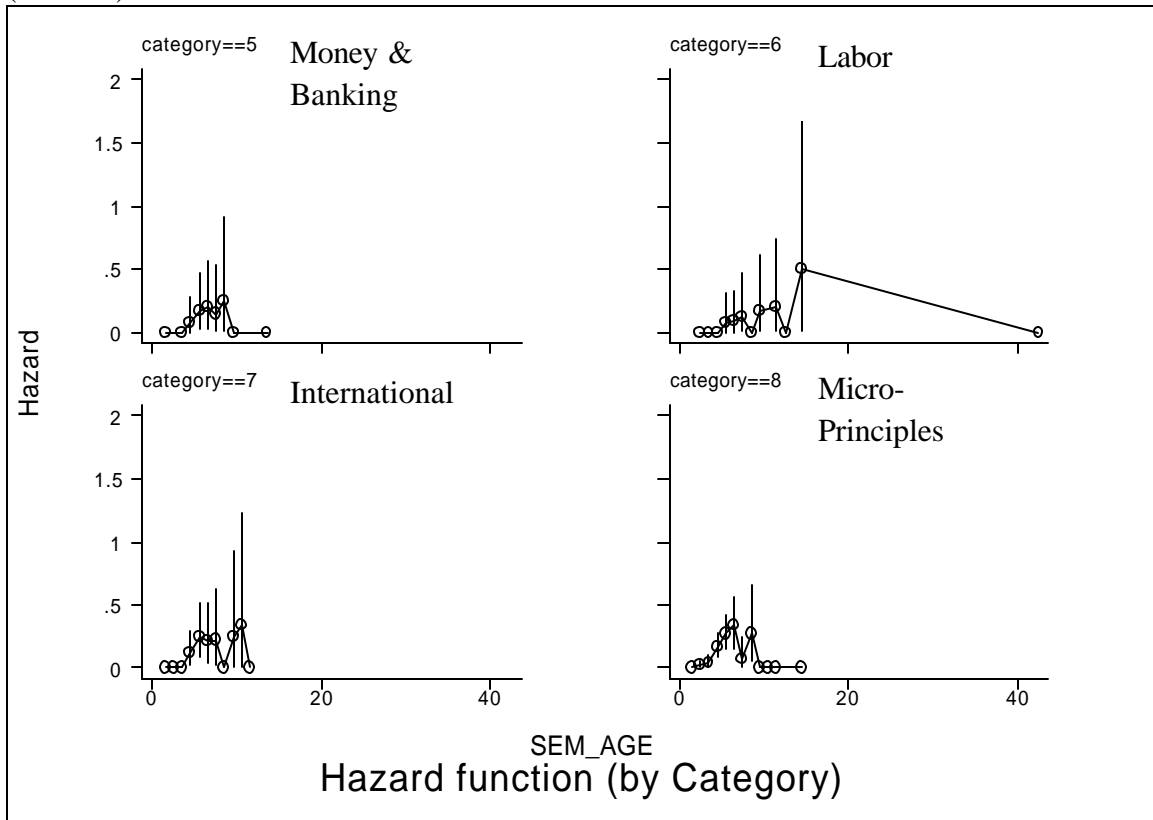


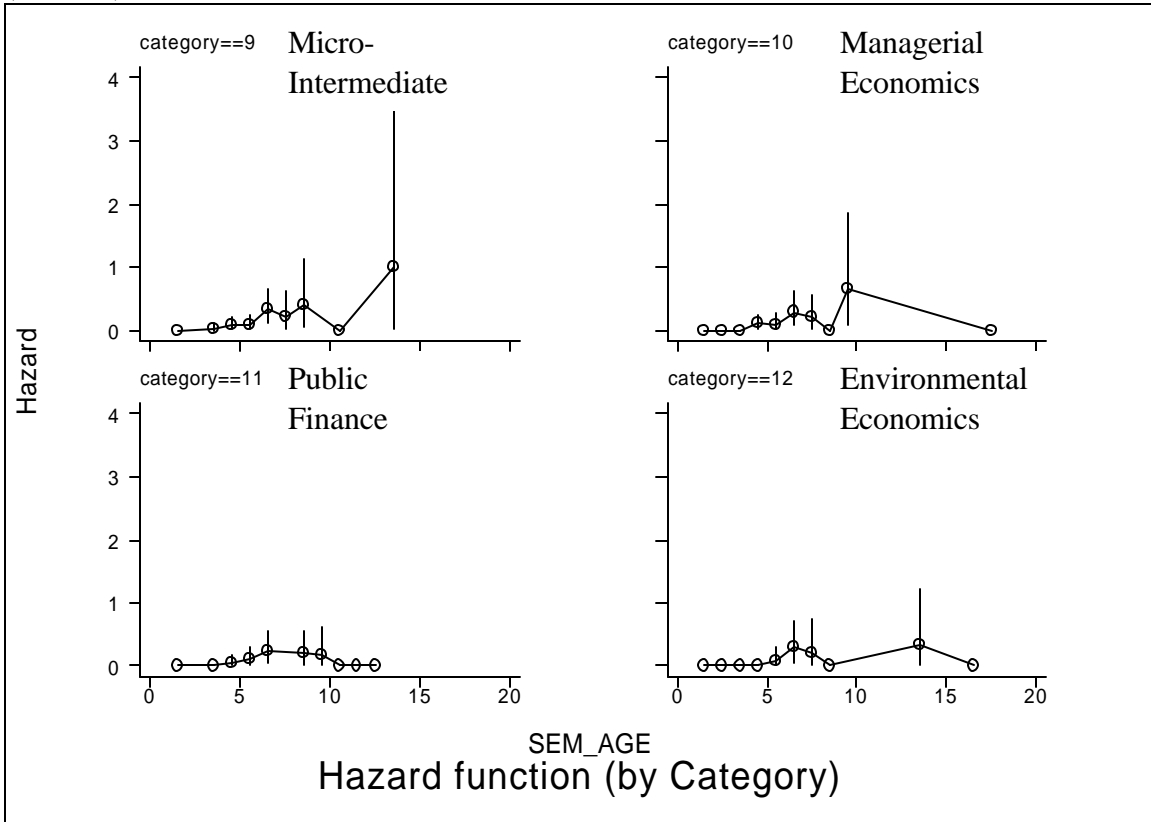
Figure 3: Hazard Rates by Textbook Categories (Panel A)



(Panel B)



(Panel C)



(Panel D)

