To the Graduate Council:

I am submitting herewith a dissertation written by Richard Guy Cox entitled "Three Essays in Industrial Organization." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

Sidney Carroll, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

THREE ESSAYS IN INDUSTRIAL ORGANIZATION

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Richard Guy Cox
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ABSTRACT

This dissertation consists of three core parts. The first shows that prices may serve as signals of unknown product quality even when a costly return policy is in place. The part also contains empirical evidence suggesting that consumers do believe that prices are signals of quality. The empirical section contains data collected from an internet auction of used computers conducted as http://www.uce.com. The second part shows that when firms assimilate a technology in an asymmetric fashion this may have the result of a price increase. Some examples are provided. Also, the part shows that a dominant firm with a superior technology may strategically license its technology to induce exit from the industry. The third part examines the theory of the relationship between industry concentration and price-cost margins. Arguments are made that Cournot developed a theory consistent with efficiency theory of Demsetz.

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PART 1: GENERAL INTRODUCTION AND OVERVIEW

1.1 Introduction

This dissertation contains three essays related to industrial organization and more specifically to Bertrand (1986) and Cournot (1963) competition. The first essay is an empirical study of Wolinsky's (1983) modification of the Bertrand game. Bertrand's initial game consists of players (which are firms) lowering their prices in an effort to increase sales. Price settles at marginal cost. Wolinsky, however, showed that when consumers perceive price to be a signal of unknown quality firms may not lower their price to increase sales as consumers will infer that the lower price means inferior quality and hence not purchase the good from that firm. I provide an empirical test of Wolinsky's assertion by examining a market for used computers.

The next two essays examine Cournot competition and more generally the work of Cournot. In one of the essays I consider that firms with asymmetric technologies engage in Cournot competition. I consider what occurs when there is some change in the cost of the firms. I consider three different cases. First is the case of licensing. A low cost firm sells its superior technology to a rival. The second case is that of patent removal. A patent held by the dominant firm is bought out allowing access by all firms to the patented technology. The third case is that of some external shock which lowers the cost of all firms. In each of the cases I provide an example of how the technological improvements lead to an increase in price and deadweight loss.

The last essay discusses the relationship between Cournot's work and the work of Demsetz (1974). There I argue that Demsetz's belief that cost differences drive the concentration-profitability relationship is consistent with the work of Cournot.

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PART 2: PRICES AS SIGNALS OF QUALITY

2.1 Introduction to Part 2

If something costs more it must be better. Likely, we do not all agree with the previous sentence. Still, it is possible to show that prices can serve as signals of quality, see for example Wolinsky (1983). In a Bertrand game firms may not have sufficient incentive to lower price when price serves as a signal of quality. Lowering the price has a negative effect on sales as some consumers infer low quality and do not purchase. This paper makes two contributions to the literature on prices as quality signals. First, many firms offer a return policy. In this case it is unclear that consumers will refuse to purchase at a slightly lower price since they can return the item if quality is low. I show that when there is a "small" return fee prices continue to serve as signals of quality. [1] Second, it may be interesting to discover whether or not people truly believe the remark "if something costs more it must be better." I provide an empirical test using a natural experiment. [2]

Quality is sometimes associated with durability, but not always. This fact introduces some potential confusion into tests of price as a signal of quality when considering buyers' beliefs. If quality and durability were synonymous then it would be possible to test the relationship between price and quality by simply using duration data. Of course, low quality firms may not report hazard rates

[1]The size of the return fee can simply be the cost of visiting the store to make the return when quality gaps are twice as large as in Wolinsky (1983). In essence the existence of the return policy will require that quality differences be larger than in the case where there is no return policy.

[2]By natural experiment I mean an experiment which was not planned by the researcher by rather occurs in a true market setting.

and hazard rates from laboratory testing may differ from real-use hazard rates. More importantly, this will not necessarily tell us anything concerning buyers' beliefs.

It is possible, nonetheless, to test buyers' beliefs concerning all aspects of quality and a price signal. I assume that buyers value higher quality more than lower quality. Survey or experimental data about consumers' willingness to pay for an object, given non-binding prices, provides useful information about buyers' beliefs, when buyers value quality. I use data from a "natural" experiment to test whether buyers believe that prices signal product quality in a framework similar to that of Wolinsky.

I begin noting that in bargaining problems a fixed and unyielding price is not stated. An example might be an advertisement stating a price followed by the term or-best-offer. Clearly, the or-best-offer statement allows buyers to make meaningful offers below the suggested price. This same setting can accommodate the issue of quality uncertainty. Consider two newspaper advertisements for essentially the same piece of furniture; e.g., oak dressers with the same dimensions and same make. If all of the relevant features are stated then price conveys no information. However, all of the good's characteristics might not be known. Thus, the fact that one good has a higher suggested price may indicate that it is in better condition; i.e., the dresser has fewer scratches or watermarks.

I test buyers' beliefs about prices as signals of product quality, in a setting

similar to that mentioned above. First, the seller suggests a non-binding price for a good. The seller states some of the good's characteristics. Some, characteristics, which are relevant to the goods quality and hence value, may not be mentioned so that there is asymmetric information with the sellers being better informed than buyers. [3] Buyers make offers on the good; these may be below the suggested price. If a seller accepts an offer then both seller and buyer pay a fee to permit the buyer to inspect the good. Upon inspection, the buyer may either accept or reject the good. Rejecting the good has an additional charge. Buyers and sellers have complete anonymity and reputation effects are therefore nonexistent. I posit that if offers to buy are positively correlated with deviations from the expected suggested price, given the known characteristics, then buyers believe price to be a signal of quality.

The possibility of a higher suggested price on the part of the seller signaling better quality in the setting described above shares similarities (but has some differences) with the literature on the subject. The relationship between price and quality is discussed in Wolinsky (1983). In his model buyers do receive an imperfect signal of quality (imperfect as the signal has some stochastic element). Buyers can obtain the imperfect signal through pre-purchase inspections. In his framework such inspections are costless given that the consumer is in the market and planning a purchase. Still, in planning and attempting a purchase a consumer

[3] Unlike in Viscusi (1978) sellers cannot certify, even at a cost, quality.

will incur the cost of visiting the firm. This cost is assumed to be small relative to differences in product quality. Also, in Wolinsky's setup, firms choose the level of quality they wish to produce. In the setting above quality is exogenous, and pre-purchase inspection comes at some cost similar to Wolinsky's model, but there is a costly return policy. [4]

The introduction of a costly return policy makes it unclear, then, that the high suggested price indicates quality or can be taken as "good news" in the Milgrom (1981) sense (i.e., buyers interpret a high suggested price as an indication of quality). If consumers are allowed to perfectly verify quality before final purchase then price cannot convey any information concerning quality if such inspection is costless. However, here we have the case of liquidated damages, as in the case of a common values auction. Because there is a post inspection return fee a separating equilibrium may still exist. I show in section 2.2 below that this is the case.

Several other papers are also worth mentioning here. Milgrom and Roberts (1986) construct a model in which reputation plays an important role, as does repeated interaction. They use such a model to explain more the reasons for advertising than the use of price as a signal of unknown quality. In the setting I

[4]Of course, in the furniture example and other scenarios purchase is not mandatory after the object is viewed. A prospective buyer may find that the object is not worth the money. This case may be as costless as the setup in Wolinsky. The relevant difference begins when search is costly given that upon receiving a perfect signal there is a cost associated with quitting the purchase. In the empirical case below viewing the object comes at some cost and there is an equal cost of quitting the sale.

mention it is clear that there are no reputation effects and that repeat purchases are not at issue. Additionally, this paper is not about advertising.

Chan and Leland (1982) consider the case (among others) that price is known to consumers but that quality is costly to observe. They find that firms may offer a single price but multiple quality levels. Informed consumers purchase the high quality good while uninformed consumers purchase randomly from both high and low quality providers. The result is analogous to that of Varian (1980) where uninformed consumers randomize over low and high price firms while informed consumers always purchase at the low price.

Another paper of interest is that of Cooper and Ross (1984). They find that when there are both informed consumers, consumers who know the true quality of the good, and uninformed consumers, those who do not know the true quality, price can convey some information about product quality. Informed consumers provide a positive externality to uninformed consumers. In their model they suggest that "ripoffs" or low quality provided at a high price, will be infrequent when average cost rises as sales fall. Firms are unable to be profitable when no informed consumers purchase from them. Both of these works assume that there are both informed and uninformed consumers. In the presentation below there is no necessity of differences in information among buyers. (See Tirole, 1988 for an overview of the relationship between quality and price signals).

I proceed with the model of bidding (or offer) behavior in section 2.2. In

section 2.3 I explain the market (or natural experiment) I examine and the data which I collected to provide some empirical tests. I report the statistical findings in section 2.4, along with some interpretations. I conclude in section 2.5.

2.2 The Model

The seller of object i has reservation price r_i which is known only to him. The reservation price lies in $[\underline{V}_i, \overline{V}_i]$.[5] Distinct objects have distinct reservation prices, $r_i > \overline{V}_{i+1}$. Object i has a vector of known characteristics X_i. r_i is nondecreasing in X_i. The seller chooses a signal, ψ . This signal is the suggested price; it is some positive real number. The seller receives for his sale $\lambda b - s$, where $(1-\lambda)b$ is a fee paid to a sale facilitator (such as an auction house). Note that the fee is some percentage of the bid; i.e., $0 < \lambda < 1$. s is a fee which is paid to provide the object to the buyer.

Buyers have expected value $V_i = V_i(X_i, \psi_i)$ for object i. A buyer may submit a bid b_i for object i. If the bid is accepted both buyer and seller pay a fee s to allow the buyer to obtain/inspect the object. The buyer may then accept or reject the good. If the object is accepted the buyer has total payment $b_i + s$ and the seller has total receipt of $\lambda b_i - s$. To avoid trivial non-existence $V_i - s \geq b_i$ and $\lambda b_i - s \geq \underline{V}_i$, or $V_i \geq [\underline{V}_i + (1+\lambda)s]/\lambda$. That is, buyers must strictly value the object more than the minimum reserve price.

[5]Low value sellers might also be interpreted as being risk averse or having low discount factors.

If the object is rejected after inspection the buyer has total payment $2s$ and the seller has profit $-s$.

The distance between any two possible values for V_i is strictly greater than $2s$; i.e., $V_i > V_{i+1} + 2s$. In other words, the cost of inspection is "small" relative to the value differences in the goods. Wolinsky employs a slightly different assumption, namely he allows the distance between qualities to closer. In his model there is no return policy which allows a smaller gap between qualities offered.

I assume each buyer to have utility $u = V_i - b_i - s$ if the bid is accepted and the buyers does not reject the object after inspection, $u = -2s$ if the bid is accepted but the sale canceled after inspection, and $u = 0$ otherwise. Buyers are risk neutral expected utility maximizers. The buyer's problem is to maximize

$$F_i(b)[\rho(V_i + -b_i - s) + (1 - \rho)(-2s)].$$

Where F is the cumulative distribution function of the reservation price; $F_i(b) = Pr(b \geq r_i)$. Also, $\rho = \rho(b_i - V_i)$ is the probability that the good is accepted after inspection, and is a function of the difference between the bid and the true value of the object. In equilibrium this will be one. The buyer's maximization problem implies that for $V_i > V_j$ it must be the case that $b_i > b_j$. This is a result of the distribution of the reservation prices.

