AN ANALYSIS OF BIDDING BEHAVIOR AT U.S. FOREST SERVICE TIMBER AUCTIONS

by

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ABSTRACT

The Forest Service is mandated to receive a "fair market value" for its timber. Noncompetitive bidding may lead to lower than fair market values of timber and thus large losses in federal revenues. Knowing where noncompetitive bidding is most likely to occur may allow the Forest Service to effectively mitigate noncompetitive bidding and antitrust resources to be allocated efficiently. A multi-stage procedure is developed for identifying the market areas where bidding is least competitive. The third stage of the procedure introduces an innovative method for analyzing the competitiveness of bidding behavior. This new method compares the differential impacts of regular and nonregular bidders on bid price. The application of the multi-stage procedure to nine forests in Washington and Oregon reveals noncompetitive bidding may have been present in two forests between 1973 and 1981. Analyses of later years (1985-90) reveal, however, that the noncompetitive bidding that may have been present in earlier years greatly diminished.

CHAPTER 1

INTRODUCTION

The U.S. Forest Service is mandated to receive a "fair market value" for national timber. It is recognized that the potential for noncompetitive bidding exists and that such practices can lead to lower than competitive market prices for timber. Because the Forest Service is one of the largest suppliers of stumpage in the United States, selling billions of board feet of timber each year, the potential losses in federal revenues from widespread noncompetitive bidding are large.[1]

Concern over noncompetitive bidding is reflected in the National Forest Management Act passed in October 1976. This act states, "The Secretary of Agriculture shall take such action as he may deem appropriate to obviate collusive practices in bidding for trees . . ." (16 U.S.C. 472a). Concern about noncompetitive bidding practices was also the focus of Congressional hearings in 1977 (U.S. Congress, Committee on Agriculture 1977). All of the attention focussed on noncompetitive bidding and resulting revenue losses is not without justification. Though only a handful of antitrust cases involving the timber industry have been successfully prosecuted, the difficulty of achieving convictions in such cases suggests that more noncompetitive bidding may exist.

[1] The Forest Service sold 11.5 billion board feet in 1981, 6.4 billion board feet in 1991 and 4.4 billion board feet in 1992 (USDA Report of the Forest Service, 1882, 1992, 1993).

While noncompetitive bidding clearly results in a transfer of revenue from the federal government (and indirectly taxpayers) to timber purchasers, the effects on total social welfare are less clear. The quantity of timber supplied by the Forest Service is not responsive to price. Therefore, lower prices caused by noncompetitive bidding do not affect the quantity of timber supplied by the Forest Service and there is no deadweight loss from noncompetitive bidding—only a transfer from taxpayers to purchasers of Forest Service timber. If, on the other hand, the quantity of timber supplied by the Forest Service were responsive to price (*i.e.*, the Forest Service timber supply curve were upward sloping), lower timber prices from noncompetitive bidding would cause the Forest Service to supply a less than optimal quantity of timber—resulting in a deadweight loss.

The objective of this thesis is to develop a procedure for identifying markets that appear most likely to have noncompetitive bidding so that antitrust resources may be allocated efficiently to such areas. It is useful to begin by defining the terms "noncompetitive bidding behavior," or "cooperative bidding" as they will be used in this thesis. There are two types of noncompetitive bidding (Carlton and Perloff 1990). The first occurs when bidders form an explicit agreement not to compete with each other (that is, to collude) for the purpose of obtaining timber at a less than competitive price. In situations where it is unnecessary for bidders to form an explicit agreement not to compete, they may do so implicitly. This is the second type of noncompetitive bidding. Bidders who have been in a market for a while may come to know the other bidders well and be able to predict their bidding behavior. Through what is termed "conscious parallelism," bidders may reach a silent understanding not to bid competitively against one another, thereby realizing financial gains.

Sometimes Forest Service market areas are referred to as noncompetitive because they have relatively few bidders at sales or relatively low bid prices. Labeling a market based on these characteristics may be inappropriate or misleading because the characteristics may not accurately reflect the true nature of the bidding behavior in the market. Although there may be few bidders in an area, they may bid competitively. Likewise, average bid prices may be low in some areas (due, for example, to higher harvesting costs) even though prospective buyers bid competitively. For similar reasons, it may not be appropriate to label areas with many bidders and relatively high bid prices as competitive areas. The competitiveness of a market area is more accurately measured by the actual bidding behavior, not by the potential symptoms of noncompetitive bidding.

Knowing where noncompetitive bidding is the most prevalent would allow the Forest Service to efficiently discourage noncompetitive behavior and focus antitrust resources where they will be the most effective. The Forest Service may be able to adjust auction procedures, advertised prices and appraisal methods to reduce noncompetitive bidding behavior.

The structure of this thesis is as follows. Chapter 2 presents a brief description of how the Forest Service sells timber, followed by a review of literature relating to noncompetitive bidding at Forest Service timber auctions. The literature reviewed includes auction theory literature, industrial organization literature on cartel formation, court summaries of successfully prosecuted antitrust cases involving bid rigging at Forest

Service timber auctions, and previous studies that specifically examine noncompetitive bidding at Forest Service timber auctions. In Chapter 3 a multistage procedure for finding noncompetitive bidding at timber auctions is developed. The third stage of the multistage procedure introduces an innovative method for searching for cooperative bidding—the method compares the differential impact of regular and nonregular bidders on bid price. In Chapter 4 the multistage procedure is used to examine Forest Service markets in the Northwest for noncompetitive bidding patterns. Chapter 5 summarizes the empirical results and discusses their implications.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a brief overview of Forest Service timber sales procedures is presented, followed by a review of literature that provides background information useful for the analysis in Chapter 3 of bidding behavior at Forest Service timber auctions. The literature falls into four categories: theoretical auction literature; pertinent industrial organization literature; court summaries of successfully prosecuted antitrust cases of bid rigging at Forest Service timber auctions in the Pacific Northwest; and previous studies that examine noncompetitive bidding at Forest Service timber auctions.

How the Forest Service Auctions Timber

When the Forest Service decides to sell a tract of timber, it must determine the advertised price of the tract. This price, also referred to as the reserve price, represents the minimum amount for which the Forest Service is allowed to sell the tract. The first step in determining the advertised price is to cruise the timber tract. When the Forest Service cruises a tract it gathers estimates on the volume and quality of species, plus other tract characteristics, which it uses to calculate the appraised price. Before 1979 all nine Forest Service regions were required to calculate the appraised price using the Residual Value (RV) method. The RV method entails first estimating the value of milled products producible from the timber tract for sale, then subtracting manufacturing costs, logging costs, and a profit and risk margin for the buyer. The residual value that remains represents an estimate of the value of the standing timber to the buyer. The tract of timber is then advertised and sold for no less than the rate indicated by the RV appraisal method (or at a predetermined base rate if the base rate is higher than the indicated advertised rate).

The RV appraisal method requires estimates of the value of milled lumber, manufacturing and logging costs, and tract characteristics. To reduce some of this costly data gathering, Forest Service regions were given the option of switching from the RV to the Transaction Evidence (TE) appraisal method in 1979, and at that time the eastern and southern regions switched to the TE appraisal method. The TE appraisal method varies from region to region, but the basic principle is to use the bid prices from recently sold (presumably competitive) auctions to determine the appropriate advertised price for a sale tract. For example, in Region 1 regression analysis using data from similar past sales allows the Forest Service to determine the appraised price of a new sale tract based on its characteristics. Using past timber sales data to determine current advertised prices saves Forest Service resources. The Forest Service still cruises the tracts to get an estimate of species volume and other tract characteristics, but (where the TE method is used) it no longer needs to estimate the total value of milled products from a tract, manufacturing costs, or profit and risk margins in order to calculate the appraised price.

The RV appraisal method's ability to consistently estimate fair market values began to be questioned in the late 1970s when bid prices often exceeded the Forest Service advertised price in western regions where the RV appraisal method was used. Private and public sectors recommended that the Forest Service adopt the TE appraisal methods in its six western regions (U.S. Department of Agriculture 1986) Beginning in the mid 1980s, and continuing until 1994, all of the western regions switched from the RV to the TE appraisal method.[2]

Once the appraised price is determined, the Forest Service advertises the sale for a period of thirty days, after which a public auction is held to determine who will purchase the tract. The Forest Service uses two auction mechanisms to sell timber—the English auction (also known as the open or oral auction) and the first-price sealed-bid auction. If timber is to be sold using a sealed-bid auction, the interested bidders each submit a sealed bid. On the designated sale date, the bids are opened and the qualified bidder submitting the highest bid wins the auction, provided the bid is at least equal to the Forest Service advertised price. If the timber is to be sold using an oral auction, a preliminary sealed-bid auction is held followed by the oral auction. Bidders must submit sealed bids at least equal to the Forest Service advertised price to qualify for the oral auction. Bidding at the oral auction begins with the highest price offered in the preliminary sealed bid auction[3] Bidders at an oral auction continue to increase their bids until only one bidder remains.

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[2] Alaska has not been required to use the TE appraisal method. The TE appraisal method assumes that the past sales upon which the method is based were sold competitively. In Alaska there are only a handful of sales each year and very few bidders, so it is assumed by the Forest Service that these sales are noncompetitive. Therefore Alaska is allowed to continue using the RV appraisal method.

[3] Usually the highest price in the preliminary sealed bid auction will be equal to the Forest Service advertised price because there is no need for a bidder to submit a higher bid.

After the auction the Forest Service publicly announces the identity of the winning bidder and the amount of the bid.

Auction Theory

Three topics studied in the auction literature are relevant to Forest Service timber auctions and are discussed below. The three topics are (1) the impact on cooperative bidding agreements of choosing a particular auction mechanism, (2) the classification under which a particular auction belongs, and (3) the relationship between number of bidders and expected bid price. These issues are germane to Forest Service timber auctions because the Forest Service sells timber via two auction mechanisms; the classification of Forest Service auctions is unclear; and the relationship between the number of bidders and the expected bid price is important to the analysis of bidding behavior conducted in this thesis.

Auction Mechanism

As explained above, the Forest Service uses either sealed-bid or oral auctions to sell timber. In the auction literature, cooperative bidding agreements are believed to be more stable when oral auctions are used than when sealed-bid auctions are used. As Mead argues:

> . . . In oral auction bidding where the identity of bidders is usually known, such tactics as preclusive bidding and punitive bidding are facilitated. In addition, collusive practices are more easily policed by the participants. In contrast, sealed bids introduce an element of uncertainty, making each of the above practices either impossible of more difficult (Mead 1967, p.195).

