

# **EC2212 Industrial Growth & Competition**

## **PROJECT GUIDE Spring 2003**

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Kenneth L. Simons

Thanks to Clara Manzillo and James Lambert for help in preparing this 2003 version.

## Projects, Assignments, and Due Dates

You choose a particular research topic to analyze during the course. Every project will involve collection of some empirical evidence (or simulated data in rare cases), analysis of the evidence, and a write-up with reference to the relevant literature. As the course goes along, I will guide you to go through these processes. You will be part of a team that gathers key information, but ultimately you will do your own analyses and write your own report. You and your team should start reading and gathering relevant information right away. Biweekly assignments will help you prepare the final project report, because each assignment requires you to do a key piece of the project work.

Note the following due dates. Assignments are due in your seminar classes and will be discussed but not be collected; you will tick a sheet indicating whether you have done the assignment. Two copies of the final project report must be handed in to the department office by noon on the last day of the spring term.

28 Jan.	Assignment 1	Team report: literature review about the team's topic
11 Feb.	Assignment 2	Team report: data listing and documentation (data collection required!)
25 Feb.	Assignment 3	Individual report: literature review about your topic
11 Mar.	Assignment 4	Individual report: data analysis
18 Mar.	Assignment 5	Draft version of your final project
28 Mar.	Project Report	<u>Two</u> copies of your final report due by <u>12:00 noon</u>

A first task in the course is to select a project topic. Because you need to get moving quickly, you will choose during your first seminar session. A list of the projects available to choose appears below. Items in the list (1) have a substantial amount of relevant, hard-hitting information available from multiple sources; (2) are appropriate for solid analytical work including statistical analysis; and (3) relate to the material in the course, so that you can approach the work using multiple theoretical concepts drawn from the course. Only one team, all in the same seminar group, may address each topic (number). Within teams only one student may be assigned to each sub-topic (letter).

Two copies of your project report are due in the Economics Department Office by Friday 28 March at 12:00 noon. The department has taken the policy that late assignments receive grades of zero, so it is critical to finish your project well in advance! The project report must be completed by you, not by your team. The report may include sections written by the team as long as the authors are clearly identified; however, expect to receive a grade of zero if you submit only a team-written part of a report. Don't forget to put your name on the front of your report.

Almost all projects will require trips to libraries in central London. It's a fact of life that empirical research in economics requires field work, and much of that fieldwork is in libraries, with almost no university library having a strong selection of the kinds of materials needed for your project. Nonetheless, I have done what I can to try to keep your trips manageable, and I have ordered many useful materials for Bedford library.

If you need advice or feedback, two former EC2212 students have kindly agreed to help: James Lambert (J.H.Lambert@rhul.ac.uk) and Clara Manzillo (C.A.Manzillo@rhul.ac.uk). Contact them by email. Alternatively, ask me (Ken Simons) during a seminar session or office hour.

## Goal of the Project

You have to come up with evidence about your industry and use it to answer some interesting question for that particular industry. In answering the question, you should either:

1. Test the relevance or validity of existing ideas (“theories”) about how industries work,
2. Use the evidence to argue for a new conception (you are responsible for showing how your conception differs from past ones, and ideally for coming up with evidence that lets you test in what ways your view fits the evidence better than other ideas),
3. Or both.

### **All projects must include the following components:**

- Discussion of one or more specific economic theories.
- Data collection and documentation so someone could replicate your work.
- Use of your data to test predictions of the theories. This will in part involve statistical test(s), using survival analysis (taught in the course), ordinary regression (taught in quantitative methods I), or other techniques.
- Citations of relevant literature, and a reference list. The citations and list of references must appear in the format of a leading economics journal such as the *American Economic Review*. This takes time and trips up some students who don’t think about it well in advance, so plan ahead for citations and references!
- An introduction and conclusion with clear statements of the thesis (point) that you end up finding from the research.

Partial credit may be awarded if you do not fulfil all of these components.

### **A typical outline of your project is:**

- Introduction, goal of the paper. This should make clear some specific question you are addressing.
- Overview of the literature relevant to your theme or question. Discuss relevant theories. For projects on industries, include any relevant information on the historical development of the industry, such as the leading firms, important features of the product, and key technological innovations.
- Description of data (as well as sources of the data) and statistical methods used for empirical analysis.
- Data analysis to test implications of theories/models encountered in the course.
- Comment on the results of the statistical analysis and draw conclusions about the validity of the theoretical models considered.
- Summarize findings, list limitations associated with the data analysis, propose interesting directions for later study or government/firm policy conclusions.

Your outline may vary from this typical approach.

## Topics

Two kinds of projects are available: projects on industries, or projects on broader themes.

### Projects on Industries

Each team deals with an industry (choose a number below), and each member of the team deals with an analytic issue (choose a letter).

#### **Industries:**

1. Aircraft\* [up to 5-6 people]
2. Automobiles [5-10 people ok depending on analytic issues; see below]
3. Cement [up to 5 people]
4. Lasers\* [2-4 people]
5. Radios [3-5 people]
6. Trucks\*\* [4-6 people]
7. Software\* [2-3 people]
8. Zippers [2-4 people]
9. Shipbuilding [2-3 people]
10. Railroads [2-4 people]
11. Video games [up to 6 people]
12. Television receivers [up to 6 people]
13. Motorcycles [up to 5 people]

Industries 1, 2, 5, and 12 are known to involve shakeouts.

Industry 4 did not experience shakeout, and 8 had very little shakeout.

Industries 4, 7, and 11 relate to market niches.

Industry 3 has been shown to have a turnover of corporate leadership.

Industry analyses should generally be carried out for the UK except where noted otherwise in the analytic issues below. However, industries marked \* may best be analyzed internationally for all themes (hence the "international" category is disallowed), and trucks is marked \*\* because it is best analysed for the US given available data.

In most industries, certainly 1-6 and 8, you are expected to focus on the early decades of the industry, possibly excluding recent decades. This is because the course is largely about competitive dynamics over a long time span and how such long-term trends shape an industry, particularly during the formative years of the industry.

#### **Analytic Issues:**

- A. Firm entry.
- B. Firm exit and survival.
- C. Technology.
- D. Geography.
- E. Evolution of market share and of firm sizes.
- F. Advertising (OK to analyze in industries 2, 5, 7, and 12 only).
- G. Development of a history-friendly computer model calibrated to real industry data.
- H. International competition (OK to analyze in industries 2, 3, 5, 6, 9, 11, & 13 only).

More Analytic Issues for Automobiles (Industry 2) Only:

- I. Automotive components (other than tires).
- J. France 1800-1960 (you must be fluent in French).
- K. Germany 1800-1960 (you must be fluent in German).
- L. Italy 1800-1960 (you must be fluent in Italian).
- M. Japan.

Each student on your team should initially choose a separate analytic issue. You may change analytic issues during the term, as long as no other student is dealing with the issue you switch to.

Occasionally legitimate data problems arise that may mean several issues are not feasible for study. If so, ask the course instructor for advice. One possible solution is to have multiple students dealing with different aspects of one of the above issues.

#### Projects on Broader Themes

14. Contributions of different industries to national economic growth and productivity growth. Team members choose different countries: A. UK, B. US, C. Japan, D. Germany, E. France, F. Italy, G. South Korea, H. Taiwan, I. Brazil, ask for approval for others. [up to 9+ people]

15. Long-term changes in leading US firms, their R&D, and size-R&D relationships. Team members divide up the different industry segments: A-F. See Business Week annual R&D scoreboards for the industry segments. [up to 5 people]

Whatever question/theme you choose, make sure you will have plenty of evidence, especially quantitative evidence, to make your case. In your final report also make sure you discuss key literature about your question/theme even though the key literature does not talk about your industry in particular.

## Suggested Questions to Address

The suggestions given here are only some of the many possible issues you could address. You are welcome to find other interesting questions related to the topic. A good source of ideas for alternative questions is relevant literature: you might look for articles, books, and working papers (try the internet) with ideas about the issues that matter regarding your topic.

- A. Firm entry:

How did the number of entering firms change over time, and why? What kinds of firms entered in different years? What factors did entrants bring with them at the time of entry that seem to have made entrants successful or unsuccessful?

Exactly what questions you can ask depends on what kinds of information you can obtain. Can you determine whether the firms previously produced in another industry, or whether the founders have experience in another industry? What factors attracted entry of firms or entrepreneurs, and how can you measure these factors – this is challenging, but you may be able to obtain stock market price indices or counts of the number of technical articles or numbers of members in professional associations who presumably have the right skills. Where did firms start, and where were the people who started the firms before entering the industry? What kinds of products did entering firms produce – did they serve some kind of specialist markets?

You may relate your analyses to data on firm exit, as long as the story you tell is somehow related to entry, e.g. what characteristics matter for entrants.

- B. Firm exit and survival:

Evidence about the number of firms, entry, exit and market share may suggest that your industry fits one of the common evolutionary industry patterns considered in the course: shakeouts, turnover of corporate leadership, or continual entry and exit. You might prove that the reasons why this pattern occurred agree with the reasons inherent in some theories (or conversely in no existing theories), and prove that the reasons in some other theories are wrong for your industry.

For example, did earlier entrants have an advantage manifested in greater eventual market shares or lower rates of exit? Why did they have such an advantage, or why not? What evidence can you use to document this advantage or lack of advantage, e.g., can you show that earlier entrants had greater rates of innovation or advertising than later entrants?

Or, was the Schumpeterian hypothesis right or wrong in your industry? In what ways specifically, did large versus small firms have an advantage? Were large versus small firms the primary sources of innovation (and did large firms innovate more than their share of the market suggests), and was this seemingly the reason for differential rates of exit? Use your evidence about your industry to argue for and against Schumpeter and the many authors who have contributed to the debate.

Or, if it is relevant to your industry, show how product differentiation and the characteristics of each firm's products, have changed over time. Use the information you collect to discuss theories of product differentiation, and explain why various theories are wrong or right in the context of your industry.

