AN ABSTRACT OF THE THESIS OF

Irina Phillips for the degree of Master of Science in Economics presented on September 6, 2002.

Title: The Determinants of Library Prices of Biology Journals: An Econometric Analysis.

Redacted for Privacy

Abstract approved: _____ John P. Farrell

Increases in the prices of scholarly journals have exceeded the general rate of inflation for the last decade and more. In the face of this "serials crisis," libraries have found it increasingly difficult to maintain essential journal collections. This thesis investigates the causes of the serials crisis in biology using data generated for a study conducted by the Mann Library of Cornell University for 1988 and 1994 and updated by the author for 2001,

The major goals of this thesis are to elaborate some alternative explanations of the crisis, identify econometrically the chief determinants of biology journal prices, and test the theory that prices are significantly determined by market structure. Existing literature sheds some light on price determinants—specifically, technical characteristics (including frequency and size), publisher's legal form (profit vs. non-profit), location (domestic or foreign) and scale (circulation) have been found to be statistically significant—but this work is incomplete and sometimes contradictory.

OLS and GLS regression analysis conducted in this thesis confirms that the determinants of biology journal prices are country of origin, journal size and frequency, circulation, and publisher's legal form. There is no evidence, however, that greater concentration increases prices. According to this analysis, monopoly power is not a problem in biology journal publishing.

This thesis makes some modest contributions to current research: it is the first econometric identification of biology journal prices determinants, includes the first test of the effect of market concentration and confirms some results of previous research.

The Determinants of Library Prices of Biology Journals: An Econometric Analysis

by
Irina Phillips

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented September 6, 2002
Commencement June 2003

Master of Science thesis of Irina Phillips presented on September 6, 2002.

APPROVED:

Redacted for Privacy

Major Professor, representing Economics

Redacted for Privacy

Head of the Department of Economics

Redacted for Privacy

Dean of the Graduate School

I understand that my thesis will become part of the premanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Redacted for Privacy

Irina Phillips, Author

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES IN APPENDIX

LIST OF ABBREVIATIONS

ATC	Average Total Cost
AVC	Average Variable Cost
C&C	G.A. Chressanthis and J.D. Chressanthis
CIRC	Circulation
Comm	Commercial Publisher
D	Demand
FC	Figure Content
FREQ	Frequency
HHI	The Herfindahl- Hirschman Index
ISI	Impact Factor
JEE	*Journal of Economic Entomology*
MC	Marginal Cost
MR	Marginal Revenue
MSP	Market Share Determined by Total Pages
MSR	Market Share Determined by Total Revenue
MSP'	MSP, Expressed in % and Squared
MSR'	MSR, Expressed in % and Squared
NUS	Country of Origin (non-US)
PG	Average Number of Pages per Issue
SCI	Science Citation Index

The Determinants of Library Prices of Biology Journals: An Econometric Analysis.

Chapter 1. INTRODUCTION

In this chapter I present the facts of the current journal crisis, indicate their significance, state the research questions and give an overview of the organization of the thesis.

The main fact is that scholarly journal subscription prices have risen faster than inflation. From 1988 to 2001 the CPI increased 55.9% while average biology subscription rates increased 250.7%.

The second fact is that commercial publishers charge on average much more than non-commercial publishers. Using my sample averages non-commercial publishers charged $238.72 in 1988 and $790.07 in 2001; the corresponding averages for commercial publishers were $444.33 and $1592.96 in 1988 and 2001, respectively. The gap in 1988 was 86%, in 2001 – 102%. See Table 1 in Appendix.

The third fact is that foreign publishers charge more than their North American counterparts. The difference in 1988 was $300.31, and in 2001 it was $801.29.

Price increases in scientific journals were significant enough to cause the so-called "Serials Crisis". Libraries had to cancel subscriptions to journals that the faculty considered essential.

The purpose of this thesis is to provide insights and answers to these questions: Why did the prices increase so rapidly? What determines prices in the publishing sector in general? Why is the gap between commercial and non-commercial publishers and between domestic and foreign publishers so high and why has it increased? Finally, how does market structure influence price in scientific publishing?

The thesis is organized into four major chapters. I present a selective literature review in Chapter 2, where the selected articles were all written by economists and contained econometric analysis. Chapter 3 is devoted to overview of the publishing industry. Chapter 4 reviews alternative explanations of the serials crisis, explains the regression models, used in the study, and discusses the results with emphasis on economic variables. The last chapter (Chapter 5) concludes and offers some ideas for improvement.

Chapter 2. LITERATURE REVIEW

General Overview

Economic analysis of the area of scientific publishing started when J. A. Ordover and R. D. Willig (1978) modeled the pricing of a single title to institutional and individual subscribers. H.C. Petersen (1989, 1990, 1992) used regression-based techniques to find determinants of library prices for journals across many academic fields. B.R. Kingma and P.B. Eppard (1992) studied the welfare effects of third-degree price discrimination between the library and individual journal markets. L. Lieberman, R. Noll and W.E. Steinmuller (Stanford Group) (1991, 1992) wrote several papers for the Andrew W. Mellon Foundation, where they provided economic analysis of the production and pricing of scientific journals with specific attention to circulation and economies-of-scale. They found that publishing is characterized by economies of scale at the individual title level.

G. A. Chressanthis and J. D. Chressanthis (C&C) (1994) investigated what determines the library prices of the top-ranked economics journals and came to the conclusion that prices are increasing because journals are increasing in quality and size. Recently T.C. Bergstrom (2001) published a significant paper on the differences between commercial and non-profit economics journals, M. J. McCabe (2002) on the impact of mergers on journal pricing and demand elasticities, and R. W. Meyer (2000) on pricing practices and monopoly power.

In addition to C&C several other studies (H. H. Barschall, 1988; S.R. Moline, 1989) have identified the principal attributes of serials which explain relatively high prices, as well as price increases. Subject matter or discipline is of particular importance, because of historical price trends and different elasticities of demand. Titles published by commercial publishers tend to be more expensive than those published by learned societies and associations or other scholarly publishers (university presses or research institutions). Other specific attributes that affect costs are number of issues per year, number of pages per issue, the

presence of art work, formulas and special graphics - naturally correlate positively with price. Journals that contain advertising were found to have lower prices.

Other studies (R. L. Houbick, 1986; F. C. Lynden, 1988) have specifically considered the pricing practices of foreign commercial publishers, whose titles are offered at the highest prices. Some price differential is to be expected, since increased distribution costs have to be recovered in some way. The question is whether the difference in prices is justified by the distribution cost differentials.

The findings of two papers that I used the most in creating my model are presented in more detail below.

Stanford Group Findings

Librarians and publishers hold opposite positions when they discuss the causes of scientific journals price increases. Librarians very often accuse publishers of price discrimination (compared to individual subscriptions) and abuse of market power, they use charts of price increases, report growing shares of library budgets spent on journals, and compare prices across the disciplines and among publishers. But simply reporting increases in journal prices is not enough to conclude that publishers are reaping monopoly profits. Publishers may be increasing prices to offset increasing costs of production. Unit costs may be increasing because of declining circulation, expanding journal size (volume) through publishing more pages per issue and more issues per year, and improving product quality (mostly physical appearance) by using better (and more expensive) paper and publishing photographs and special graphics.

The Stanford group settled on 225 journals for which they found both price and circulation information. For these journals they physically examined 11 years of issues (1977-1988) for information on number of pages and issues and physical characteristics.

The model assigns to circulation a major role in explaining trends in prices. The demand equation relates the paid circulation of the journal to its price and its

standing among other journals in its subdiscipline. The supply equation relates the price of the journal to measures of cost including circulation, the number of pages published in each year, and journal frequency. Increasing circulation raises total costs but lowers unit costs (and because of this price). The other two factors are expected to raise costs and price.

Estimation was performed separately for each equation by two stage least squares using single equation instrumental variables. The demand equation was identified by instruments for price including the frequency of the journal, a measure of promotion derived by subtracting paid circulation from press run, and a dummy indicating that the journal size was not over 7x10". Price has the correct sign and is significant at the 5% level for all years and the impact factor for years after 1982 has the correct sign and is significant.

The supply equation could not be identified using single year regressions and therefore the data were pooled across years by using dummies (1988 is the omitted year). Results indicate that paid circulation, pages and frequency are all of the correct sign and significant at the 5% level.

The Stanford group also applies a single-equation approach where, using ordinary least squares, the log of price was regressed against such characteristics as the size of the journal (not oversized), existence of page charges, typesetting, paper quality, paid circulation, number of pages, number of issues per year, and presence of advertising.

The authors expected paid circulation, typesetting and paper quality to be negatively correlated with cost and price. The results show that paid circulation continues to be significant and of the correct sign. Typesetting is insignificant for most years and of the incorrect sign for most of the years where it is significant. Paper has the correct sign in all years of the sample but is significant in only the last three years.

Factors that may be associated with increased cost include paid circulation, number of pages, journal frequency, and the absence of page charges. The

coefficients on all of these variables are of the correct sign and significant for every year of the sample period, indicating that cost increases for these variables are likely to be passed on to subscribers.