Noting that the solution to the buyer's objective function is $b_i^* = b_i^*(V_i; \psi_i)$, the seller must choose a profit maximizing signal ψ_i. The seller's problem is to

maximize

$$\gamma(X_i)[\rho(\lambda b_i - s) - (1-\rho)s].$$

Where γ is the probability of receiving a bid above $(r+s)/\lambda$. In this specification the probability of receiving an acceptable bid does not depend on ψ. If price is a signal of quality and high quality goods face greater demand then higher values of ψ will have greater probabilities of receiving a bid. On the other hand, if ψ is at the same time some indication of the seller's reservation price, which is correlated with the good's quality, then an increase in the signal will deter bidding. (Empirically I find that γ does not depend on ψ). Because the seller knows the true value (quality) of the object, he knows that for a given bid, ρ takes on the value of either one or zero. Note that the seller's objective function cannot be maximized by choosing a signal which elicits bids for which $\rho = 0$. Here, sellers do not lose sales by lowering the price, rather increasing the price results in an increase in the expected bid.

It is important to verify that the sellers do indeed engage in equilibrium behavior. Because of similarities with Wolinsky's work I proceed somewhat loosely. There exists a separating equilibrium if for every $\psi_i > \psi_j$ then $V_i > V_j$, where $i \neq j$ and buyers have the prior belief that if $\psi_i > \psi_j$ then $V_i > V_j$ so that this implies an ordering of expected bids $b_i > b_j$. Also, the buyers' beliefs must be confirmed which is the case when sellers equilibrium behavior preserves the

ordering of the signal with the ordering of the true values. Proving that this is the case is straightforward.

Suppose that $\psi_i > \psi_j$ when $V_i < V_j$ so that $b_i > b_j$. Now, if ψ_j is a profit maximizing signal then on inspection the buyer will not purchase object i. A buyer returns the object when $b - V > s$, the loss associated with keeping the object exceeds the cost of returning it. Now, since $V_j > V_i + 2s$ and $b_i > b_j$ we can see that $V_j - b_j > V_i - b_i + 2s$ which is just $b_i - V_i > b_j - V_j + 2s > s$. So, the object is rejected. In this case the seller of object i has net profit of $-s < 0$ and so would do strictly better not to participate in the market (or to alter his signal). If, on the other hand, ψ_i is a profit maximizing signal then the seller of object j is clearly not maximizing profit. This is all that is needed to show the existence of a separating equilibrium.

Buyers have a credible threat of returning the object. Hence, no vendor can do better by deviating from the equilibrium strategy, i.e. lying about the value of the object. With the exception of the costly return policy this argument is that of Wolinsky; namely, price is a signal of quality. The existence of liquidated damages requires only an increase in the distance between quality levels.

2.3 Market and Data

Market

In this section of the paper I focus on a specific Internet web site which

conducts an auction for computers. [6] The company maintaining the web site and conducting the auction has changed certain features of the web page and sale protocol; everything below applies to the market as it was at the time the data were collected. A listing of computers for sale is posted, and visitors are able to submit bids on the computers listed after registering with the auction house. The only "cost" to registering is time (which for some people may be valuable, but I assume not very). Primarily used computers are auctioned but on rare occasions a new computer is listed. If a person is interested in selling a computer he can list the computer on the web site; there is no fee for listing a computer.

Also listed with the computer is a schedule of characteristics, including make and model, and the seller's suggested price. This price is only a suggestion of the value. It is not binding and should not be interpreted as a reservation price. Bids above the suggested price can be rejected (this has been observed, but rarely). Bids below can be accepted (this could not be observed since once a computer is sold it is no longer listed). Decision to sell is made by the owner, who is informed of each bid via e-mail. Again, it is important to recognize that the asking price is not the reservation price . Only the seller knows his true reservation price.

United Computer Exchange (the company which maintains the website, hereafter UCE) does not charge a listing fee but does receive a commission on all finalized sales. The selling process begins when a bid is made. Making a bid

[6]The United Computer Exchange is a clearing-house for used computer sales and maintains a web site, www.uce.com, to conduct an auction of computers.

requires filling out a registration form so that UCE can identify and contact the bidder. All bids on a computer are immediately sent by e-mail to the owner of the computer. All bids are also listed on the web site, which is how I gained access to the data. Also noted with the bids is an indication of whether or not the seller has seen the bid yet. The mechanism that UCE employs ensures that identification of buyer/seller by each other is impossible. Likewise, then, repeated interaction (if it takes place) is not discernable. Consequently there is no possibility for reputation effects to be a part of the auction. [7]

If the seller accepts the bid, then the actual sale is arranged. First the buyer must send the appropriate funds to the exchange, and the seller ships the computer to the exchange, located in Atlanta. The seller pays the shipping cost. UCE then inspects the computer to assure that it is the computer that was advertised and that it is in good condition. If there are flaws with the computer (e.g., it is dirty), certain fees are charged the seller, and UCE attempts to correct the problem. No guarantee is made by UCE concerning the computer. It acknowledges to all parties that it might not be entirely thorough in its inspection.[8]

In order to obtain the computer, the buyer must pay delivery cost (from Atlanta). Two days are allowed after receiving the computer for the buyer to

[7] Again, this is a distinction from the work done by Milgrom and Roberts.

[8] This fact indicates that there is a lack of information on the part of the bidder; he is not guaranteed that the computer will be in the advertised condition and so quality is imperfectly conveyed by the specifications of the computer. In other words quality certification does not preceed the payment of s.

verify quality or "goods as promised". During this time the computer can be shipped back and the sale canceled.[9] Otherwise the sale is finalized, and the seller receives his portion of the winning bid. The fact that the sale can be cancelled at some cost provides an additional link with the theoretical model. Sellers will not find it profitable to "lie" because this will leave the computer unsold and unavailable to the seller. The computer is held in Altlanta which means that the seller foregoes opportunities to sell the computer in a home market and if computers depreciate quickly then the additional time to sale is important.

Data

The data were collected from the Internet auction for computers at http://-www.uce.com. All observations were taken during the month of July, 1998, from the 14th to the 28th. On the 28th the entire sample was updated to include any posted bids made in the two-week period. Initially there were a total of 876 bids on 416 computers. Information for an additional 177 computers which did not receive any bid was also recorded. From this sample, some computers were dropped from the final data. First, all computers for which the size of the hard drive was listed as zero were dropped. Also if the number of hard drives was different from one (i.e., zero or two) the observation was deleted. Some new or factory refurbished computers are auctioned and these were left out of the

[9]This is in distinction from the work of Wolinsky wherein there is no return policy.

sub-sample. To avoid some dummy variables with few observations I dropped those with zero or two floppy disk drives and those with some network other than Ethernet.[10] The final sample then contains 723 bids on 345 computers with 149 more computers that did not receive any bid. (A total of 99 computers were dropped). All observations are for desktop Apple computers (CPUs).[11]

Each observation contains information on some of the item's characteristics, the suggested price (ASK) and the bids made (BID), both is U.S. dollars. Table 2.1 contains summary statistics for the suggested price and for the bids as well as the additional characteristics mentioned below. Recorded characteristics of interest are: size of the hard drive (SIZE), speed of the computer (SPEED), amount of random access memory (RAM), amount of video RAM (VRAM), and the number of additional storage devices (NSTOR).[12] Some qualitative attributes were recorded as dummies (0 if does not have and 1 if has). These qualitative attributes are: has a keyboard (KEY), has a mouse (MOUSE), has graphics (GRAPHICS), has audio (AUDIO), has an Ethernet hook up (NTWRK), has a modem (MODEM), and finally whether or not a comment was made by the seller (COMMENT). In addition to these characteristics the model was recorded. The number of weeks that the computer has been listed (WEEKS), up to twenty, was also recorded. The number of weeks will be of interest below in helping to assess

[10]Only four computers had some network different from Ethernet.

[11]The web site also lists IBM computers as well as printers, monitors, etc.

[12]SIZE and RAM are measured in megabytes, SPEED is measured in megahertz, and VRAM is measured in kilobytes.

TABLE 2.1, Summary Statistics on Computer Characteristics.

Summary Statistics				
	ALL COMPUTERS		AT LEAST ONE BID	
	MEAN-NUMBER		MEAN-NUMBER	
BID			572	(422)
ASK	813	(604)	946	(538)
WEEKS	11	(7)	12	(6)
SPEED	86	(67)	103	(58)
RAM	38	(39)	45	(36)
VRAM	720	(1185)	899	(1111)
SIZE	950	(1461)	1169	(1388)
KEY	410	(0.83)	284	(0.82)
MOUSE	427	(0.86)	302	(0.88)
COMMENT	371	(0.75)	264	(0.77)
GRAPHICS	311	(0.63)	225	(0.65)
AUDIO	335	(0.67)	243	(0.70)
NTWRK	234	(0.47)	181	(0.52)
MODEM	167	(0.34)	115	(0.33)
NSTOR	0.59	(0.59)	0.69	(0.49)

Notes: Means are given for those variables which are quantitative and number is given for those which are qualitative. Standard deviation is in parentheses for means and percent of total for number. SPEED is measured in megahertz. RAM and SIZE are measured in megabytes. VRAM is measured in kilobytes. ASK and BID are in U.S. dollars. The mean BID was calculated from a total of 723 bids submitted on the 345 computers. There were a total of 494 computers.

the probability that a computer receives any bid.

Because sold computers are not listed, the observations on the site change over time and it is not possible to observe the winning bid on any computer. (However, some of the bids may actually be winning bids since for some of the bids recorded the seller had not yet seen the bid).[13] The lack of the winning bid makes me unable to answer other interesting questions. Still, the results below are meaningful. An explanation for why the lack of any winning bids should not cause concern is necessary. I provide an explanation below, with the results, where the context will make the reasoning more clear.

This market and the associated data provide a natural experiment for testing the hypothesis that buyers believe price to be a signal of quality. Because the data were collected from an actual market there is no worry that buyers' offers reflect anything but their true optimizing bid. At the same time sellers' suggested prices should also be consistent with maximizing behavior. That is, the "subject's" behavior is not influenced by my own research interests. The test concerning buyers' beliefs is simple and is described in the next section.

[13]Visiting the web site will clarify how this is possible. Listed with each of the bids is a notice that the bid has been seen or not seen by the seller. Any not seen bid may then subsequently be accepted and hence be a winning bid.

2.4 Statistics and Results

Again, summary statistics for the bids, suggested price, and characteristics are presented in Table 2.1. Mean bid price is 572 dollars while for those computers receiving at least one bid the mean suggested price is 946 dollars (813 dollars for all computers), a notable disparity of over 370 dollars. Most computers have a keyboard and, likewise, most have a mouse. Concerning the dummy variables, most of the computers do posses the characteristic. This may create the problem of a high degree of multicollinearity with the intercept term. WEEKS has no interpretation since all computers listed for more than twenty weeks were recorded as being listed for twenty weeks.

Not all computers receive a bid. There is no reason to think that submitting a bid is simply a random event. We might expect that the probability of obtaining a bid is conditional on the characteristics of the computer. If "worse" computers yield potentially less surplus then demand for these computers may be lower than for computers which are "better". Then these "worse" computers are less likely to receive a bid. Table 2.2 presents results for a linear probability model along with the results of a probit estimation each has two specifications, one with fixed effects and one without.