- C. Technology:

How quickly did new technologies diffuse among firms (or countries) in your industry, and after a new technology was created, what factors affected how quickly

or slowly different producers (or countries) adopted the new technologies? Use statistical evidence for your industry to analyze these patterns. Relate your findings to conclusions or arguments made by other researchers studying diffusion or technology. Were particular technologies locked-in for your industry, and did this occur despite that the locked-in technologies were not the best available? Show that the phenomenon of lock-in is especially important to explain what happened in your industry, and demonstrate the effect it had on competition and the survival of companies. Or prove that lock-in is a totally useless concept for your industry. Discuss your findings in the context of other important research and theories about lock-in.

If there is something interesting to be said about the use of patents and lawsuits in your industry, discuss the patterns that occurred in your industry, and use your findings to talk about theories related to patenting. In particular, discuss in what ways the traditional economic arguments for patents are right for your industry, and in what ways they are wrong. Relate your findings to other researchers' findings.

- D. Geography:

If your industry had a major effect on the development of a particular city or region, prove what kind of effect it had (as part of your discussion, consider how the development of the city/region affected the industry locally). Does this match with Jane Jacobs' characterizations about the causes of city growth and the causes of stagnation? Does it match with similar findings by other researchers who have considered similar topics?

If agglomeration was important in your industry, and firms benefited from being near each other, why did these advantages of nearness occur? Prove that, among the reasons that have been suggested for why nearness matters, some reason(s) were particularly important, but other reasons were completely or nearly irrelevant. Relate this to the conclusions or arguments of other researchers (who most likely did not study your specific industry).

- E. Evolution of market shares and firm sizes:

Analyze the distribution of firm sizes in your industry. To the extent possible, also analyze how and why the distribution of sizes has changed over time. Relate your findings to the literature on Gibrat's law and the skew distribution of firm sizes. Show to what extent previous theories are right or wrong in the context of your industry, and explain why.

Analyze the determinants of firm growth in your industry, using data on the changes of firms' sizes (in this market) over time. Compare the findings from your statistical analyses with related findings by other researchers. In what ways are the findings similar, in what ways do they differ, and why?

- F. Advertising:

Show that advertising caused part of the market (the types of the product bought by consumers who pay attention to advertising) to become extremely concentrated, while another part of the market did not. Sutton shows a pattern like this in some of the food product industries he analyses. Explain why this happens in your industry. In particular, use evidence about your industry to show whether this pattern happens in your industry for the same reasons considered by Sutton, or whether it happens for different reasons.

Please note, this requires collection of evidence about advertising in your industry, which is not trivial. However, there are books that document firms' advertising spend for TV, radio, and newspaper ads, and if you can identify this kind of source in at least some years (maybe only recent years), you can marshal the evidence to compare between firms and maybe across time.

- G. Computer model:

For this topic, computer-programming skills are required, or at least decent mathematical skills and a willingness to learn about relevant software such as Stella or Vensim. Develop a mathematical model of the entry, exit, and growth of companies, as well as possibly other factors such as technological innovation. Compare your model with other mathematical models of firms and industries. Simulate competitive patterns in your industry model, and relate the model to the industry you are studying. Can you calibrate the model to real data, and does that tell you anything useful? Does the model provide a basis for policy conclusions?

Your statistical analysis need not be complex, but you should relate the model to the data somehow. For example, what hypotheses are suggested by the model, and could you test these statistically? Alternatively, one means to fit some parameters in your model to real-world data may be nonlinear least-squares regression: choose parameters to minimize the sum of squared differences between results of the model and real-world data.

- H. International competition:

Discuss the survival of producers internationally in the face of trade and the effect of protectionism. Argue that national government policies caused some dramatic and perhaps surprising patterns in your industry. For example, you might argue that government policies caused the firms in your industry to go out of business or lose most of their sales in the face of international competition (as has been argued for the US cement industry). Alternatively, if someone has already made such an argument, show that their argument is wrong.

- I-M. More analytic issues for automobiles:

You might deal with any of the above sorts of issues, or something else related to the course – for whatever topics you can obtain information.

- Broader theme 14. Contributions of industries to growth and productivity growth:

Which industrial sectors experienced the greatest growth and/or productivity growth in the nation you are studying, or in specific regions within the nation? To what extent can the success of national economies, or of regions, be attributed largely to success in certain industries? If certain types of industries are most important, why were they so successful and others not? How might characteristics of the national environment matter to success in the alternative industries that together make up the whole economy? What evidence can you bring to bear to show this? What are contrasting views and what evidence can you use to assess the contrasting views?

- Broader theme 15. Long-term firm R&D changes:

Within the industrial sector you are studying, you might address several questions. How much did the rankings of leading firms change over time, what did this mean in terms of the sizes and profits of the firms, and why did some firms gain while others lost? How does R&D seem to relate to the story? In particular, do theories related to



the so-called Schumpeterian hypothesis make sense among the industries and firms you are studying? You might test the Schumpeterian hypothesis and address why the tests yield the results you find. You might also analyze how R&D relates to recent profit (do firms do more R&D when they earn more profit, or only when there is greater opportunity for *future* profit?), or how R&D relates to future growth (does more R&D now correlate with more growth later, and why or why not?).

## Assignments

The five assignments are as follows.

### Assignment 1 – Team report: literature review about the team’s topic

Your team’s task in this assignment is to look up literature related to the industry or other topic the team is studying, and to write a brief background report on the topic. What is important is that the team collects material that can help all members during the project, and that everyone on the team gains some background knowledge that will be helpful with each person’s individual project. The information should be bound together into a report form and copies distributed to team members. Participants in the team benefit by sharing the information collected; there is no obligation for teams (in fact I hope you won’t) to share this information with team members who don’t do their part in the work.

Detailed requirements of this assignment:

- 3-5 pages long, or longer if you get ambitious.
- Include a list of references, in exactly the same format used by a major economics journal such as the *American Economic Review*. Cite the references in precisely the same way references are cited in the journal.
- To find information, see (a) the bibliographies at the end of this projects guide, and (b) the “Library Searches for Projects” section of this guide.

### Assignment 2 – Team report: data listing and documentation (data collection required!)

Your team’s task in this assignment is to collect key data required for your projects, describe the data and how you got them, and present the actual data. Pertinent kinds of data are discussed below. The information should be bound together into a report form and copies distributed to team members. Participants in the team benefit by sharing the information collected; there is no obligation for teams (in fact I hope you won’t) to share this information with team members who don’t do their part in the work.

Detailed requirements of this assignment:

- You choose the appropriate number of pages.
- Explain where your data come from and how you collected them. Ideally, anyone should be able to follow the process you describe and end up with exactly the same data.
- Include a list of references, in exactly the same format used by a major economics journal such as the *American Economic Review*. Cite the references in the same way references are cited in the journal.
- Include printouts (and if necessary photocopies) of your data.

Keep in mind that this assignment provides raw material for all team members to use in their projects.

You will need to record data in electronic form so you can make use of it. I suggest you enter data in Excel and email copies to team members. The “statistics for survival analysis” section of this project guide describes how to convert data from Excel to Stata. If you think your data are useful I would be most happy to be CCed a copy when you email data. If you CC a copy to me, the data may be used for future years of the course (conceivably I may use it myself although usually I have to do a lot more to get data in a form useful for publishable research).

For studies of industries, relevant information includes:

1. Lists of the firms in the industry and the years in which they produced the product (ideally determined for all years but at least for selected years separated by long spans of time, e.g. every 10 years 1900 to 1990).
2. Based on (1), the total number of companies and the numbers of companies that entered and exited in each year, in total and perhaps broken down into categories such as firm types or geographic regions.
3. Any other information you can collect systematically about each company such as their number of employees or output, details of their product lines, and geographic location (this will depend on what information is available and in some cases you may be able to collect information only for some firms – e.g. those listed on stock markets).
4. Any available information about total industry-wide output and average price in each year of the industry's history.
5. Any available information about technological change in the industry (patent data and information from previous researchers may be especially useful).
6. Any available information about market shares of companies in specific years.
7. Any other information you think is useful from studies of the industry, market research reports, trade journals, government documents such as Census of Manufactures reports and anti-trust studies, or other sources.

The most important information is #1, which can be put to good use by all members of the team.

For studies of industries, useful data sources for #1 include: For aircraft, Phillips' 1971 book *Technology and Market Structure: A Study of the Aircraft Industry* (see the readings for week 6 of the course). For automobiles, the UK entries in the *Beaulieu Encyclopedia of the Automobile* (Bedford Library oversize 629.2203 BEA) or similar sources (ask me in the seminar). For cement, *Kelly's Directory* (see the beginning of the bibliographic chapter on specific products / industries at the end of the course notes), or perhaps the British Cement Association in Crowthorne, Berkshire ([www.bca.org.uk](http://www.bca.org.uk)). For lasers, trade publications have annual listings of which companies make different types of lasers, notably the *Laser Focus Buyer's Guide*. For radios, *Kelly's Directory* (see the beginning of the bibliographic chapter on specific products / industries at the end of the course notes). For software, among other sources there is the annual publication the *Software Users Year Book* which is available at some London libraries (try the on-line catalogs of for example Imperial College Library and also the British Library). For zippers, *Kelly's Directory* (see the beginning of the bibliographic chapter on specific products / industries at the end of the course notes).

Users of *Kelly's Directory* please ask me for advice. The Guildhall Library and the British Library have copies of the directory, but it is a substantial problem for them to be able to make copies available *en masse*. So I will try to help you in ways that may avoid having to visit these libraries at all. If you do visit and need multiple volumes, the libraries may need to be informed in advance of your visit and we will need to coordinate between groups, so that the librarians can make accessible the volumes involved. You are not allowed to photocopy *Kelly's Directory* at Guildhall Library or virtually anywhere, because of the excessive weight and fragility of the volumes, so it is best to arrange to take laptop computers with you and enter data directly into Excel. Through 1970, the directory includes separate sections for London versus the rest of Britain; you will want to use both sections. A good approach is to start with the earliest year and enter all information in the spreadsheet,

then make a copy of that year's information and alter it as necessary to reflect the right information for the next year.