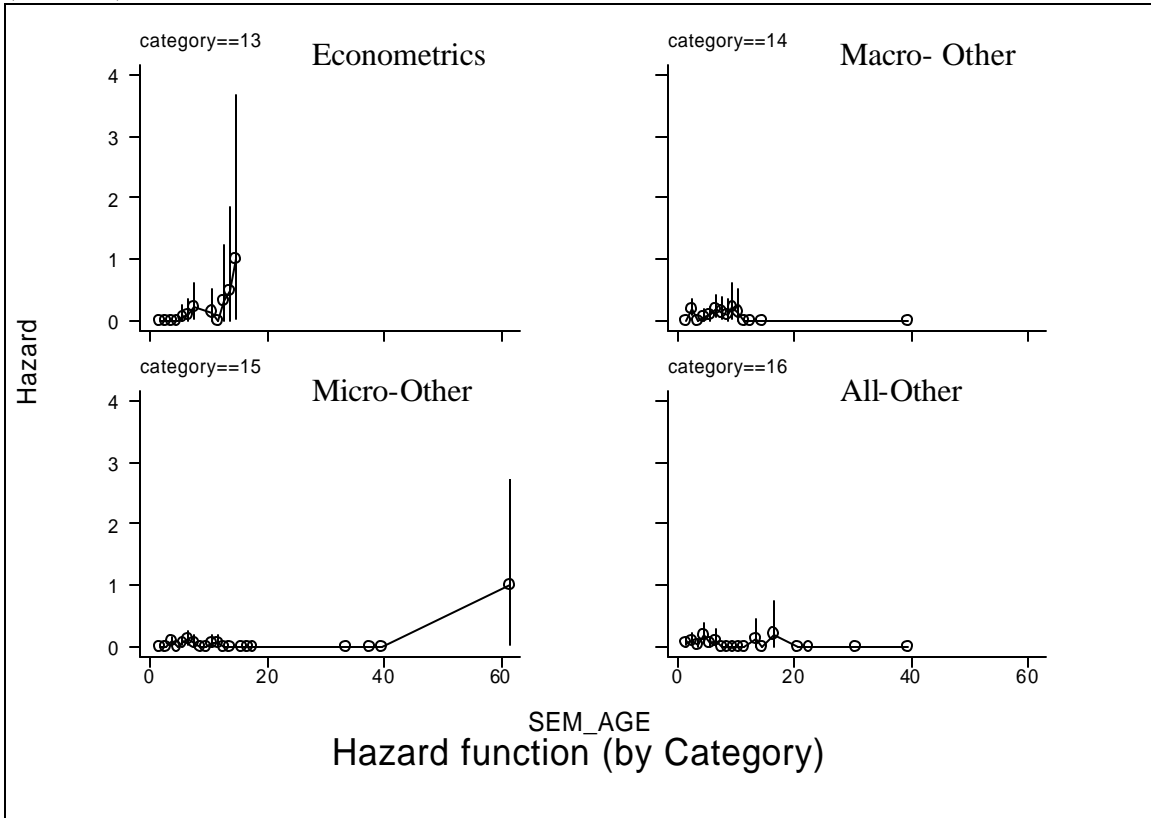


Figure 4: Survival Function, All Samples

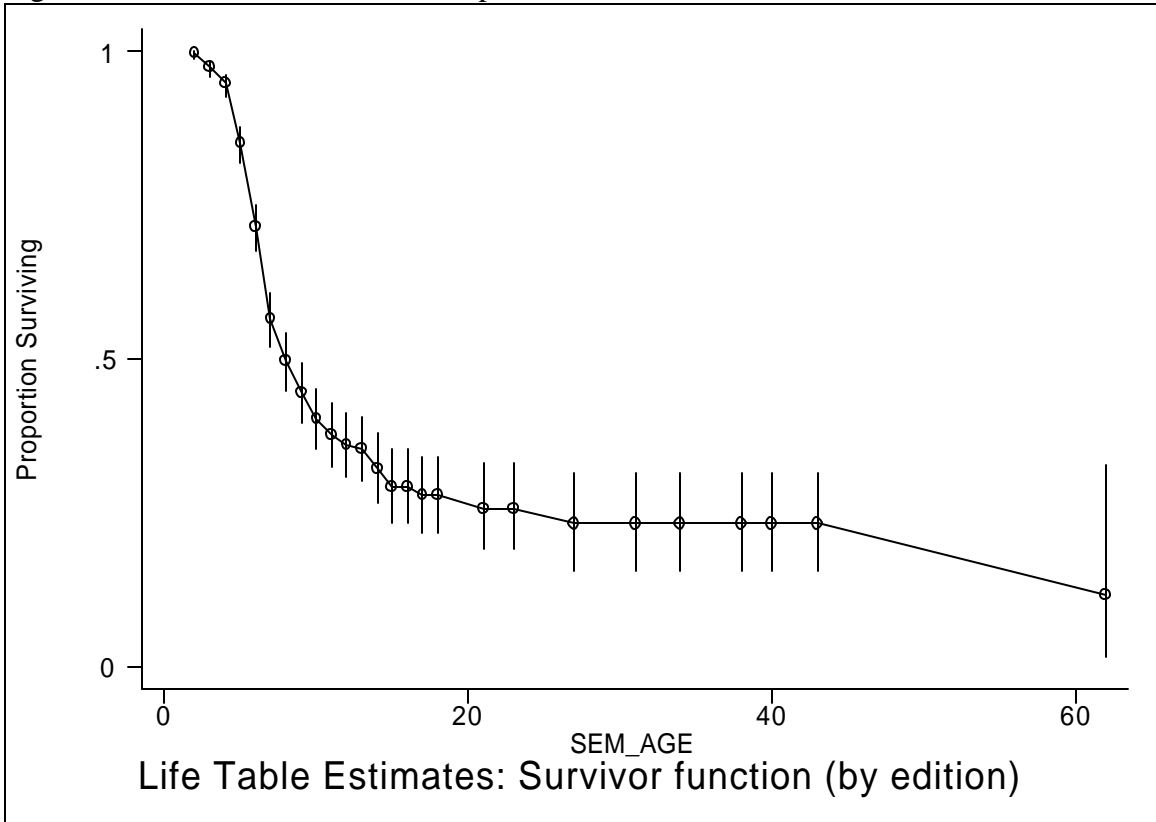


Table 1: Textbook Revision Decision (Dependent variable=Revision), Semester Data

	Model 1 Base Model	Model 2 Category*ln(a ge)	Model 3 Split population	
Used-Ratio	1.3990*** (0.3332)	1.0643*** (0.3149)	1.2520*** (0.3476)	
ln(Age)	0.8829*** (0.2164)			
Market Size	0.0561*** (0.0132)	0.0622*** (0.0146)	0.0415*** (0.0139)	
N of competition	-0.0106 (0.0129)	-0.0070 (0.0147)	0.0043 (0.0157)	
Fall	-0.5760*** (0.1385)	-0.5915*** (0.1413)	ln(age)*catego ry	-0.6353*** (0.1288)
History			1.0294*** (0.3937)	1.3888* (0.7593)
Introductory	0.9369** (0.4106)	-0.1042 (0.9056)	1.8063*** (0.3050)	-0.6924 (1.8637)
Macro-principles	0.8632* (0.4676)	0.5403 (0.8953)	1.3529*** (0.2924)	-0.3460 (1.9274)
Macro-intermediate	1.0240*** (0.3949)	0.6544 (1.1526)	1.3253** (0.5934)	-0.3979 (2.3865)
Money & Banking	0.4734 (0.5199)	0.6765 (1.2367)	1.0409 (0.6793)	-1.0092 (3.1369)
Labor	0.6812 (0.4381)	0.9185 (1.1634)	0.9894** (0.4061)	1.5029 (2.1431)
International	1.0042*** (0.3817)	-1.0923 (1.0147)	2.4632*** (0.3553)	-0.4918 (2.1260)