The fixed effects model includes dummies for the computer model and only uses those observations for which there were at least two observations of the same model. The results are generally consistent with each other in terms of the sign

TABLE 2.2, Probability of Bid

	OLS	PROBIT	OLS	PROBIT
INTERCEPT	0.06	-2.00*	0.28*	-1.44*
	(0.14)	(0.697)	(0.08)	(0.3)
WEEKS	0.02*	0.108*	0.02*	0.08*
	(3.4E-3)	(0.019)	(2.8E-3)	(0.01)
ASK	-1.0E-4	-3.9E-4	-4.1E-5	-6.3E-5
	8.1E-5	(3.9E-4)	(3.7E-5)	(2.4E-4)
SPEED	8.3E-4	0.007	2.6E-3*	0.01*
	(7.4E-4)	(0.005)	(3.6E-4)	(2.3E-3)
RAM	4.3E-4	0.006	1.1E-3	0.01*
	(4.5E-4)	(0.006)	(7.1E-4)	(4.2E-3)
VRAM	3.3E-5*	4.3E-4*	1.0E-5	1.5E-4
	(1.2E-5)	(1.8E-4)	(1.4E-5)	(9.8E-5)
SIZE	3.4E-6	3.1E-4	4.3E-6	1.7E-4
	(6.7E-6)	(2.3E-4)	(7.8E-6)	(1.4E-4)
KEY	-0.16*	-0.66*	-0.13*	-0.42
	(0.064)	(0.298)	(0.06)	(0.22)
MOUSE	0.11	0.31	0.09	0.31
	(0.07)	(0.31)	(0.07)	(0.24)
COMMENT	-0.02	-0.25	-0.02	-0.05
	(0.045)	(0.24)	(0.04)	(0.16)
GRAPHICS	0.08	0.42	0.02	0.18
	(0.057)	(0.32)	(0.06)	(0.21)
AUDIO	-0.14*	-0.596	-0.06	-0.32
	(0.07)	(0.36)	(0.07)	(0.24)
NTWRK	0.04	0.069	0.05	0.12
	(0.05)	(0.28)	(0.05)	(0.17)
MODEM	-0.07	-0.37	-0.07	-0.34*
	(0.047)	(0.25)	(0.04)	(0.16)
NSTOR	0.07*	0.33	0.10*	0.22
	(0.033)	(0.23)	(0.04)	(0.15)
FIXED EFFECTS	YES	YES	NO	NO
N	430	430	494	494
R^2	0.52		0.247	
$\overline{R}^2$	0.403		0.225	
$\ln L$		-123		-215
LR$\sim \chi^2$		289*		173*

Notes: * denotes statistical significance at the 0.05 level or better. Standard errors in parentheses are Halbert White s.e. for the OLS regression. Standard errors in parentheses are derived from the hessian of lnL function evaluated at the maximum likelihood estimates for PROBIT estimators.

of the coefficient and significance. (Below, where no confusion should result I will use coefficient to mean the estimate for the coefficient and significant will mean statistically significantly different from zero).

Those probit estimators, which are significant at the .05 level, are the coefficients for: the intercept term, WEEKS, SPEED, RAM, and MODEM where no fixed effects were included. With fixed effects SPEED, RAM, and MODEM drop from significance while VRAM and KEY are now significant. This makes intuitive sense, as it indicates that the longer a computer has been posted, the more likely it is to receive a bid and the better a computer is (in terms of being faster and having more memory), the more probable a bid. Also MODEM has a negative coefficient, which may suggest a preference on the part of buyers for network hook-up as these can be viewed in some sense as substitutes. The negative coefficient on KEY is somewhat confusing though. The coefficient on ASK is negative, as we might expect in a reservation price explanation; however, it is not significant. This indicates that the signal is not a serious deterrent of bidding. To a degree this is consistent with a rejection of the implication that the ask price is a signal of the true reservation value of the seller. If increasing the level of one's reservation price has no influence on the probability of receiving a bid then sellers would set arbitrarily high ask prices in a model where the price is a signal of the true reservation price.

The probability of receiving one bid is not the whole story. Some computers

receive multiple bids. For computers that receive at least one bid we might anticipate that again better computers will be in higher demand and hence receive more bids. To test this I ran additional regressions. OLS estimators from the regression on the number of bids as well as Poisson estimators are presented in Table 2.3 as well. Again, there are two runs with each (with and without fixed effects).

Note that for the regressions on the number of bids, the coefficient estimated for ASK is positive, small, and significant when fixed effects are not included. This is contrary to what we might expect under the assumption that higher ask prices reflect higher reservation prices with no correlation to a common value component. If ASK is perceived to signal quality and higher quality computers are in greater demand then the result is consistent with the separating equilibrium story of quality signaling. To be more clear about the interpretation of the estimator consider that newer computers will have higher ask prices and we might think that there are more people looking to buy a new computer than there are trying to buy an old computer. Of course, when fixed effects are included the coefficients are negative but with standard errors which are considerably larger than the coefficients. Now again, in the Poisson regression the coefficient on WEEKS and SPEED enter positive and significant. The coefficient on VRAM now is also positive and significant in three of the four estimations and nearly significant in the fourth. The coefficient on MODEM is now also significant but

TABLE 2.3, Poisson Regressions.

	OLS	POISSON	OLS	POISSON
INTERCEPT	0.21	-0.78*	-0.24	-1.83*
	(0.24)	(0.16)	(0.27)	(0.73)
WEEKS	0.06*	0.05*	0.072	0.056*
	(0.01)	(0.01)	(0.011)	(0.009)
ASK	6.1E-4*	1.8E-4*	-2.3E-5	-9.5E-5
	(1.8E-4)	(7.1E-5)	2.9E-4	(1.7E-4)
SPEED	8.9E-3*	5.6E-3*	0.001	7.2E-4
	(1.7E-3)	(7.2E-4)	(2.9E-3)	(0.002)
RAM	9.7E-5	4.7E-4	7.2E-4	5.3E-4
	(2.9E-3)	(8.7E-4)	(2.3E-3)	(0.001)
VRAM	1.5E-4	7.2E-5*	2.2E-4*	1.1E-4*
	(9.1E-5)	(3.0E-5)	(8.3E-5)	(3.6E-5)
SIZE	-4.0E-5	-2.9E-5	-5.7E-5*	-4.1E-5
	(4.6E-5)	(2.9E-5)	(2.9E-5)	(3.4E-5)
KEY	-0.24	-0.19	-0.36*	-0.299
	(0.15)	(0.13)	(0.14)	(0.159)
MOUSE	0.26	0.19	0.23	0.15
	(0.17)	(0.15)	(0.15)	(0.17)
COMMENT	-0.19	-0.15	-0.17	-0.10
	(0.15)	(0.09)	(0.13)	(0.12)
GRAPHICS	0.22	0.11	0.19	0.158
	(0.14)	(0.13)	(0.14)	(0.157)
AUDIO	-0.11	-0.05	-0.16	-0.22
	(0.16)	(0.14)	(0.17)	(0.18)
NTWRK	-0.07	-0.01	-0.21	-0.076
	(0.12)	(0.09)	(0.13)	(0.13)
MODEM	-0.48*	-0.29*	-0.38	-0.27*
	(0.13)	(0.09)	(0.13)	(0.13)
NSTOR	-0.21	-0.05	-0.12	-0.039
	(0.14)	(0.07)	(0.11)	(0.088)
Fixed effects	NO	NO	YES	YES
R^2	0.352		0.57	
$\ln L$		-714		-508
LR$\sim \chi^2$		171*		328*

Notes: * denotes statistical significance at the 0.05 level or better. Standard errors in parentheses are Halbert White standard errors for the OLS results and for the POISSON results they are derived from the hessian of $\ln L$ function evaluated at the maximum likelihood estimates.

negative; again, perhaps, few people are interested in the MODEM option if it is viewed inferior to the NTWRK option. In sum, it appears that buyers are most interested in the speed aspect of the computer. Figure 2.1 shows the distribution of the number of bids placed on each computer.

Now, in testing the prediction that the bids are increasing in the signal ASK, we must first recognize that the characteristics should explain a great deal of the variation in ASK and in the bids. That is, these characteristics determine the common value component of the computer so ASK and the level of bids should be highly correlated. However, controlling for the characteristics it is not clear that ASK and the level of bids should be correlated. If they are not then this is an indication that ASK does not serve as a signal of quality, whereas if they are correlated then this suggests that buyers believe that ASK conveys some additional information not observed with the characteristics. This may include an unknown measure of how the seller has treated the computer.

First, then I estimate a hedonic equation of the characteristics based value of each computer. I estimated the following equation [14](results not shown):

$$ASK = X\beta + ERROR. \tag{2.1}$$

Where X contains the characteristics of the computer as well as an intercept term and ERROR is a standard Gauss error term. Let $\hat{\beta}$ be the OLS estimate of β.

[14]The functional form follows the setup of Lancaster (1966) and has the associated pitfalls but serves as a meaningful first approximation.

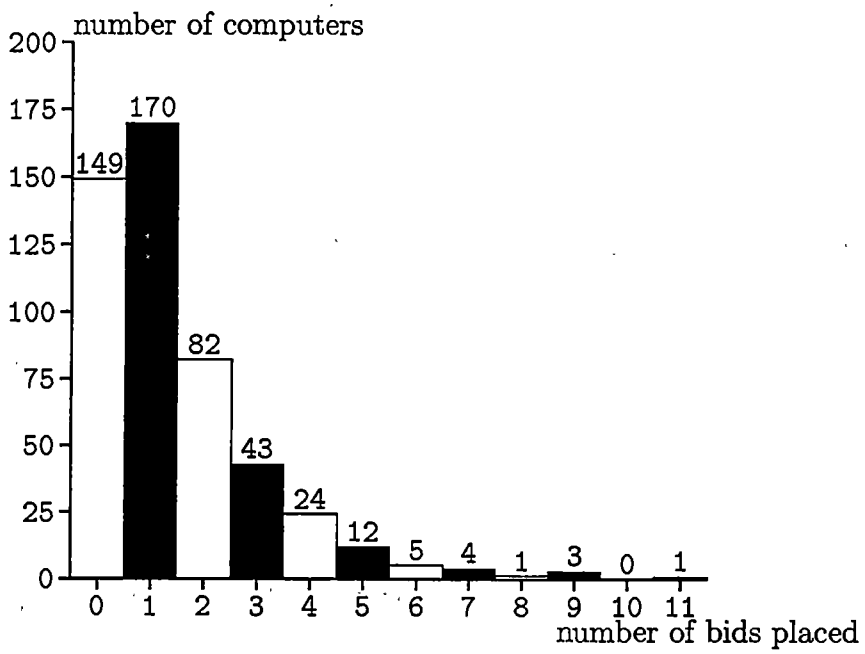

Figure 2.1, Distribution of Bids.

The equation was also estimated using the natural log of the continuous variable, the square of the continuous variables and a quadratic equation with the value of R^2 varying between 0.76 to 0.79. Thus the characteristics do explain a great deal of the variation in the ask price. From this I obtain the ERROR term to be used as an explanatory variable, ERROR=ASK-$X\hat{\beta}$. ERROR is that portion of the ask price which cannot be accounted for by the characteristics of the computer. When ASK-E(ASK;X)>0 this implies that ERROR>0 or in words we would say that when the seller asks a higher price than is expected given the attributes of the computer the error term is positive. Now Regressing the bids on ERROR gives an indication of how the bidding behavior is correlated with that portion of ASK which cannot be explained by the known common value components. If the bids are positively correlated with the level of ERROR then this indicates that higher than anticipated ask prices lead to higher bids as is predicted by the assertion that ASK is a signal of quality.

In regressing the bids on ERROR I also include the inverse Mill's ratio (IMR), which are obtained from the probit estimators in table 2.2. IMR is added to correct for the sample selection bias resulting from not using those observations where no bid was made. (Please refer to Greene, 1997 for a discussion of sample selection bias). The inverse Mill's ratio is needed to obtain the two stage Heckman estimators, which I report in Table 2.4 (an economic interpretation of the coefficient on ASK is given below).

TABLE 2.4, Regression on Bids.