Team 14 is studying contributions of different industries to national economic growth and productivity growth. Team 14 should collect data on (1) value added and (2) hours worked, and/or similar relevant measures. (Note that value added divided by hours worked tells you labor productivity; ideally you could also determine total factor productivity.) This information should be collected for different industries (at as detailed a level as possible – e.g. preferably at the 4-digit rather than 2-digit level), for each of the countries studied by members of the team. This should be recorded in a spreadsheet. Potential sources of information include the *International Yearbook of Industrial Statistics*; at least the 1997 edition is in Bedford Library. There may also be electronic sources already available; LSE library has many CD-ROMs of data (you can save on floppy disks) and these may include what you want. The information should be shared among the team, so that each member can make comparisons with other countries; however each team member will focus primarily on a specific country and will eventually need to collect additional information to help understand the specifics of that country. (The team is welcome to look jointly for further country-specific information, which optionally may be included in assignment 2.)

Team 15 is studying long-term changes in leading US firms, their R&D, and size-R&D relationships. Team 15 should compile data from annual R&D scoreboards in *Business Week* magazine; I can supply the team with a copy of some years of the R&D scoreboards to help the team get going. You will need to compile the information in an Excel spreadsheet. The information should be shared among the team, so that each member can make comparisons across industries and can analyze the full dataset; however each team member will focus primarily on a few broad industry groups and will eventually need to collect additional information to help understand the specifics of those industry groups. (The team is welcome to look jointly for further industry-group-specific information, which optionally may be included in assignment 2.)

### Assignment 3 – Individual report: literature review about your topic

Your task in this assignment is to review the literature and collect important descriptive information (and if appropriate data) for your individual topic. Focus in part on past research and theories relevant to your topic, as you will want to either test theories in the context of your industry or topic, or explain how the empirical facts fit with the theories. Take a copy of your completed assignment to the seminar session.

Detailed requirements of the assignment:

- At least 3-5 pages long, but much more is ok if you think it appropriate.
- Explain key theories pertinent to your project, and discuss your preliminary views of how the theories fit with the facts for your project.
- Discuss as appropriate some relevant descriptive empirical information you collected, or summarize key information sources you have found for key types of empirical information for your project. If you collected data, explain where your data come from and how you collected them; ideally, anyone should be able to follow the process you describe and end up with exactly the same data.
- Include a list of references, in exactly the same format used by a major economics journal such as the *American Economic Review*. Cite the references in the same way references are cited in the journal.
- If appropriate, include printouts and/or photocopies of your data.

After completing this assignment, you want to be ready to actually analyze your information and data and to form conclusions. You may even have begun some of the analysis.

#### Assignment 4 – Individual report: data analysis

Your task in this assignment is to analyze the data and other empirical information for your project. If appropriate, use survival analysis, ordinary regression, or other statistical techniques. Write up your results in a way that clearly explains what issue you analyzed, how you did the analyses, and what conclusions you reached. Take a copy of your completed assignment to the seminar session.

Detailed requirements of the assignment:

- At least 3-5 pages long, but more is ok if you think it appropriate.
- Use survival analysis if you are studying firm exit and survival in a specific industry.

Survival analysis may also be appropriate if you are studying entry, technology, geography, market share, advertising, or international competition in a specific industry (e.g. did firms with a particular pre-entry experience, with high technology use, located in geographic clusters, with high past market share, with high advertising emphasis, or located in particular countries, have lower exit rates than other firms?).

- Use ordinary regression if you are studying long-term changes in leading US firms, their R&D, and size-R&D relationships. Ordinary regression may also be useful for many other projects, for example if you are studying contributions of different industries to national economic growth and productivity growth.
- Cite your data sources. (You may also wish to integrate assignments 1-3 into this assignment, as you should be beginning to prepare your final report.)
- Include a list of references, in exactly the same format used by a major economics journal such as the *American Economic Review*. Cite the references in the same way references are cited in the journal.
- If appropriate, include results of data analyses from Stata. Ideally you should put the results of survival analyses or regressions into nice-looking tables, as you can see in economics journals, rather than just copying the results from Stata into a word processor.

After completing this assignment, you should be working to create the final version of your project report.

#### Assignment 5 – Individual report: draft version of your final project

Your task in this assignment is to have put together a first draft of your final project report. This gives you enough opportunity to discuss it during the seminar and make modifications. Most importantly, you should have a clear thesis statement and an outline of your arguments that help prove the point. These will be useful for discussion.

Detailed requirements of the assignment:

- A first draft of your final project report.
- Know your thesis statement (the point you are making), and have it clearly written in one brief sentence.
- Have an outline (probably with bullets) of the main arguments you are making, based on evidence collected by you and your team.

Don't forget that two copies of your project report are due in the Economics Department office by noon on the last day of the term.

## Library Searches for Projects

Here are some tips to help you find information for research projects. This guide is tailored especially for empirical work in industry economics. (Warning: Internet addresses may go out of date.)

1. EconLit. Go to the Royal Holloway Library web page and (under “resources – bibliographic”) click on EconLit. EconLit is a database search system with information about a lot of economic literature. It only covers recent years, but nevertheless, it should be a good starting point.

Try some searching related to your topic and see what you can find. For example, if your topic is the shampoo manufacturing industry, you might try typing searching for the following:

shampoo  
soap not soap opera  
toiletries

You will discover that shampoo is not a well-researched topic, but there are a couple articles that might be of use. Or if your topic is the automobile industry, you might try:

automobile or automobiles  
(automobile or automobiles) and industry

You can also narrow down the search in other ways. If you want only publications from particular dates or only books, for example, try an “advanced search” or see the on-line documentation for EconLit.

Save a list of all the promising books and articles you find. Don’t forget about multiple spellings; for example, if you’re looking for “tyres”, you’ll find more under “tires”.

2. Search Bedford Library’s catalog of books.

3. Search for relevant books at a few other libraries in the University of London or elsewhere in London. Notably, the LSE library is online at internet location “<http://libexp.lse.ac.uk>”. Another place to search is the British Library, which is available on the internet from location “<http://blpc.bl.uk>”.

4. The National Union Catalog, downstairs in Bedford Library. Often you can find some useful books and journals about an industry if you look up the name of a product in the catalog. It’s divided into earlier and later time periods.

5. Dissertations often take too long to get for a one-term project, but: One of the most useful sources for information about industries is PhD dissertations. They’re a hit-or-miss source, but sometimes they have the best information available about industries. To find out about dissertations, you look them up electronically in Dissertation Abstracts International. Bedford Library used to get paper copies of this through 1990 — they’re shelved upstairs with the journals. However, the paper copies are nearly useless; you need to do an electronic search. Various libraries in the University of London have a CD-ROM version available for use at a computer.

You can order copies of most US (and some international) dissertations from University Microfilms International (see internet site [www.umi.com](http://www.umi.com) if you don’t mind

spending some money, but bear in mind that there is a substantial ordering delay). For dissertations in the UK, you may be able to get them in a London library or through interlibrary loan. When getting dissertations from London libraries, call ahead and make sure they have them on site — sometimes they have to have them brought from depositories which can take as long as two days. One depository is the huge brick building with no windows that's just down the hill from the Royal Holloway dorms. If a dissertation or book or journal happens to be there, you can call them and make arrangements to just go to their reading room right here on campus.

6. Online bookstore catalogs. There are a couple large catalogs that you can search electronically online — regardless of whether you're buying any books. In the US, a good store is Amazon; in the UK, try Amazon UK or the Internet Bookshop. Their catalogs have different entries, so it sometimes helps to search all of them (Amazon US tends to have the best information). Once you have found promising references, you can look them up in libraries around London.

To access these bookstores on the internet, type the following locations into Netscape:

<http://www.amazon.com>  
<http://www.amazon.co.uk>  
<http://www.bookshop.co.uk/>

7. Sooner or later you're going to end up looking up information in libraries in London. So here is an introduction to some libraries likely to be useful:

#### British Library.

- Books: Just about everything printed in the UK, and a good bit more.
- Catalog: <http://blpc.bl.uk/>
- Location: St. Pancras (near the King's Cross / St. Pancras station).
- Entry: To get into the library, you need to get an entry card from the librarians — talk first to the Royal Holloway librarians. You will need to explain what research you are doing; the librarians are picky about letting students in for research projects, so if you are going you should have good reason (e.g. explain what you need from them that you can't get elsewhere in London).
- Closed stacks: It takes a while for books to be brought to a reading room, since they're usually brought from offsite. Once you have a reader's card, you can telephone first to have books gotten out in advance.

#### London School of Economics & Political Science.

- Books: Loads of economics, business, and industry books.
- Catalog: <http://libexp.lse.ac.uk>
- Location: Closest to the Holborn tube stop — walk down Kingsway and turn left on Portugal Street. Or, walk from Waterloo to the river, go across the Waterloo Bridge (near the National Film Theatre), walk up that curving street called the Aldwych, and turn left on the street just after the main road (i.e., just after Kingsway).
- Entry: As a University of London student, you can get in with your student ID, after speaking with the librarians. But check with the Royal Holloway librarians first, in case of a change in policy.
- Open stacks: Most books are available on-site.

City Business Library.

- Books: Lots of business books — I'm told it's the best library, for example, for the chemical industry.
- Location: 1 Brewers' Hall Garden
- Information — Recorded: 0171 480 7638. Humans: 0171 638 8215.

Guildhall Library.

- Books: A range of useful business- and industry-related books, especially historical books. Among them is the International Directory of Company Histories in about twelve volumes — if you need a general briefing about a company, have the most recent volume brought out, then look in the index to find which volume you need. This directory covers most of the world's very major companies.
- Catalog: On-site. Also see: <http://www.ihrinfo.ac.uk/gh/>
- Location: From Waterloo, take the Waterloo and City line to Bank, then look at the local area map before you leave the underground station. You want the London Guildhall, not Guildhall University which is a former polytechnic that is entirely separate.
- Entry: Open admission.
- Closed stacks: They're quick about bringing up the books.

8. My web site ([www2.rhul.ac.uk/~uhss021](http://www2.rhul.ac.uk/~uhss021)), in the “Course Materials for Students” section, has useful web links for industry-related projects.

9. The department's web site (Current Students section) has pointers to some pre-existing datasets.

10. For looking up articles in economics journals, note that many leading journals are accessible at Royal Holloway electronically, notably via the JSTOR, ScienceDirect, and ABI/Inform services. A list of electronic journals is on the library's web page, and these services may be accessed from a computer at Royal Holloway.