The Stanford group papers are important because of good econometric analysis (different approaches, hypothesis tests results, etc.). However, there are minuses connected to lumping all disciplines together and ignoring foreign publishers (the main concern of librarians).

Chressanthis & Chressanthis

The objective of their research was the analysis of the determinants of library prices for the top 99 economics journals concentrating on quality and using a single regression approach (similar to the second method applied by Stanford group). Production costs are related to publication frequency, number of articles and pages, type of material (text versus formulas and tables, illustrations and graphs, etc.), economies of scale, page size, quality of the print and paper.

C&C's model is based on the following assumptions: Individual and library subscription markets are independent[1]. Library demand is more price inelastic than individual demand (see articles of Byrd (1990) and Machlup (1977)), and therefore publishers tend to concentrate on library demand as the main source of revenue. Higher journal quality may lead to both higher individual and library demand.

The dependent variable is the 1985 library subscription rate. The independent variables are: individual subscription rate, dummy variable for advertising, dummy variable for illustrations, three dummy variables for country of origin (USA used as a base region), number of years of journal existence, journals quality (defined according to the work of G.C. Durden, and others, 1991), total number of pages, journal frequency, total annual circulation for the journal, and four dummies for types of publishers (commercial is the base).

[1] This assumption is not valid. Changes in the individual market can change the library market.

Positive signs are expected for quality indicators and changes in the structure of production costs (increases in total pages and journal frequency). Journals with larger circulations are expected to have economy of scale advantages and lower library price. Negative signs are expected for the four dummy variables representing type of non-commercial publisher, because they reflect the profit motivation of commercial publishers. They also reflect the fact that non-profit publishers may have sources of external funds (membership dues, page charges or grants), which subsidize journal operations. Journals published by foundations have significantly lower prices than others.

Major findings: an individual subscription price increase of $1 would increase library subscription prices by $1.24- 1.27 on average. Journals published in Europe were priced about $18.31-20.71 higher than those published in the US. This difference may be connected to the extra costs associated with publishing abroad, or be a result of market power used by dominant western publishers.

An increase in journal age by one year decreases library prices by about 43-55 cents. An increase of journal volume by one page increases library price by 3 cents.

The journal quality measures exhibited the greatest variation with respect to their effect on prices. Circulation was significant only when all of the journal quality measurements were taken into account[2].

This paper raises interesting and significant questions about factors affecting journal prices, but the econometric results, except the summary table, were not available for inspection and therefore have to be accepted on faith.

Conclusion

Previous studies found that the price of the scientific journal depends on the journal discipline, profit motivation of the publisher and country of origin. It also

[2] There is a problem with this parameter. It simply sums all quality measurements and does not take into account their correlation.

depends on journal popularity (circulation), quality and size. Previous research as well as traditional economic theory suggests that market structure may be influencing pricing decisions in scientific journals. This thesis tests the importance of all the parameters named above plus some indicators of market concentration for biology journals.

Two approaches to the analysis of price problem prevail in modern literature: demand-supply model and single regression equation for prices. This thesis is using the second method because it is less data intensive.

This thesis is trying to overcome shortcomings of the previous studies by concentrating on one discipline and simplifying quality indicators.

Chapter 3. SCIENTIFIC PUBLISHING: MARKET STRUCTURE AND MARKET POWER

In this chapter I will give a brief history of scientific communication, describe organization of the publishing industry, determine its market structure, and discuss increased concentration and mergers.

Evolution of scientific journals

The first scientific journals appeared more than two centuries ago, and were certainly an improvement over private correspondence. Since then the number of journals has grown steadily, mostly because of the growth of scientific societies, which are major sponsors of journals. Publication costs were recovered mostly from members' dues, which included journal subscription. The number of articles published by any one author was relatively small, and many members did not publish at all. Library subscriptions were not a significant source of income for publishers. Although most science journals were published by societies, other nonprofit institutions such as universities, museums and governments published some. Commercial publishers were generally not attracted to the field because there was little potential for profit.

A science boom followed World War II. The number of U.S. science and engineering Ph.D.s awarded each year tripled between 1958 and 1968 and continued to increase until the early 1970's. (T. J. Walker, 1988). Many colleges upgraded to universities, with corresponding library growth. Support for research was generous and easily available, so total submissions to journals grew significantly, and the number of serials also grew.

Commercial publishers entered the scene in the late 1950's. Pergamon Press (now part of Reed Elsevier) started 250 journals in 25 years. The strategy of commercial publishers was either to start journals in long-established fields with the goal of surpassing existing journals, or in revolutionary new research areas (for example *Phytochemistry*, *Evolutionary Biology*, *Nutritional Biochemistry*). In both

cases, the journals were started by inviting famous scientists in the specialty to be members of an editorial board for the journal. Many scientists agreed to participate as they saw opportunities to increase their status and publishing opportunities for their field or specialty. Commercial publishers used the presence of these distinguished scientists to attract the attention of both subscribers and authors to start the journal on its way to becoming indispensable to the world of science.

Scientific societies at about the same time found they could no longer manage and subsidize so much publication. Granting foundations found themselves paying for research that could not be published in time. In 1961 the federal government approved the payment of page charges from federal grants to nonprofit publishers as a new source of revenue. This resulted in an increase in the size of established journals and the start of new journals. For example, the Entomological Society of America doubled the size of its *Journal of Economic Entomology* (*JEE*) during the four years after introducing page charges, and started a new journal, *Environmental Entomology*, which by its second year exceeded the pre-page-charge size of JEE (T.J. Walker, 1988).

During the science boom years of 1950-1970's a new tendency in publishers' revenue evolved, when libraries and institutions, not individuals became the most important subscribers.

In early 1980's libraries started to feel that their budgets did not allow acquisitions of more serials, and a gap between serials published and serials acquired appeared. Publishers set their subscription prices in advance based on the expected subscription volume. The gap is between the expected volume and the real subscription level. The deepening of this gap caused the serials crisis.

Industry Organization of Scientific Publishing

There are many participants in creating scientific journals. Scientist-authors are the primary producers of articles. At the same time they provide other inputs such as reviewing, editing, and writing commentary letters. They are also

consumers of the final products (database, journal or article). The group of readers consists not only of scientists, but also students and the general public. Publishers (learned societies, associations, government organizations, University presses, and commercial organizations) are secondary producers.[3] And finally libraries, academic institutions, and industrial organizations are facilitators of reading. They bring the final product to the individual, who is going to consume it by reading.

The scientific communications sector is a complicated mixture of different kinds of journals. Journals can be divided into very technical primary journals that report original findings, and secondary journals carrying information processed for more general readership.

Journals maybe distinguished based on the type of publisher. Other classification may be based on the primary language of publication or country of origin.

Between 6.5 to 8 % of all biology titles from my study were published by University presses, between 40.5 to 42.8% by societies and associations, and between 45.1 to 46.8% by commercial publishers. Other subject fields may have different proportions between types of publishers. 43% of biology journals originated outside of the United States and Canada.

Market Structure on the Example of Biology Journals

There are two different approaches to market definition in scholarly journals. One view is that there are many small journal niches with the extreme that each journal is a unique and distinct product. The other approach is looking at journals in one discipline as a portfolio of substitutes, which can be ranked according to their quality/ price ratios.

Problem with market definition exists in other industries as well. What is the right way of defining soft drinks market: by companies such as Pepsi, Coke,

[3] Until the 1990's there was also a significant group of intermediaries or sellers of the journals to libraries, individuals and institutions. The modern tendency is to buy or subscribe directly from the publisher.

etc. or by soft drinks taste groups (lemon soda, rout beer, etc.)? Both approaches are valid.

Market power exists in a variety of different forms, from simple name recognition to vertical and horizontal integration. A company with market power is able to set prices at an uncompetitive level and to force competitors out of a market. Market share is not the only determinant of market power. Companies exert market power through anti-competitive practices, affiliate relationships, and etc.

Journal reputation is important; past achievements create the current subscription base. Previous technological advantages create an edge too. Entrance into the market is difficult because in order to achieve sufficient subscription base, a journal has to be of high quality and interest, possess unique features and be able to gain prestige, weight and name recognition in academic circles.

Concentration ratios are one of the most common tools used to examine an industry's structure and, consequently, the ability of a group of companies to exercise some control over a market. A common measure of concentration is the N-firm concentration ratio - combined market share of the largest N firms. The most common number used in market analysis is four.

The Herfindahl-Hirschman Index is calculated by summing the squares of the market shares of all firms in the industry: $HHI = \Sigma (MS_i*100)^2$. Higher HHI provides higher potential for the exercise of market power. A HHI below 1000 is not considered a concentrated market. Industries with a HHI between 1000 and 1800 have some degree of concentration. If the Index is greater than 1800, the degree of monopoly power potentially exercised by the dominant companies is typically judged to be significant.