Micro-principles	0.9340* (0.4900)	0.3843 (0.9896)	1.5079*** (0.3924)	-1.1942 (1.9203)
Micro-intermediate	1.0060*** (0.3551)	-0.1718 (1.1471)	1.8503*** (0.5127)	0.7152 (2.0098)
Managerial	0.8970** (0.3999)	0.2840 (1.0838)	1.4967*** (0.5440)	-1.2797 (2.3350)
Public finance	0.5887 (0.4813)	0.1880 (1.1555)	1.3804** (0.5427)	0.4806 (2.2457)
Environmental	0.2782 (0.4996)	-0.5028 (1.1905)	1.6075** (0.6726)	-1.4724 (2.6252)
Econometrics	1.0554** (0.5206)	-0.3712 (1.6573)	1.7799*** (0.5719)	0.8540 (2.4835)
Macro-other	1.3767*** (0.4219)	2.4254** (1.1892)	0.4929 (0.6102)	3.1023* (1.8060)
Micro-other	0.0829 (0.5861)	2.4130*** (0.9273)	0.0310 (0.2656)	3.2515* (1.7869)
All other	0.9103* (0.4959)	3.5377*** (0.9503)	-0.4579 (0.3836)	4.0629** (1.7317)
Const.	-9.4433*** (1.2352)	-9.3145*** (1.5095)		-11.4703*** (2.2565)

Cost variables	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Firm dummies	Yes	Yes	Yes
$p = \text{Pr}(\text{never fail})$			0.15
Likelihood ratio test of $p=0$			prob=0.00
Observations	2472	2472	2472
Log likelihood	-772.11	-740.97	-727.74
* significant at 10%; ** significant at 5%; *** significant at 1%			