Robinson (1985) explains why there is more incentive for cartel members to cheat when auctions are oral rather than sealed-bid. It is assumed that a cartel will chose a designated winner from among its members, who, according to Robinson, should be the bidder with the highest valuation. At an oral auction the cartel-selected bidder is willing to bid until his valuation, V, is reached. Because every other bidder's valuation is less than V, there is no benefit for them to bid against the bidder with the highest valuation. In a sealed-bid auction, however, there is some degree of bidding uncertainty. It may be that the bidder with the highest valuation will leave a large enough gap between his bid and his valuation for another bidder to win the auction and profit. This is why the incentive to cheat on a collusive agreement is higher at a sealed-bid auction than at an oral auction.

For the most part, the oral auction has been the mechanism chosen by the Forest Service to sell the rights to harvest timber. Concerns about the noncompetitive bidding at timber auctions, combined with the National Forest Management Act of 1976 and articles such as Mead's (1967), prompted the Forest Service to switch to primarily sealed-bid auctions between 1976 and 1978. The theory that cartel agreements are less stable at sealed bid auctions was the reasoning behind the period of sealed bid auctions (U.S. Congress, Committee on Agriculture 1977). Hansen (1986) examined the results of the Forest Service change in policy to sell timber via sealed bid auctions. Using 1977 data from the Pacific Northwest, Hansen found expected revenue differences between sealed-bid and open auctions to be between $1 and $6 per thousand board feet (mbf), depending on the estimation technique used. The point estimates were not statistically significant, and when compared to an average bid price of $134 per mbf, do not seem economically significant either.

Auction Classification

Two different classifications for auctions have been identified in the auction literature—independent-private-values (IPV) and common value (CV). The two assumptions necessary for an auction to be modeled as IPV are that each bidder (1) knows his own valuation of the object to be sold, does not know anyone else's valuation of the item, but believes their valuations, as well as his own, are drawn from some probability distribution, and (2) each bidder's valuation is not conditional on any other bidder's valuation—valuations are statistically independent. An example of an auction that could be modeled as IPV is an auction for a painting that is not to be resold. Forest Service timber auctions are often classified as IPV because each bidder has his own cost structure.[4] Each bidder knows what it will cost him to harvest and/or process the timber from a tract. If these costs vary greatly among bidders, then bidders' estimates of the value of a tract (and their bids) will be independent from one another. Under the IPV classification, knowing any other bidder's valuation of a tract will not change a bidder's own valuation.

The other classification of auctions is common value. The main criterion an auction must meet to be modeled as CV is that the object being sold has an objective worth or a market value that is the same to all bidders. None of the bidders know this

[4] For examples of IPV modeling see Johnson (1979); Carter and Newman (1993); Paarsch (1993); Baldwin, Marshall and Richard (1994).

value, but they all try to estimate it from the information they collect. The bidders' estimated values of the object are draws from some probability distribution whose mean and variance are conditional on the true value of the object. All bidders and the seller are assumed to know the distribution.

The CV model allows bidders' valuations to be correlated. Observing another person's bid provides useful information about the true value of the item. A bidder who learns of someone else's bid may choose to revise his own bid. An oral auction may therefore result in higher (or lower) bids than a sealed-bid auction when the CV model is appropriate. At an open auction, a bidder can observe others' bids and adjust his own bid as new information is revealed about the actual value of the object. This is not the case in a sealed-bid auction.

Forest Service timber auctions can be modeled as CV because bidders expend resources to estimate the market value of a tract. If Forest Service timber auctions can be modeled as either IPV or CV, how do the very different IPV and CV aspects of Forest Service timber auctions reconcile?[5] In reality many auctions fall somewhere between CV and IPV, and timber auctions are no exception.[6] It is not a goal of this thesis to try to

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[5] See the discussions in McAfee and McMillan (1987); Paarsch (1992); and Carter and Newman (1993). For examples of CV modeling see Leffler, Rucker, and Munn (1994); Leffler and Rucker (1991); and Schroeter and Smith (1994) .

[6] A general model that allows auctions to be combinations of CV and IPV, and that has CV and IPV auctions as special cases, was developed by Milgrom and Weber (1982a).

determine which classification, IPV or CV, is more appropriate for timber auctions.[7] Because timber auctions have a mixture of IPV and CV characteristics, the resolution of that question is difficult. Instead a theoretical result common to both IPV and CV auctions, the nature of the relationship of number of bidders to expected bid price, will be used to develop the bidding behavior model used in this thesis.

Impact of Additional Bidders on Expected Bid Price

IPV Auctions. The study of noncompetitive bidding behavior requires some knowledge of competitive bidding behavior. Of particular interest is how a change in the number of homogeneous, competitive bidders (bidders who draw their valuations from a single distribution) change the expected bid price. McAfee and McMillan (1987) discuss this relationship for IPV auctions. Some background information is required, however, to understand their discussion.

McAfee and McMillan show that when bidders are homogeneous and risk neutral and payment is a function of bids alone, under the IPV model four different auction mechanisms yield the same expected revenue to the seller. Two of the auction mechanisms examined by McAfee and McMillan, the first-price sealed-bid and English auctions used by the Forest Service, have already been discussed. The other two auction

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[7] An attempt to clarify auction classification was made by Paarsch (1992), who developed an empirical method to determine the appropriate auction classification. Applying his models to auctions for tree planting contracts in British Columbia, Paarsch rejects the IPV model in favor of the common value model.

mechanisms are the second-price sealed-bid auction and the Dutch auction.[8] McAfee and McMillan show that the price generated from English and second-price auctions will be equal to the second highest valuation, and in the Dutch and first-price sealed-bid auctions the price will be equal to the expected value of the second highest valuation conditional on the winning bidder's valuation. On average the bid prices from the four auctions will be equal. This result is known as the Revenue Equivalence Theorem.

Given the preceding, it can be shown that as the number of homogeneous, competitive bidders is increased, the expected bid price will increase at a decreasing rate, and as the number of bidders approaches infinity, the bid price will approach the highest valuation. This occurs because as the number of bidders increases, the second-highest valuation approaches the highest valuation, in other words, the second order statistic approaches the first order statistic in the distribution of valuations. The result is that expected bid price as a function of number of bidders can be represented by the curve in Figure 1. Because of the Revenue Equivalence Theorem, the curve in Figure 1 can represent the response of expected bid price to number of bidders in English, Dutch, and first- or second-price sealed-bid auctions.

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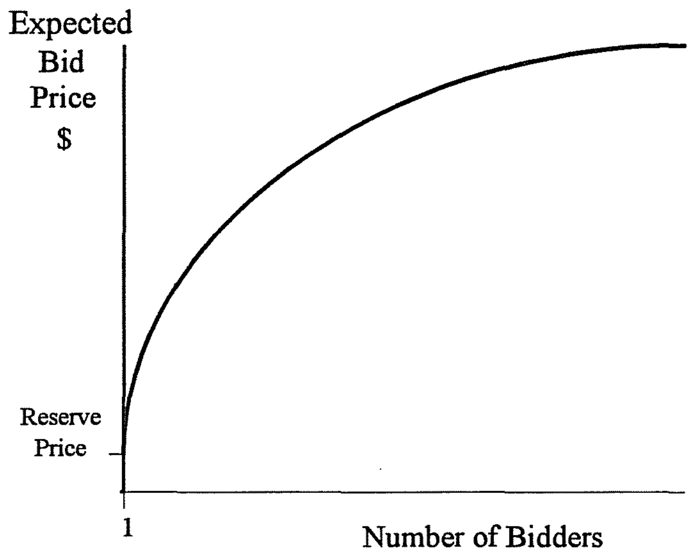
[8] The second-price sealed-bid auction is similar to the first-price sealed-bid auction except the highest bidder pays the amount bid by the *second*-highest bidder. The Dutch auction is like the English auction, except rather than ascending bids, descending bids are posted or called out by the auctioneer until a bidder indicates he desires to purchase the object at the posted price.

Figure 1. The Relationship of the Number of Bidders to Expected Bid Price in a Competitive Setting.



CV Auctions. French and McCormick (1984) discuss the relationship of the number of bidders to expected bid price when auctions are common value in nature and the object is sold via first-price sealed bid. To understand the relationship, recall that in CV auctions bidders try to estimate the true value of the object for sale, and at an oral auction they glean useful information from observing other bidders' bids. If a bidder wins the auction, then he knows that he had the highest valuation for the object, indicating that he may have over-estimated the object's value. This is known as the winner's curse. To counter the winner's curse, each bidder in a sealed-bid, common value auction assumes he has the highest valuation of the object and then adjusts his valuation downward.

Once the valuations are adjusted for the winner's curse, bidders determine the appropriate bid based on the new, lower estimate of the object's value. A bidder can increase his expected profit by bidding ΔX dollars below his winner's-curse-adjusted valuation of the object. However, if a bidder bids too low (ΔX is too large), he may lose the auction to another bidder. As the number of bidders increases, the probability increases that a bidder will lose to another bidder by bidding ΔX dollars less than his winner's-curse-adjusted valuation. To combat the increased probability of losing when the number of bidders increases, a bidder will raise his bid (decrease ΔX) and thereby decrease his expected profit. The more bidders there are, the less the difference between the first and second highest information samples, and the more the bidders raise their bids. Therefore, as in the IPV scenario, the expected bid price at a first-price sealed-bid CV auction will increase at a decreasing rate as the number of bidders increases. Expected bid price as a function of the number of bidders will look like the curve in Figure 1, with the expected bid price asymptotically approaching the actual value of the object.

French and McCormick do not deal explicitly with any oral auction mechanisms, but one can imagine a similar set of conditions for oral CV auctions as well. As the number of bidders increases at an oral auction, both the information samples and the valuations of the first and second-highest bidders become closer. The only difference is that at oral auctions the bidders can gain a more accurate estimate of the valuations of other bidders and simultaneously readjust their own bids to reflect that added information. So, again, bid price as a function of the number of bidders can be represented by the curve in Figure 1. Thus, for auctions under either the IPV or CV classification, the expected bid price functions are concave in the number of bidders. The shape of the expected bid price function is used to develop a bidding behavior model later in this thesis. The fact that the shape is the same under either auction classification allows us to circumvent the problems of classifying Forest Service timber auctions as either IPV or CV.