HHI can be calculated in natural terms using total number of pages per publisher ($MS_i= PG_i*FREQ_i*CIRC_i / \Sigma PG_i*FREQ_i*CIRC_i$), or in money terms, using total revenue figures ($MS_i= P_i*CIRC_i / \Sigma P_i *CIRC_i$). Details are in Table 1 below. The traditional approach to calculating this index is HHI 2, where market share is determined for each publisher. The previous example of soft drink

companies may be helpful again here in understanding what these equations mean. However, I am interested in an alternative indicator of market power. Every

Table 1. Industry Herfindahl- Hirschman Index

Parameter	2001
Number of Publishers	65
HHI 2 R	1943.3
HHI 2 P	2319.7
Number of Journals	168
HHI 1 R	1301.2
HHI 1 P	2304.9
Top Players *	
Nature Publishing Group	1911.2 (82.4) 972.8 (50.1)
American Association for the Advancement of Science	334.2 (14.4) 921.6 (47.4)
Reed Elsevier	16.7 (0.7) 10.8 (0.6)
American Society for Biochemistry and Molecular Biology	14.2 (0.6) 7.0 (0.4)
American Society for Microbiology	13.2 (0.6) 1.9 (0.1)
Scientific American	6.8 (0.3) 0.2 (0.0)

* Top number is publisher's share in the industry Total Page HHI (HHI2 P), lower number is the share in the industry Revenue HHI (HHI2 R). Numbers in parenthese stand for % share.

scientific journal is unique to some extent, and so potentially has some market power. HHI 1 is calculated assuming that every title has its own market share and affiliation to the publisher is not important, although the publisher does the pricing. Continuing the soft drink drink analogy, consumers care about particular brands and the producer's name is less important.

The total number of publishers declined from 1988 to 2001, while the number of journals was relatively stable. If HHI P is calculated using total pages, then the numbers show a significant degree of market concentration. If calculated with total revenue, then HHI R numbers reflect some monopoly power, but not oligopoly.

Nature Publishing Group and the American Association for the Advancement of Science held the top two market shares. The top number in Table 1 corresponds to the publisher's share in industry HHI for total pages (% in the parentheses), and the lower number for total revenue.

I picked 173 journals, because of their importance for the biology field, but they are not the whole market, only a relatively stable part of it. New journals are born every year, some quit the market, but overall slow growth prevails. When a new journal appears and becomes successful it reduces the subscription base of the existing journals under assumption of unchanged demand. So the circulations of existing journals tends to decline if there are an increasing number of substitutes on the market.

Significance of Different Kinds of Mergers

If you look at each journal as a distinct market, then publishers of individual titles have the ability to achieve monopoly returns even without mergers. Marc McCabe supports the view that mergers of highly differentiated products do matter for achievement of monopoly power. Journals have some ranking and there is competition between individual titles across broad disciplines for library subscription budgets.

McCabe builds his pricing model on the distribution of library budgets and journals relative quality (if prices are equal, higher quality journals experience higher demand). He specifies that consistent evidence of merger-related price increases provide support for market power explanation. For example, the merger between Elsevier and Pergamon resulted in post-merger prices for 1992-1994 exceeding the market average by 17%. Pre-merger prices were 7% higher. The influence of mergers in the second half of the 1990's is less significant. McCabe assumes that this is explained by the delay in merger impact.

Mergers can create or increase problems with affiliate relationships and horizontal market power. Acquisitions eliminate potential competitors (other publishing companies). The size of the merging companies makes a difference when assessing the impact of mergers on industrial concentration. If small companies merge with each other, competition may be strengthened; if large companies merge with each other, the reverse may occur. The median and average sizes of the merger transactions provide an important clue about what is happening in this regard.

Conclusion

To conclude this section and the chapter, there is a potential for monopoly power abuse on both sides of the journals market, whether through publishers merging, or coalitions of librarians (both of which are happening). If HHI is measured by revenue market share then the biology journals market appears relatively competitive, but if measured by total pages it tends towards oligopoly. If the second case is true, then mergers between biology publishers may lead to significant increase of market power for some of the top players (for example Reed Elsevier) and deepen the serials crisis, especially if demand is not increasing fast enough.

Chapter 4. DETERMINANTS OF BIOLOGY JOURNALS' PRICES

There are several possible explanations of the serials crisis. In this chapter I briefly discuss most of these explanations before putting some of them to econometric tests.

Alternative Explanations of Biology Journals Pricing

Serials crisis is a shorter term for serial inflation combined with a large and increasing gap between prices charged by commercial versus noncommercial publishers and foreign versus domestic publishers. Most of the competing explanations of this crisis can be presented in terms of elementary micro economic theory.

First, the goals of publishers are important. Commercial publishers are profit maximizers, whereas non-commercial publishers (societies, associations, foundations, charities, universities and government organizations) are dedicated to sales maximization subject to a balanced budget constraint.

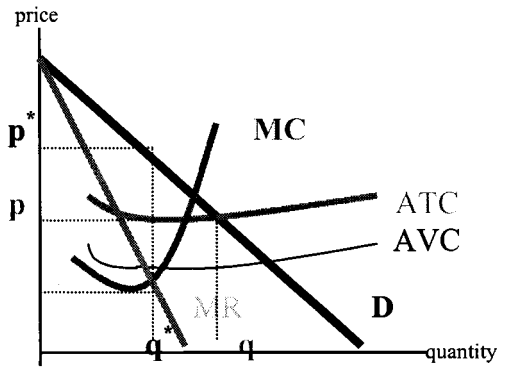

Figure 1. Commercial versus Non-profit Publisher

Assume cost and revenue as depicted in Figure 1. A commercial publisher in a situation of imperfect competition will sell quantity q^* at price p^*. In contrast, non-commercial publishers will choose price so as to just cover average total cost (ATC); i.e. they will sell q journals at a price of p, where $p^* > p$ and $q^* < q$. This is equivalent to the textbook example comparing an unregulated public utility monopoly to one regulated on the basis of average cost pricing. The commercial publishers will act like unregulated monopolists, raising prices and restricting output. Smaller circulation and higher price for commercial journals therefore is the expected norm.

It follows that the pricing response to an increase in demand for both kinds of publishers can be dramatically different (see Figure 2). If demand increases, the commercial publishers will always charge a higher price (increase from p^0 to p^1). The non-commercial publishers are expected to react according to their ATC. If there is an increase in ATC, the non-commercial publishers will raise price, but if ATC declines they will lower price in response to an increase in demand. In our

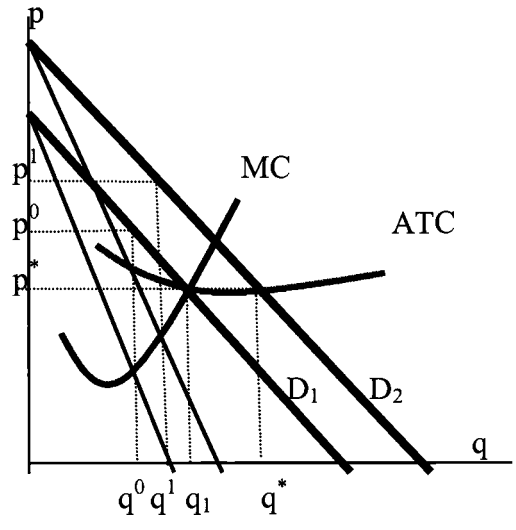

Figure 2. Pricing Reaction of Commercial Publisher to Demand Increase

example the increase in price is very small, while the increase in quantity (from q_0 to q^*) is significant. Under both demand conditions non-profit publishers produce more output than commercial publishers.

Figure 1 assumes that both non-commercial and commercial publishers face the same demand curve, but in reality this case is unlikely. Commercial publishers are careful to select journals with high demand and low elasticity. Under low elasticity an increase in price will lead to increase of the revenue despite the reduction of circulation. Non- commercial publishers have other goals (besides profit) in mind. For academic circles, publication per se is the objective because of the role it plays in promotion and prestige, whereas governments are driven by the responsibility to disseminate new knowledge.

Figure 1 also assumes that both kinds of publishers have identical cost structures. This simplification is not very realistic. Non-commercial publishers, especially societies and associations, attract editing and reviewing for far less than commercial publishers. The lower cost of inputs leads to lower total costs, and allows non-commercial publishers to charge lower prices compared to their commercial counterparts. Thus the gap between commercial and non-commercial prices may be partly explained by different cost structures.

Next, an argument favored by publishers: journals today are significantly different from journals of the past. They are bigger, better and offer more features (color graphics and electronic attributes). Because of such qualitative changes, the apparent change in price is false; i.e. adjusted for quality the price increase is less and perhaps even negative.

Concentration in scientific publishing, as in other sectors has increased because of both natural growth and mergers. The increased market power of some players (in particular commercial publishers such as Elsevier, Kluwer, Springer) allows them to extract larger profits. This argument is commonly used by librarians, who also worry that the new pricing approach of offering complete

collections of journals as databases will allow publishers to implement almost perfect price discrimination.