APPENDIX A: Textbook Categories Included in the Estimation

Category Number	Category Name	Original MIR Category Names
1	Introductory	Introductory, Principles
2	History	History
3	Macro-Principles	Macro-Principles
4	Macro-Intermediate	Macro-International
5	Money and Banking	Money and Banking
6	Labor	Labor
7	International	International
8	Micro-Principles	Micro-Principles
9	Micro-Intermediate	Micro-Intermediate
10	Managerial Economics	Managerial Economics
11	Public Finance	Public Finance, Government and Business
12	Environmental Economics	Environmental
13	Econometrics	Introductory Econometrics
14	Macro-Other	Macro All Other, Macro-Advanced, Econ. Development and Planning, Forecasting, Econ. Of Developing Nations, Comparative Economic Systems
15	Micro-Other	Micro All Other, Micro-Advanced, Industrial, Health, Urban Economics, Game Theory, Statistical Methods, Mathematical Economics, Theory
16	All-Other	All Other

APPENDIX B: Textbook Revision Decision (Dependent variable=Revision), Annual Data

	Model 1 Base Model	Model 2 Category*ln (age)	Model 3 Split population
Used-Ratio	1.5452*** (0.3754)	1.2155*** (0.3964)	2.0040*** (0.5297)
ln(Age)	0.4300** (0.2057)		
Market Size	0.0353*** (0.0083)	0.0365*** (0.0085)	0.0200** (0.0081)
N of competition	-0.0138 (0.0147)	-0.0117 (0.0156)	-0.0113 (0.0189)
		ln(age)*category	ln(age)*category
History		0.8456** (0.3899)	1.3043** (0.6469)
Introductory	0.7725** (0.3905)	1.0844 (0.7132)	0.8838** (0.3569)
Macro-principles	1.2029 (1.2124)	0.6054* (0.3405)	1.7657*** (0.5065)
Macro-intermediate	0.6022 (0.4460)	1.1389 (0.7101)	0.9811 (1.2394)
Money & Banking	1.1016** (0.4631)	1.2405 (0.7945)	-10.7923 (115.9576)
Labor	0.3780 (0.5800)	0.9218 (0.8854)	0.6242 (2.0470)
International	0.4342 (0.4794)	0.5986 (0.8555)	0.8526** (0.4188)
Micro-principles	0.9472** (0.4052)	0.3975 (0.8522)	1.8349*** (0.4931)
Micro-intermediate	0.6443 (0.4511)	1.0772 (0.7626)	0.7435* (0.4260)
Managerial	0.9432** (0.3960)	0.3264 (1.0496)	-0.1046 (1.7554)
Public finance	0.8790** (0.4169)	1.0245 (0.7421)	-1.2316 (1.8618)
Environmental	0.5315 (0.5342)	1.1458 (0.8029)	0.5285 (0.5396)
Econometrics	0.1005 (0.4608)	0.6285 (0.6860)	0.6374 (0.5458)
Macro-other	1.0989** (0.5272)	0.2272 (1.2707)	1.6211** (0.6799)
	0.8746* (0.4942)	1.9844** (0.9780)	-0.0693 (0.7551)
			2.6876** (1.2280)
			0.1449 (0.5811)

Micro-other	0.1488 (0.5390)	1.7409** (0.8880)	-0.3142 (0.5257)	2.5446** (1.2281)	-0.3491 (0.3781)
All other	0.5452 (0.4558)	2.4816*** (0.7089)	-0.8864* (0.4529)	3.1309*** (1.1872)	-0.8239* (0.4819)
Const.	-7.5910*** (1.4501)	-8.2281*** (1.5991)		-13.0533*** (2.5112)	
Cost variables	Yes	Yes		Yes	
Year dummies	Yes	Yes		Yes	
Firm dummies	Yes	Yes		Yes	
$p=\text{Pr}(\text{never fail})$				0.214	
Likelihood ratio test of $p=0$				0.00	
Observations	1087	1087		1087	
Log likelihood	-494.21	-477.63		-449.71	
* significant at 10%; ** significant at 5%; *** significant at 1%					