Industrial Organization Literature Relating to Noncompetitive Behavior

Theories for why and how cooperative bidding coalitions form can be found in the industrial organization literature. The characteristics of industries and firms that enable noncompetitive coalitions to form and be successful have been identified using studies of cartels that have been convicted of violating Section 1 of the Sherman Act.[9] The characteristics necessary for a successful coalition fall into two categories; those that allow a noncompetitive coalition to form and those that prevent a coalition from breaking apart because of cheating by members.

Factors that Promote the Formation of Noncompetitive Coalitions

A low expectation of severe punishment promotes cooperative coalitions. Cooperative groups only form when they do not expect to be caught by the government or when the penalties imposed by the government are very low. If the expected punishment of forming a cartel is high, then the net gains from forming one will be low, and vice versa.

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[9] Section 1 of the Sherman Act states that "every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations is declared to be illegal . . ." (15 U.S.C.A. § 1). Thus Section 1 forbids explicit cartels.

During periods when the Department of Justice has been relatively lax in enforcing antitrust laws, cartels have been more prevalent (Posner 1970).

Low organizational costs facilitate noncompetitive coalition formation. The more complex the negotiations, the greater the cost of forming a coalition. Few firms involved in a coalition, highly concentrated industries, and trade associations are among the factors that keep organizational costs low. Setting up meetings and keeping them secret from the government is much easier when there are only a few firms involved. Studies of Department of Justice price-fixing cases support this argument. One examination by Fraas and Greer (1977) found that out of 606 cases, the median number of cartel members was eight and the mode was four. Another study by Hay and Kelly involving ten years of Department of Justice cases found the mean number of cartel members was 7.25 and 48 percent of all cases involved six or fewer firms (Hay and Kelly 1974).

Trade associations are a way to lower the costs of setting up meetings, and the meeting do not need to be kept secret. Most trade associations meet regularly and are a mechanism for coordinating activities among association members. It is easy to see how trade associations lower the organization costs of noncompetitive coalitions. In studies done by Hay and Kelly, and Fraas and Greer, trade associations were usually involved in cartels that had above average numbers of members.

Highly concentrated markets lower the cost of cartel formation because it is easier for firms to form cooperative agreements, either explicitly or tacitly, to reduce the price paid at auctions. When bidders coordinate their actions so as not to compete without any explicit arrangements, they are colluding tacitly.[10] This may be accomplished easily in concentrated markets because bidders quickly become knowledgeable about the bidding behavior of others. For example, in the case of Forest Service timber auctions, Bidder X may figure out that Bidder Y will likely win a particular auction and, based on that knowledge, may choose not to compete with Bidder Y at the auction. Bidder Y may do the same favor for Bidder X by not competing at an auction in which he knows Bidder X will be interested. Though there is no expressed agreement between the two bidders, they have tacitly agreed not to compete.

The relative ease of establishing tacit cooperative agreements in highly concentrated markets may suggest that there is little need for explicit cooperative agreements in these markets. It may be assumed that explicit cooperative agreements will be found more often in markets with a low concentration because tacit collusive coordination is virtually impossible there. Hay and Kelley (1974) dispute this point. They agree that tacit agreements are more likely to occur in highly concentrated markets than in unconcentrated ones, but they also present evidence that explicit agreements are also more likely to occur in highly concentrated markets.[11] Therefore both tacit and explicit

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[10] This is also known as "conscious parallelism."

[11] Hay and Kelley did a study of horizontal price fixing cases. The objective of the study was to determine if there was a specific set of characteristics associated with the product or product markets that have been the subjects of price fixing. In thirty-eight of fifty price fixing cases the concentration ratio (presumably four-firm concentration ratio) was greater than fifty percent. According to Hay and Kelley, "This suggests that concentration is an important determinant of the ability of firms to collude."

noncompetitive behavior are more likely to occur in highly concentrated markets than in unconcentrated markets.

Though market concentration can be used in the search for noncompetitive behavior, concentration does not imply that noncompetitive bidding necessarily exists. While cooperative bidding behavior is more likely to occur in highly concentrated markets, competitive bidding can also occur in concentrated markets and may be the norm. Concentrated markets may even arise from competitive behavior. As Demsetz explains (1973, p. 1), "Under the pressure of competitive rivalry, and in the apparent absence of effective barriers to entry, it would seem that the concentration of an industry's output in a few firms could only derive from their superiority in producing and marketing products or in the superiority of a structure of industry in which there are only a few firms." Demsetz goes on to caution the use of measures of market concentration in antitrust policy. He argues that reducing concentration in markets where concentration arose out of competition and efficiency acts to punish firms for being efficient and innovative and may therefore be detrimental.

An example of markets becoming concentrated via competitive conditions can be found in the timber industry. In the timber industry a market may be highly concentrated because the timber is too sparse to support a large number of mills in any one geographic area. Also, hauling costs may preclude outside mills from entering a market and being competitive. The natural environment and cost conditions cause the market to be concentrated. It would not make sense for such a market to contain many bidders. When the small number of bidders get together, they may however, bid either competitively or noncompetitively.

Enforcing Noncompetitive Coalition Agreements

Some of the market characteristics that aid in the formation of noncompetitive coalitions also reduce the costs of enforcing noncompetitive agreements. Coalition agreements are easier to enforce if cheating on agreements is easily detected or prevented. Relatively few firms in a coalition is one characteristic that reduces the costs of cheating. With relatively few firms in a coalition, the members' behavior is much easier to monitor and deviations from coalition agreements are much easier to detect. Also, large, noncompetitive coalitions are presumably more likely to be detected by the government.

The ability to police cheating by observing changes in price is important to the stability of coalition agreements. In the case of Forest Service timber auctions, the ability to find out who wins an auction and how much they pay would facilitate a noncompetitive group's ability to police cheaters. In fact, the results of Forest Service timber auctions are made public, making it easier for coalitions to police themselves.

Coalitions may be designed with incentives to prevent cheating. Two possible methods for preventing cheating on coalition agreements in the timber industry are to assign to members either market areas or fixed market shares. If coalition members are caught cheating, they can expect retaliation from other coalition members.

Successfully Prosecuted Forest Service Antitrust Cases

Since 1970 there have only been three successfully prosecuted bid rigging cases in the Pacific Northwest. In most conspiracies all members must benefit in some manner, and this was true in each of these antitrust cases. One case, *United States v. Champion International* (557 F.2d 1270 [1977]), involved an explicit bid rotation scheme that began as a tacit agreement among bidders not to compete. The other two cases, *United States v. Walker* (653 F.2d 1343 [1981]) and *United States v. Astoria Plywood Corp., et. al.* (869 F.2d 1288 [9th Cir. 1989]), involved payoffs to bidders who agreed not to compete. The payoffs were in the form of logs from the sales, favors, or cash. Details in each of these cases follow.

United States v. Champion International, et al.

Seven corporate and individual defendants were convicted of conspiracy to eliminate competition in bidding for Forest Service timber. The defendants were in the lumber and plywood business in or near the Detroit Ranger District in the Willamette Forest in Oregon. The defendants were knowledgeable about the production capacities and product mixes of each other's mills, and it was the government's theory that the defendants exchanged this information in order to acquire timber tracts with little or no competition.

The history of the bidding behavior in the Detroit District is as follows. Prior to 1967 local bidding at Forest Service timber auctions was very competitive. This "bidding war" came to a sudden end on June 2, 1967, when defendant Vernon Morgan "was surprised" to find no one bidding against him at an auction. Morgan decided to find out what would happen if he chose not to bid against another defendant, Freres, in an auction later that same day. From this experiment a new bidding pattern for obtaining timber tracts at or near the appraised price was established.

The court agreed with the defendants that the new bidding behavior arose out of their specific knowledge of the market conditions by "normal economic forces." Despite the innocent beginnings of the noncompetitive bidding, however, it eventually evolved into explicit collusion. There was evidence that bidders or their agents began meeting occasionally to discuss upcoming timber sales of interest to each of them. Without the meetings the bidders who would be interested in future sales probably could have been predicted by the bidders familiar with the market, but the defendants did not leave it to chance. The government was unable to find direct evidence of an express agreement by the bidders to collude, but argued the circumstantial evidence proved the existence of a tacit agreement. Among this evidence was the methodical manner in which the defendants took turns acquiring the tracts.

United States v. Walker

On June 23, 1972, the Forest Service opened bids from six bidders for the sale of two tracts of timber in Oregon. The six bidders were George E. Walker, the Murphy Company, Coos Head Timber Company, West Coast Orient Company, and two other companies not involved in the case. All of the written bids were for the Forest Service reserve price except for Walker's, which was higher, and no oral bids were offered. Therefore, Walker won the auction.

The government contended that Walker rigged bids with three other bidders. The other parties involved included an agent for the Murphy Company, Coos Head Timber Company, West Coast Orient, and two bidders who failed to bid—Matthews and Ocean Terminals Company. The government's theory was supported by circumstantial evidence of payments made either directly or indirectly by Walker to these five parties as payoffs for agreeing that Walker would win the sale.

The payoff scheme went like this: The day after the sale Walker and Matthews entered into an agreement to share all profits and costs of the two sales. Walker failed to honor the agreement, instead sharing profits with the Murphy Company's agent, Smejkal, with whom he had a profit-sharing agreement dated three days before the sale. The timber tracts had a large amount of Port Orford cedar that Walker sold to West Coast Orient for resale to Japan. Walker had West Coast Orient pay Smejkal $100,000. Matthews testified that Walker indicated the payments were to keep Murphy from bidding at the two sales. Walker sold the Douglas fir on the tracts to Coos Head for $90 per thousand board feet, $40 below the market value. A West Coast Orient official testified that Walker said this procedure saved him from having to write checks to Coos Head for the $40 amount. Walker insisted West Coast Orient use Ocean Terminals Company for loading and storing the logs bought from him, even though Ocean Terminals Company charged $11 more per thousand board feet than West Coast Orient's usual handler. West Coast Orient agreed to do so on the condition that the excess payments be subtracted from the sale price West Coast Orient paid to Walker.

Walker was convicted for conspiring to defraud the United States by bid-rigging a timber sale by the U.S. Forest Service. He was sentenced to a two-year term, but only required to serve ninety days, and required to pay a $10,000 fine. Smejkal, a codefendant, was acquitted.

United States v. Astoria Plywood Corp., et al.