## Collecting Data about Technological Change

How can you compile data on invention and innovation by companies? This chapter suggests several approaches and gives you selected examples.

### Patents Data

Patents granted in the US, UK, and other countries provide insights into firms' technological activities. Patents are also relatively easy to access, making it practical to use patent data for industry research.

### Patent Classifications

Government patent offices in the US, the European Union, and other regions classify patents into categories according to the type of technology used. There is also a worldwide patent classification system. If you want to find all patents about a specific topic, searching for words in a title or abstract may be insufficient. For example, patents related to televisions may not include the word "television" in their titles and abstracts. Therefore it can be important to determine which categories and subcategories are relevant for your search.

The categories and subcategories are called "classes" and "subclasses", and you can find their definitions on the internet when you do a search through US or European patent offices. To illustrate how classes and subclasses work, consider European patent category B29D30, "Producing pneumatic or solid tyres or parts thereof." The European categorization system is based on the International Patent Classification (IPC) system. B29D30 falls within IPC section B, "Performing operations; transporting." Within IPC section B, numbers denote the IPC class. IPC class B29 pertains to "Working of plastics; working of substances in a plastic state, in general." Within B29 are various IPC subclasses; B29D pertains to "Producing particular articles from plastics or from substances in a plastic state." Within B29D are various IPC main groups, including B29D30.

The other main groups within B29 may include patents that relate to tire manufacturing processes, such as rolling out sheets of rubber, which is part of the process of making tires. But they also pertain to the making of many other kinds of rubber products, and rubber companies that produce no tires presumably will have lots of patents in these other categories. If you want to identify people and companies active with tire technology specifically, it is probably better just to use main group B29D30, since it pertains *only* to the production of tires and tire parts.

B29D30 of course has a lot of subdivisions within it. B29D30/02 is an IPC subgroup for "Solid tyres." B29D30/04 is an IPC subgroup for "Resilient fillings for rubber tyres; filling tyres therewith." B29D30/06 is an IPC subgroup for "Pneumatic tyres or parts thereof." Sometimes the European Patent Office introduces yet more subdivisions. B29D30/06B pertains to "Vulcanising tyres; vulcanising presses for tyres." Within that, B29D30/06B1 pertains to technologies with "The vulcanising medium being in direct contact with the tyre." B29D30/06B2 pertains to "Loading or unloading the presses." And there are plenty more categories within B29D30 (and likewise within B29D30/06 and B29D30/06B) that have not been mentioned here.

If you need to look up the correct categories, you will need to look carefully at the on-line manuals of classification for patents.

A good way to get started is to search for some relevant terms (e.g. “manufacturing pneumatic tyres”) in patent titles and abstracts, find some relevant patents, and see how they are classified. This can help you find the right places in the classification scheme. Also, when you look up classifications, you will see cross-references that may help you find relevant categories.

### **Content in Patents**

Depending on which online system you use for your patent search, or whether you use old-fashioned paper methods or you look at the full text of patents, you will find various useful information. Relevant information includes:

- Title of the patent.
- Inventors of the patent.
- Assignees who get the rights to the patent if and when it is approved. These may include people and companies, so this is a good place to search for the name of a company.
- Application number.
- Patent number.
- Geographic locations of inventors and/or applicants.
- Abstract.
- Claims made in the patent. If a patent is granted, these detail exactly what technology the patent owner owns.
- Citations of previous literature and patents related to this patent.
- From other patents’ lists of citations, it is possible to determine which patents cited this patent. Indeed, some patent search services give you a list of all patents that cited this patent.

Depending on the search service you use, you may be able to search using any of these types of information. Thus, you could find all patents with assignees including “Monsanto”, the name of a drug company.

### **Estimating the Importance or Value of a Patent**

It is difficult to assess the value of a patent. Experts may be able to subjectively assess how “good” a patent is, but this would be a difficult task. Firms may have estimates of how much money was generated by a patent, but if so these are generally considered important competitive information and kept secret. So is there some way to measure the value of a patent, or at least to compare how important patents are relative to each other?

Two methods are sometimes used. The first is rarely used because of the difficulty of collecting information, but it provides a direct economic measure. In the UK, France, and Germany, patent-holders must pay periodic renewal fees to keep their patents in force. The renewal fees may rise substantially over time, and hence whether the holder pays a renewal fee provides a measure of whether they expect it to be at least as profitable as the expense (and hassle) of renewal. Renewal fees were used for example in articles by Pakes (1986) and Schankerman and Pakes (1986), who showed that accounting for changes in patent value can explain national trends that otherwise might seem puzzling.<sup>1</sup> However, these authors obtained information for all

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<sup>1</sup> See also Pakes (1985) for an alternative approach to measuring the economic value of US patents. Ariel Pakes, “On Patents, R&D, and the Stock Market Rate of Return,” *Journal of Political Economy*, 93 (2), April 1985, pp. 390-409. Mark Schankerman and Ariel Pakes, “Estimates of the Value of Patent Rights in European

patents nationwide courtesy of the British, French, and German patent offices; obtaining information about the renewal of specific patents rather than total numbers of renewals is more difficult (that is, I am not sure whether or where the information can be obtained).

A second method is more practical for general use, in that the necessary information can easily be obtained electronically (at least for US patents in recent decades) for specific patents. This is to see how many other patents cite a specific patent. You need to be careful about how you measure this; for example by the year 2001 it is hardly surprising that a patent published in 2000 would have few or no citations, while a patent published in 1980 would be more likely to have had many citations by now. You might compute the number of citations per year over the first 20 years after a patent was published, or you could only examine patents that are at least 5 years old and check how many patents they had in the first 5 years after being published. The amount of citations provides a very noisy but still useful way to estimate how important is a given patent compared to other patents.

### **Electronic Patent Searches on the Internet**

To carry out US patent searches on the internet, use web site “<http://www.uspto.gov/web/menu/search.html>”. An index to the US classification system is available there. To carry out European or worldwide patent searches, use web site “<http://gb.espacenet.com/>”. For detailed information about patents from the UK Patent Office, use web site “<http://www.patent.gov.uk/patent/index.htm>”. When you do a search, carefully choose which “fields” of information in which to search (title, abstract, assignee, year, etc.). Document your work so you can figure out later on what you did in your search, and so you can report it to others.

### **Information to Collect Using Patent Data**

What kind of information might you collect? Depending on your needs, you might compile the following information:

- For a given type of technology, the number of patents granted each year. This lets you examine trends in technological activity, such as the decline of horseshoe patenting after the rise of the automobile.
- For a given type of technology, the names of companies (and perhaps individuals) that have been patenting in this technology area. This is an indicator of which companies have been active in developing a technology. (You may miss companies that protect their technology through secrecy not patents, that own subsidiaries that do the patenting, or that use patents granted to employees.)
- For a given type of technology, the numbers of patents each company received or submitted each year. Rather than just knowing which companies were active in developing a technology, this also lets you assess how active companies were in comparison to each other.
- For a selection of companies (perhaps ones you know produce a given product), the numbers of patents each company received in each year, perhaps restricted to a given type of technology. This lets you compare firms’ differing levels of R&D activity, in general or in a specific type of technology. (Beware that if the

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Countries During the Post-1950 Period,” *Economic Journal*, 96 (384), December 1986, pp. 1052-1076. Ariel Pakes, “Patents as Options: Some Estimates of the Value of Holding European Patent Stocks,” *Econometrica*, 54 (4), July 1986, pp. 755-784. These articles can be obtained electronically via JSTOR.

companies are very different — e.g. a drug company versus a steel company — their numbers of patents per year may differ simply because of different “propensities to patent” in different kinds of industries.)

- For a selection of companies, the numbers of patents each company received each year in a selection of different technology areas. This lets you assess to what extent companies’ technological activities span multiple areas; e.g., companies producing television receivers may benefit not only from patents relating to television but also from patents relating to electronics in general.
- Whenever you collect data on patents, you could also record the number of citations per year (e.g. over the decade after the patent was granted). This lets you could use the rate of citation as a measure of importance of patents, so you can perform whatever patent analyses you carry out using not total numbers of patents, but the sum of the patents’ importance ratings.
- For analyses of companies, you might gather additional patent information from other countries. This lets you construct a measure of how much each company was active internationally.

### **Census of Manufactures Productivity Data**

The US and UK governments collect periodic censuses of companies. Both governments publish reports about various broadly aggregated industries using the data collected. The reports tend to include information about productivity. Using productivity data over time, you have an industry-wide measure of technological change. Generally such information is not broken down by type of firm (although rare exceptions exist), but just seeing how much productivity improved in which years can tell you a lot. As an example, Table 1 reports labor productivity over time in the US automobile industry. A leap in productivity is apparent between 1909 and 1914, when Ford Motor and other companies began to put into place some of the mass production techniques that Henry Ford made famous.

Table 1. Labor Productivity in US Automobile Manufacturing, 1899-1937

	Automobiles Produced per Wage Earner during Year	Value Added per Wage Earner during Year
1899	1.66	\$1314
1904	1.89	1401
1909	1.68	1552
1914	4.51	2176
1919	4.90	3320
1921	7.52	3564
1923	9.66	3618
1925	9.80	4108
1927	9.09	3977
1929	11.84	4475
1931	8.05	3333
1933	7.60	2660
1935	10.14	2900
1937	9.88	3144

Source: US Census of Manufactures data reported in Federal Trade Commission (1939, p. 7).

## **Lists of Innovations**

Patent data have the important advantage of being available for individual firms, not just for an industry as a whole. But they have disadvantages too. One disadvantage is that patents do not reflect many kinds of product and process improvements made by companies. Contrary to common mythology, patents do not give companies much of the financial benefits of a new technology, in actual practice in most industries. This is in part because patents tend to be difficult to enforce and easy to get around by designing alternative techniques. (The pharmaceutical and chemical industries come close to the common mythology. In most industries patents in large numbers are used as bargaining tools and as support in lawsuits to help keep out companies that aren't big players in the industry.) Hence the motives that drive patenting can differ substantially from the motives that drive innovation, and many kinds of innovations are never patented.