	HECKMAN 2S	HECKMAN 2S	HECKMAN 2S	HECKMAN 2S
INTERCEPT	763*	662*	613*	502*
	(36)	(54)	(26)	(45)
ERROR	0.349*	0.345*	0.33*	0.33*
	(0.054)	(0.053)	(0.081)	(0.079)
COMMENT		123*		142*
		(52)		(49)
IMR	-645*	-627*	-394*	-382*
	(58)	(57)	(49)	(48)
Fixed effects	NO	NO	YES	YES
N	345	345	295	295
R^2	0.438	0.454	0.208	0.234

Notes: * denotes statistical significance at the .05 level or better. The standard errors are in parentheses and their derivation can be found in Greene (1997) p. 980-981. Fixed effects were used in the derivation of ERROR and IMR for the indicated columns.

In addition to ASK there is yet one other potential signal of quality which is chosen by the seller. This is COMMENT. Comments made by the seller were exclusively of a positive nature; i.e., I never saw any comment indicating that the computer was in bad condition or had a virus. Knowing this I anticipate that the coefficient on COMMENT will be positive. Also note that for these regressions the error term is known to be heteroskedastic and the appropriate variance-covariance matrix can be found in Greene (1997).

Finally, Table 2.4 contains the regressions on the high bid for each computer receiving at least one bid. (I use the high bid since it most closely approximates the possible transaction price.) Consistent with the theory I find that ERROR has a positive coefficient which is highly significant. Likewise, the coefficient on COMMENT is positive and significant. To interpret the coefficients recall that ERROR represents a dollar of ASK which is unexplained by the hedonic equation. So for every dollar in the ask price beyond what would be anticipated (given the characteristics of the computer) the high bid increases by about thirty-three cents. If a comment is made this raises the high bid by one hundred and forty-two dollars (on average). This, though, is not clear in meaning since the comments range from statements such as the computer is "almost new", "hardly used", or "a great computer" to more concrete statements that the computer comes with some specified software or even a monitor.

Still, one might wonder if ASK is simply picking up the effects of some other

omitted variables. If ASK is (highly) correlated with some omitted variable(s) which increase the value of the computer then what is the interpretation if any? First it appears that there are two types of omitted variables. One type is that which may be known to "informed" buyers. An example may be the actual weight and dimensions of the CPU; a buyer who is knowledgeable about computers may be able to determine this from the computer model. In essence the fixed effects model assumes that all buyers are informed. A second type of variable may be the private information of the seller. This includes such ware and tear variables as number of hours of use and number of hours exposed to extreme temperatures. Then as long as some omitted variable is the private information of the seller and/or not all of the buyers are "informed" we can easily interpret ERROR (or ASK) as a proxy for such omitted variables as reflect on the quality of the computer. [15]This use of ASK as a proxy is consistent with the interpretation of ASK as a signal of quality.

As a final note, above I mentioned that I do not have any winning bids. I was only able to record information on computers that had not yet been sold. Not having the wining bids does not cause a problem. Only if actual (realized) winning bids tend to be lower for higher ask prices will the results be reversed or negated. This would have the effect of flattening the regression line. Since it does

[15]Here informed and uninformed buyers play a similar role to that mentioned in Chan and Leland or Cooper and Ross. However, the private information of the seller provides a distinction. Also, note that both types of consumers are not necessary for the result.

not appear to be a likely scenario that actual winning bids should be lower for higher asking prices, I doubt there is reason to question the result on the ground that no winning bids were observed. If anything, the use of winning bids should strengthen the result or increase the magnitude of the coefficient on ASK.

Other possible explanations

I should note that there are other explanations for the observed relationships in the data. One which seems important is the distribution of the error terms in the estimation of ASK. Using the Breusch-Pagan/Godfrey test, with all right hand side variables, the assumption of homoskedasticity is rejected. Then, if the heteroskedastic nature of the error terms is due to wrong functional form some explanatory variable may actually be correlated with the error in a way such that the regressions of BID on ERROR is picking up this relationship.

Still, because the existence of heteroskedasticity only indicates that the *variance* of the error term is correlated with the data, and not the value of the error term we can see that this does not create an inconsistency with the explanation of prices as signals of quality. Heteroskedasticity implies that some observations will have higher probabilities of large errors, but it does not state that these errors will be positive or negative. In this case observations with greater variance in the error term can be viewed as observations for which the seller has relatively more private information. This level of private information may be correlated

with any of the explanatory variables without being inconsistent the theory of this paper.

2.5 Conclusion

When the cost of bidding is low, signals about the seller's reservation price have negligible effects on the probability of buyers placing a bid. An explanation for the correlation between the signal of suggested price and the bids is that the suggested price is some indication of quality or at least that buyers believe the suggested price to signal product quality. It is not uncommon to hear an individual express the idea that if something costs more it must be better.

In short I find that even in the face of a costly return policy prices can serve as signals of product quality and I provide empirical evidence that buyers believe that this is true.

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PART 3: ADVERSE EFFECTS OF COST REDUCTIONS AMONG FIRMS WITH ASYMMETRIC TECHNOLOGIES

3.1 Introduction

Economists interested in industrial organization are generally concerned not only with anti-competitive behavior but also with how firms' "competitive" behavior will influence price. Consider that firms compete in the research and development race to develop some new technology. At the same time firms may seek to license an already existing technology. In this paper I examine the anti-competitive effects of the ability of a dominant firm to license its superior technology. I also consider cases where technological shocks are not due to licensing. Still, licensing is (in my opinion) the most interesting case.

Recently, Yi (1999) has shown that a dominant firm can use its ability to license its superior technology to strategically deter entry into a market. He considers the case that there is one monopolist, dominant firm, and two potential entrants. The two potential entrants undertake costly research and development projects for the purpose of entering the market. When one of the two entrants successfully develops a technology and enters the market, the monopolist will license a technology to the other entrant. This action lowers the return to R& D for entrant developing its own technology and hence lowers the incentive to invest in R& D. Entry is deterred.

In this paper I consider (among other things) licensing as a strategy to induce exit. Similar to Yi I consider the case in which there is a dominant firm with a superior technology. There are at least two other firms which also differ in their

technologies, a middle and high cost firm respectively. Licensing the superior technology to the middle cost firm will result in an increase in output from the middle cost firm. When quantities are strategic substitutes the dominant firm and high cost firms will then reduce their output. However, this reduction in output is more "hurtful" to the high cost firm. In some cases the high cost firm will exit.

Importantly, the reduction in the number of firms can lead to an increase in price. More generally I show that this increase in price can result from other causes of technological changes in industries where firms assimilate the new technology in an asymmetric fashion. In addition to licensing I consider the cases of patent expiration or government buyout and input subsidies granted to an industry.

Two comments are in order before I move to the results of the paper. The first concerns the possibility of firms differing in their technologies over time, and the second concerns the differences of this work and that of Williamson (1968).

Many industries consist of firms with distinct technologies producing homogenous goods. Examples include titanium dioxide, sugar, which is produced from cane or beet, and coal. Even with similar observable technologies, firms may still differ in their cost structure due to management techniques or other factors such as learning-by-doing. The idea that firms do differ in their technologies is generally associated with Demsetz (1973). However, the Demsetz argument does

not address cost asymmetries over time.

Still, it is possible that firms vary in a noticeable way over time. Consider the example of titanium dioxide. In the first half of the century titanium dioxide was produced using a process involving the reaction of sulfuric acid and low-grade titanium feedstocks (ilmenite ore). In the 1940's DuPont developed a "chloride" process which it began to implement successfully in 1951. In the 1960's other firms also began operation of plants using a chloride process. At the time DuPont's advantage over the other firms was years of learning-by-doing. This advantage may have eroded over time. However, DuPont's plant used ilmenite ore as the primary input for their chloride process while the other firms in the industry used rutile ore in their process; around 1970 the price of rutile rose unexpectedly giving DuPont a marked advantage. (See Dobson, Shepard, and Stoner 1994). While the incidents in the titanium dioxide industry are not of special concern, it does provide an example of how costs may differ, even over time.

This paper is analogous to the work of Williamson (1968) and hence a few words are in order concerning their similarities and differences. Williamson's paper shows that gains in efficiency can have ambiguous effects on price when market power is simultaneously influenced. This is the thrust of the current paper as well. However, I wish to show that in some cases where policy pushes for efficiency gains that these may actually have the result of increasing price. Williamson's paper treats the case of horizontal merger. This paper examines

the case of technological shocks.

When firms engage in Cournot competition it is known that if the firms are symmetric then any two firms which merge, when there are strictly more than two firms, will experience a decline in profit after the merger unless there are efficiency gains (see Farrell and Shapiro, 1990). In Williamson's case the efficiency gains are an essential part of the ambiguity. Here I make explicit the efficiency gains. Our result of price increase is due to exit from the industry by small firms. Important policy questions arise which are not a part of the Williamson analysis. In his paper the concern is on merger approval as made by the Federal Trade Commission. In the settings I examine there is no place for the preemption of a merger. The policy questions concern licensing of technologies, patent life and protection, and industry wide factor input subsidies.

This paper proceeds as follows, I present some examples in section 3.2. In section 3.3 I provide general results with some conditions on costs and demand. I conclude in section 3.4 and discuss some implications of the work.

3.2 Examples

3.2.1 Licensing

I provide some illustrative examples for a more clear motivation of the subject. In each of the examples I will consider that the firms produce a homogenous good.

At the same time I will assume that the firms have distinct production processes and/or access to inputs. I assume that the first firm to enter the industry benefits from a superior technology to that of any future entrant, this may be consistent with learning-by-doing. Each successive firm to enter the industry has an inferior technology, or higher cost of production. This occurs for each entrant so that costs for Firm 2 are lower than costs for Firm 3 (where Firm 2 is the second entrant and Firm 3 is the third entrant and so on).

Entry into the industry and maintenance therein requires the payment of a sunk cost (fixed cost with scrap value of zero) in each period. Let Ψ represent the sunk cost. For simplicity, this sunk cost is the same in all periods and is identical for all firms. In other words, every firm in the industry must reenter/enter in each period. A firm 'exits' the industry if it does not reenter so that Ψ is only a quasi-sunk cost; firms that produce zero do not pay Ψ. All firms have the same firm specific technology in all periods; Firm 1 is Firm 1 in all periods, Firm 2 is Firm 2 in all periods, and so on. Additional firms enter the industry until the next entrant cannot cover sunk costs.

Let the inverse demand function for the product be:

$$p(Q) = 10 - Q.$$

Here, Q is the industry output; q_i is the output of Firm i, and $Q = \sum_i q_i$. Entry (maintenance) into the industry requires the payment of a sunk cost in each

period of one i.e. $\Psi = 1$. The marginal cost of production for Firm i is $\phi_i(q_i)$, and the firm's total cost of production is $\Phi_i(q_i)$. All firms seek to maximize own firm profit. Let each firm produce the Cournot level of output q_i^*. (No firm produces negative output so that $q_i^* \geq 0$ for all i). Firm i will enter the market if and only if:

$$\pi_i = (10 - \sum_{i=1}^{n} q_i^*)q_i^* - \Phi_i(q_i^*) - 1 \geq 0.$$

Let the above cost functions be linear and the marginal cost equal i; that is, total cost is just i times output, $\Phi_i(q_i) = iq_i$ and $\phi_i(q_i) = i$. In this case there will be only three firms that enter the industry if the firms engage in the type of competition described by Cournot (1963). This is an equilibrium outcome. (Other forms of competition will be discussed below). The third firm earns zero economic profits. The resulting price is four. Industry output is six. Table 3.1 shows the respective firm outputs and profits. These numbers, and those below, are worked out in the appendix using the formulae derived in the following sections of the paper.

Now consider that the dominant firm considers altering the profit function of its rival via a change in ϕ_{-i}. This takes place when the dominant firm shares (or sells) some aspect of its technology with one of the inferior firms, so as to lower the rival firm's costs. Now consider that Firm 1 shares (sells at zero price) some of its technology to Firm 2. Suppose that this sharing of technology results in a

Table 3.1, Costs and Price With No Licensing.