Journal proliferation has also contributed to the problem. Publication in prestigious science journals such as *Science* and *Nature* is difficult. Hence it is easier to establish new and more specialized journals in subdisciplines, as has happened for example in biochemistry. Out of 14 biochemistry journals five are published by societies covering biochemistry in general. Elsevier is publishing 6 biochemical titles, specializing in the combination of biochemistry with other disciplines (*Advances in Carbohydrate Chemistry and Biochemistry, Biochemical and Biophysical Research Communications, Nutritional Biochemistry, Comparative Biochemistry and Physiology*). The remaining biochemistry publishers also specialize in narrow areas of biochemistry. The result is a proliferation of high-cost, small-run journals. Small scale implies high average cost because fixed costs are spread over fewer subscribers.

In addition, journal proliferation has resulted in pressure on the libraries to subscribe to even more journals in an era of shrinking budgets. Individuals typically subscribe to one or two of the most essential journals. If new potentially significant journals appear, it is easier to ask the library to subscribe and bear the cost. When publishers offered online access to the journal content for the license holders (librarians), there was a wave of cancellation of individual subscriptions as users switched to the less expensive alternative. Publishers tried to recoup the lost revenues by charging even higher prices to libraries.

A final point relates to the stock bubble of the 1990s. Publishers were in the center of the communications high tech boom and many over-invested in information technology. These investments also drove serials prices upwards.

Thus a variety of factors related to supply, demand, technology and the profit motivation of publishers lie behind the serials crisis. In the balance of this chapter, I apply econometric analysis to shed some light on the importance of some of these explanations. More specifically, I will test econometrically the

significance of the relationship between price and market structure, the country of origin, circulation, the type of publisher, and certain technical journal characteristics.

Data

Journals were selected based on the Cornell Journal Price Study, which was also the major source of data for 1988 and 1994. See Appendix for more information on the selection criteria. In total 173 titles were studied.

Data for 2001 were gathered from several resources: prices, circulation, frequency and number of pages were obtained from publishers' web pages and direct contact; citation coefficients were taken from journal citation reports.

Science Citation Index (SCI) reflects total number of citations made to the journal during current year. Impact factor (ISI) is the ratio of SCI to the number of articles, letters, and reviews published in a journal during the previous two years. These two coefficients are strongly correlated and therefore do not occur together as independent variables in the regressions below.

Type of publisher was determined by the copyright agreement. If the copyright holder was a society, association or university press, then the type of publisher was not considered as commercial.

Descriptive statistics are presented in Table 2 below.

Table 2. Descriptive Statistics for Titles

Variable		Mean (SD)	Max	Min
Price	1988	318.20 (367.34)	1774.11	23.06
	1994	454.44 (508.02)	2491.456	26.04
	2001	766.67 (820.66)	3125.108	16.45
CIRC	2001	9264 (39364)	470000	600
NUS	1988	0.428 (0.496)	1	0
	1994	0.431 (0.497)	1	0

Table 2. Continued

Variable		Mean (SD)	Max	Min
NUS	2001	0.429 (0.496)	1	0
FC	1988	0.084 0.069)	0.432	0
	1994	0.086 (0.059)	0.261	0
SCI	1988	10399.29	172720	0
	1994	(25358.71)	265329	0
	2001	16081.93 (40006)	344256	0
		20574.02		
		(50371.42)		
ISI	1988	3.468 (5.375)	48.31	0
	1994	4.145 (6.174)	42.17	0
	2001	9.267 (60.444)	779	0
FREQ	1988	11.549 (10.466)	52	1
	1994	12.284 (10.934)	52	1
	2001	12.786 (10.963)	52	1
PG	1988	223.353 (178.577)	1122	15.833
	1994	235.961 (219.345)	1716.333	19.76
	2001	233.059 (180.948)	1125.333	46.5
Comm	1988	0.451 (0.499)	1	0
	1994	0.450 (0.499)	1	0
	2001	0.464 (0.500)	1	0

Econometric Models and Techniques

There are two models. The first is valid for all three years (1988, 1994 and 2001) and specifies title price determinants such as size, quality, frequency, figure content, country of origin and type of publisher.

The second model, applicable only to the year 2001, takes into account the effect of market structure on price. It has two variants: 1) price of each individual title, 2) price of a typical journal of each biology publisher.

Econometric techniques used in the research are ordinary and generalized least squares with two dummy variables. Table 5 provides variable definitions.

The estimating model 1 is as follows:

$P_t^1=\acute{\alpha}+\beta_1 * PG_t +\beta_2 * NUS_t+\beta_3 * Comm_t +\beta_4 * Quality_t+\beta_5 * FREQ_t+\beta_6 * FC_t +\tilde{e}_t$, where FC_t is included for 1988 and 1994, and $Quality_t$ is measured as ISI_t or SCI_t . One run of the 2001 regressions includes CIRC as an explanatory variable.

The model 2 first variant is:

$P_t^2=\alpha+\gamma_1 * MS_t+\gamma_2 * NUS_t+\gamma_3 * Comm_t+\gamma_4 * PG_t+\gamma_5 * FREQ_t+ \gamma_6 * Quality_t +\tilde{e}_t$

The second variant is:

$P_t'=\alpha'+\gamma'_1 * MS_t+\gamma'_2 * NUS_t+\gamma'_3 * Comm_t+\gamma'_4 * PG_t+\gamma'_5 * FREQ_t+ \gamma'_6 * Quality_t +\tilde{e}_t$, where MS_t is one of four measures of concentration.

Variable Definition

Table 3. Data Set Definitions and Variable Construction

(Expected Sign of Coefficient and Unit Measure in Parentheses)

Variable	Definition
Dependent Variables	
P^1 and P^2	Annual library subscription rate for a journal ($)
P'	Annual circulation-weighted subscription rate of a typical journal of particular publisher ($)
Explanatory Variables	
CIRC	2001 journal circulation (-, number)
FREQ	The number of issues published by the journal, including any special issues (+, number)

Table 3. Continued

Variable	Definition
Explanatory Variables	
PG	Average pages per issue (+, number)
Page	Total annual number of pages (+, number)
Char	Average number of characters per page (+ number)
SCI	Science Citation Index. The total number of cites per year (+, number)
ISI	Impact Factor. SCI divided by the number of articles, letters, reviews and other sources, published in that journal during the previous two years (+, number)
FC	% of pages with special graphics, pictures, photographs (+, %)
NUS	1 if a journal is published outside the United States and Canada, 0 for all other cases (+, dummy)
Comm	1 if a journal is published by a commercial publisher, 0 otherwise (+, dummy)
MS…[1]	Market share of individual title (+, units)
MS…[2]	Market share of a particular publisher (+, units)
MSR	Market share determined based on revenue (+, units)
MSP	Market share determined based on number of total pages (+, units)
MS…'	Market share, expressed in % and squared (+, units=$(\%)^2$)

Rationale for Expected Signs

Each additional issue carries extra costs for at least binding and mailing. Higher cost leads to higher price, and so the sign for frequency is expected to be positive (+).

More pages in the journal are equivalent to more information, which costs more, so price is higher, and the expected sign is (+). The same rationale applies to figure content (+).

Higher quality products have higher demand and higher prices if commercial publisher publishes the journal. If the journal is published by a non-commercial entity, price reflects costs and the effect of the quality is ambiguous (+/-).

The coefficient for country of origin is expected to be positive (+), consistent with all the previous studies. Labor costs in publishing sector are found to be higher in Europe than the US. Exchange rate uncertainty and additional delivery costs are also significant.

The type of publisher dummy is also expected to be positive (+), because commercial publishers are profit oriented agents, who will charge more than the agent whose goal is primarily knowledge dissemination, other things equal. There is also an argument that associations and societies are able to attract free or significantly underpaid resources, reducing their cost in comparison with commercial publishers.

Publishers with larger market shares have the opportunity to exploit their privileged market position, so it is rational to expect that journals or publishers with higher MS will charge higher prices (+).

Presentation and Discussion of First Model

The results of the first model estimation are presented in Tables 4, 5 and 6 below.

For 1988 the model explains about 40% of price variation. Type of publisher, country of origin, frequency and journal size were all positive and significant at 0.01 level. Quality indicators were both negative and significant, although ISI has a larger coefficient. Higher quality journals are cheaper. Figure content was not important in 1988.

Table 4. First Model Estimation for 1988

Explanatory Variable	$Price_{1988}$	$Price_{1988}$
Intercept	-175.872 (-2.438)*	-101.282 (-1.477)
SCI	-0.005 (-3.803)**	
ISI		-17.048 (-3.416)**
PG	0.398 (2.617)**	0.415 (2.626)**
FC	116.765 (0.348)	98.298 (0.291)
Comm	141.945 (2.956)**	188.682 (3.891)**
NUS	270.814 (5.455)**	252.198 (4.974)**
FREQ	24.793 (7.244)**	17.508 (7.374)**
N	161	161
R^2	0.431	0.421
Adjusted R^2	0.409	0.400
F	19.443	18.694

* 0.05 significance level, ** 0.01 significance level, t-statistics in parentheses

Regression results for 1994 (Table 5) are similar to 1988. The explanatory ability of the model improved slightly to more than 46% of price variation. Country of origin, type of publisher and both technical characteristics are positive and significant at the 0.01 level and coefficients are slightly higher compared to 1988. Both quality indicators are negative and significant with ISI coefficient having a higher value. The figure content characteristic (FC) became important in both variants.