### **Using Lists of Innovations**

Thus lists of innovations, compiled by arduous work from industry experts or extensive industry literature, can be a boon for industry analysis. In some cases you may be lucky enough to find existing lists. For example, Abernathy, Clark, and Kantrow (1983) catalog 631 automobile innovations from 1893 to 1981 and for each identify the innovating firm, the year of innovation, and a subjective ranking of the innovation's impact on the manufacturing process. Klepper and Simons (1997) use this information to analyze trends over time in firms' development of product and process innovations of various types, in the process testing theories about industry evolutionary processes.<sup>2</sup>

It can be valuable to distinguish between product versus process innovations, and perhaps between other categories of innovations. Many theories of industry competitive dynamics stress the differing roles of product versus process innovation, implying for example that product innovation might be most important in early years and process innovation most important in later years.

### **Compiling Lists of Innovations**

Compiling your own lists of innovations may be possible for some industries, although you will need to be prepared for a lot of work. One example is a list I compiled of innovations in television set manufacturing processes. The US television manufacturing industry turns out to have been very open about revealing its ongoing changes in manufacturing processes around the time when manufacturing took off in the 1950s. Indeed, engineers gained respect for themselves and their companies in part through articles written about their manufacturing lines, and trade journals gave cash awards to people who wrote in with tips about how to improve manufacturing methods. In part the great interest attached to television manufacturing stemmed from the enormous interest generated by the advent of widespread consumer use of television. This makes the TV set manufacturing industry unusually amenable to analysis of its process innovations during this period, providing insights into the changing manufacturing process that are unavailable in most industries.

To compile lists of television process innovations, I began by using an annual index of trade and technical articles. I checked each year of the *Industrial Arts Index* (later *Applied Science and Technology Index*) from 1946 to 1971 to find any articles

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<sup>2</sup> See also Klepper and Simons (2001) for related work analyzing the impact of technology on firm survival.

pertaining to television manufacturing. This index is likely to be of use for any manufacturing industry. By searching the indexes methodically, I identified all relevant articles. Of approximately 210 relevant articles, I obtained and analyzed 198 articles. In each I read closely to identify any new manufacturing techniques described for televisions. The result was a list with 264 innovations by US firms actually making televisions (rather than components). Each was ranked subjectively on a 7-point scale according to its likely impact on manufacturing costs. I also created a typology of different types of innovations, pertaining to methods of inserting components, soldering them together, moving them along assembly lines, testing, etc.

A classification system may turn out to be extremely valuable to give insights about what sorts of innovations happened in what years by what firms. For the television process innovations, I used the categories listed in Table 2, identifying each by a letter code. Similarly, if you compile your own data, you will want to create a classification system that delineates important categories and that is easy to use without making mistakes when you record your own data.

For your own work, you will most likely need to record data in spreadsheet form. Be methodical about recording other pertinent data, including the source of information from which you identified an innovation. As an example, Table 3 lists the first innovations recorded in my television process innovations list, from the years 1947 through 1950. The columns of the table give the year of publication of information, the producer(s) responsible for the innovation, the nature of the innovation, the subjective ranking of impact on manufacturing costs, the category, and the source of information.<sup>3</sup>

Table 2. Categories Used for Classification of TV Process Innovations

A	Assembly of chassis (manual)
B	Putting chassis & other parts into cabinets
C	Cabinet making
D	Design change to assist assembly (decrease faults, reduce materials use)
E	Assembly of chassis (automatic)
J	Jigs [related to category P]
M	Conveyors and movers
N	Crating and packing
O	Other
P	Positioning methods, including chassis trunnions
R	Chassis frame building and riveting
S	Soldering
T	Testing and alignment
W	Preparation (not making) of parts for assembly or automatic insertion
X	Printed circuit boards
Z	Manufacture of coils and yokes

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<sup>3</sup> Sources of information include E for *Electronics*, TT for *Tele-Tech*, and FMM for *Factory Management and Maintenance*. Twenty other journals were also sources in later years.

Table 3. Initial Part of List of TV Process Innovations

Year	Producer(s)	Innovation	Rank	Cat.	References
1947	RCA, Philco	assembly lines with conveyor belts	7	M	E Oct 47 p132, TT Mar 48 pp36-38
1947	RCA	trunnion supports inverted chassis for working positions	4	P	E Oct 47 p132
1947	RCA, Emerson	automatic socket riveting to chassis	3	R	E Oct 47 p132, TT Oct 48 p33
1947	RCA, Emerson	use of air-gun nut runners and screw drivers	3	A	E Oct 47 p132, TT Oct 48 p33
1947	RCA	use of operation sheets at assembly stations	2	A	E Oct 47 p132
1947	RCA	overhead conveyers for chassis and materials	4	M	E Oct 47 p132
1947	RCA, Emerson	testing: setups for i-f, r-f, and deflection tests	5	T	E Oct 47 p133, TT Oct 48 pp34-35
1947	RCA, Philco	central test signal source	4	T	E Oct 47 p133, TT Nov 48 p76
1947	RCA	coil winding machine (with automatic indexing, compression, set of molding compound, cooling, and cutting)	3	Z	E Oct 47
1948	Telequip Radio	monitoring scope	1	T	TT Feb 48
1948	Philco	establishment of incoming parts inspection and statistical quality control	3	O	TT Mar 48 p37, TT Nov 48 pp84-85 &90, E Apr 50 p91, TT Apr 53 pp112&147-148
1948	Philco, Emerson	pass-along assembly line with rolling cradles in tracks	4	M	TT Mar 48 pp36-38, TT Oct 48 p33
1948	Emerson	plywood jig for master cable assembly	1	J	TT Oct 48 p32
1948	Emerson	roller skids for chassis, with ball bearing rollers	1	M	TT Oct 48 p35
1948	Emerson	mirror allows operator to make adjustments at rear while viewing screen	2	T	TT Oct 48 p35
1948	Philco	punch presses for chassis	3	R	TT Nov 48 pp66-67&90
1948	Philco	nailboards for checking punch presses	2	R	TT Nov 48 pp66-67&90
1948	Philco	oil coating of chassis frames before punching	2	R	TT Nov 48 p90
1948	Philco	electro-plating of chassis frames	3	R	TT Nov 48 p90
1948	Philco	cabinet design and manufacture for TV sets, and outsourcing decisions as necessary	3	C	TT Nov 48 pp70-73&87
1948	Philco	continuity tests	5	T	TT Nov 48 pp76-78, E Oct 52 p258
1948	Philco	standardized width for test equipment mounting	1	T	TT Nov 48 p78
1950	DuMont	closely spaced riveting machines to facilitate passing chassis between operators	2	R	FMM Mar 50, E Apr 50
1950	DuMont	storage racks built for gentle movement of parts on fork lift trucks	2	M	FMM Mar 50 p71, E Apr 50
1950	DuMont	conveyor dips for loading heavy parts	3	M	FMM Mar 50, E Apr 50 p88
1950	DuMont	tilt & turn table for packing sets in cases	2	N	FMM Mar 50 p72, E Apr 50 pp86-87

Table 3 continued.

Year	Producer(s)	Innovation	Rank	Cat.	References
1950	DuMont	missing roller technique for turning of carton when packing	1	N	E Apr 50 pp87-88
1950	DuMont	tool for twisting paired leads of resistors or capacitors	3	A	E Apr 50 pp88-89
1950	DuMont	jigs for clamping and holding parts during subassembly of potentiometers	3	J	E Apr 50 pp88-89
1950	DuMont	lead-cutting gage	2	W	E Apr 50 p89
1950	DuMont	automatic lead cutting machine (manually loaded, includes a counter)	4	W	E Apr 50 p89, E May 52 pp258-262
1950	DuMont	carton-holding easel stands for easy access to parts	1	A	E Apr 50 p89
1950	DuMont	chicken-feeder parts supply boxes	2	A	E Apr 50 pp89-90
1950	DuMont	easy-slide-on test benches, convenient and ergonomic	3	T	E Apr 50 pp89-90
1950	DuMont	CRT housing for bench use, for testing chassis	2	T	E Apr 50 pp90-91
1950	DuMont	fixture for measuring effects of stray magnetic fields from transformer on CRT picture	2	T	E Apr 50 pp90&92
1950	Zenith	automatic positioning devices for riveting, automatic tripping of riveting anvil when operator turns cam track to correct position	4	R	FMM Aug 50
1950	Zenith	new chassis design to obviate need for welding and rivet washers	3	R	FMM Aug 50
1950	Zenith	rotating parts bins with parts in order needed, automatically indexes with riveting machine	3	A	FMM Aug 50 p103
1950	Zenith	foot switch to control air for floating anvil head positioning	2	R	FMM Aug 50 p103
1950	Tel-Instrument, Air King (CBS)	improved, lower-cost test equipment (80% lower testing costs)	5	T	TT Sep 50, & see Apr 51

### Measuring Technology in Use from Catalogs or Directories

Innovation is one measure of technological leadership, but it is by no means the only pertinent measure. Innovation only reflects which firms were first to introduce new technologies. Perhaps even more important is whether firms manage to adopt a technology or develop and produce a product based on a technology. Often the key information can be easily and publicly obtained, to be able to adopt a technology or to design and produce a product. But obtaining the information is very different from putting it to use in practice! The reality usually involves a lot of hard work that is the less-glamorous bulk of the work in R&D and product/process engineering. Usually the information that must be obtained is not in a single document, but spread across many documents and many people's know-how. Adoption or production require getting what information is worth obtaining given the varying difficulty of getting different kinds of information, and then a lot of hard work. Therefore, information about which companies have adopted an innovation or are selling a particular product variant can be an extremely valuable measure of firms' technology leadership.



Catalogs and directories of an industry sometimes indicate which companies make which types of products. For example, I have used directories to determine which firms sold tires incorporating important new designs valued by consumers, which firms manufactured hard disk drives of different sizes, and the operating speeds of different firms' computer chips. All of these indicators have been used as measures of firms' technological leadership or laggardliness relative to competitors. When recording information from catalogs or directories, be systematic; record information for each firm in the available data sample, clearly indicate sources of information, record the year or years to which information pertain, and develop classification schemes that are useful given the available information.