On March 22, 1985, the Forest Service auctioned the "Up and Adam" timber tract. Three companies, Hoh River Timber Inc., Astoria Plywood Corp., and Seattle-Snohomish Inc., submitted sealed bids. Astoria bid $20.50 above the minimum amount while the other two companies bid the minimum amount. Evidence was introduced to show that Hoh River had originally intended to bid up to $275,272 over the Forest Service reserve price (or $34 more per mbf). At the oral auction following the opening of the sealed bids, none of the three companies made an oral bid, so the sale went to Astoria Plywood.

Before the sale the timber managers for Astoria Plywood, Hoh River Timber, and Seattle-Snohomish met to discuss who wanted logs from the sale and who would win the auction, and it was agreed that Astoria Plywood would win the sale. Howard Wolf, the timber manager of another firm, Portac, told the Hoh River timber manager (Dean Hurn) that Portac wanted logs from the sale. Dean Hurn passed along that information at the pre-sale meeting of timber managers, and it was agreed that Portac along with two other companies would get the Douglas fir from the tract. When the sealed bids were opened, the Hoh River timber manager did not submit an oral bid because he had agreed not to bid against his competitors.

On February 23, 1987, a federal grand jury indicted Astoria Plywood, Hoh River Timber, Portac Inc., and Howard Wolf (Portac's timber manager). Astoria Plywood and Hoh River Timber were charged with conspiracy in restraint of trade in violation of Section 1 of the Sherman Act. Astoria and Hoh River pleaded guilty to this conspiracy charge. Portac was charged with having "willfully aided, abetted, counseled, commanded, induced or procured" the formation of the conspiracy. Wolf was charged with making false material declarations under oath before the grand jury.

Studies Directly Related to Noncompetitive Bidding at Forest Service Timber Auctions:

Only a few empirical studies have examined the competitiveness of Forest Service timber auctions. The studies presented here will be loosely grouped into two categories. The first category contains studies of noncompetitive bidding at Forest Service timber auctions that use the Forest Service advertised (or reserve) price in some manner. The use of the Forest Service advertised price, as explained later, is somewhat problematic. Studies that provide alternatives to the use of the Forest Service advertised price fall under the second category of studies.

Studies That Compare Bid Price to
Forest Service Reserve Price.

A study by Mead and Hamilton (MH) (1968) used the ratio of the bid price to the appraised price as a measure of competition. If the bid-appraisal ratio was less than 1.01

or if there was only one bidder, a sale was classified as noncompetitive. The percentage of sales classified as competitive was used as a measure of competition.[12]

The MH approach to classification of noncompetitive sales relies on the closeness of the bid price to the Forest Service appraised price. If the Forest Service appraised price is close to the fair market value of a sale, the bid-appraisal ratio will be close to one, and the sale could be classified as noncompetitive though it was sold competitively. Similarly, if the Forest Service appraised price is much less than the fair market value of a sale, the bid-appraisal ratio could be large enough for a sale to escape classification as noncompetitive even though bidding was noncompetitive.

A study done be Richard Haynes (1980) used the amount overbid to classify sales as either competitive or noncompetitive, where overbid was defined as bid price minus road costs and appraised stumpage. Sales were classified as noncompetitive if their overbids were less than one-half of 1 percent of the average overbid for the appraisal zone in which the sale was located. Haynes then used the statistical procedure of discriminant analysis to separate the sales classified as noncompetitive into two separate groups. As explained by Haynes (1980, p. 29),

> The first group includes sales that prospective bidders would generally evaluate as undesirable because of low potential profitability. Little competition would be expected on these sales. The second group

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[12] Some characteristics of bid and appraised prices should be noted. Prior to 1984 timber prices were established at the time of sale, but payment was not required until the timber is actually cut. In addition, the average sale contract length was three years. Thus (during the time periods of HM's and Haynes studies) competitive bid prices reflected undiscounted expected future timber values (Rucker, 1984). The Forest Service appraised price, however, may be considered a proxy for *current* timber values, therefore bid and appraised prices measured different values.

contains sales that have many of the attributes of competitive sales but, nevertheless, when sold, were noncompetitive. This latter group could be further studied for suspicious bidding patterns.

Haynes applied his discriminant analysis approach to data for fiscal years 1975 and 1976. He estimated discriminant functions for each Forest Service appraisal zone rather than estimating functions on a smaller scale, which, as Haynes explained, resulted in a loss of power to the discriminant approach.[13] Haynes' analysis of the two years of data indicated that most sales sold at bid prices close to the Forest Service appraised price were noncompetitive "because they appear to bidders to have low potential profitability" (Haynes 1980, p. 30). According to Haynes, potential profitability is based on the quality aspects of the sales, but he does not define it further.

Haynes did find some suspicious sales in one Forest Service district in California (Region 5). Out of a total of five sales sold in the district over a two year period, four sales were originally classified as noncompetitive and then reclassified via discriminant analysis as having characteristics indicating the sales should have been sold at a higher price. Closer examination revealed that the same four bidders bid on the four noncompetitive sales but did not bid on the one "competitive" sale that took place.

Haynes' classification criterion for noncompetitive sales, size of overbid, depends on the Forest Service's estimate of appraised price and road costs. For sales determined via discriminant analysis as having small overbids even though they have attributes of competitive sales, it may be the case that for those particular sales, the Forest Service appraised price actually was quite close to the fair market price. In this situation the

[13] Appraisal zones often cover large areas encompassing several forests.

overbid method of classification of sales would classify the sale as noncompetitive and the discriminant analysis would indicate that the sale had characteristics similar to competitive sales, but was sold noncompetitively, thus placing the sale in the second group. The sale would be targeted as suspicious even if bidding actually was competitive. Similarly, when the Forest Service appraised price falls far below the competitive fair market price of a sale, the sale may appear to be sold competitively because it has a large enough overbid to escape being classified as noncompetitive, but the bid price may also fall substantially below the competitive fair market price of the sale given its tract characteristics. The fact that the sale's bid price is below the competitive fair market price makes the sale suspicious, but by using Haynes' methods the sale would be overlooked. Like MH's method of measuring noncompetitive bidding, Hayne's method is susceptible to errors in identifying suspicious sales.

Because both MH's and Haynes' methods are based on the appraised price, their measures of competition are only comparable in areas where the appraisal methods are identical. Though the complication of different appraisal methods did not exist for the data periods used in MH's or Haynes' studies, using their methods to evaluate competition across Forest Service Regions in later years (1979–94) would not be appropriate where regional appraisal methods differ.

Luke Froeb and Preston McAfee (1988) comment on the difficulty of using the closeness of bid price to the Forest Service reserve price to search for noncompetitive behavior. Froeb and McAfee studied the few successfully prosecuted antitrust cases in the

Pacific Northwest and claim that none of the cases would have been easy to spot by comparing the final bid price to the Forest Service appraised price. They say,

> The problem is that there are many different types of conspiracies. All conspiracies feature low winning bids but, as noted above, there are many tracts in many areas that are let at or near the appraisal. Data screening to pick up anticompetitive behavior based on bids near the appraisal would result in a large number of false leads (Froeb and McAfee 1988, p. 7).

Froeb and McAfee do hypothesize where noncompetitive bidding will be the most prevalent. According to them, noncompetitive behavior is fostered by repeated contact among bidders and differences in bidders' timber transportation costs. Froeb and McAfee believe timber transportation costs are crucial in determining who wins a timber tract—especially where timber is sparse. In such areas, mills will be farther apart and have different transportation costs. Bidders whose mills are closest to the timber tracts are the most likely to win because they have a cost advantage in transportation costs over the other bidders. Eventually, through repeated contact, bidders may realize that it would be mutually beneficial to form a cooperative agreement not to compete with the bidder closest to a tract.

The allocation of tracts in the presence of a cooperative agreement is the same as it would be if competitive bidding had occurred. In both the competitive and noncompetitive cases, the firm closest to a tract is the most likely to win the tract, but the bid price will be lower in the noncompetitive case than in the competitive case. Because the auction outcome is very similar in both cases, legal action against such cooperative agreements could be very difficult unless explicit proof of noncompetitive bidding is available.

Studies That Do Not Rely on
Forest Service Reserve Price

Two studies have been completed that do not rely on the relationship of bid price to Forest Service appraised price to measure the amount of noncompetitive bidding behavior at timber auctions. In a paper examining whether the Revenue Equivalence Theorem held for sealed-bid versus oral Forest Service auctions, (mentioned previously) Robert Hansen (1986) also examined whether collusion exists at Forest Service timber auctions. Instead of using bid-appraisal ratios or amount overbid in his analysis, Hansen used the residuals from a regression explaining bid price for sealed-bid and oral Forest Service timber auctions.

Hansen relied on the standard auction literature theory that says if bidders are attempting to collude, they will be more successful at oral auctions than at sealed-bid auctions. Because cartels usually have more success at lowering the bid price at oral auctions, if a cartel exists, one would expect the residuals from a bid price regression to be smaller at oral auctions than at sealed-bid auctions.

Like Froeb and McAfee, Hansen suggested that noncompetitive behavior should be more prevalent in some markets than in others. He said that there may be considerations, other than auction method, that make stable cartel formulation so difficult that it can effectively be ruled out. Sealed bids should dominate oral bids only where the "other considerations" are not strong enough to prevent cartel formation. Hansen thought the most important consideration that may hinder a cartel would probably be potential competition. He used two different proxies for potential competition: number of potential bidders and percentage of timber volume bought by the four largest buyers (four-firm concentration ratio). Where potential competition is low, sealed bid prices should be greater than oral bid prices.

Hansen used auction data from 1977 and concentration ratios (calculated from 1976 data) that were available for each of the ten regions. He computed the differences between the average sealed-bid and oral auction residuals for each region. Hansen then ran two separate regressions, one with the concentration ratio as the independent variable and the other with number of potential bidders as the dependent variable (both with the difference in average residuals as the dependent variable). Those regressions tested the relationship between potential competition and dominance of sealed bid prices over oral bid prices. Neither the coefficient on concentration ratio nor the coefficient on potential number of bidders was statistically significant, providing no support for the hypothesis that collusion was present.

Hansen's empirical method of testing the effect of potential competition on the average difference between sealed and oral auction residuals may not have been sensitive enough to detect any actual relationship. Forest Service regions cover large forested areas and each region can encompass many forests, but most bidders bid in only one or two forests. Therefore, by using potential competition measures and differences in average residuals computed on a regional basis, the different bidding patterns occurring in each forest may have been smoothed out. Had the potential measures of competition and differences between average sealed-bid and oral auction residuals been computed on a smaller scale, for example, by forest, the coefficients on the potential competition proxies may have been significant. Hansen did not address this point.