Price=4			
Firm	ϕ	q	π
1	1	3	8
2	2	2	3
3	3	1	0

new marginal cost for Firm 2 of 1.9. Assuming lumpiness in the technology so that reduction must be at least 0.1, this is the profit maximizing level of technology for Firm 1 to share.

Now Firm 3 can no longer remain in the industry without sustaining losses. Hence Firm 3 will not reenter by paying the periodic sunk cost. The three firm oligopoly reduces to a duopoly. As might be expected, the increase in concentration is accompanied by an increase in price. (It should not be obvious that price will increase since there has also been a reduction in cost). Price is now 4.083, while industry output is now reduced to 5.91. Table 3.2 shows the firm specific results. Consumers' surplus changes from 18 to 17.46 while industry profit changes from 11 to 15.54. This represents an increase in the sum of profit and consumers' surplus, but it is not an improvement in each independently.

In this example an improvement in technology which makes the good less costly to provide actually results in an outcome which is less efficient (there is an increase in the amount of deadweight loss). The quantity produced moves further away from the competitive equilibrium quantity produced while the price increases. The price-cost margin increases as well. Also, note that profits for both Firm 1 and Firm 2 increase; Firm 2 benefits from Firm 1's "benevolence".

Now, consider the possibility that many firms benefit from the divulgence of the superior technology. Perhaps it is unlikely that a dominant firm gives away some cost reducing technology. The example above though is still consistent with

Table 3.2, Costs and Price With Licensing.

Price=4.3			
Firm	ϕ	q	π
1	1	3.3	9.89
2	1.9	2.4	4.76
3	3	0	0

itself. Firm 2 will not share the technology with Firm 3, so for only one firm to receive a cost reduction is not implausible. Firm 2 will actually be willing to purchase the technology at a positive price. However, Firm 1 is also willing to bear some cost to give the technology to Firm 2.

3.2.2 Patent Erosion

Suppose as above that firms in an industry produce a homogenous good (no product differentiation). Entry and exit in the industry is as above with sunk costs being required in each period. Production costs will follow the notation used above. Again marginal cost is constant for every firm. Still, the dominant firm enjoys the lowest cost and so on as above. The marginal cost for all relevant firms are given in Table 3.3.

The inverse demand function is:

$$p(Q) = 20 - Q.$$

Again Q is industry output. Each firm seeks to maximize profits, and will enter the industry only if:

$$\pi_i = (20 - \sum_{j=1}^{n} q_i^*)q_i^* - \phi_i q_i^* - \Psi \geq 0.$$

Again assume that the firms produce their Cournot level of output. Let the sunk cost be 4/25. In this setting four firms will enter the industry. Table 3.3 shows

Table 3.3, Costs and Price With Patent.

Price=6.4			
Firm	ϕ	q	π
1	0	6.4	40.8
2	2	4.4	19.2
3	4	2.4	5.6
4	6	0.4	0
5	8	0	0

their respective outputs and profits. Industry output will be 13.6. Price will be 6.4.

Now suppose that the dominant firm (Firm 1) obtained its low cost through a superior technology, which is patented. Recent work concerning patents include Lanjouw (1998) and Kremer (1998). Their work particularly that of Kremer follows the more usual case that, universal access to the patented information improves social welfare. Lanjouw focuses on the fact that the private possession of the superior technology has value to the firm through higher profits. Our result is that the opposite can be true; Firms may earn higher profits without the patent and that social welfare can be reduced through the removal of a patent. [16]

Another paper by Spence (1984) treats the evolution of costs through innovation (this is similar to the work of Sutton 1998). His work however suggests cost reduction occurs through product differentiation, and that this can have positive spillover effects. Again our presentation here shows an opposite case (I say opposite but more technically the results apply to two distinct cases since here the product is homogeneous throughout time).

Under the protection of the patent, the technology may be known but other firms are unable to implement it. The remaining firms differ in either their ability to implement a technology or in the technologies they possess, or both. This difference in implementation ability and/or technologies gives firms 2-4 distinct

[16]The literature on patents is extensive. Please refer to either Lanjouw (1998) or Kremer (1998) for references and more discussion.

cost functions.

Suppose now that the patent expires so that all firms have access to the superior technology. Clearly, Firm 1 experiences no change in cost function. The remaining firms all have lower costs. However, they have different abilities in implementing the new technology. The new costs reflect the same order as before; that is Firm 2 is still better able to implement a technology (and therefore faces lower cost) than Firm 3, etc. Costs for the new quantity game are given in Table 3.4.

Lapse of the patent leads to an equilibrium, (again Cournot) with only three firms in the industry. Firm 4 is no longer able to produce positive output and cover costs. The new price is 6.4375. Quantity produced is now 13.5625. Again the rise in concentration results in an increase in price. The availability of the technology leads to an inferior resource allocation. Consumers' surplus moves from 92.5 to 91.97 while profit increases from 65.6 to 68.5. This represents an increase in total social welfare but again this increase is not desirable on the part of consumers. Finally consider a case in which all firms (including the dominant firm) experience lower costs.

3.2.3 External shock

Suppose that all firms in the industry are confronted with an external shock (for example the price of some input goes down). (For a brief discussion of models of

Table 3.4, Costs and Price Without Patent.

Price=6.4375			
Firm	ϕ	q	π
1	0	6.4375	41.28
2	1.85	4.5875	20.89
3	3.9	2.5375	6.28
4	5.95	0	0

external shocks see a recent article by Lambson and Jensen (1998) or the references therein). For example, a common input price decreases. If firms use this input differently then costs will decline at different rates for the various firms. To save words this example mimics the first example above with its corresponding inverse demand function $p(Q) = 10 - Q$, and all the initial conditions for Table 3.1. Consider the new costs in Table 3.5.

Note that all firms have lower costs. Exit occurs and price increases while the industry output declines. Once again we observe that a reduction in cost can lead to lower levels of output and a movement away from the efficient outcome. Consumers' surplus declines, moving from 18 to 17.88 and profit rises from 11 to 17.09.

We might question the assumption of Cournot competition in the above settings. Examples one and three are identical with regards to the initial firm level marginal costs. In both of these cases it would be more profitable for the dominant firm to engage in limit pricing. However, if we assume a capacity constraint such that marginal cost is constant up to some level after which it is infinite then Cournot competition is preferable to limit pricing. In the second example, patent erosion Cournot competition yields higher profits to the dominant firm than would limit pricing. In that case a price of slightly less than 2.15 would make the second firm unable to cover the fixed cost (assuming that the market is split evenly after the price setter announces the price). Then profit would be

Table 3.5, Costs and Price
With Global Shock.

Price=4.016			
Firm	ϕ	q	π
1	.25	3.767	13.183
2	1.8	2.217	3.914
3	2.9	0	0

about $2.15 \times 17.85 - 1 = 39.27 - 1 = 38.27$ but this is less than 40.8 which obtains from Cournot competition.

Similarly Stackleberg will change the specific profit levels which obtain in the examples but does not change the result of the paper. The output of each firm can still be expressed as a function of the marginal costs and is increasing in the marginal costs of the rival firms and decreasing in the own firm marginal cost. Then in Stackleberg competition we may have a firm with zero or small profit which will exit when a change in costs occurs.

At a more general level the high cost firm reduces its output to zero because quantities are strategic substitutes. Hence, models in which this is not the case may not obtain the same result.

Each of the examples serves to show that improvements in technology (reduction in costs) may serve to increase industry price. In any (all) of the three settings above this change in costs can have the socially undesirable effect of reducing industry output. The one common occurrence in the examples is that the firm (which formerly produced positive quantities) with the highest costs is driven out of the industry.

3.3 Results

The above examples serve to show that when costs are reduced in an industry price may actually rise when there is no fluctuation in demand. The influence

of concentration on price has a greater magnitude than the influence of cost reduction. The above examples leave us with little information about when concentration has a dominant influence on price. More general conditions are helpful to understand what is taking place in the above examples.

Consider an industry producing a homogenous good. The industry is characterized by firms which differ in their cost functions (they have distinct technologies). I make the analysis simple by assuming marginal cost to be everywhere constant. Firms enter the industry in each period by paying a non-recoverable fee with zero re-sale value (sunk cost). In other words maintenance in the industry requires periodic payment of a sunk cost.[17]Firms will enter the industry until entry by the next firm will result in negative profits. Firms engage in Cournot competition so that the last entrant into the industry is the last firm that satisfies:

$$\pi_i = p(Q)q_i^* - \phi_i q_i^* - \Psi \geq 0. \tag{3.1}$$

Where again q_i^* is the ith firm's Cournot equilibrium level of output. Trivially, $q_i^* > 0$ for all entrants as production of zero is equivalent to, not entering; the last entrant produces a positive quantity.

Now suppose demand is linear so that $p(Q) = K - Q$, and the marginal cost of producing is constant everywhere for all firms with ϕ_i being the marginal cost of firm i. Then let there be n firms in the industry; that is firm $n+1$ cannot

[17]The sunk cost may be zero although in the examples it was not. The use of a sunk cost (or fixed cost) permits that a firm making positive output may still make zero economic profit.

cover the sunk cost associated with maintenance in the industry. For the n firm industry the Cournot output of firm i is:

$$q_{in}^{*} = \frac{K + \sum_{j \neq i} \phi_j - n\phi_i}{n+1}. \tag{3.2}$$

Equation (3.2) can be derived fairly easily by: differentiating the objective function of Firm i with respect to its own output; then solving for $\sum_{j \neq i} q_j$; substituting this back into the equation for q_i; and solving for q_i. Tirole (1988, p.220) shows a similar result for the case of linear demand, constant marginal cost where all firms have equal cost. Allowing the firms to differ in costs does not introduce major complications in finding an exact formula for each firm's production level. Again Novshek (1984, 1985) provides a more general result showing the existence of an equilibrium without providing specific formulae for the output decision of all firms; (3.2) will be more useful for what takes place below. With the same n firm scenario it follows immediately that the Cournot equilibrium price will be:

$$p^{*} = \frac{K + \sum_{i}^{n} \phi_i}{n+1}. \tag{3.3}$$

Knowing this it is easy to state conditions under which a decrease in cost will result in an increase in price. If marginal cost(s) declines, the only way for price to increase (assuming no change in demand and continued Cournot competition, i.e. ignoring collusion) is through a decline in the number of firms in the industry. We then must consider when a firm will exit. First we notice a result on the

markup over marginal cost of each firm.

Result 1 *The markup over marginal cost for each firm is equal to the firm's output (unit free), i.e.* $p^* - \phi_i = q_i^*$.

Proof: Multiply ϕ_i by $(n+1)/(n+1)$, and subtract this from p. The result is q_i^*. End of proof.

Using this result it is possible to state the following with regards to the last firm's decision to remain in the industry under any new cost structure.

Result 2 *The nth firm will exit (not reenter) the industry if some change in technologies results in firm i having marginal cost* ϕ_i' *and* q_i' *is the new Cournot level of output (with the new cost structure) and* $(q_n') < \sqrt{\Psi}$.

Proof: From result 1 note that the square of output is profit with the exclusion of any fixed or sunk cost. Then if the result is not true this implies $\pi = (q_n')^2 - \Psi \geq 0$. End of proof.

From result 2 we know that under certain conditions firms may exit even though costs have decreased. Still, result 2 does not give the specific conditions on the changes in the cost structure, which will lead to firm reduction in output. I show below that a firm's output will be reduced if its cost reduction is less than the industry average reduction in marginal cost holding the own firm reduction at zero. Clearly then some firm must be below the average (unless all

cost reductions are the same) and so some firm will reduce its output. However, I will be concerned with the last entrant; I am interested in the "marginal" firm. Formally I introduce the following proposition.