### **Technology Measures from Other Sources**

Be open-minded about potential sources of information. For example, a friend of mine did an excellent study of technological change in the tennis racket industry by recording claims made in firms' advertisements about their tennis rackets. In many industries there may be no sources of information about technological change, but if you are clever and look at lots of possible ways to collect technology measures, you are likely to find some useful information source.

## Statistics for Survival Analysis

This section will give you some basic skills to analyze data about the “survival” of companies. **In this course, we generally will consider survival not in the sense of companies continuing to exist or not, but simply in terms of whether they continue to produce a particular sort of product.** If they do not continue to produce the product, the reason is probably that they were outcompeted in some sense -- most likely they no longer made a profit in the business.

The analysis of firms’ survival below uses the Stata program, available in the Computer Centre. Plan ahead so you can get a computer! The section shows you how to use Stata to analyze survival data with one particular dataset, then has you analyze a different dataset to practice your skills. You will want to take this section with you to the Computer Centre and use it while you work.

The treatment given in this section is very simple. You will learn to control for only one (or a few) variables at once, and you will mainly consider survival to some particular “age.” A separate handout will be given later explaining how to do statistical survival analysis with regression equations, somewhat like the OLS regression you have used before. The later handout will let you use any number of control variables and will address survival to all ages, but it requires some more sophisticated concepts that we will discuss during a seminar session.

### Collecting Data on Firm Survival

Here are notes about how to collect data on the entry and survival of firms. At the same time as you collect survival data, it is generally valuable to collect other information such as firms’ geographic locations, size, sales strategy, etc. And if you come across information about total industry output, price, imports and exports, profits, stock prices, and other figures of interest for the time period(s) you are analyzing, these of course are likely to be useful as well. I am going to focus here on firms’ entry and survival.

Collecting entry and survival data can be a big job! To do it well, you need a list of each company that is in the industry, or ever was in the industry, and the years in which they produced the product. Sometimes this is easy to get if you can find the right books — for example, for the British automotive industry, and probably for the motorcycle industry as well, there are books that tell the years in which each company produced the product. But most often you will not have such a book. Instead, you will have to find some annual directories that provide lists of companies.

If you are doing a service industry, the best place to look may be telephone directories. By looking through different years of the London Southwest telephone directory, you can figure out for example what restaurants have been in the whole of the southwest London area, and when they were in business. (The British Telecomm Archive in London has back copies of telephone directories; it’s located near the Embankment tube stop, and you have to call them in advance to let them know you’re coming — dial an operator on 100 and ask for the Archive.) If for practical reasons you need to focus on just a few towns worth of restaurants and only check the phone books every 3 years instead of every year, that’s okay! For published research you would have to do a more thorough job, but I am only expecting you to do enough to learn how. (If you want to go further and try to publish something, by all means feel free.)

The information you come up with from the phone books will end up looking something like this:

Peking Chinese	1976-1996	take-away	main
Ali Baba	1982-1983	eat-in	side
Egham Deli	1995-1996	take-away	main
The Olive Grove	1984-1996	eat-in	main
Ristorante Bella	1987-1992	eat-in	side
Hula Loopa	1979-1985	eat-in	side
Tinned Food Express	1986-1986	take-away	side
Founder's Dining Hall	1888-1996	eat-in	side
etc.			

Here, I've given the name of the firm, the dates it existed, and some other information about it. The third column tells whether you can eat in the restaurant or have to take your food away from it. The fourth column tells whether the restaurant is on a main street versus a side street.

**Be sure to carefully write down the source of your information and how you made any decisions about how to catalogue the data. You may need to use this information to explain what you did to others, to retrace your own work if necessary, and to identify and fix potential problems with the data collection.** You'll definitely need this information for your project report.

For manufacturing firms, the best place to look is annual trade registers. There are a number of such books that tell you who is making a product, where they are located, and often other information such as their size and product details. For UK firms, *Kelly's Register* is one good source. (The Guildhall library has copies of Kelly's and other trade directories.) Other sources deal with international firms and that focus on particular kinds of products, such as high-tech products. Ask the reference librarians at the libraries I've described to you earlier; they may have good ideas about what register is best for your industry. If you can find a library that keeps back issues of the register, you can use the back issues to check when each firm was manufacturing the product.

**Make sure to catalogue firms that have gone out of business during the time you check, not just the firms that are still around!** (This is recorded in the restaurants example, as the table includes the last year the restaurant was open.) Otherwise you will have no way of asking whether certain characteristics of firms affected whether they went out of business. For example, it may be that restaurants on side streets tend not to last very long; to analyze whether this is the case, you have to know which restaurants went out of business.

### Analyzing Firm Survival

You'll analyze data on firms' survival as an example for this assignment. The techniques used here can be applied to various other issues that you might be addressing, such as the time between when automatic teller machines (ATMs) became available and when banks adopted the machines, or the time between hiring and either firing or promotion for male and female employees. These issues of course do not concern the survival of companies, but they concern analogous situations -- in all cases someone or something was in a situation A until at some time a change to a situation B occurred. In terms of the survival of companies, the someone or something is a company, situation A is that the company is producing a product, and situation B is that the company is no longer producing the product. In terms of adoption of ATMs, the someone or something is a bank, situation A is that the bank did not have an ATM, and situation B is that the bank did have an ATM. In terms of employee firing or promotion, the someone or something is a worker, situation A is

that they are an un-promoted employee, and situation B is that either they have been fired from the job (situation B1) or that they have been promoted to a higher-level position (situation B2).

Go to the Computer Centre and log onto a computer. Once the computer has started up, there is a button to the lower left that lets you start programs. Look in the Academic Programs, Economics section, and start the program “Stata” (not “Stella”).

When the program starts up, you will see several windows. “Command” is where you will type commands to tell it what to do. “Review” keeps track of the commands you’ve issued. “Results” shows the results of your commands. “Variables” tells what variables are in the computer’s memory.

### Loading Data from a Text File

To try out how the program works, load some data into memory. In the command window, type:

insheet using P:\stata\tvs.txt

Then press return to read in the data. The “insheet” command tells Stata to read in a file of data. The data file was saved from a spreadsheet program, such as Excel, and looks like this:

name	start	end	merge	foreign	prevind
Admiral	1948.75	1978	0	0	1
Advent	1975	1981	0	0	0
Air King Products, Pathe Television, CBS-Columbia	1948.75	1956.5	0	0	1
Air Marshal	1951.5	1952.5	0	0	0

(etc.)

If you ever need to transfer your own data from Excel to Stata, try copying and pasting, or do the following: 1. Put all the data into Excel. Each column should correspond to one variable, and each row should correspond to one data point (such as a company). (If you are supposed to have missing data in any cells, leave the cells blank.) 2. Make sure the spreadsheet has one row before the actual data. In this first row, give the names of the variables. The names of variables can have up to 8 letters (or numbers, but numbers cannot go at the start of a variable name). In the example above, the names of variables are “name”, “start”, etc. 3. Save your file as usual if you want. 4. From the File menu, choose Save As..., and set the file type to Text - Tab Delimited. Save the file under a new name. The file should now be ready to read into Stata using the “insheet” command as above.

The file you just read in contains a list of firms that manufactured television sets in the US. It comes from information that I’ve collected from the trade register *Television Factbook*. In the file, each line has six pieces of information: (1) the company’s name (or an abbreviated form), (2) the approximate date at which it began producing TV sets, or 1948.75 for the relatively small group of companies that began manufacture before that date, (3) the approximate date of its last year of production, or 1989 for all firms that continued producing beyond 1989, (4) a 1 if the firm ceased to exist because it was acquired or merged, a 0 otherwise, (5) a 1 if the firm is owned by non-US operators, a 0 otherwise, (6) a 1 if the firm participated in a previous electronics business before it began manufacturing televisions, a 0 otherwise. You may use the data for this class, but you should ask me for permission before using them otherwise.

## Examining and Editing the Data

Near the top of the screen, there are some buttons. One of them says “Editor”. Click on this button to display the data. Look through the data and find the line for “Thomson”. I have deliberately placed an error in this line of data. In the “start” column is the date 1902. In fact, Thomson entered the US industry in 1987. Click on the number 1902, type 1987, and press return. You have fixed the error.

Take a look through the rest of the data and familiarize yourself with what it looks like. When you are done, press the “Preserve” button to keep your change to the data. Then, close the window, using the X button in the upper right.

## Information about the Data

Before you proceed, click on the Log... button in the upper-left of the screen. This creates a file that records all the results of what you are doing as you use Stata. Create the file on your F: disk or on a diskette in the A: drive. You can give it any name you want (.log will be added to your name). Doing this may also create an extra window on the screen, called the Stata Log window, which has a scrolling bar so you can see your earlier work.

Type “**describe**” in Stata’s command window (and press return). Stata tells you how many observations (i.e., companies) are in the data, and what variables there are.

Type “**list**”. Stata prints out the data in the results window. Since there are lots of data, it shows some, and then waits before showing the rest. Press a key to see more data, or press the Break key to stop looking at the data.

Type “list start end” to look only at the start and end variables.

Type “list start end in 101/110” to see only the 101st to 110th firms.

Type “list start end in -10/-1” to see only the last ten firms.

Type “list name if foreign==1” to see only the foreign-owned firms.

Type “list name if start<=1948.75” to see which firms had begun production by the date 1948.75.

Type “list name if end>=1989” to see which firms were still producing as of 1989.

Type “**summarize**”. Stata tells you the number of observations for which it has data on each variable (note: the dataset can sometimes contain “missing data” in some cells of the Editor, causing the numbers to differ). It tells you the mean value and standard deviation of each variable, and the lowest and highest values of that variable.

## Creating New Variables

In addition to entering variables by reading them from files or entering them in the Editor, you can create new variables based on existing variables. Type:

**generate totalage = end - start + 1**

This command creates a new variable named “totalage”. For each company, totalage equals the date at which it ended production, minus the date at which it started production, plus one. For example, Admiral started and ended production in 1948.75 and 1978, so its totalage is 30.25. I’ve added 1 because the start and end dates are really the dates of publication of the trade registers in which it was first and last listed, and really the average company probably began production 6 months earlier and ceased 6 months later (6 months + 6 months = 1 year).