Another study of the competitiveness of Forest Service timber auctions that does not rely on bid price ratios or amount overbid was done by Baldwin, Marshall and Richard (BMR) (1994). Bid prices may be relatively low for two reasons given by BMR. The first is the occurrence of noncompetitive bidding, and the second is an increase in the supply of timber by the Forest Service. The goal of BMR was to determine if price variations, after controlling for demand conditions, are better explained by collusion or by variations in timber supply conditions.

The modeling of Forest Service timber auctions by BMR is unusual because they treat sequential Forest Service timber auctions as multi-object auctions. They argue that the fact that one is in possession of a data set implies that more than one object has been sold. Most theoretical auction literature deals with single object auctions and almost all of the empirical timber auction literature treats timber auctions as single-object sales.

For their multi-object theory, BMR draw from the work of Milgrom and Weber. In an independent-private-values auction framework where M objects are being sold and where each bidder has a positive valuation for one item and a zero valuation for more than one item, many auction schemes are revenue equivalent and expected bid price will be equal to the expectation of the M+1 order statistic.[14] Based on this, the application of a multi-object auction framework to Forest Service timber auctions is questionable. It is

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[14] When the M+1st bidder stops bidding, one of M items is awarded to one of the last M active bidders for the M+1st highest valuation.

difficult to imagine bidders having a positive valuation for only one of M sequential timber auctions and BMR do not indicate how the value of M is empirically chosen.

BMR also base their study on theoretical models requiring that the auctions analyzed be oral, independent-private-values auctions. To have a data set containing only IPV auctions, BMR restricted their original data set to contain only second-growth timber sales. Because second-growth timber is much more homogeneous than old-growth timber, the variation in the estimation of timber volume and quality is greatly reduced, and the common value nature of timber sales is reduced. Most of the variation in bidders' valuations of the tracts will stem from differences in the bidders' cost functions, so the auctions can be classified as IPV. By having these restrictions, BMR reduced their data set of 3355 sales from 1975 to 1981 down to only 108 sales.

BMR estimate five maximum likelihood models: noncooperative with no supply effects; collusive with no supply effects; non-cooperative with supply effects; and two nested models that include both collusion and supply effects.[15] In the cooperative model with no supply effects and in the nested models with both collusion and supply effects, BMR employ a bidder proximity dummy as a covariate in the maximum likelihood analysis. A measure of bidder proximity was the most obvious covariate that BMR could devise to specify collusion. The bidder proximity dummy was equal to one if the winning bidder and the second highest bidder were located in the same county and zero otherwise.

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[15] According to BMR, changes in demand coincide with shifts of the underlying value distribution. Thus, BMR control for demand effects by specifying the moments of the value distribution in their empirical models.

The bidder proximity dummy came the closest to being significant in the cooperative model with no supply effects with a t-statistic equal to 1.76. According to BMR, this suggests that a better index of bidder proximity might produce a significant improvement of the collusive model.

The most dramatic results came with the estimation of the two nested models. From the likelihood results it appears that once collusion is accounted for, changes in supply have little effect. According to BMR, collusion appears to be the major cause of non-aggressive bidding rather than changes in supply.

CHAPTER 3

THEORETICAL DEVELOPMENT OF A MULTISTAGE PROCEDURE FOR FINDING NONCOMPETITIVE BIDDING

This thesis follows and expands upon a method presented by Richard Posner to search for noncompetitive behavior (Posner 1976). The method that Posner presented, which he called the "economic" approach, has two stages. The first stage of the economic approach is to search for market areas with characteristics that allow noncompetitive behavior to thrive. The second stage is to examine market areas identified in the first stage as likely to have noncompetitive behavior to determine whether such behavior is actually present.[16]

The first stage of the economic approach serves two purposes. The primary purpose of the first stage is to allocate limited antitrust resources as efficiently as possible by guiding antitrust officials to the areas where noncompetitive behavior is most likely to occur. A second benefit of the first stage is that it allows ambiguous behavior to be evaluated as either competitive or noncompetitive. A questionable practice that occurs in a market area exhibiting competitive characteristics is not likely to be considered

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[16] This type of approach was also suggested by Hay and Kelley (1974). They did a study of horizontal price fixing cases, the objective of which was to try to find market or product characteristics common to most price fixing cases. Hay and Kelley suggested that if patterns existed, an enforcement program could be designed to investigate the most likely areas of price fixing.

noncompetitive behavior. The same behavior in a market area exhibiting noncompetitive characteristics might provide further support for the suspicion of cooperative bidding.

This thesis adapts the economic approach presented by Posner to fit the problem of searching for cooperative bidding behavior at Forest Service timber auctions. The modified economic approach presented here, called the multistage procedure, has three stages that are discussed in detail below. Briefly, the first stage of the multistage procedure is to look for market areas with characteristics that facilitate noncompetitive bidding behavior. The second stage uses statistical techniques and inter-market comparisons to identify the markets where noncompetitive bidding may be occurring most frequently. The third stage examines the markets selected from the first two stages for further evidence of noncompetitive bidding.

Using the multistage procedure is beneficial for two reasons. First, like Posner's economic approach, the multistage procedure is designed to guide limited antitrust resources to the markets with the least competitive bidding. The second benefit of the multistage procedure is that it does not rely on the Forest Service estimate of advertised or appraised price to identify noncompetitive market areas or sales as do the studies performed by Mead and Hamilton, Haynes, and Baldwin, Marshall and Richard. Therefore, unlike some previous studies, the multistage procedure may not suffer from the same potential problem of classifying sales as noncompetitive even though bidding was competitive and vice versa.

Stage One: Market Concentration

The first stage of the multistage procedure is to search for markets with characteristics that promote noncompetitive bidding behavior. In the timber industry, there are several market characteristics that could be used in this stage. These market characteristics include high market concentration, barriers to market entry, the market's antitrust record, and possibly the homogeneity of bidders.[17] Of course, these market conditions are in addition to the industry and firm conditions mentioned in the industrial organization literature summarized in Chapter 2. Firms must have a low expectation of getting caught, there should be low organizational costs to arrange explicit agreements, and cheating by fellow coalition members must be easily detected. Ideally, one would like to have measurements of all of these market characteristic variables for each market area. If such measurements were available, one could isolate the most suspicious markets based on the descriptive statistics of all of the variables. Unfortunately, obtaining measurements

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[17] It is reasonable to believe that the more homogeneous the bidders are, the more frequently noncompetitive agreements will be reached. Similar bidders are more likely to be interested in the same sales, and rather than continually competing against one another, they may arrive at mutually advantageous agreements not to compete. Unfortunately, observing *heterogeneous* bidders may indicate that bidders have successfully divided up the market so that they can avoid competing with each other. For example, one bidder might agree to bid on predominantly western hemlock sales, while another might agree to bid on predominantly Douglas Fir sales, thereby decreasing competition.

for most of the market characteristics would be extremely difficult.[18] The most practical market characteristic available for use in this thesis is market concentration.

As discussed in Chapter 2, it is easier for firms in a highly concentrated market to form cooperative agreements. Therefore, highly concentrated markets are a reasonable place to begin searching for noncompetitive behavior. Two measures of market concentration are used in this thesis. The first measure is the combined market share of the four largest firms, or the four-firm concentration ratio, and the other is the Herfindahl-Hirsch Index (HHI). The HHI is the sum of the squared market shares of the individual bidders. If a market includes ten firms, for example, with equal market shares, then the HHI equals 1000 (or 10×10^2).[19] If a market has four firms with equal market shares, the HHI equals 2500 (or 4×25^2). The lower the HHI, the less concentrated and (presumably) the more competitive the market.

According to Posner, the HHI is a better measure of market concentration than the four-firm concentration ratio because it automatically incorporates the effect of a fringe of small firms on the likelihood of cooperative bidding behavior. For example, if the four largest firms in a market each controlled 20 percent of the market, then the four-firm concentration ratio equals 80. The value of the HHI, on the other hand, depends on how

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[18] Developing a scale of bidder homogeneity would involve gathering data on all of the bidders in the market areas studied. This would be very time consuming and complete data are not likely to be available. Because there have only been three successfully prosecuted cases in the timber industry since the 1970s, looking at market areas' antitrust records does not hold much promise either.

[19] In the HHI calculation, market shares are expressed as whole numbers. For example, a bidder controlling ten percent of a market would have a market share of 10 in the HHI calculations.

the remaining 20 percent of the market is divided among the other bidders. If one firm has the remaining 20 percent of the market, the HHI equals 2000 (5×20^2). If five equal-sized firms control the remaining 20 percent of the market, the HHI equals 1700 [$(4 \times 20^2) + (5 \times 4^2)$]. The nature of the competitive fringe is reflected in the HHI, but not in the four-firm concentration ratio.

In using market concentration to search for noncompetitive behavior, one should keep in mind Demsetz's warning that markets may become concentrated through competitive behavior. It would be hasty to assume that because a market is concentrated, noncompetitive bidding necessarily exists.[20] This is one reason for using measures of market concentration as a first indicator of areas likely to contain noncompetitive bidding behavior, but not relying solely upon such measures. Additional steps are taken to search further for noncompetitive bidding behavior in stages two and three.

Stage Two: Comparisons to the Benchmark Market

The first stage provides a general idea of where noncompetitive bidding is likely to be present. The purpose of the second stage is to search further for market areas that have the highest probability of containing noncompetitive behavior. Using statistical procedures, the market that appears most competitive acts as a benchmark to which the more suspicious markets (as identified in the first stage) are compared for the purpose of identifying the least competitive markets.

[20] It should be noted that the HHI and four-firm concentration ratio only measure current market concentration and do not account for the ease of market entry.

An obvious variable to compare among Forest Service timber markets, as a measure of the degree of competitive bidding is average bid price (on either a per-acre or per-thousand board feet basis). A lower average bid price in a market area with characteristics that promote noncompetitive bidding (for example, with high concentration) would lend support to the suspicion that noncompetitive bidding is taking place in that market.

Unfortunately, simple comparisons of mean bid prices may be misleading. The observation that timber tracts may, on average, sell for less in particular markets indicates little. A lower average bid price may exist either because bidders are bidding cooperatively or because timber tracts in low-bid markets have less desirable characteristics. A simple comparison of means will not indicate which scenario is true. To be informative, any procedure for comparing mean bid prices between markets must control for differences in tract and sale characteristics. Controlling for tract and sale characteristics allows more accurate measurement of the extent to which differences in mean bid prices between forests are due to cooperative bidding behavior. Two methods are used for comparing average bid price between markets while controlling for differences in timber tract and sales characteristics.