Result 3 *Let $\phi_i' = \phi_i + \Delta\phi_i$ with $\Delta\phi_i \leq 0$. Outputs are q_i and q_i', when marginal costs are ϕ_i and ϕ_i' respectively. Here $q_i' < q_i$ if and only if $\Delta\phi_i > \sum_{j\neq i}\Delta\phi_j/n$. (Assuming no entry or exit)*

Proof:

$$q_{in}^* = \frac{K + \sum_{j\neq i}\phi_j - n\phi_i}{n+1}$$
$$> \frac{K + \sum_{j\neq i}(\phi_j + \Delta\phi_j) - n\phi_i - n\Delta\phi_i}{n+1} = q_{in}'.$$

Which implies,

$$\frac{\sum_{j\neq i}\Delta\phi_j - n\Delta\phi_i}{n+1} < 0.$$

Which implies,

$$\frac{\sum_{j\neq i}\Delta\phi_j}{n} < \Delta\phi_i.$$

End of proof.

We can think of this result as stating that output increases only for firms whose cost decline by more than the industry average. Now as a first instance we need only examine the cases which apply to result 3. In other words we are not interested in those cases which result in the last entrant increasing its output. This will, generally yield the more anticipated result, that industry

output increases. This would imply that the last entrant was able to reduce its cost by more than the average; or it was a leader in the implementation of the newly available technology. Then if output declines for a given firm we need only know the change in the cost structure and the previous level of profit. The magnitude of the decline in output though is at issue. It is of interest to know when q_i' (the new level of output) becomes zero. We restate result 2 then in terms of cost only.

Result 4 *Firm i will exit iff:*

$$\left| \frac{2\sum_{j\neq i}\Delta\phi_j - 2\Delta n\phi_i}{n+1} + \left(\frac{\sum_{j\neq i}\Delta\phi_j - \Delta n\phi_i}{n+1}\right)^2 \right| > \pi_i$$

and

$$\frac{2\sum_{j\neq i}\Delta\phi_j - 2\Delta n\phi_i}{n+1} + \left(\frac{\sum_{j\neq i}\Delta\phi_j - \Delta n\phi_i}{n+1}\right)^2 < 0.$$

Proof: The term above is just change in production related net revenues. If this decreases by more than the previous level of profit the firm will not be able to cover the sunk cost. End of proof.

The concern is with when the decrease in costs results in an inferior outcome (inferior allocation of resources). The mere fact that one or more firms exit the industry does not imply that price will necessarily increase with industry output decreasing. The decrease in the number of firms must have a sufficient influence to outweigh the improvements in technology. Figure 3.1 applies to the licensing

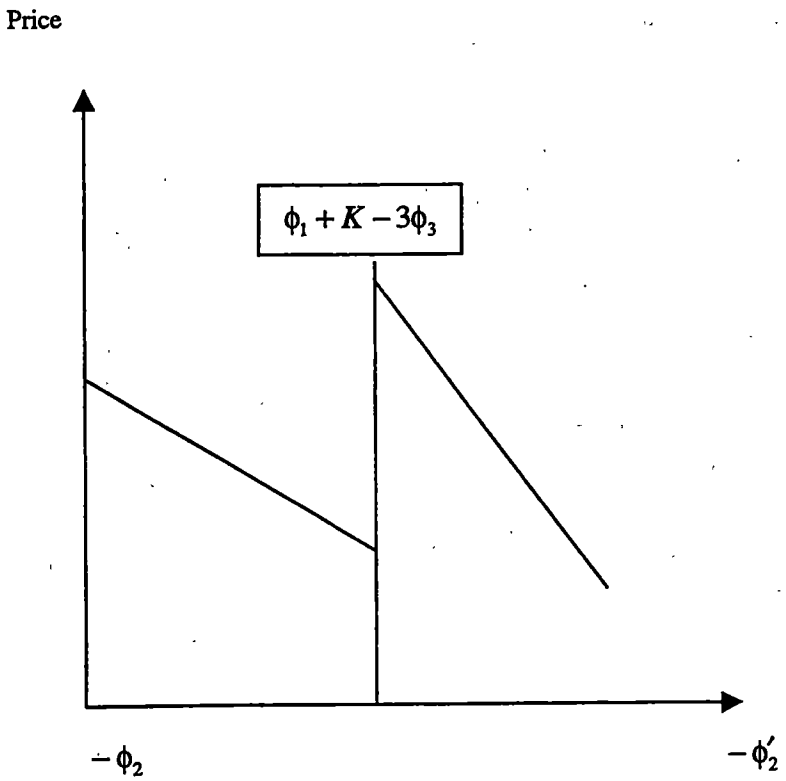

Figure 3.1

case when there are three firms in the industry and shows that for some range price will decline. The general result is below.

Result 5 *If k firms exit the industry and p_n^* is the equilibrium price before the change in costs, then price will increase if:*

$$kp_n^* > \sum_{i=1}^{n} \phi_i - \sum_{i=1}^{n-k} \phi_i'.$$

Proof: Start with (3.3). Establish the inequality

$$\sum_{i=1}^{n-k} \phi_i' > \frac{-kK + (n-k+1)\sum_{i=1}^{n} \phi_i}{n+1}.$$

Simplify this to see

$$\sum_{i=1}^{n-k} \phi_i' > \sum_{i=1}^{n} \phi_i - k\frac{K + \sum_{i=1}^{n} \phi_i}{n+1} = \sum_{i=1}^{n} \phi_i - kp_n^*.$$

Now rearrange the inequality to see the result. End of proof.

More simply the result states that price will increase if the reduction in costs is less than a weighting of the number of firms exiting, where each exiting firm is weighted by the old price.

In sum, improvements in technology then are not always beneficial (to the consumers or even all firms). The expiration of a patent does not always result in the enhancing of competition (depending on ones interpretation of the word competition). Patent expiration though and external shocks to the industry are of course exogenous to the industry. No firm can control either of these influences. Sharing technology, however, is an internal decision and may in fact lessen competition and increase dominant firm profits.

3.3.1 Return to the Licensing Example

Consider again the licensing case in which the dominant firm chooses the profit function of its rivals. The dominant firm can share its superior technology (completely or incompletely) with any or all of the inferior firms. Sharing technology results in "higher" profit functions for the firms receiving reductions in cost. Hence, in the initial stage of the game the dominant firm chooses what level of technology to share. We may wonder when is it advantageous to share technology with an inferior firm.

First we note that it cannot be advantageous to share any technology (at zero price) unless the resulting market structure will support fewer firms. This is easy to see when looking at (3.1)-(3.3). The dominant firm will share some portion of its technology only if its profits will increase. Then let ϕ_i be the marginal cost for firm and let these be constant for all i. Firm 1 can give Firm 2 some new technology resulting in a new marginal cost of production for Firm 2 of ϕ_2' with $\phi_1 \leq \phi_2' \leq \phi_2$. If there are n firms in the industry with no technology sharing then Firm 1 will share ϕ_2' with Firm 2 that satisfies:

$$0 \leq \left(\frac{K + \sum_{i=1}^{n-1} \phi_i' - n\phi_n}{n+1} \right)^2 < \Psi.$$

For $\Psi > 0$ and the term in brackets equaling zero when $\Psi = 0$ (again Ψ is the sunk cost).

The term in brackets is bounded below by zero as Firm 1 will not share more

technology than is needful to cause the last firm to exit. Then we need not worry about negative output by the last firm. Note that it may not be possible to squeeze out the last firm. The same conditions from above (see result 4) will need to hold for the firm to exit. Then it is clear that Firm 1 will share ϕ_2' with Firm 2 if the conditions for result 5 are satisfied.

3.4 Conclusion

With this note I make it clear that the results of technology improvements are not always output increasing. Each situation of reduction in cost must be analyzed as a specific case. The result is shown for patent expiration, external shocks, and technology sharing. The primary assumption in all cases is that firms differ in their technologies and in the case of patent expiration in their ability to implement a technology. All that I have said above occurs for those cases where increases in concentration have a prevailing influence. [18]

Asymmetries in costs among firms play an important role in markets. They act as a barrier to entry as well as their dynamic nature can act as an impetus for exit. Either way they act to increase market concentration.

In the case of technology sharing we may be hesitant about referring to this as collusive behavior. Nevertheless, the result is a movement toward a less com-

[18]Lambson (1987) has already shown that in industries with some fixed cost and same technologies that concentration leads to higher profits even without collusion, here though I consider changes in concentration and asymmetric technologies which, lead to higher profits, again without collusion.

petitive environment. Firms make greater profits without actually colluding. Increases in concentration may have effects, which outweigh cost reductions. Resources may be allocated in an inferior manner.

APPENDIX

Here we provide the calculations for the numbers presented in the tables. First recall equation 3.2 :

$$q^*_{in} = \frac{K + \sum_{j \neq i} \phi_j - n\phi_i}{n+1}.$$

Then output for firm 1 is

$$d = \frac{10 + 5 - 3}{4} = \frac{12}{4} = 3.$$

And result 1 tells us that profit is just the square of output minus the sunk cost. So we have $3 \times 3 - 1 = 8$.

For firm 2 the output will be

$$q = \frac{10 + 4 - 6}{4} = \frac{8}{4} = 2.$$

Then profit is just 4-1=3. While for firm 3 we see that output will be

$$q = \frac{10 + 3 - 9}{4} = 1.$$

So that profit is just 1-1=0.

Now looking at table 3.2 we first consider whether or not firm 3 will remain in the market. Calculating firm 3's output we have

$$q = \frac{10 + 2.9 - 9}{4} = \frac{3.9}{4}.$$

We can see then that the firm produces less than one unit and hence has revenue above variable costs less than one. The firm will not be able to cover the sunk

cost and hence will not enter. With two firms in the market we can now calculate the output and profit for the remaining firms. Firm 1 has output

$$q = \frac{10 + 1.9 - 2}{3} = \frac{9.9}{3} = 3.3.$$

This gives profit of 10.89-1=9.89. Now for firm two

$$q = \frac{10 + 1 - 3.8}{3} = \frac{7.2}{3} = 2.4.$$

Then profit is 5.76-1=4.76. For tables 3.3 through 3.5 some rounding occurs but the calculations are made in the same fashion.

Some of the proofs are provided with greater detail and explanation. Consider result 1. This result simply implies that larger firms will have a greater markup over marginal cost and hence price-cost margin. This is easy to understand since price is uniform in a homogenous good industry and those firms with lower costs produce more output. To obtain the proof simply multiply ϕ_i by $(n+1)/(n+1)$. Recall that

$$p^* = \frac{K + \sum_i^n \phi_i}{n+1}.$$

Now subtracting ϕ we will have

$$\begin{aligned} p^* - \phi_i &= \frac{K + \sum_i^n \phi_i}{n+1} - \frac{n\phi_i + \phi_i}{n+1} \\ &= \frac{K + \sum_{j \neq i}^n \phi_j + \phi_i}{n+1} - \frac{n\phi_i + \phi_i}{n+1} \\ &= \frac{K + \sum_{j \neq i}^n \phi_j - n\phi_i}{n+1} \\ &= q_i^*. \end{aligned}$$

This is precisely result 1.