Click on the Editor button and have a look at the new variable you’ve created. When you’re satisfied, close the Editor window.

Next, create another variable that tells which companies' data are "right-censored". Right-censoring means that a company still existed when you stopped collecting data. To create the variable, type:

```
generate censored = end==1989
```

The new variable equals 1 if end equals 1989, or 0 otherwise. After you generate variables, it's important to make sure that they came out okay, lest you inadvertently make an error. Use the summarize command, the list command, and perhaps the Editor to check that the data are okay!

```
summarize censored
```

```
list end censored
```

You should see that censored equals 1 or 0 (corresponding to true or false), and that it equals 1 only if a firm has an end date of 1989.

### **Two-by-Two Tables: Checking for Early-Mover Advantage**

In the following analysis, I am going to assume that companies with starting dates of 1948.75 would not have been producing televisions in earlier years, had there been a register of producers then to tell us. This is an approximation, but it's a pretty good approximation because after World War II, no firms began producing TVs in the US until 1946, and we've already assumed (by adding 6 months before the first date to each firm's totalage) that these firms began in 1948.25. In fact, 30 firms were producing TV sets in the US by the end of 1947, and almost none before then. Some half-dozen companies also produced sets until the US entered the war, but production was suspended during the war.

To check for an early-mover advantage, let's ask whether companies managed to survive at least ten years, and how that varies with time of entry. First, we will need to ignore some companies, because we don't know whether they survived at least ten years. For any company that entered after 1979, we don't always know whether it survived ten years, because we only have data up to 1989. Also, among companies that entered after 1979 and didn't survive ten years, including them would bias the results in favor of an early-mover advantage hypothesis (to see why, imagine what the results below would be like if there were a million companies that entered in 1980 and they had the same chance of surviving ten years as early entrants, but we only included the data for the companies we knew had exited before 1989). So, type the following:

```
generate usedata = start<=1979
```

This creates a new variable called "usedata" which equals 1 if and only if start<=1979 for all the companies we want to use, and 0 for all the companies we don't want to use.

Now, we'll need to decide what to call early versus late entrants. I'll arbitrarily pick a dividing line by saying that early entrants are companies that got into manufacturing of TV sets before 1949. So, type:

```
generate early = start<1949
```

Again, the variable created equals 1 if start<1949, 0 if start≥1949. To find out which firms survived at least ten years, type:

```
generate tenyear = totalage>=10
```

Again, the variable created equals 1 if totalage≥10, 0 if totalage<10. You now have all the variables you need to do the analysis.

To create a table of survival length versus time of entry, type:

```
tabulate early tenyear if usedata, row exact
```

The tabulate command tells Stata to make a table, showing how many firms fall into each category (0 or 1 in this case) of the variables “early” and “tenyear”. The “if usedata” tells Stata to use only the data that we wanted, for firms that entered by 1979. The result will look like this:

early	tenyear		Total
	0	1	
0	72 71.29	29 28.71	101 100.00
1	53 75.71	17 24.29	70 100.00
Total	125 73.10	46 26.90	171 100.00

Fisher's exact = 0.600  
1-sided Fisher's exact = 0.322

The early entrants (early = 1) consist of 70 firms, 53 (75.71%) of which did not survive ten years, and 17 (24.29%) of which did. The later entrants (early = 0) consist of 101 firms, 72 (71.29%) of which did not survive ten years, and 29 (28.71%) of which did. There is a total of 171 firms in the data that we used to make the table. Given that only 24% of the early entrants survived at least ten years, versus 29% of the later entrants, it looks like the later entrants did better than the early entrants! This seems to be the opposite of an early-mover advantage.

Of course, maybe the early and later entrants just had equal chances of surviving to age ten. If that guess were right, there would still be some random variation in who got lucky and succeeded versus who didn't. You could hardly expect the percentages of firms surviving at least ten years to come out exactly equal among the two groups. Well, in this case, suppose it really were true that the early and later entrants had exactly equal chances of surviving to age ten. If so, it turns out that there would be a 60% chance (i.e., 10% better than a fifty-fifty chance) of getting percentages that are at least as far apart as the 24% and 29% are apart in this example. In other words, if it's really the case that early entrants survived ten years with the same chance as later entrants, then the result we're seeing is hardly surprising. It could be that earlier entrants did have a disadvantage relative to later entrants, but this certainly doesn't dispel the notion that neither group of firms had a disadvantage relative to the other. The 60% above comes from the “Fisher's exact = 0.600” in the results. In the “tabulate” command, the “exact” at the end of the command was a request for this information.

Now, what about surviving twenty years? Type the following commands:

```
generate twenyear = totalage>=20
drop usedata
generate usedata = start<=1969
```

The first command above creates a new variable for surviving at least twenty years. The second command removes the variable called “usedata”, deleting it from Stata's memory. The third command creates usedata all over again, but this time using only firms that entered by 1969, i.e., at least 20 years before the end of the dataset.

Okay, now create the table as before, but using “twenyear” in place of “tenyear”. This time the results look like this:

early	twentyyear		Total
	0	1	
0	88 95.65	4 4.35	92 100.00
1	55 78.57	15 21.43	70 100.00
Total	143 88.27	19 11.73	162 100.00

Fisher's exact = 0.001  
1-sided Fisher's exact = 0.001

You can see that 21% of early entrants survived at least twenty years, versus 4% of later entrants. Wow! It seems that early entrants had a much higher chance of surviving to age 20 than did later entrants. The fraction of early entrants surviving this long was more than five times higher than that of later entrants. But perhaps there is a doubter among you who says, bah humbug, the chances of surviving twenty years are identical for the two groups, and any differences are just random variation. Well, in this case, it seems you don't need to doubt. Of course all sorts of random events could occur by chance, but here the chance of such a striking difference occurring randomly is around one in a thousand (0.001).

Now do the same thing once more for thirty-year survivors. (In the process you will generate a variable called "thirtyyear".) You will see that 5 of 70 early entrants survived at least thirty years, and 1 of 79 later entrants survived this long. It would be interesting to know who was the 1 long-lived late entrant. Type:

**list if thirtyyear==1 & early==0**

This gives you a list of the data for all companies that survived 30 years (thirtyyear is 1) and that were not early entrants (early is 0). The only such company turns out to be Sylvania Television, which started in 1949.75. It is practically an early entrant, and if we had used 1950 instead of 1949 to define who is an early entrant, then we would have gotten the result that absolutely none of the later entrants survived thirty years. This is a disadvantage of this approach; we have had to arbitrarily choose the dividing lines of early vs. later entrants and of a number of years survived.

You can also compare firms' survival based on whether they were participants in a previous industry. If you now type:

**tabulate prevind thirtyyear if usedata, exact**

you will discover that the six firms surviving at least 30 years were all firms that had been involved in electronics manufacturing before they started making TV sets.

By the way, the tables you created are called two-by-two (or 2x2) tables. The test to see whether the results could be just random outcomes, if in fact the chances of survival were the same for the two groups, is called "Fisher's exact test." Sometimes people use a  $\chi^2$  ("Chi-squared") test instead of Fisher's exact test, but Fisher's exact test is better when sample sizes are small.

If you are using data where lots of companies existed before the first year in which you have data, be careful about what kinds of conclusions you draw. Suppose that only companies with very skilled managers survive for at least twenty years. Among firms that were already producing when your data begin, most have very good managers, because otherwise they would not have survived! If you count these companies as being at age 0 at the beginning of your data sample, then of course they are going to have higher percentage survival rates than later entrants, simply because



they have better managers on average. It is best to use what information you have to improve your analysis. For example, if you know how long these companies have been producing the product, and you know that no companies that existed before the sample begins survived more than  $N$  years, you could compare the percentage of companies surviving from age  $N$  to age  $N + m$  ( $m > 0$ ), for early vs. later entrants, or for firms with previous background in electronics versus firms without, etc.

### Kaplan-Meier Survival Curves

To avoid the disadvantage of having to arbitrarily choose dividing lines for age and entry time, you can use other approaches. One is the “survival curve” approach that I showed in lecture. To be able to use this approach, you’ll need to tell Stata which of your variables describes firms’ total number of years survived, and which tells whether the data are right-censored. If you are missing data for the earlier years of the industry, and it’s not reasonable to approximate the situation as if you weren’t, then you have left-truncated or left-censored data. If you know how long all companies were producing before your data begin (e.g., for company A, if you know that company A began producing in 1967 even though your data begin in 1975, then company A was in the sample 8 years before your data begin), then you can still analyze the data despite the left-truncation or -censoring. However, if you have left-truncation or -censoring, you will implicitly be making some assumptions, which you should learn about before analyzing your data this way.

To use this approach, Stata needs to know the “age” (number of years since it began producing the product) of each company when it ceased production, or its age at the most recent year for which you have data if it was still producing. Assuming some companies were still producing as of the most recent year you have data, it needs to know who these “right-censored” companies are. And if you have left-truncated or left-censored data, it needs to know the age of each company when your data began.

Here and above I am assuming that you have data on pretty much all firms in your industry, or at least in a certain geographic region of the industry. If you leave out short-lived firms, or smaller firms, or half of the firms that began production during the first ten years of your data, or etc., then you might introduce all kinds of biases in the results.

For the TV set data, the variable “totalage” is the age Stata needs to know. To take care of right-censoring, create a new variable as follows:

```
generate failed = censored==0
```

This variable “failed” is 1 if the company was not censored, i.e., if it ceased television production before the end of the data, and 0 if it was still producing in 1989. (Stata requires that you use 1 for failed and for not.) Tell Stata about your data as follows:<sup>4</sup>

```
stset totalage, failure(failed)
```

The “st” in “stset” stands for “survival-time”. This command sets Stata’s knowledge about these survival-time data. If you had left-truncated or left-censored data, and you had another variable “startage” that told how “old” each company was (how many years it had been producing the product) at the start of the data, then you could issue the command<sup>5</sup>

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<sup>4</sup> This command is given for Stata version 6.0. In Stata 5.0, you would type: `stset totalage failed`

<sup>5</sup> This command is for Stata version 6.0. In Stata 5.0, you would type: `stset totalage failed, t0(startage)`

stset totalage, failure(failed) time0(startage)

But, since that's not a problem in the case of these TVs data, there's no need to issue this command. (And if you do, you'll get an error message because there's no variable named "startage" anyway.)