The coefficients of 2001 model (which excludes FC because of data unavailability) are different from the 1988 and 1994 estimates. That may signal significant structural changes in the industry. Type of publisher, country of origin and frequency are positive and significant; the value of these coefficients increased

in comparison to both 1994 and 1988. Average journal size lost significance when quality was measured by ISI, and ISI lost significance and reversed its sign.

Table 5. First Model Estimation for 1994

Explanatory Variable	$Price_{1994}$	$Price_{1994}$
Intercept	-346.216 (-4.175)**	-182.639 (-2.268)*
SCI	-0.006 (-5.307)**	
ISI		-23.547 (-4.354)**
PG	0.503 (3.426)**	0.425 (2.870)**
FC	1045.708 (2.067)*	913.191 (1.727)***
Comm	221.087 (3.777)**	287.690 (4.716)**
NUS	331.705 (5.463)**	300.685 (4.720)**
FREQ	35.718 (8.770)**	24.312 (7.975)**
N	164	163
R^2	0.512	0.486
Adjusted R^2	0.493	0.466
F	27.412	24.585

*0.05 significance level, **0.01 significance level, ***0.10 significance level, t-statistics in parentheses

Table 6. First Model Estimation for 2001

Explanatory Variable	$Price_{2001}$	$Price_{2001}$
Intercept	-432.709 (-3.449)**	-215.466 (-1.725)*
SCI	-0.006 (-4.574)**	
ISI		0.059 (0.074)
FREQ	59.833 (9.944)**	39.662 (8.981)**
PG	0.770 (2.676)**	0.258 (0.912)

Table 6. Continued

Explanatory Variable	$Price_{2001}$	$Price_{2001}$
Comm	484.643 (5.232)**	525.955 (5.319)**
NUS	377.244 (3.807)**	411.634 (3.886)**
N	166	165
R^2	0.520	0.456
Adjusted R^2	0.505	0.438
F	34.612	26.605

* 0.10 Significance level, ** 0.01 significance level, t-statistics in parentheses

Table 7. Corrected First Model

Explanatory Variable	$Price_{1988}$	$Price_{1994}$	$Price_{2001}$
Intercept	-128.173 (-2.525)**	-62.089 (-1.830)*	-195.427 (-3.196)***
ISI	-19.625 (-3.643)***	-11.982 (-2.466)**	0.342 (1.031)
PG	0.596 (4.758)***	0.373 (6.916)***	0.887 (5.494)***
NUS	283.634 (7.176)***	414.280 (3.923)***	517.930 (6.098)***
Comm	352.964 (3.692)***	273.428 (3.819)***	1031.69 (4.663)***
FREQ	15.894 (7.846)***	23.968 (7.407)***	26.750 (10.567)***
FC	-19.025 (-0.108)	-98.464 (-0.448)	
N	161	163	165
R^2	0.457	0.484	0.555
Adjusted R^2	0.436	0.464	0.541
F	21.614	24.347	39.632

*0.10 significance level, ** 0.05 significance level, *** 0.01 significance level, t-statistics are in parentheses

Explanatory ability of the model improved when SCI was used as quality indicator and worsened with ISI.

The data used in this thesis are cross-sectional, so it is necessary to test for violations of basic OLS assumptions. After computing the analog to the Harvey test of heteroskedasticity, it was found that data for all years violates the assumption of constant error variance over all sample observations, therefore it is necessary to implement data matrix transformation and use generalized least squares. The results of corrected model are presented in Table 7.

After correction for heteroskedasticity FC became unimportant for 1994 also. The other change is that size of the journal (PG) became significant for 2001.

Frequency of publication (FREQ) was significant and increasing for all model variations and years. Prices in general increased faster for the journals that are published more frequently.

Higher prices are associated with increase in average journals size. Additional page cost $0.60 in 1988, $0.37 in 1994 and $0.89 in 2001. Additional issue per year caused price increases of $16 in 1988, $24 in 1994 and $27 in 2001.

The role of commercial publishers in journals' crisis is increasing. The average price of a journal published abroad by commercial publisher was $508 in 1988, $626 in 1994 and $1354 in 2001. In 1994 commercial publishers charged $273 more than non-commercial, less than in 1988 and 2001 when they were charging $353 and $1032 more respectively.

Unit increase in ISI led to price drop of $20 in 1988, $12 in 1994.

It was possible to estimate all three years together, but after constructing the correlation matrix for each year's errors and finding that they are uncorrelated, it was not necessary because separate estimations are as good as simultaneous estimation.

The log-linear model was used as an alternative model specification, but the fit of the model deteriorated and this approach therefore was rejected.

The data on circulation is available only for year 2001. This important variable is included into the model. See Table 8 below.

Circulation variable increased the explanatory power of the model. For both ISI and SCI variations circulation was negative and significant, although not very large. ISI lost its significance for 2001, but SCI is significant and negative. The effect of frequency is increased and the effects of country of origin and type of publisher decreased.

Table 8. Model with CIRC

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
NUS	392.604 (4.001)*	441.501 (5.971)*	378.088 (3.946)*	453.34 (6.160)*
ISI	0.124 (0.168)	0.301 (0.846)		
SCI			-0.004 (-2.414)**	-0.003 (-3.179)*
FREQ	46.976 (10.877)*	32.480 (11.828)*	56.999 (9.702)*	41.764 (10.644)*
PG	0.246 (0.938)	0.789 (4.542)*	0.549 (1.923)***	1.119 (5.503)*
Comm	570.464 (6.205)*	1002.32 (5.144)*	532.787 (5.879)*	1200.065 (6.086)*
N	165	165	166	166
R^2	0.54	0.58	0.55	0.60
Adjusted R^2	0.52	0.57	0.54	0.58
F	30.463	36.803	32.866	39.025

*Significance at 0.01 level, ** 0.05 level, *** 0.10 level

An increase in circulation by 1000 copies leads to a price reduction of $3-5. The negative coefficient on CIR tells us that scale effects are important and the market is competitive (cost savings are passed to the subscribers).

If the journal is published by a commercial publisher abroad, its price on average was $1238 if the quality was reflected by ISI ($1319 if SCI was used in the model). Additional page cost was in the range of $0.80-1.12. An extra issue in 2001 lead to a journal price increase of $32-42.

Correlation Analysis

Correlation matrices (given in Tables 2-4 of Appendix) show significant correlation between the quality indicator SCI and frequency. This means that journals with higher SCI tend to be published more frequently. Bigger journals get more cites.

The correlation matrix for 2001 reveals very high, almost unit, correlation between all market share indicators and circulation. That means that high circulation journals possess market power. Previous studies already found a relationship between circulation and price, and I confirmed these findings in Table 10; so this variable is excluded from the second model.

Presentation and Discussion of Second Model

Four different indicators of industry concentration are used in the second model. The first two are regular market shares determined in natural terms (number of pages) MSP and money terms (revenue or total sales) MSR. Second two are components of industry HHI index: market shares (expressed in percents) are squared MSP' and MSR'.

Regression models were performed for all indicators with ISI and SCI specifications using straight OLS and transformed GLS to fix the heteroskedasticity problem (see Tables 9-12 above).

Table 9. Determinants of Library Subscription Prices for Title Model with MSP

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-414.882	-327.103	-327.15	-257.915
	(-3.385)*	(-4.539)*	(-2.766)*	(-3.911)*
MSP[1]	-4860.41	-5220.07	-6811.37	-5527.83
	(-3.017)*	(-6.294)*	(-5.063)*	(-4.787)*
NUS	394.156	445.965	413.465	472.944
	(4.070)*	(6.142)*	(4.194)*	(6.190)*
SCI	-0.003	-0.002		
	(-2.126)**	(-2.388)**		
ISI			0.144	0.318
			(0.194)	(0.894)
FREQ	57.972	41.552	49.631	34.487
	(9.822)*	(10.640)*	(10.892)*	(11.653)*
PG	0.565	1.032	0.291	0.841
	(1.954)***	(5.394)*	(1.106)	(4.950)*
Comm	523.599	1124.146	557.113	1077.731
	(5.736)*	(6.266)*	(6.041)*	(5.687)*
N	166	166	165	165
R^2	0.55	0.60	0.53	0.58
Adjusted R^2	0.53	0.59	0.51	0.56
F	31.820	40.417	29.879	35.930

*Significance at 0.01 level, ** 0.05, *** 0.10 level, t-statistics are in parentheses.