We also wish to establish more clearly the derivation of (3.2). Begin with the profit function for the firm

$$\pi_i = (K - \sum_{j=1}^{n} q_j)q_i - \phi_i q_i$$

Differentiating we obtain

$$\frac{d\pi_i}{dq_i} = K - \sum_{j \neq i} q_j - 2q_i - \phi_i = 0$$

this holds $\forall i$. Now we can see that

$$q_i = \frac{K - \sum_{j \neq i} q_j - \phi_i}{2}.$$

But this measure includes the output of the other firms. Then we must solve for their combined output

$$\begin{aligned}\sum_{j \neq i} q_j &= \sum_{j \neq i} \frac{(K - \sum_{i \neq j} q_i - \phi_j)}{2} \\ &= \frac{(n-1)K}{2} - \frac{\sum_{j \neq i} \phi_j}{2} - \frac{(n-1)q_i}{2} - \frac{n-2}{2} \sum_{j \neq i} q_j.\end{aligned}$$

Then we see that

$$\frac{n \sum_{j \neq i} q_j}{2} = \frac{(n-1)K}{2} - \frac{\sum_{j \neq i} \phi_j}{2} - \frac{(n-1)q_i}{2}.$$

So that we have

$$\sum_{j \neq i} q_j = \frac{(n-1)K}{n} - \frac{\sum_{j \neq i} \phi_j}{n} - \frac{(n-1)q_i}{n}.$$

Plugging this into q_i we get

$$q_i = \frac{K}{2} - \frac{nK - K}{2n} + \frac{\sum_{j \neq i} \phi_j}{2n} + \frac{nq_i - q_i}{2n} - \frac{\phi_i}{2}.$$

From this we obtain

$$\frac{(n+1)q_i}{n} = \frac{nK - nK + K}{n} + \frac{\sum_{j \neq i} \phi_j}{n} - \frac{n\phi_i}{n}.$$

From here it is clear that

$$q_i = \frac{K + \sum_{j \neq i} \phi_j - n\phi_i}{n+1}.$$

Now we wish also to consider the impact of technological improvements on a measure of social welfare. First it is clear that consumers' surplus decreases. This is mind we should recognize that even in the case of an increase in social welfare there is an equity issue. That is, we may view this as rent seeking behavior. We define welfare W as the sum of consumer surplus and profit. For the linear demand case treated in the text we have:

$$\begin{aligned} W =& \frac{1}{2}\left(\frac{nK + \sum \phi_i}{n+1}\right)^2 \\ &+ \frac{(K + \sum \phi_i)(nK + \sum \phi_i)}{(n+1)^2} - n\Psi - \sum \left(\frac{K + \sum \phi_j - n\phi_i}{n+1}\right)\phi_i. \end{aligned}$$

Lamentably this expression cannot be made pretty. We rewrite:

$$\begin{aligned} W =& \frac{n^2K^2 + 2nK^2 + 2nK\sum \phi_i + 3(\sum \phi_i)^2}{2(n+1)^2} \\ &- n\Psi + \frac{n\sum \phi_i^2}{n+1} - \frac{\sum(\phi_i \sum \phi_j)}{n+1}. \end{aligned}$$

Now supposing after a change in marginal costs one firm exits. The new measure of welfare

$$W' = \frac{n^2K^2 - K^2 + 2nK\sum\phi_i' + 3(\sum\phi_i')^2}{2n^2} - (n-1)\Psi + \frac{(n-1)\sum(\phi_i')^2}{n} - \frac{\sum(\phi_i'\sum\phi_j')}{n}.$$

Then $W' - W$ is ambiguous. In each of the examples in the paper the result was an increase in welfare; however the direction of the change will depend on the specific case.

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PART 4: ON THE CONSISTENCY OF DEMSETZ WITH COURNOT

4.1 Introduction

Over the years there has been considerable debate concerning the relationship between concentration and profitability. Sufficient empirical studies have been undertaken to make it clear that indeed, statistically there is a positive correlation between concentration and profitability or markups over cost. The point of contention is generally not that such a relationship exists but rather concerns the cause of such a relationship. If there are potentially distinct causes for the relationship then these might imply distinct public policies for enhancing efficiency or some other such thing that policy makers might care about.

Beliefs about the theoretical reasons for such a relationship can have far reaching implications for public policy. Specifically we might consider the issue of a deconcentration policy. If one believes that concentration facilitates collusion and that this is the cause of the relationship between concentration and profitability then one might favor a policy of deconcentration. The firms in deconcentrated industries would now be less capable of collusion than when they were part of a relatively concentrated industry.

However, if one believes that firm asymmetries cause high levels of concentration, then this may have different implications for a policy of deconcentration. By firm asymmetries I mean some firms are more efficient than other and that those efficient or low cost firms will produce a higher level of output than those firms which are less efficient. This implies a higher level of concentration than the

case when all firms have the same cost structure, given that the number of firms is equal. This view, that firms are asymmetric in their costs, is consistent with the finding that concentration is correlated with profitability. This is because large firms have low cost and are therefore more profitable. If an individual holds this view he may feel that deconcentration is a harmful policy. Deconcentration would have the effect of eliminating the most efficient firms from the industry.

In this paper I focus on the beliefs commonly associated with Harold Demsetz and Leonard Weiss, what I will call the Demsetz-Weiss debate. I say debate because their beliefs differ and in fact they were able to confront each other on the issue at a conference at the Columbia Law School in 1974. I use the word belief for two reasons. First, because Demsetz himself uses the term, he states his "belief".[19] Second, as no evidence exists as to the true cause of the statistical relationship we all are left only to either sit on the fence or express a belief for which we can present no hard evidence, just as in religion. I argue in this paper that Cournot provides the theoretical basis for Demsetz's belief, and that economists conducting statistical studies of the concentration-profitability relationship generally ignored the theoretical implications of Cournot (until Demsetz) but that at the same time Cournot would be hesitant about the policy prescriptions associated with Weiss for reasons entirely different from those of Demsetz.

The purposes of this paper then are three.[20] First I will to discuss the

[19]Demsetz titles his paper "Two Systems of Belief About Monopoly".

[20]Notably then, this paper does not attempt to ascertain the current status of the debate on

Demsetz-Weiss debate and show that although Weiss argues that his view is consistent with Cournot in truth Demsetz's view is consistent with Cournot. The problem is that (as I will suggest below) Weiss confuses the number of firms in an industry with a measure of concentration in an industry. (Weiss's view will be consistent with Cournot when firms are symmetric and hence have equal market share, which is something we rarely observe). In referring to Cournot I mean to refer to his *Researches into the Mathematical Principles of the Theory of Wealth* (hereafter *Researches*). Cournot's book provides the groundwork for a theory of the concentration-profitability relationship quite distinct from his more well known result that there is an inverse relationship between the number of firms and the markup over marginal cost. I assert that Cournot's theory of concentration is entirely consistent with Demsetz's belief concerning oligopolistic industries.

Second, this paper suggests that a certain degree of ignorance concerning *Researches* can account for the existence of the controversy concerning deconcentration. By this I mean that if economists had been more familiar with *Researches* than they were in the Bain era then perhaps they would have seen what Demsetz later argued; namely that cost difference can explain both concentration and profitability and hence their correlation. If pre-Demsetz economists had focused on

the concentration-profitability relationship. Rather it attempts to shed some additional light on the state of thing in 1974. For more recent work in this area please see Salinger (1990).

many atheoretical statistical studies of the concentration-profitability relationship which lead policy makers to consider deconcentration.[21] I must note, however, that the term "atheoretical" is more a reflection Demsetz view. It seems that the individuals conducting such statistical studies did so having in mind some theory of the use (or abuse) of market power or that concentration facilitates collusion.

Third, in this paper I assert that, although Cournot (or the spirit of Cournot) and Demsetz may be in agreement concerning the cause of the concentration-profitability relationship, their feelings on public policy related to this relationship would be distinctly different. Cournot would not make any statements concerning a deconcentration policy while Demsetz adamantly argues against such a policy.

4.2 The Demsetz-Weiss Debate

Referring to the Demsetz-Weiss debate we are concerned with the theoretical basis for the relationship between concentration and profitability. [22] Demsetz has argued that there does not exist any true theoretical foundation for any such relationship. [23] He suggests that it is market share which result from efficiency that

[21] An example being the Concentrated Industries Act submitted in 1968.

[22] Most of the references and quotes below from Demsetz and Weiss are taken from papers presented at a special conference on industrial concentration sponsored by the Columbia Law School in 1974.

[23] Interestingly Demsetz does provide an explanation or theory for the relationship. It seems that what Demsetz would refer to as the lack of theory is similar to the remarks by Donald Dewey (1977), implying that there is no immediate relationship between the two, concentration and profitability, but that some other variable may affect the two at the same time. Then it is this alternate variable that is of interest. This is an argument that concentration per se does not cause profitability.

makes *firms* profitable. Of course, if an industry is characterized by a few large firms then it will have a high level of concentration, and as the large firms are profitable so is the industry. At the same time Weiss argued that many theories exist for the relationship between concentration and profitability. Most concerning of these theories were those which suggested that high levels of concentration facilitated collusion. Industries which are highly concentrated have lower costs of arranging and enforcing collusive agreements. [24] Additionally there are concerns that large firms produce at levels beyond the "minimum efficient scale". In either of these cases it may be socially beneficial to implement a divestiture or deconcentration plan. I wish to make clear the two points of view.

First, I discuss the side of Demsetz. Demsetz certainly felt some concern that the relationship was simply a statistical relationship without any economic implications for a direction of causality. Perhaps the finding that there existed a (positive) relationship was due to the use of "bad" data or poor econometric specifications by the many economists undertaking these studies. Most obvious of the problems is that measures of profitability are not measures of economic profits but rather accounting profits. In essence he suggested that statistical relationships are insufficient for justifying any policy action. Some theory must explain the statistical finding, and Demsetz argued that no appropriate theory existed. Referring to the market concentration doctrine Demsetz states

[24] See for example Stigler's paper (1964) concerning the probability of detecting a price cut with differing numbers of firms.

> No serious theoretical basis yet exists for this doctrine, notwithstanding Weiss's efforts to demonstrate the existence of such a basis. Weiss does marshal enough "theories" of oligopoly to make a very convincing case. But the case he makes is mine. [p. 166]

Although Demsetz's remark precedes the work of Cowling and Watterson it is fairly clear that, as he says, many "theories" did exist. Now, many of these worked through the number of firms argument. These theories however posited a rapid decline in profitability with small increases in the number of firms. As the number of firms in almost all industries was (and is) sufficiently large to approximate perfect competition then Demsetz asserts that his "system of belief" is even supported by the work of Weiss.

Demsetz points to the fact that if the number of firms alone cannot explain the differences on profitability then these differences must come from variance in the levels of efficiency. His belief is that the concentration-profit relationship is not an artifact of collusion but rather of the fact that industries with asymmetric firms result in high levels of concentration and that the asymmetry is due to some firms being more efficient than others. He argues:

> If industries are *persistently* concentrated, the fundamental reason will be the prevalence of large scale advantages. Such firms will record higher profits because the market has not yet grown sufficiently; in order to bring smaller, less efficient firms into production, price will need to be high enough to cover their unit cost, and this means that price will need to be high enough for *accounting* profits to be recorded in these industries. Of course, these industries will be highly concentrated ones. [p 177](his emphasis)

Weiss places himself at difference with Demsetz. He argues that the relationship has a theoretical basis and that it should be a cause of concern among economists and policy makers. Weiss provides a review of the theory concerning the concentration doctrine. He states "The first in point of time and still one of the most often cited was that of Cournot...[his] theory unequivocably predicts that price will rise with concentration" [p. 188]. Of course, since number of firms and concentration are not one and the same thing it is not clear that Cournot's theory, as expressed by Weiss, truly provides any basis for the relationship. Still, Weiss asserts that theoretical foundations do exists for the concentration-profitability relationship and that Demsetz is in the wrong to suggest otherwise. He mentions

> some commentators [i.e. Demsetz] on the concentration-monopoly power relationship have said that there is no theoretical basis for it – an allegation that is clearly false and should be put to rest [p.192]

Weiss does give a somewhat lengthy review of various theories. To spare the reader his lengthy review I only quote Weiss's summing up statement on the existing theories. He states

> Bain and Chamberlin point to some critical level of concentration; Cournot and Stigler suggest that margins rise at an increasing rate with concentration; and most of the other theories might be interpreted to imply that margins rise in a fairly continuous way with concentration. [p. 193]

I do not see that Cournot's theory concerning the number of firms supports Weiss's arguments. However, if we can see that Cournot's comments concerning

the asymmetries which may exist between firms suggests (as Cowling and Watterson) that a relationship exists between concentration and profitability then to be sure Weiss is justified in asserting that a theory exists. This theory, however, has a quite different implication than the others which are proposed and which Demsetz criticizes as not being "serious". Alternate theories suggest either collusive behavior or some sense of taking advantage of ones position in the market. That is, firms produce beyond the efficient level in order to deter entrance and therefore keep the industry highly concentrated and at the same time economically profitable.