To see summary information about the data, type the command:

**stsum**

The resulting information shows you, among other stuff, the age by which 25%, 50%, and 75% of the companies had ceased production (i.e., they had "stopped surviving"). To see similar information according to whether companies were early entrants, you can type

**stsum, by(early)**

Of course, you can do the same for firms that were previous electronics producers versus those that were not.

To see the percentage of companies surviving to each age, type the command:

**sts graph**

A graph will appear. If you are doing your own project, you may wish to Copy the graph and Paste it into a word processing program. To see the percentage of early versus late entrants surviving to each age, type:

**sts graph, by(early)**

Similarly, you could examine the fraction surviving to each age for companies that produced in a previous industry versus those that did not:

**sts graph, by(prevind)**

Or you could do both at once:

**sts graph, by(early prevind)**

You may want to make the y-axis logarithmic, so that a straight line on the graph represents a constant chance of exit per year. E.g., if 10% of companies went out of business each year, the percent surviving would be a straight line on the graph. To do so, use the ylog option at the end of the command; e.g.,:

**sts graph, by(early) ylog**

When a group of firms goes extinct (none surviving) at some age, its line will head straight down.

To print the data instead of drawing a graph, type

**sts list**

or

**sts list, by(whatever)**

The result will be a long list of numbers that tells you exactly what appears in the graphs.

Suppose you create two survival curves, e.g., for earlier and later entrants. If someone tells you, "The real chances of survival to different ages must be the same for earlier and later entrants. Any differences you see in your graph are just because of random chance variations." Is there a way to analyze this possibility, like you did with the two-by-two tables? Yes. You can use statistical tests known as the "log-rank", "Wilcoxon", and "Cox" tests. The log-rank test turns out to be most sensitive to differences between the curves at older ages, whereas the Wilcoxon test is more sensitive at younger ages.<sup>6</sup> To carry out a log-rank test in Stata, type (for the example of early versus later entrants)

**sts test early, logrank**

---

<sup>6</sup>See Hans-Peter Blossfeld and Götz Rohwer, *Techniques of Event History Modeling*, Mahwah, New Jersey: Lawrence Erlbaum Associates: 1995.

The results of the test will include the statement “Pr>chi2 = ... #####”. The number shown here is the probability that just by chance, if the real odds of survival to different ages are the same for earlier and later entrants, you would get survival curves as different as they are. For example, a number of 0.02 would be about a 2% chance. To carry out a Wilcoxon test, you would type “sts test early, wilcoxon”.

## Summary of Key Commands for Survival Analysis in Stata

Below, items in [brackets] are optional.

### **insheet** using "filename"

Reads your data from a text file.

"Filename" might be, for example, "F:\courseproject\data.txt".

In Excel, each column should correspond to one variable such as company name or date of exit, each row should correspond to one data point such as a company, and the initial row should contain the names of the variables in the data. From the File menu, choose Save As... and select the type “Text, Tab-Delimited”. Then you can use the “insheet” command in Stata.

### **describe** [variables]

Tells the number of data points (“observations”) and variables, and the names of all variables as well as how they are stored in the computer’s memory.

Or, type the names of 1 or more specific variables for information about just them.

### **summarize** [variables] [if expression] [, detail]

Tells the mean, standard deviation, minimum, and maximum for each variable.

Using the optional “if expression”, you can look at just selected data points.

For example: “summarize firmsize if country == 3”. This provides summary information for the variable called “firmsize”, but only for data points where the variable “country” equals 3. (Always use the double equal sign, ==, to check whether two variables equal each other.)

Using the optional “, detail” at the end provides more detailed information.

### **list** [variables] [if expression]

Prints out the values of your variables (all of them, or just the ones you specify).

Use the optional “if expression” as with the “summarize” command above.

### **generate** newvar = expression [if expression]

Creates a new variable with the name you specify in place of “newvar”. The expression can be any mathematical formula using your variables. Appropriate values are calculated separately for every one of your data points. For example:

generate aplusb = a + b

generate logage = log(age) (Nb. Log is the natural logarithm.)

generate c = 1

generate isold = age >= 20 (If age >= 20 (true), then isold becomes 1; otherwise (false) is old becomes 0.)

generate sqrtage = age ^ 0.5 (Age raised to the power 0.5.)

generate expage = exp(age) (e raised to the power of age.)

generate bigold = (age >= 20) & (firmsize > 0.2)

(Like the “generate isold” above, but the “&” symbol means “and”. bigold becomes 1 if age >= 20 and firmsize > 0.2; otherwise bigold becomes 0. Similarly, use the “|” (vertical bar) symbol to mean “or”.)

Using the optional “if expression” causes Stata to generate new numbers only when the expression is true, otherwise the new numbers are “.” which is how Stata represents missing data. Be careful because Stata treats . as equal to positive infinity. For example if “gen age = year - entryYr if fromUK” causes age to equal . for firms not from the UK, using “summarize myvar if age>10” will include non-UK firms! because for them age is treated as infinite (instead you could use “summarize myvar if age>10 and age<.”).

**tabulate** var1 var2 [if expression] [, exact row]

This is for two variables that each take on 2, or a few, values. For example, the variables might be named old (which, say, has values 0 for companies under 30 years old and 1 for companies at least 30 years old) and size (which, say, has values 1 for companies with 1-99 employees, 2 for companies with 100-999 employees, and 3 for companies with 1000 or more employees).

The exact option forces Stata to compute a Fisher’s exact test, testing the hypothesis that two rows in the table have different probabilities of any individual being in any of the columns.

The row option tells Stata to compute percentages in each row.

See Assignment 2 for a full discussion.

**display** expression

This is a handy calculator. For example, “display 17 / 32 + 2.81” or “display exp(2.75 \* 2)”.

**drop** varname

Deletes a variable from Stata’s memory. It’s gone for ever, unless you’ve saved it in a file on a floppy disk or hard disk.

**stset** deathagevar, [failure(diedvar)] [time0(entryagevar)] [id(idvar)] <sup>7</sup>

Tells Stata that your data involve survival times. You must specify a variable name, in place of “deathagevar”, that tells the age at time of death – for example the number of years a company had been producing the product at the time it exited.

You must use stset before using the commands stsum, streg, stcox, etc. below.

If some of your data points died but others did not, you must specify a “diedvar” which equals 1 for data points that died and 0 for all other data

---

<sup>7</sup> This command is stated for Stata version 6 or 7. For version 5, the format is:  
stset deathagevar [diedvar], [t0(entryagevar)] [id(idvar)]

points. For example, create a variable called “failed” that equals 1 for companies that exited but equals 0 for companies that were still in business at the last time when you could obtain data.

If any of your data points entered the data sample after age zero, specify their precise ages at time of entry using “, time0(entryagevar)” at the end of the `stset` command. For example, if your data come from industry trade registers from the years 1905-1980, but perhaps some companies actually began producing before 1905, try to find out exactly when each company started producing and enter the initial age of all companies in a variable called “startage”. The initial age will be 0 for all companies that entered after 1905, but some of the companies that were listed in 1905 actually started earlier. (If you cannot obtain this information, you will not be able to analyze the effects of age correctly, although if only a few companies were above age 0 at the start, results may be approximately correct. A good idea is to create an extra variable that equals 1 for companies whose age was some unknown amount greater than 0 at the start, and that equals 0 for all other companies, and to include that variable in statistical analyses, such as `stcox`, that consider the effects of age.)

If you need to use data that change over time for a given individual, company, etc., then you can create a version of the data that has one row for each period of the individual’s life. Then you can enter a different value of the data in each row. For example, if you have 77 companies, and they survive on average 10 years each, then you could create a new version of the data with 770 rows of data – one row for each year of life for each company. Then you need to create an identification variable, such as “firmnum”, which has a unique number for each firm. Thus, if the first firm in your dataset survived 8 years, the second survived 12 years, etc., then `firmnum` might equal 1 for the first 8 lines of data (indicating that they correspond to the first firm), 2 for the next 12 lines of data (indicating that they correspond to the second firm), etc. You must also create new variables indicating (a) the age of the firm at the beginning of the period in each row of the data, (b) the age of the firm at the end of the period in each row of the data, and (c) whether or not the firm exited at the end of the period in each row of the data 0 = didn’t exit and 1 = exited. If you name these variables a, b, and c, then you should use the `stset` command exactly as follows: “`stset b, failure(c) time0(a) id(firmnum)`”.

**stsum** [if expression] [, by(varname)]

Provides summary information about survival in your data.

Use the “, by(varname)” option to provide different summary information for all data with different values of a variable. For example, use “, by(country)” if you have a variable named “country” that tells whether a firm is from country 1, 2, 3, or 4.

**sts graph** [, by(varname)] [ylog]

Creates a Kaplan-Meier survival plot for your data.

Use the “, by(varname)” option as in the `stsum` command above.

Use the “ylog” option to make the y-axis logarithmic. This way a straight line on the graph corresponds to a constant rate of exit.

**sts list** [, by(varname)]

Similar to “sts graph”, but prints out the numbers from the graph(s).

**sts test** varname, logrank or wilcoxon or cox

Tests whether two or more groups of firms (or whatever the data are about) have the same hazard and survival functions. Prints out a “p-value,” which is very small (near zero) if the notion that the hazard and survival functions are identical is implausible. The p-value can be any number from 0 to 1, and it means – in some sense – the probability that you could get such different survival curves if in truth the survival curves are identical. There are different senses in which you could do such comparisons, and hence you need to choose from one of three common tests: logrank, wilcoxon, or cox. (You can find out more about these tests in books about survival analysis.)

## Bibliography for Specific Industries

This compilation is far from complete, but nonetheless is useful as a starting point for research on specific industries. In some cases I have indicated call numbers in Bedford Library, or simply the fact that a source is in Bedford Library or another library. Items with a bar at the left are particularly useful or important for study of the industry.

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