Table 10. Determinants of Library Subscription Prices for Title Model with MSR

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-428.871	-353.221	-313.191	-246.518
	(-3.459)*	(-4.702)*	(-2.584)**	(-3.601)*
MSR[1]	-4796.113	-4435.23	-7943	-5604.01
	(-2.214)**	(-3.164)*	(-4.167)*	(-3.558)*
NUS	390.013	475.733	416.179	475.366
	(3.977)*	(6.200)*	(4.125)*	(6.126)*
SCI	-0.004	-0.003		
	(-2.822)***	(-3.269)*		
ISI			0.127	0.319
			(0.166)	(0.858)
FREQ	59.824	42.764	49.220	33.799
	(10.063)*	(10.760)*	(10.275)*	(10.870)*
PG	0.624	1.131	0.260	0.804
	(2.136)**	(5.579)*	(0.965)	(4.509)*
Comm	520.100	1179.82	566.837	1037.607
	(5.598)*	(6.286)*	(5.987)*	(5.446)*
N	166	166	165	165
R^2	0.53	0.58	0.51	0.55
Adjusted R^2	0.52	0.57	0.49	0.54
F	30.364	36.955	27.345	32.822

*Significance at 0.01, ** at 0.05, *** at 0.10 level, t-statistics in parentheses

Table 11. Determinants of Library Subscription Price for Title Model with MSP'

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-418.774	-384.592	-301.647	-241.192
	(-3.400)*	(-4.921)*	(-2.526)**	(-3.459)*
MSP'[1]	-0.966	-0.773	-1.446	-1.351
	(-2.702)*	(-1.680)***	(-4.523)*	(-3.002)*
NUS	399.772	458.012	428.678	474.548
	(4.098)*	(6.296)*	(4.284)*	(6.097)*
SCI	-0.004	-0.003		
	(-2.735)*	(-3.583)*		
ISI			0.160	0.330
			(0.211)	(0.871)
FREQ	57.669	43.285	46.221	32.374
	(9.682)*	(10.692)*	(10.473)*	(11.211)*
PG	0.591	1.183	0.240	0.780
	(2.038)**	(5.651)*	(0.900)	(4.289)*
Comm	521.587	1226.138	563.183	987.521
	(5.677)*	(6.600)*	(6.010)*	(5.493)*
N	166	166	165	165
R^2	0.54	0.58	0.52	0.54
Adjusted R^2	0.52	0.57	0.50	0.53
F	31.195	36.823	28.294	31.309

*Significance at 0.01, ** at 0.05, ***at0.10 level, t-statistics in parentheses

Table 12. Determinants of Library Subscription Price for Title Model with MSR'

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-418.946	-382.948	-304.648	-246.393
	(-3.402)*	(-4.896)*	(-2.552)**	(-3.557)*
MSR'[1]	-1.873	-1.371	-2.798	-2.468
	(-2.714)*	(-1.652)	(-4.563)*	(-3.070)*
NUS	398.806	456.765	426.752	465.303
	(4.090)*	(6.280)*	(4.270)*	(6.160)*
SCI	-0.004	-0.003		
	(-2.685)*	(-3.516)*		
ISI			0.161	0.333
			(0.213)	(0.883)
FREQ	57.838	43.346	46.728	32.858
	(9.727)*	(10.723)*	(10.518)*	(11.319)*
PG	0.583	1.173	0.235	0.782
	(2.006)**	(5.557)*	(0.881)	(4.298)*
Comm	522.460	1225.804	563.872	1022.103
	(5.685)*	(6.575)*	(6.023)*	(5.528)*
N	166	166	165	165
R^2	0.54	0.58	0.52	0.55
Adjusted R^2	0.52	0.57	0.50	0.54
F	31.219	36.866	28.405	32.738

* Significance at 0.01, ** at 0.05 level, t-statistics in parentheses

Results of the title model show that foreign publishers were charging higher prices than their North American counterparts (in the range of $446-476). Commercial publishers' prices were higher than non-commercial on average by $986-1226. An additional page per issue caused a price increase in the range of $0.78-1.18. Printing an additional issue per year corresponds to an increase of $32-43 in price. The quality indicators show the same tendency as in the model without market concentration parameters. SCI is significant and negative, but very small in the absolute value. ISI is positive, insignificant and not very large.

Regular market share indicators MSR and MSP are significant, negative and very large in the absolute value with large standard errors. A small increase in market share (1% or 0.01) causes a price decline in the range of $44-56.

Modified market share indicators MSR' and MSP' are also significant, negative, but small in absolute value with small errors. The results give no sign of the abuse of monopoly power.

In the title model all market shares are determined for each individual title. In usual industry analysis market shares are determined for the particular publisher. Variants of the second (publisher's) model are introduced in Tables 13-16 below.

In the publisher's model specification each additional page increases price by $0.35-1.31. A frequency increase of one issue causes a price increase of $25-49 per title. Foreign journals were priced $143-347 higher than North American ones. Commercial publishers charged $571-1508 more than non-commercial publishers. The quality indicator ISI was insignificant for all market share specifications. SCI was insignificant when market share was reflected by MSP, probably the result of correlation. For all other market share specifications it was significant, negative, but small in absolute value (0.002-0.004 range). The highest explanatory power (adjusted R^2) was received under the MSP variation, when market share is significant, negative and large. Increase in market share causes price to drop by

Table 13. Determinants of Library Subscription Price for Publisher Model with MSP

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-349.537	-37.609	-203.718	-87.756
	(-2.267)**	(-0.720)	(-1.558)	(-1.982)***
MSP^2	-3036.26	-4156.55	-3962.62	-6235.81
	(-2.198)**	(-2.215)**	(-3.198)*	(-3.742)*
PG	1.060	0.361	0.712	0.385
	(2.517)**	(2.732)*	(1.964)***	(3.148)*
FREQ	41.618	30.059	32.355	31.698
	(4.694)*	(3.394)*	(5.269)*	(6.027)*
SCI	-0.003	0.000		
	(-1.535)	(0.078)		
ISI			-3.293	12.623
			(-0.638)	(1.478)
NUS	292.347	142.887	308.940	294.634
	(2.431)**	(2.448)**	(2.515)**	(3.365)*
Comm	412.994	570.775	417.269	969.567
	(3.234)*	(1.399)	(3.218)*	(2.670)*
N	73	73	73	73
R^2	0.47	0.86	0.45	0.78
Adjusted R^2	0.42	0.85	0.40	0.76
F	9.581	69.154	8.995	38.632

*0.01 significance level, ** 0.05 significance level, *** 0.10 significance level, one tailed test; t-statistics is given in parentheses

Table 14. Determinants of Library Subscription Price for Publisher Model with MSR

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-372.311	-232.111	-175.13	-70.454
	(-2.373)**	(-3.512)*	(-1.294)	(-1.438)
MSR^2	-2559.31	4070.838	-3971.61	-6598.96
	(-1.376)	(1.154)	(-2.250)**	(-2.964)*
PG	1.182	0.663	0.716	0.352
	(2.763)*	(3.586)*	(1.901)***	(2.377)**
FREQ	42.757	48.887	29.705	29.948
	(4.703)*	(6.521)*	(4.606)*	(5.026)*
SCI	-0.004	-0.002		
	(-2.084)**	(-1.877)***		
ISI			-3.644	11.578
			(-0.681)	(1.218)
NUS	293.484	177.844	325.938	313.624
	(2.377)**	(3.454)*	(2.553)**	(2.944)*
Comm	402.751	1490.405	407.052	813.369
	(3.064)*	(3.953)*	(3.009)*	(2.115)**
N	73	73	73	73
R^2	0.44	0.54	0.41	0.47
Adjusted R^2	0.39	050	0.36	0.43
F	8.728	13.174	7.640	9.852

*0.01 significance level, ** 0.05 significance level, *** 0.10 significance level, one tailed test; t-statistics is given in parentheses

Table 15. Determinants of Library Subscription Price for Publisher Model with MSR'

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-348.049	-350.316	-178.842	-183.032
	(-2.238)**	(-3.936)*	(-1.364)	(-2.640)**
MSR'^{2}	-1.159	-0.819	-1.576	-1.519
	(-1.964)***	(-0.991)	(-2.898)*	(-1.871)***
PG	1.064	1.312	0.659	0.850
	(2.482)**	(4.845)*	(1.783)***	(3.907)*
FREQ	40.649	34.578	29.286	24.527
	(4.545)*	(7.254)*	(5.023)*	(7.384)*
SCI	-0.003	-0.003		
	(-1.750)***	(-2.599)**		
ISI			-3.295	-0.012
			(-0.630)	(-0.004)
NUS	299.548	314.858	324.428	346.97
	(2.465)**	(4.539)*	(2.604)**	(4.696)*
Comm	408.289	1507.604	410.888	990.704
	(3.174)*	(4.121)*	(3.130)*	(2.990)*
N	73	73	73	73
R^2	0.46	0.70	0.44	0.67
Adjusted R^2	0.41	0.67	0.39	0.64
F	9.298	25.886	8.514	22.523

*0.01 significance level, ** 0.05 significance level, *** 0.10 significance level, one tailed test; t-statistics is given in parentheses

Table 16. Determinants of Library Subscription Price for Publisher Model With MSP'

Explanatory Variable	$Price_{2001}$	$Price_{2001}$, Corrected	$Price_{2001}$	$Price_{2001}$, Corrected
Intercept	-346.102	-341.671	-178.156	-180.156
	(-2.229)**	(-3.863)*	(-1.364)	(-3.019)*
MSP'^{2}	-0.620	-0.550	-0.832	-1.206
	(-2.031)**	(-1.169)	(-2.956)*	(-1.679)***
PG	1.067	1.299	0.670	0.565
	(2.506)**	(4.916)*	(1.822)***	(2.842)*
FREQ	40.256	33.790	28.887	35.187
	(4.504)*	(7.079)*	(5.039)*	(9.641)*
SCI	-0.003	-0.002		
	(-1.735)***	(-2.488)**		
ISI			-3.297	-5.852
			(-0.632)	(-0.599)
NUS	299.975	328.779	324.219	275.375
	(2.473)**	(4.636)*	(2.609)**	(4.465)*
Comm	407.647	1477.182	409.450	1218.87
	(3.180)*	(4.093)*	(3.130)*	(3.560)*
N	73	73	73	73
R^2	0.46	0.70	0.44	0.76
Adjusted R^2	0.41	0.67	0.39	0.74
F	9.376	25.303	8.605	34.409

Note: t statistics are given in the parentheses * 0.01 significance level, **0.05 significance level, ***0.10 significance level, one-tailed test.