Cournot's Theory

Now, to more plainly see that Demsetz's view (that the concentration-profitability relationship can be explained by differences in cost) is theoretically consistent with Cournot, it will be helpful to look at *Researches* and its implications concerning the concentration-profitability relationship. At the time of writing *Researches* Cournot certainly did not make any explicit statements regarding the relationship between concentration and price or profitability. [25] Of course, the type of statistical analysis which made the relationship an area of heated debate did not begin until perhaps Bain with his 1951 study of American manufacturing. Still, we will see below that an explanation for the relationship which exists empirically can be accounted for with minimal assumptions imposed on the explicit exposi-

[25] Whether or not at some later point Cournot did develop such a theory more explicitly I do not know.

tion of Cournot and that this is consistent with Demsetz's belief (that efficiencies explain the concentration-profitability relationship). I maintain that Cournot's implicit theory of the relationship between concentration and profitability rests upon asymmetries in the technologies of firms.

My remarks focus to some extent on the distinction between "number of firms" and "concentration". I say this as I mentioned above that it appears that Weiss confuses number of firms in an industry with level of concentration in an industry. I say this because it is well known that Cournot accounts for the fact that under his assumptions, as the number of firms increases profits decline. And an increase in the number of firms necessarily decreases concentration.[26]

Along these lines it is nothing new to assert that Cournot had a theory of the concentration-profitability relationship. At the same time, when referring to the statistical studies providing evidence of a relationship, number of firms is not used as an explanatory variable, but rather some measure of concentration is used. It is important to recognize the difference between number of firms and measures of concentration such as the four firm concentration ratio. Still, Tirole (1988) reminds us of the implications of the number of firms in the Cournot symmetric cost setting and its distinction from the Bertrand (1986) model:

> The Bertrand model tells us that market price and industry profits are independent of the number of firms in the industry. Thus,

[26]Of course an increase from five to six firms does not necessarily change the four firm concentration ratio and has no impact on the eight firm concentration ratio but in general the statement is true.

> profitability and concentration are unrelated. The Cournot model, however, exhibits a negative correlation between number of firms and profitability. [p. 222]

The Cournot model mentioned above by Tirole, however, is not a theory so much about concentration as it is about the number of firms in an industry and profitability. The distinction is that two industries may have the same number of firms and yet differ in various measures of concentration and in measures of profitability. Number of firms and concentration will only be perfectly related measures when the firms are identical, the symmetric case. In this case all firms have the same market share so number of firms provides the same information as other measures of concentration such as the four firm concentration ratio. I argue below that Cournot's theory not only shows this relationship with the number of firms but also with respect to the level of concentration, therefore treating the asymmetric case.

I think it helpful to refer to Cournot's *Researches* explicitly. Cournot begins, as far as we are concerned, with what is now convention, "it will be convenient to adopt the inverse notation $p = f(D)$", the inverse demand function which in turn implies a homogeneous product [page 66]. For the sake of completeness p is industry price while D is industry output and f is simply some rule. Cournot moves through his now famous analysis of the symmetric oligopoly case and later examines the case of asymmetric firms.

The asymmetric case has been neglected in the sense that many implications of it have failed to appear in the literature. Again referring to Cournot's *Researches* he gives the following definitions and derivations. Defining ϕ_i as the cost function for firm i he notes also that $\phi_i(D_i)$ is firm i's cost of producing D_i units and ϕ_i' is the marginal cost of the firm. We have for output D_i the following relationship:

$$D_1 - D_2 = \frac{1}{f'(D)}[\phi_1'(D_1 - \phi_2'(D_2)]. \tag{4.1}$$

This is followed with the recognition that $f'(D)$ must be negative so that we will have the following [27]:

$$D_i > D_j \qquad \text{implies} \qquad \phi_i'(D_i) < \phi_j'(D_j).$$

(See p. 70). The implication of this is quite simply that the superior firm will have a greater share of the market.

Leaving Cournot's work for a moment, note that the firm with the greatest market share also has the greatest level of total revenue. (Under Cournot competition there is product homogeneity and one price). Now, if the dominant has lower marginal cost not only at the equilibrium level of output but instead has lower marginal cost (almost) everywhere then it is clear that the dominant firm is also the most profitable firm.

Now, suppose that there are n firms in an industry. Then let the concentration ratio for the a largest firms be denoted CRa. Then provided that $n > a$ we note

[27] In the text the result is shown to be opposite but this must be a typesetting error as the derivation is straightforward.

a lower bound on CRa:

$$CRa \geq \frac{a100}{n}. \tag{4.2}$$

This corresponds to all firms having identical technologies or cost structures. Similarly for the Hirschmann-Herfindahl index (HHI) we have a lower bound:

$$HHI_n \geq \frac{10000}{n}. \tag{4.3}$$

Now suppose that we have the case where firms have asymmetric technologies. Then we necessarily move to a setting in which the concentration measure is greater. In fact Tirole (1988) provides a derivation of an exact measure for increases in profitability and the HHI with some assumptions from Cowling and Watterson (1976). Cowling and Watterson show that industry profits are positively correlated with the Herfindahl when firms have constant marginal cost and the absolute value of the price elasticity of demand ϵ is constant in an industry over time. In Tirole's formulation he has ϵ equal to one. Let Π be industry profit, Π_i be firm level profit, c_i is marginal cost, s_i is market share, p is market price, q_i is firm output and Q is industry output. We have:

$$\Pi = \sum_{i=1}^{n} \Pi_i = \sum_{i=1}^{n} (p - c_i)q_i = \sum_{i=1}^{n} \frac{ps_i q_i}{\epsilon} = \frac{pQ}{\epsilon} \sum s_i^2 = K \sum s_i^2.$$

Where K is a positive constant. However their assumptions of constant marginal cost and a constant industry price elasticity of demand equal to one are likely not universally true. Hence, we note that empirically there is not a monotonic relationship between the Lerner index and the HHI.

Still, we can examine the arguments of Cournot and the simple setting above to derive some general conclusions which will be similar to those of Cowling and Watterson and yet more general. Consider that some industries face increasing marginal cost. Now for pricing which occurs on the elastic portion of the demand curve we note that an increase in the asymmetry increases industry total revenue. This is easy to see since an increase in the asymmetry means less output on the part of the weak firms which in turn implies that they face a lower marginal cost and hence the price must be lower than otherwise. On the elastic portion of the demand curve a decrease in the price results in an increase in total revenue. It is likewise clear that industry total costs have diminished. This is again assuming that the marginal costs are increasing both in the range of output for the symmetric as well as the asymmetric case. This is analogous to the finding of Cowling and Watterson that empirically we may observe the ever present case of increased profitability associated with increases in concentration while still allowing for exceptions.

It appears then that, if anything, Cournot's theory lends support to the beliefs of Demsetz. Demsetz assertions precede the workings of Cowling and Watterson but both suggest asymmetries among firms. Cournot did comment on the issue of asymmetries between firms. Although he did not fully develop a theory of the relationship between concentration and profitability, his work immediately leads to a theory which suggest that this relationship follows immediately from firm

differences. Cournot's theory and Demsetz's belief are consistent with each other.

4.3 Deconcentration Policy Implications

Bain's 1951 study sparked a series of many articles which examined the profitability of manufacturing industries. Weiss (1974) provides a long list of such studies conducted mainly in the 1960's. The studies generally found positive and statistically significant (at conventional levels) relationship between concentration and accounting profits. Such studies were quite popular as evidenced by their number. Interest in this research, that of examining the relationship between concentration and profitability, was also had by policy makers. Policy makers became concerned that high levels of concentration was anticompetitive and therefore considered various deconcentration policies. (See for example the Hart bill and the Neal Report contained in the appendices of Goldschmid et.al. 1974). The contemplation of a deconcentration policy was the impetus for the 1974 conference on Industrial Concentration held at Columbia Law School.

If pre-Demsetz economists had paid more attention to *Researches* then there may have been less focus on the atheoretical studies of the concentration-profitability relationship and less interest in a deconcentration policy. Demsetz argued that the concentration theory and deconcentration policies were not motivated by sound economic theory and that there were no theories suggesting that the relationship was truly due to anticompetitive practices. Similarly Donald Dewey

(1976) suggests that a theoretical motivation for the concentration-profitability studies was critically lacking. As I argued above the Demsetz belief is consistent with the work of Cournot; then if economists had examined *Researches* more carefully (for example in the 1950' and 1960's) they might have seen what Demsetz later argued and abandoned interest in the concentration-profitability relationship.

The work of Demsetz did have the effect of shifting the views of policy makers. In the 1970's policy makers did not fervently pursue a deconcentration policy. Nonetheless, if economists had examined more carefully *Researches* and not gone on an atheoretical witch-hunt this would have saved some valuable resources. Namely the time of economists spent on research into the empirical relationship between concentration and profitability and the time spent by policy makers examining the need for a deconcentration policy.

4.4 Conclusion

Finally, I think that Cournot's theory is consistent with the point of view of Demsetz, but with some qualifications where policy prescriptions are concerned. Demsetz argument is that it is not concentration, which leads to profitability at the industry level but rather, dominant firms, having won the competitive race, become large and at the same time profitable. Hence, the true relationship is that market share and profitability are correlated. Of course, as firms in an

industry become large measures of industry concentration also become large. In this case we can only separate the work of Weiss and Demsetz by examining market share and observing as Demsetz (1973) did that small firms, even in highly concentrated industries are not highly profitable. Now, as Demsetz argues that no theory exists and Weiss argues that one does I must clearly side with Weiss. Cournot's theory immediately implies the findings of Demsetz. But, without depth of study or thought this same theory can be construed to imply the result of Weiss. The main issues here are views toward collusion, merger, and divestiture. The Weissian view finds concentration to be problematic while the Demsetzian view is that everything is fine as is. And what about Cournot? It appears that Cournot was less inclined to make any comment about whether or not this would be any type of problem or not. Demsetz has a free market bend and Weiss has an interventionist bend but I expect no inclination either way from the man who says

> I am far from having thought of writing in support of any system, and from joining the banners of any party; I believe that there is an immense step in passing from theory to governmental applications; I believe that theory loses none of its value in thus remaining preserved from contact with impassioned polemics; and I believe, if this essay is of any practical value, it will be chiefly in making clear how far we are from being able to solve, with full knowledge of the case, a multitude of questions which are boldly decided every day. [Cournot 1963: 4]

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PART 5: OVERALL CONCLUSION

5.1 Summary

In this dissertation I have shown that prices can serve as signals of quality even when there is a costly return policy. Additionally, I have provided some empirical tests concerning buyers' beliefs about prices as signal of quality. In part 3 I showed that the dominant firm in an industry can license its superior technology in a strategic fashion so as to induce exit and thereby raise profit. Lastly, in part 4 I argued that Cournot's and Demsetz's theories concerning the relationship between concentration and profitability are consistent with each other.

VITA

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