Mean Bid Prices Calculated from Restricted Data Sets

The first method used to compare markets' mean bid prices is to restrict the sales used in the calculation of the mean bid price in each market to be similar. For example, mean bid prices may be calculated using only timber sales where the tract is composed of a minimum percentage of a specific species or where the density of timber meets a minimum requirement or where some combination of requirements is met. Using similar sales in each market to calculate mean bid prices provides more assurance that the differences in average bid price are caused by differences in bidding behavior rather than tract characteristics.

This first method, restricting sales used to calculate the mean bid price in each market to be similar, provides a good starting point for comparing competitiveness of bidding between two markets, but there are still problems with this approach. The main difficulty is choosing which of the many sales and tract characteristics to control. It would be ideal to have a sample of tracts in each market in which all of the tract and sales characteristic variables fell into predetermined ranges. Restricting the range of every tract and sale characteristic would greatly reduce the number of sales available to calculate bid price means, and the values of the bid price means would be dependent on the criterion set for each variable. Thus, this first method of comparing bid price means, though useful, logical, and straightforward, is weak because it does not control for all of the tract and sale characteristics desired.

The Price Decomposition Procedure.

The second method used in this thesis to compare bid price means between markets has the ability to control for many market characteristics simultaneously. This method, henceforth referred to as the price decomposition procedure, uses regression analysis to decompose the difference in average bid prices between markets into two components. One component accounts for the difference in mean bid prices due to differences in tract and sale characteristics between markets. The second component measures the difference in mean bid prices due to differences in the bidders' valuations of those tract and sale characteristics. The second component is useful for examining differences in bidding behavior between forests.

The price decomposition procedure has three steps. The first step is to calculate the difference in average bid prices for the two markets being compared. All of the sales in both markets are used with no restrictions on variables. The second step estimates separate bid price regressions for each market using bid price per acre as the dependent variable. The third step decomposes the difference in mean bid prices into the price difference due to differences in tract and sale characteristics and the price difference due to differences in valuations of tract and sale characteristics.

To demonstrate in more detail how the price decomposition procedure works, assume that in the first stage of the multistage procedure for finding noncompetitive bidding Market A is one of four market areas that is more prone to noncompetitive bidding. Market B, on the other hand, appears to have the most competitive bidding. Market B is the benchmark to which Market A and the other markets are compared. Once the markets are compared to Market B, they can be ranked in order of the estimated amount of competition in each market. The least competitive market(s) then will be further analyzed in stage three.

Consider the comparison of Market A to Market B using the price decomposition procedure. The first step in the price decomposition is to calculate the difference in average bid prices between Market A and Market B. The second step is to estimate separate bid price regressions for Market A and Market B. The general form of the hedonic regression equation explaining bid price is

$$P = X\beta + \epsilon, \tag{2.1}$$

where P is the winning bid price, X is an n×k matrix of observed tract and sale characteristics, β is a k×1 vector of regression coefficients, and ϵ is a random error term. The β's are interpreted as the marginal values of an additional unit of the corresponding X characteristic of the sale. Estimating two separate regressions allows the coefficients for the two markets to be different. The two regressions can be written as

$$\begin{aligned} P^A &= X^A\beta^A + \eta \\ P^B &= X^B\beta^B + \mu, \end{aligned} \tag{2.2}$$

where A and B superscripts denote markets A and B, and η and μ are random error terms. Differences in winning bid prices for markets A and B are generated from either differences in X, the matrix of tract and sale characteristics, or differences in β, the matrix of marginal valuations of tract and sale characteristics.

The bid price regressions can be used to compare markets by recalling that in an OLS regression, the estimated relationship passes through the means of the dependent and independent variables. Mathematically,

$$\begin{aligned} \bar{P}^A &= \bar{X}^A b^A \\ \bar{P}^B &= \bar{X}^B b^B, \end{aligned} \tag{2.3}$$

where $\bar{P}^A$ and $\bar{P}^B$ are the mean bid prices for Market A and Market B, $\bar{X}^A$ and $\bar{X}^B$ are 1×k row vectors of variable means for the respective X matrices, and b^A and b^B are the OLS estimators of β^A and β^B. The difference in mean bid prices, or price differential (PD), calculated in the first step of the price decomposition procedure can now be written as

$$PD = \bar{P}^A - \bar{P}^B = \bar{X}^A b^A - \bar{X}^B b^B. \tag{2.4}$$

Adding and subtracting $\bar{X}^A b^B$ to the right-hand side of equation (1) and rearranging gives

$$PD = \left(\bar{X}^A - \bar{X}^B\right) b^B + \bar{X}^A \left(b^A - b^B\right) = DDC + DDVC, \tag{2.5}$$

where DDC is the component of the difference in mean bid prices due to differences in characteristics of timber tracts and sales between Markets A and B $\left(\bar{X}^A - \bar{X}^B\right)$ weighted by the estimate of the valuations of those characteristics from Market B $\left(b^B\right)$ and DDVC is the component of the price differential due to differences in valuations of the tract and sale characteristics between the two markets $\left(b^A - b^B\right)$ weighted by the average level of characteristics of a Market A tract $\left(\bar{X}^A\right)$.

Alternatively we can add and subtract $\bar{X}^B b^A$ to the right-hand side of equation (1) giving

$$PD = \left(\bar{X}^A - \bar{X}^B\right) b^A + \bar{X}^B \left(b^A - b^B\right) = DDC' + DDVC', \tag{2.6}$$

where DDC' is a measure of the component of the price differential due to differences in tract and sale characteristics between markets using the estimated valuations of those characteristics from Market B as weights and DDVC' is the measure of the component of the price differential due to differences in valuations of the characteristics between markets weighted by the average Market A tract. The difference in mean bid prices (PD) is the same in equations 2.5 and 2.6, so DDC + DDVC must be equal to DDC' + DDVC'. The only difference between equations (2.5) and (2.6) are the alternative weights of the two components.

For the purpose of ranking the markets according to estimated degree of noncompetitive bidding, DDVC and DDVC' are the measures of interest. DDC and DDC' provide estimates of which market has "better" timber tracts but are not useful in the search for cooperative bidding. Because the difference in mean bid prices due to differences in tract and sale characteristics between markets has been accounted for by DDC and DDC', DDVC and DDVC' will include all things other than tract and sale characteristics that impact estimated valuation—including difference in competitiveness of bidding behavior. Following similar comparisons of the other markets to Market B, the market(s) selected for evaluation in stage three is (are) the market(s) with the lowest differences due to valuation(s) of tract and sale characteristics (*i.e.*, the negative values of DDVC and DDVC' that are the largest in absolute value) when compared to Market B.

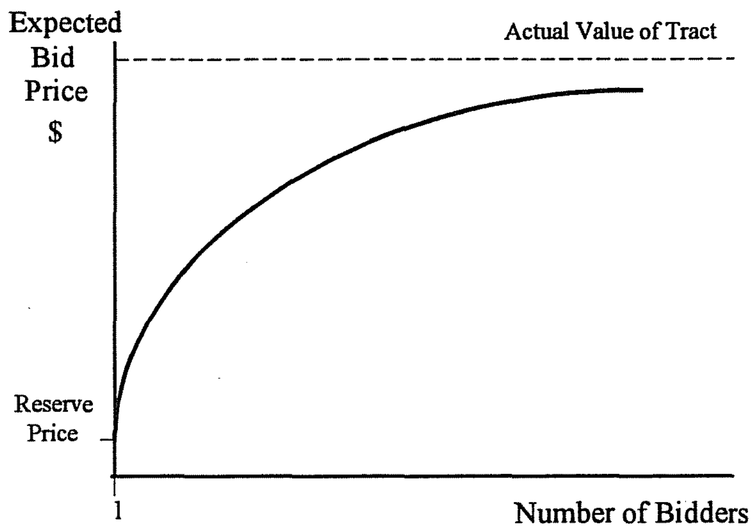
Stage Three: Regular versus Nonregular Bidders

In this stage the markets that appear the least competitive, as determined by the first two stages of the multistage procedure, are examined for further evidence of cooperative bidding. A brief review and application of auction literature from Chapter 2 is presented, expanded upon, and used to develop a bidding model. The bidding model is then used to formulate a testable hypothesis regarding the presence cooperative bidding. (The reader may wish to refer back to Chapter 2 for a more detailed discussion of the issues reviewed below.)

It was revealed in the auction literature of the previous chapter that, assuming bidders are homogeneous and bidding competitively, the price paid by the winning bidder in any of four auction mechanisms (first-price sealed-bid, second-price sealed-bid, English or Dutch), under the independent-private-values (IPV) auction classification, is the expected value of the second highest bidder's valuation of the object, in other words, the expected value of the second order statistic. As the number of homogeneous competitive bidders at an IPV auction increases, the expected bid price increases at a decreasing rate, and as the number of bidders approaches infinity the expected bid asymptotically approaches the highest valuation of the object being auctioned. In the case of a common value auction, as the number of bidders increases, the expected bid price asymptotically approaches the actual value of the object being auctioned. Figure 2 shows the relationship between the number of homogeneous, competitive bidders and expected bid price at

Forest Service timber auctions. To take into account the common value aspect of timber auctions a dotted line representing the actual value of the tract is included in Figure 2.

Figure 2. The Relationship of the Number of Bidders to Expected Bid Price Assuming Homogeneous Bidders and Competitive Bidding.



If the assumption of homogeneous bidders is relaxed, the relationship of heterogeneous bidders to expected bid price can be examined. Assume that there are two groups of bidders. Within each group the bidders are homogeneous but the groups differ systematically for various reasons, including differences in operating costs.

Within the context of Forest Service timber auctions, one group of bidders may have a cost disadvantage due, for example, to having significantly higher hauling costs than the other group. The bidders from the two groups will draw their estimates of the value of timber sales from different probability distributions. For a given number of bidders (number of bidders > 2), the cost-disadvantaged group will have a lower second order statistic than the cost-advantaged group, and therefore the expected bid price for the group with a cost disadvantage will be lower (and in common value auctions, the expected value of the tract will be lower). The expected bid price will be lower for the group of bidders with the cost disadvantage because of the heterogeneity of the cost structures of the two groups, not because they are bidding cooperatively. Figure 3 shows how Figure 2 is altered when there are two different groups of bidders—in this case bidders with or without a cost disadvantage.[21]

Now relax the assumption of competitive bidding by allowing for a group of bidders that bids cooperatively. These bidders may be from any group of bidders and they may have a relative cost advantage or disadvantage. If these bidders agree not to compete with one another, then an increase in the number of cooperative bidders at an auction has no impact on bid price. The relationship of the number of bidders that are bidding cooperatively to expected bid price is represented in Figure 3 by the horizontal line at the reserve price.