$42-62. In competitive industries small increases in MS do not affect price. In industries with market power abuse small increases in MS cause price increases. In our case the situation is unclear. In the MSR and SCI variant the MSR lost its significance and reversed sign from negative to positive after correction for heteroskedasticity. Under the ISI specification MSR is significant, negative and large.

The model with MSP' is the second best in terms of explanatory power. Under this model definition with SCI, market share lost its significance after correction for heteroskedasticity. This is also true for MSR' with SCI. Both MSR' and MSP' are significant at 0.10 level and negative under the ISI specification.

An important aim of this thesis was to investigate the effects of market structure on journal price. The expected sign for any concentration parameter is positive. The economic meaning of a significant and negative coefficient is either that there is no significant market power in the publishing market, or that the model is missing some key information. If CIRC is included as an explanatory variable in the model, then the sign for market share is positive but insignificant, but the results are unreliable because of high correlation between market share and CIRC.

Conclusion

It is possible to explain at least 40% of the variation in journal prices using the specified models. Although the introduction of market structure indicators did not prove the theoretical expectation that concentration impacts prices in the upward direction, it was a useful addition to the existing model. Conclusion: the industry is reasonably competitive; market concentration is not a problem.

Parameters for country of origin, type of publisher, size and frequency of the journal were significant for all years and model specifications, and can be regarded as valid price determinants. The quality index ISI was significant for 1988 and 1994. Its insignificance in 2001 may be explained by changes in the biology journals and a switch to new quality indicators associated with electronic access.

Heteroskedasticity was found for all years and all variants, but not always because of the same variables. The type of publisher variable was the major cause of the heteroskedasticity problem. It is necessary to correct the model for heteroskedasticity because of significant effects on some other variables in the study.

CONCLUSIONS

Summary of the Study

The purpose of the thesis was to find reliable determinants for the price of biology journals and give possible explanations for why prices increased faster than inflation. Existing literature on the subject identifies the following determinants of journal prices: size and technical characteristics of the journal, quality indicators, subject area, type of publisher, country of origin. This study attempts to introduce market structure indicators as price determinants, while checking the significance of price determinants found in the literature.

Possible explanations of the causes of the serials crisis from the point of view of micro economic theory include: profit motivation and different cost structures for commercial and non-commercial publishers, revolutionary changes in journals, concentration as a consequence of mergers, journal proliferation and recent over-investment.

The empirical findings, while confirming results of previous research, do not support the theoretical assumption about the influence of market structure on journal price, but they do not reject it completely either. This thesis is just a first step towards better analysis of the market structure of the journal industry.

Limitations of the Study and the Directions for Future Research

The major limitation of the study is the lack of important data on circulation. The data available cover only the year 2001 and are only for print runs (electronic subscriptions are excluded). The other data that could be improved are subscription prices. In both 1988 and 1994 prices were for paper versions only, while prices for 2001 included both paper and electronic publications for some publishers.

The other problem is multicollinearity (unstable coefficients) when circulation and market structure indicators were used at the same time. Future research has to solve this problem of endogeneity by finding better indicators of market structure, and applying improved econometrics (e.g., demand-supply model and/or two-stage least squares).

BIBLIOGRAPHY

Barschall, H.H., The Cost of Physics Journals, *Physics Today* 39 (Dec 1986)

Barschall, H.H., The Cost-Effectiveness of Physics Journals, *Physics Today* 41 (July 1988): 56-59

Bergstrom, T.C., Free labor for Costly Journals, *Journal of Economic Perspectives* 15(4 Fall 2001): 183-198

Byrd, G.D., An Economic "Commons" Tragedy for Research Libraries: Scholarly Journal Publishing and Pricing Trends, *College & Research Libraries* 51 (May 1990): 184-195

Chressanthis, G.A. and Chressanthis, J.D., Publisher Monopoly Power and Third-degree Price Discrimination of Scholarly Journals, *Technical Services Quarterly* 11/2 (1993)

Chressanthis, G.A. and Chressanthis, J.D., A General Econometric Model of the Determinants of Library Subscription Prices of Scholarly Journals: The Role of Exchange Rate Risk and Other Factors, *Library Quarterly 64/3* (1994)

Chressanthis, G.A. and Chressanthis, J.D., The Determinants of Library Subscription Prices of the Top-ranked Economics Journals: An Econometric Analysis, *Journal of Economic Education* 25/4 (fall 1994)

Durden, G.C., Ellis, L.V. and Millsaps, S.W., Gordon Tullock: His Journal and His Scholarship, *Public Choice* 71 (1991): 171-196

Garfield, E., The Impact Factor, http://www.isinet.com/hot/essays/7.html

Houbick, R.L., British Journal Pricing: Enigma Variations, or What Will the U.S. Market Bear? *Library Acquisitions: Practice and Theory* 10 (1986): 183-197

The Institute for Scientific Information, *Journal Citation Reports*, Annually

The Institute for Scientific Information, *Journal Performance Indicators*, (2000)

Kingma, B.R., and Eppard, P.B., Journal Price Escalation and the Market for Information: The Librarians Solution, *College & Research Libraries* 53 (November 1992): 523-535

Lewis, D.W., Economics of the Scholarly Journal, *College & Research Libraries* 50 (November 1989)

Lieberman, L., Noll, R., Steinmueller, W.E., Economic Analysis and Empirical Protocol for Examining Scholarly Periodical Pricing, Andrew W. Mellon Foundation Archive, 1991a

Lieberman, L., Noll, R., Steinmueller, W.E., Economic Analysis of Scientific Journal Prices: Preliminary Results, Andrew W. Mellon Foundation Archive, 1991b

Lieberman, L., Noll, R., Steinmueller, W.E., Proposal to the Mellon Foundation: Economic Analysis of Scholarly Periodical Costs, Andrew W. Mellon Foundation Archive, 1991c

Lieberman, L., Noll, R., Steinmueller, W.E., The Sources of Scientific Journal Price Increase, Center for Economic Policy Research, Stanford University, Working Paper, 1992.

Lynden, F.C., Prices of Foreign Library Materials: A Report, *College & Research Libraries* 49 (May 1988): 217-231

Machlup, F., Publishing Scholarly Books and Journals: Is It Economically Viable? *Journal of Political Economy* 85 (February 1977): 217-225

McCabe, M.J., The Impact of Publisher Mergers on Journal Prices: A Preliminary Report, (September1998), http://www.arl.org/newsltr/200/mccabe.html

McCabe, M.J., The Impact of Publishers Mergers on Journal Prices: An Update, *Against the Grain* (September 1999)

McCabe, M.J., Academic Journal Pricing and Market Power: A Portfolio Approach, AEA meeting in Boston, MA, 2000

McCabe, M.J., Journal Pricing and Mergers: A Portfolio Approach, *American Economic Review* 92(1, March 2002): 259-269

Meyer, R. W., Monopoly Power and Electronic Journals, *Library Quarterly* 67/4 (Oct. 1997)

Meyer, R.W., A Tool to Assess Journal Price Discrimination, *College & Research Libraries* (May 2001)

Moline, S.R., The Influence of Subject, Publisher Type, and Quantity Published on Journal Prices, *The Journal of Academic Librarianship* 15 (1989): 12-18

Noll, R., Steinmueller, W.E., An Economic Analysis of Scientific Journal Prices: Preliminary Results, *Serials Review* 18 (Spring/ Summer 1992): 32-37

Ordover, J.A., and Willig, R.D., On the Optimal Provision of Journals qua Sometimes Shared Goods, *American Economic Review* 68 (June 1978): 324-338

Petersen, H.C., Variations in Journal Prices: A Statistical Analysis, *The Serials Librarian* 17 (1/2 1989): 1-9

Petersen, H.C., University Libraries and Pricing Practices by Publishers of Scholarly Journals, *Research in Higher Education* 31 (4, 1990): 307-314

Petersen, H.C., The Economics of Economic Journals: A Statistical Analysis of Pricing Practices by Publishers, *College & Research Libraries* 53 (March 1992): 176-181

Tenopir, C. and King, D., Towards Electronic Journals, Washington, DC: Special Libraries Association, 2000

Walker, T.J., Free Internet Access to Traditional Journals, *American Scientist* 86 (1998): 463-471

Wilder, S. J., Comparing Value and Estimated Revenue of SciTech Journals, http://www.arl.org/newsltr/200/wilder.html

Wyly, B. J., Competition in Scholarly Publishing? What Publisher Profits Reveal, http://www.arl.org/newsltr/200/wyly.html

Yuster, L.C and Mullihn, J., Eds, Ulrich's International Periodicals Directory, Annual.