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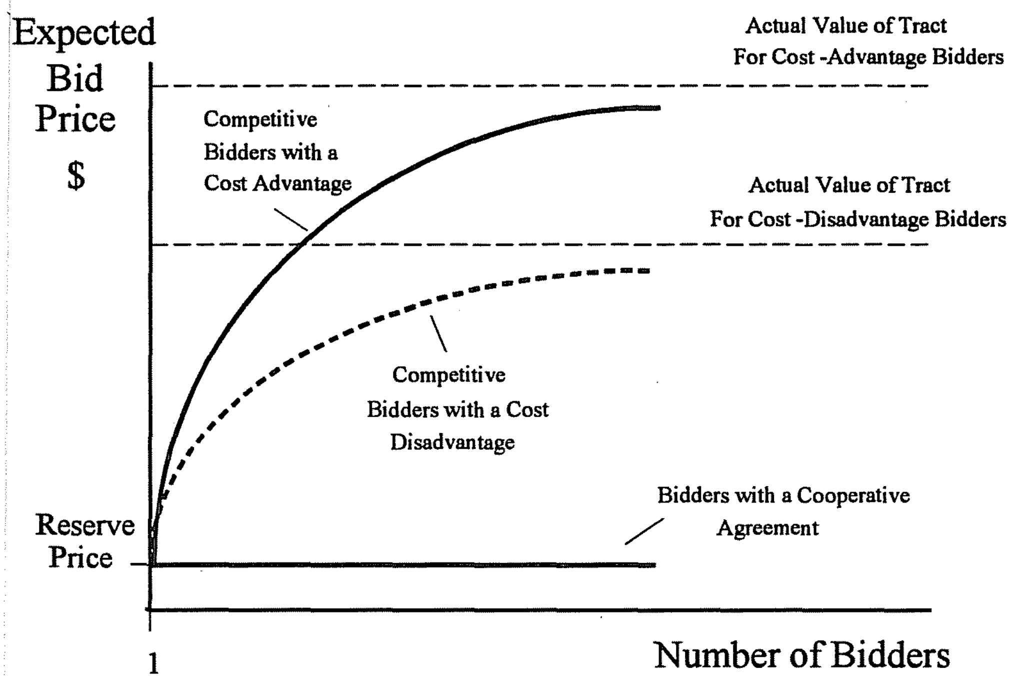
[21] The situation just described involving only two heterogeneous groups of bidders can be extended to N heterogeneous groups of bidders with homogeneous bidders in each group. Again, the number of bidders in each group is immaterial; there may be many bidders or only one bidder. If N heterogeneous groups of bidders exist, it can be expected that each of the N groups will develop its own expected value of the tract based on the group's relevant characteristics, such as the group's cost function.

Figure 3. Three Possible Relationships Between Number of Bidders and Expected Bid Price.



Three different relationships between the number of bidders and the expected bid price are shown in Figure 3. To summarize, first there is the case of completely homogeneous bidders who bid competitively. Second, there may be (competitive) cost-disadvantaged bidders who have a lower actual value of the tract and thus the expected bid price is lower for these bidders than for other bidders. Finally, bidders may bid cooperatively, meaning additional bidders have no impact on expected bid price. Because any or all of the three types of bidders may be present at auctions, it is important to know what kind of bidders are likely to be in each group, how bidders from different groups will interact, and what happens to expected bid price when more than one group is present at an auction. From this knowledge a bidding behavior model can be developed to test the actual nature of the bidding behavior in suspicious forests.

Cost-Advantage versus Cost-Disadvantage Bidders

A bidder who has a cost advantage in a particular market is expected to exploit his advantage by bidding frequently in that market and bidding less frequently in other markets where he has no cost advantage. Therefore if a bidder is observed to bid relatively frequently in a market area, such a "regular" bidder has a cost advantage in that area. Similarly, a "nonregular" bidder who bids infrequently in a given market area, has a cost disadvantage in that area.

Cooperative Bidders

It is the goal of cooperative bidders to receive positive profits by paying a winning bid price (for timber) less than the fair market value. The reward to a cooperative coalition of bidders will increase as more of the bidders with the highest valuations of a timber sale agree not to compete. If regular bidders are believed to have higher valuations of timber sales (due to their cost advantage) than nonregular bidders, they are more likely to be involved in cooperative bidding than nonregular bidders. A second reason regular bidders are more likely to participate in cooperative bidding is that regular bidders come into contact with one another more frequently than nonregular bidders. Contact allows bidders to better judge who might be willing to enter into a noncompetitive agreement. Contact also allows bidders to figure out who will bid at a sale and who will likely win, facilitating the formation of tacit agreements.

The Bidding Model

It is now possible to build a more complete model of bidding behavior and its impact on expected bid price. Assume there are R regular bidders and N nonregular bidders for a total of R+N bidders in a market area. The R regular bidders have a cost advantage over the nonregular bidders and may or may not practice cooperative bidding. If the R regular bidders bid competitively, then an increase in the number of regular bidders at an auction will increase the expected bid price at a decreasing rate, as shown in Figure 4 by the "competitive bidders with a cost advantage" curve. If in addition to the R regular bidders, some of the N competitive nonregular bidders bid at the auction they will increase the expected bid price, but by less than if they were additional regular bidders. The additional N bidders will have less of an impact than would additional regular bidders because the nonregular bidders have a lower expected value of the tract as demonstrated in Figure 3. The impact of the additional nonregular bidders, given R regular bidders, is shown in Figure 4 as the dotted adjustment to the curve that represents bidders with a cost advantage. The dotted section of the curve is flatter than if all of the bidders had been regular bidders, causing a kink at R.[22]

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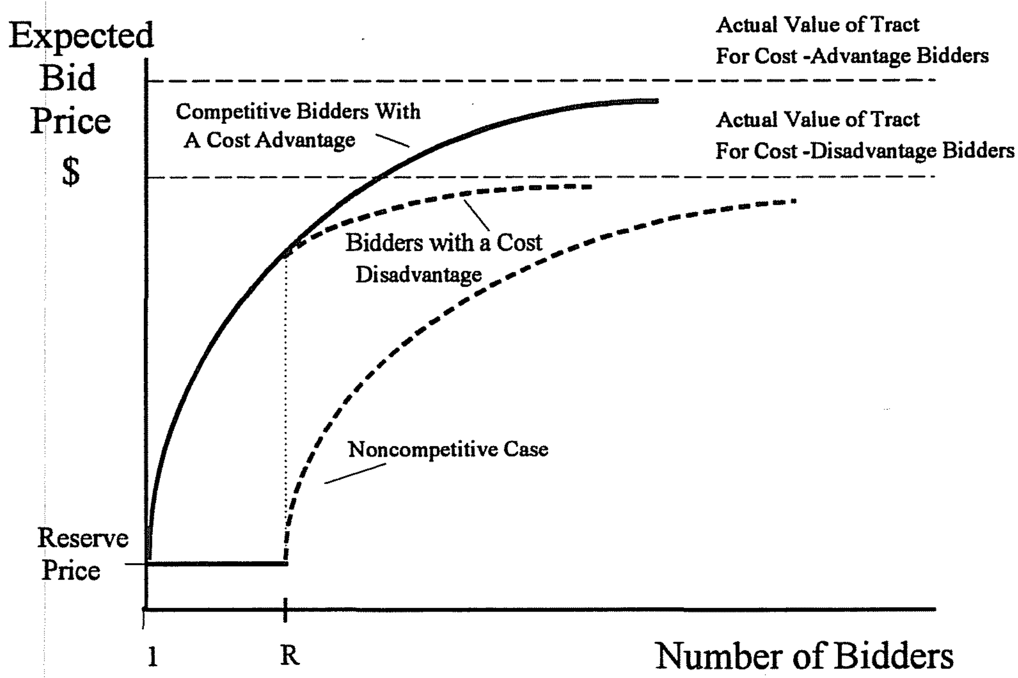
[22] The location of the kink in Figure 4 may vary depending on the number of R regular bidders.

Figure 4. How Combinations of Different Types of Bidders Affect Expected Bid Price.



The relationship between number of bidders and expected bid price is quite different if the R regular bidders bid cooperatively with one another. In the case of perfect cooperation, the R regular bidders do not compete, so in a sense additional bidders act like one bidder. This means there will be no change in expected bid price as additional R regular bidders attend an auction.[23] The N nonregular bidders still bid competitively, so when nonregular bidders are added to an auction where regular bidders are bidding cooperatively the expected bid price increases. It is assumed that when a nonregular bidder is added to an auction the cooperative regular bidders continue to cooperate with

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[23] If cooperation among bidders is imperfect, expected bid price may increase slightly between 1 and R bidders.

one another but bid competitively as a group against the nonregular bidder. This scenario is represented by the "noncompetitive case" curve in Figure 4. The "noncompetitive case" curve is kinked upward at R, the last regular bidder.[24]

Testing for Noncompetitive Bidding

From Figure 4 it is clear how the presence of cooperative bidding can be detected empirically. The key lies in the impact on expected bid price of regular versus nonregular bidders. In both cases where bidders bid competitively, the case with homogeneous bidders and the case with heterogeneous bidders, the bid function is strictly increasing with the number of bidders. When bidders bid competitively, nonregular bidders have an impact on expected bid price that is less than the impact on expected bid price of regular bidders. When regular bidders bid cooperatively, nonregular bidders have an impact on expected bid price that is greater than the impact of the regular bidders. Thus, the test to determine whether cooperative bidding is occurring in a particular market is to see whether the impact on expected bid price of additional nonregular bidders is greater than or less than the impact of additional regular bidders. If the nonregular bidders have a greater impact on expected bid price, then the results suggest cooperative bidding is taking place.

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[24] In actuality the curve does not increase until R+1, where the first nonregular bidders is added. Because the number of bidders is an integer, to be accurate all of the curves should be plotted as points, but is it easier to see the relationships between number of bidders and expected bid price if the functions are drawn continuously.