Cornell University Faculty Task Force, Journal Price Study: Core Agricultural and Biological Journals, (November 1998) http://jan.mannlib.cornell.edu/jps/jps.html

Department of Justice antitrust guidelines at http://www.usdoj.gov/atr/public/guidelines/guidelin.html

Appendix

Detailed Data Specification

The fundamental source of the data was the study performed by the Mann Library of Cornell http://adam.mannlib.cornell.edu/jps/jps.htm on 312 titles in Agriculture and Biology for 1988 and 1994.

The technical characteristics of the journals (number of pages per year, average characters per page, average figure content) were collected by electronic scanning and optical character recognition. Other data were publisher type, availability of ads, library subscription price, Science Citation Index for each title, impact factor for each title, page charges and availability of reprints. All gathered information was sent to the relevant publisher for examination and correction; the respond rate was 80%.

The study initially identified 200 biology titles through rankings in the *Journal Reports* of the Science Citation Index, which were reviewed by appropriate faculty. The result was selection of 174 titles for the study, all of which the OSU Kerr Library holds (except the *Australian Journal of Plant Physiology*). Data for 2001 were added based on Kerr Library collection and holding for 1988 and 1994 were adjusted to reflect OSU holdings, because there were some questionable titles in Cornell report (some were received free, so no price was available, some were purchased but were missing, etc.).

Prices for 1994 and 2001 are adjusted to 1988 prices, using the CPI.

Gathered mostly from publishers web pages, many prices for 2001 include subscription for both print and electronic versions, while in 1994 electronic access was not available. For two journals published by Kluwer (*Advances in Microbial Ecology* and *Evolutionary Biology*) I used prices for 2000, because they were not published in 2001.

Data on circulation were obtained only for the year 2001, by checking the publishers' web pages and contacting the publishers directly. It is for print runs only; information about electronic subscriptions is missing. Kluwer refused to provide circulation information, so circulation for this publisher is estimated by using library databases and checking the number of libraries where certain article from a Kluwer journal is available. If the article was mentioned in the library collection, it was counted as a subscription.

Data on frequency and total pages for 2001 was collected by contacting journal archives if it was available online or by checking the library shelves. Average pages (PG) are simply total annual pages divided by frequency.

Citation data for both SCI and ISI is collected using the library reference catalogues. Kerr library has a microfiche subscription from SCI Institute. The last available catalogue is for year 2000, so instead of using SCI and ISI for 2001, I am using the previous year.

NUS in my study is equivalent to Cornell's "Origin". Instead of using abbreviations for the name of the countries, I introduce a dummy variable with the value 1 if the journals is published in Europe, Japan, Australia, and 0 if it is published in the US or Canada.

Comm is a dummy variable that distinguishes commercial publishers from all the others. It will allow to see how much higher the prices of commercial publishers are for journals with similar attributes.

Appendix. Table 1. Inflation in Biology Journals

Type of Publisher	P88	P88 in 1994	P88 in 2001	P94	P01	1994-1988		2001-1988	
	$	$	$	$	$	$	%	$	%
Average	331.62	409.25	486.45	577.66	1162.84	168.42	41.15%	676.39	139.05%
North America	203.17	250.73	298.03	349.69	819.43	98.95	39.46%	521.40	174.95%
Foreign	503.48	621.34	738.55	877.47	1620.72	256.13	41.22%	882.16	119.44%
Gap	300.31			527.79	801.29				
	147.81%			150.93%	97.79%				
Commercial	444.33	538.16	652.92	777.85	1592.95	239.69	44.54%	940.04	143.97%
Non-Commercial	238.72	318.17	342.42	414.08	790.07	95.90	30.14%	447.64	130.73%
Gap	205.61			363.77	802.89				
	86.13%			87.85%	101.62%				

Appendix. Table 2. Correlation Matrixes for 1988 and 1994

Correlation 1988

	Price	ISI	PG	FC	Comm	NUS	FREQ	Page	Char	SCI
Price	1									
ISI	-0.14483	1								
PG	-0.12831	0.446388	1							
FC	0.057142	-0.0577	-0.14236	1						
Comm	0.287704	0.122474	0.103045	-0.13214	1					
NUS	0.408286	-0.26071	-0.29323	0.019527	0.222911	1				
FREQ	0.403385	0.149198	-0.28105	0.159239	-0.05301	0.018347	1			
Page	0.298067	0.113201	0.257404	0.091178	-0.2034	-0.12596	0.616107	1		
Char	0.069911	0.058416	-0.05541	0.02084	-0.26903	-0.14776	0.275105	0.310166	1	
SCI	0.087712	0.356854	0.085115	0.089118	-0.10761	-0.1343	0.701978	0.736342	0.360682	1

Correlation 1994

	Price	ISI	PG	FC	Comm	NUS	FREQ	Page	Char	SCI
Price	1									
ISI	-0.16043	1								
PG	-0.11769	0.35818	1							
FC	0.210088	-0.07212	-0.05172	1						
Comm	0.274868	0.088739	0.009708	-0.18114	1					
NUS	0.419014	-0.26064	-0.29652	0.046626	0.214545	1				
FREQ	0.473968	0.224631	-0.19464	0.268474	-0.0567	0.061345	1			
Page	0.228467	0.138468	0.432196	0.240012	-0.20006	-0.13654	0.533523	1		
Char	0.053583	0.193603	-0.09937	-0.06623	-0.26459	-0.08783	0.315713	0.219013	1	
SCI	0.072066	0.470714	0.186507	0.174254	-0.10969	-0.13051	0.676527	0.725493	0.343498	1

Appendix. Table 3. Correlation for 2001

	MSR'	SCI	CIRC	MSP'	Price	NUS	ISI	FREQ	PG	Comm	MSP	Revenue	MSR
MSR'	1												
SCI	0.5228	1											
CIRC	0.9486	0.5162	1										
MSP'	0.9979	0.5068	0.9439	1									
Price	-0.0130	0.1403	-0.0800	-0.0222	1								
NUS	0.0730	-0.1289	-0.0003	0.0754	0.3195	1							
ISI	0.0248	0.0291	0.0194	0.0242	-0.0286	-0.0948	1						
FREQ	0.3454	0.6802	0.3171	0.3254	0.5234	0.0533	0.0176	1					
PG	-0.0553	0.2707	-0.0206	-0.0516	-0.0770	-0.3282	0.0259	-0.0730	1				
Comm	0.0668	-0.1263	0.0580	0.0688	0.3227	0.2067	-0.0631	-0.0746	-0.0183	1			
MSP	0.9788	0.6312	0.9574	0.9674	-0.0021	0.0292	0.0245	0.4280	-0.0080	0.0307	1		
Revenue	0.9600	0.6105	0.9278	0.9417	0.0816	0.0527	0.0204	0.4741	-0.0369	0.0609	0.9838	1	
MSR	0.9600	0.6105	0.9278	0.9417	0.0816	0.0527	0.0204	0.4741	-0.0369	0.0609	0.9838	1	1

Appendix. Table 4. Correlation for Publishers' Averages

	CIRC	MSP'	MSR'	P'	PG	ISI	FREQ	NUS	Comm	SCI	Revenue	MSR	MSP
CIRC	1												
MSP'	0.8092	1											
MSR'	0.8181	0.9920	1										
P'	-0.0763	0.0060	0.0327	1									
PG	-0.1122	-0.0874	-0.0969	0.1525	1								
ISI	0.2312	0.2398	0.2451	0.0090	0.0738	1							
FREQ	0.4830	0.4710	0.4907	0.4179	0.1217	0.3430	1						
NUS	-0.0197	0.1310	0.1257	0.2725	-0.2446	-0.1838	0.0031	1					
Comm	0.1342	0.1721	0.1939	0.2942	-0.0792	-0.0168	-0.0455	0.3168	1				
SCI	0.5290	0.5286	0.5373	0.2286	0.3941	0.3286	0.8259	-0.1259	-0.0329	1			
Revenue	0.8054	0.9002	0.9440	0.1604	-0.0615	0.2619	0.5766	0.1161	0.2289	0.5775	1		
MSR'	0.8054	0.9002	0.9440	0.1604	-0.0615	0.2619	0.5766	0.1161	0.2289	0.5775	1	1	
MSP'	0.8759	0.9656	0.9763	0.0553	-0.0164	0.2769	0.5901	0.0743	0.1519	0.6450	0.9534	0.9534	1