Nonlinear Regression Specification. A nonlinear regression specification explaining bid price is used to compare nonregular with regular bidders' impact on expected bid price.[25] Normally in a regression explaining bid price, number of bidders (or a transformation of number of bidders) is used as a regressor. In this thesis, in order to separate the effects of regular versus nonregular bidders, number of bidders is proxied by $R + \lambda N$ and entered into the regression equation as $(R + \lambda N)^{\gamma}$. The coefficient of nonregular bidders (λ) distinguishes the impact of additional nonregular bidders on expected bid price from the impact of additional regular bidders. The flexibility of nonlinear estimation is useful because it is assumed the expected bid price function is concave in the number of bidders (assuming bidders bid competitively), but the exact value of the exponent, γ, on number of bidders is unknown. The nonlinear regression specification is

$$Bid\,Price = \alpha_0 + \beta_0(R + \lambda N)^{\gamma} + \sum_{i=1}^{k} \beta_i X_i + \epsilon, \tag{2.7}$$

where R is the number of regular bidders at a sale, N is the number of nonregular bidders at a sale, X is an $n \times k$ matrix of other tract and sales characteristics used to estimate bid price, γ specifies the curvature of the bid function (which, from auction theory, should be less than one), ϵ is a random error term, α_0 is an intercept term and the β's are regression coefficients to be estimated. The marginal impacts on bid price of the number of regular and nonregular bidders are

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[25] How bidders are classified empirically as regular or nonregular is discussed in the next chapter.

$$\frac{\partial Bid\,Price}{\partial R} = \gamma\beta_1(R + \lambda N)^{\gamma - 1}$$

$$\frac{\partial Bid\,Price}{\partial N} = \lambda\gamma\beta_1(R + \lambda N)^{\gamma - 1}.$$

The only difference between the marginal impact of regular and nonregular bidders is λ. If λ is less than one, then an additional nonregular bidder has less of an impact on bid price than an additional regular bidder, indicating competitive bidding. If λ equals one, an additional nonregular bidder has an impact on bid price equal to that of an additional regular bidder again suggesting bidding is competitive. If λ is greater than one, an additional nonregular bidder has a greater impact on bid price than an additional regular bidder, indicating cooperative bidding. In Chapter 4, equation 2.7 is estimated for each market selected from the first two stages of the multistage procedure and the estimates of λ are examined for further evidence of cooperative bidding in those markets.

Alternative Linear Regression Specifications. Linear regression specifications are not as flexible as the nonlinear specification, but they may provide additional information when nonlinear results are ambiguous. Two linear regressions are employed for this purpose in this thesis. The first linear regression includes the untransformed number of regular and nonregular bidders in the hedonic regression explaining bid price. Because the impact of nonregular bidders on bid price may depend on the number of regular bidders already present, a multiplicative interaction term between regular and nonregular bidders is included in the regression. The first linear regression specification to be estimated by OLS is

$$Bid\,Price = \beta_0 + \beta_1 R + \beta_2 N + \beta_3 RN + \sum_{i=4}^{k} \beta_i X_i + \epsilon, \tag{2.8}$$

where R, N, X, the β's, and ϵ are as defined above. The marginal changes in bid price with respect to regular and nonregular bidders are

$$\frac{\partial Bid\,Price}{\partial R} = \beta_1 + \beta_3 N$$

$$\frac{\partial Bid\,Price}{\partial N} = \beta_2 + \beta_3 R.$$

A change in bid price with respect to nonregular bidders that is greater than the change in bid price with respect to regular bidders, or $(\beta_1 + \beta_3 N) > (\beta_2 + \beta_3 R)$, is an indication that cooperative bidding is occurring.

In the second linear regression specification the total number of bidders and the percentage of nonregular bidders are included as regressors. The second linear regression specification is

$$Bid\,Price = \beta_0 + \beta_1 BIDDERS + \beta_2 PCTN + \sum_{i=3}^{k} \beta_i X_i + \epsilon \tag{2.9}$$

where BIDDERS is the total number of bidders at a sale, PCTN is the percentage of bidders defined as nonregular at a sale, and X, the β's, and ϵ are as defined above.

Though the number of regular bidders is not directly specified in Equation 2.9, the specification allows one to change the percentage of nonregular bidders while holding the number of bidders constant, which in effect alters the ratio of regular bidders to nonregular bidders. If PCTN is increased, holding the total number of bidders constant, then regular bidders are being replaced by nonregular bidders. If nonregular bidders bid more competitively than regular bidders, the coefficient of PCTN, β_2, will be positive indicating cooperative bidding by the regular bidders.

This completes the discussion of the theories involved in each stage of the multistage procedure. In Chapter 4 the multistage procedure is applied empirically to Forest Service timber auction data.

CHAPTER 4

EMPIRICAL RESULTS OF THE MULTISTAGE PROCEDURE

In this chapter the multistage procedure presented in Chapter 3 is implemented empirically using Forest Service auction data. In the first stage, measures of market concentration are used to provide an indication of where cooperative bidding may be prevalent and to identify the market to be used as a benchmark in the second stage. In the second stage a simple comparison of mean bid prices is made between markets and the price decomposition procedure is performed to identify the markets to be examined further. In the third stage, to attempt to determine whether cooperative bidding is occurring in the markets selected from the second stage, the relative impact of regular versus nonregular bidders on bid price is examined. This is accomplished using a nonlinear regression specification and two linear regression specifications.

Data Used in the Application of the Multistage Procedure

The multistage procedure is applied to two forested areas in Forest Service Region 6 (Washington and Oregon). Region 6 is of interest because most of the nation's timber comes from this Region, specifically west of the Cascade Mountains, and antitrust cases have been successfully prosecuted there. The analyses of the two forested areas are performed separately. One analysis involves five forests that run from north to south along the western edge of the Cascade Mountains. From north to south these "westside forests" are Mt. Baker/Snoqualmie, Gifford Pinchot, Mt. Hood, Willamette, and Umpqua. The second analysis involves four forests that lie in the eastern half of Washington and Oregon. These "eastside forests" from east to west are Wallowa/Whitman, Umatilla, Malheur, and Ochoco.

The two groups of forests were chosen for two reasons. First, both groups of forests cover a large territory (so fewer potentially noncompetitive markets escape detection) but not so large that empirical study is unmanageable. Second, the two groups of forests have different market characteristics. The timber in the westside forests is dense and primarily Douglas fir and hemlock, which leads to markets with many mills and a reputation for competitive bidding. The eastside forests are mostly Ponderosa pine and much less dense, leading to fewer mills and possibly less competitive bidding.[26]

The individual forests serve as the market areas examined in the multistage procedure. The data allow analysis on either a per-forest or a per-ranger district basis.[27] Preliminary analysis of the data, however, revealed that bidders tend to bid in more than one district (often three or four), so districts are too small to be reasonable market areas.

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[26] The extreme difference between eastside and westside species compositions makes inter-group comparisons empirically difficult. The regression analysis and mean bid price comparisons in stages two and three are greatly simplified if market areas having different species compositions are analyzed separately. Accordingly, the steps of the multistage procedure will be applied separately to the two groups of forests. If the two groups were more similar in species composition, all nine forests could be analyzed together and compared directly.

[27] Ranger districts are subdivisions of a forest and in Region 6 the average number of districts per forest is approximately five.

Another reason for choosing forests rather than districts to define markets is partially for convenience. To analyze the market areas covered by the nine forests in the data set on a district level would involve applying the multistage procedure to approximately forty-five districts.

Empirical Results of the First Stage of the Multistage Procedure

Recall from Chapter 3 that the first stage of the multistage procedure is to look for market areas (in this case forests) with characteristics that foster noncompetitive bidding. The most practical market characteristic available for the study of timber auctions is market concentration. Highly concentrated markets are theoretically more likely to have noncompetitive bidding. Two measures of market concentration are the four-firm concentration ratio and the Herfindahl-Hirsch Index (HHI.). The results of using each of these methods are presented below for both the westside and eastside forests.

Market Concentration Measurements of the Westside Forests

The HHI's and four-firm concentration ratios are calculated for each of the westside forests. Because of the possibility that a bidder may win an auction in one year and then not bid again for several years, the HHI's and four-firm concentration ratios are three-year moving calculations to account for the infrequency of bidding by active market participants. In these calculations, an individual bidder's market share is defined as the proportion of the total value of timber sold by the Forest Service that is won by the bidder in any three-year period. The plots of the HHI"s and four-firm concentration ratios for the five forests west of the Cascades are shown in Figures 5 and 6. Because the HHI and four-firm concentration ratios are three-year moving calculations, in the plots the points at "75" correspond to data from 1973–75, the points at "76" correspond to data from 1974–76, and so on.[28]

Figures 5 and 6 indicate that the plots of the four-firm concentration ratios and the HHI's are quite similar. In both sets of plots, the forests seem to be distinguishable until approximately 1984. After that time, with the exception of Willamette whose HHI's and four-firm concentration ratios remain below the other forests, the forests become intermingled. This bottleneck shape of the plots may be a reflection of dramatic changes that took place in the timber industry around that time, namely the crash of the timber market that occurred around 1980–81, and the subsequent reformation of timber contracts regarding payment for timber and indexing of sales.[29]

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[28] The Justice Department *Merger Guidelines* issued in 1984 suggest what HHI values are evidence that a market is concentrated. The *Merger Guidelines* indicate that the government generally will not challenge a merger between two firms if the postmerger HHI in the industry is below 1000. If the postmerger HHI is between 1000 and 1800, the merger will be challenged if the resulting change in the HHI is greater than or equal to 100 points. If the postmerger HHI is greater than 1800, then a merger generally will be challenged if resulting change in the HHI is more than 50 points (Carlton and Perloff 1990).

[29] In the late 1970s timber prices increased dramatically (possibly due in part to the speculative nature of Forest Service timber contracts at the time) and then declined rapidly in the early 1980s. Many timber contract buyers who had agreed to pay for timber at overly inflated prices faced insolvency. The timber contract holders lobbied Congress and in October 1984 the Federal Timber Contract Payment Modifications Act was passed. This Act was also known as the "Timber Contract Buy-Out" because it permitted qualifying timber contract holders to be absolved of their liabilities once they paid a specified buy-out charge (Mattey 1990). Following the crash in the timber industry, the Forest Service instituted many contract and policy changes to help prevent future crashes. For details see Morton and Rideout (1993).

Figure 5

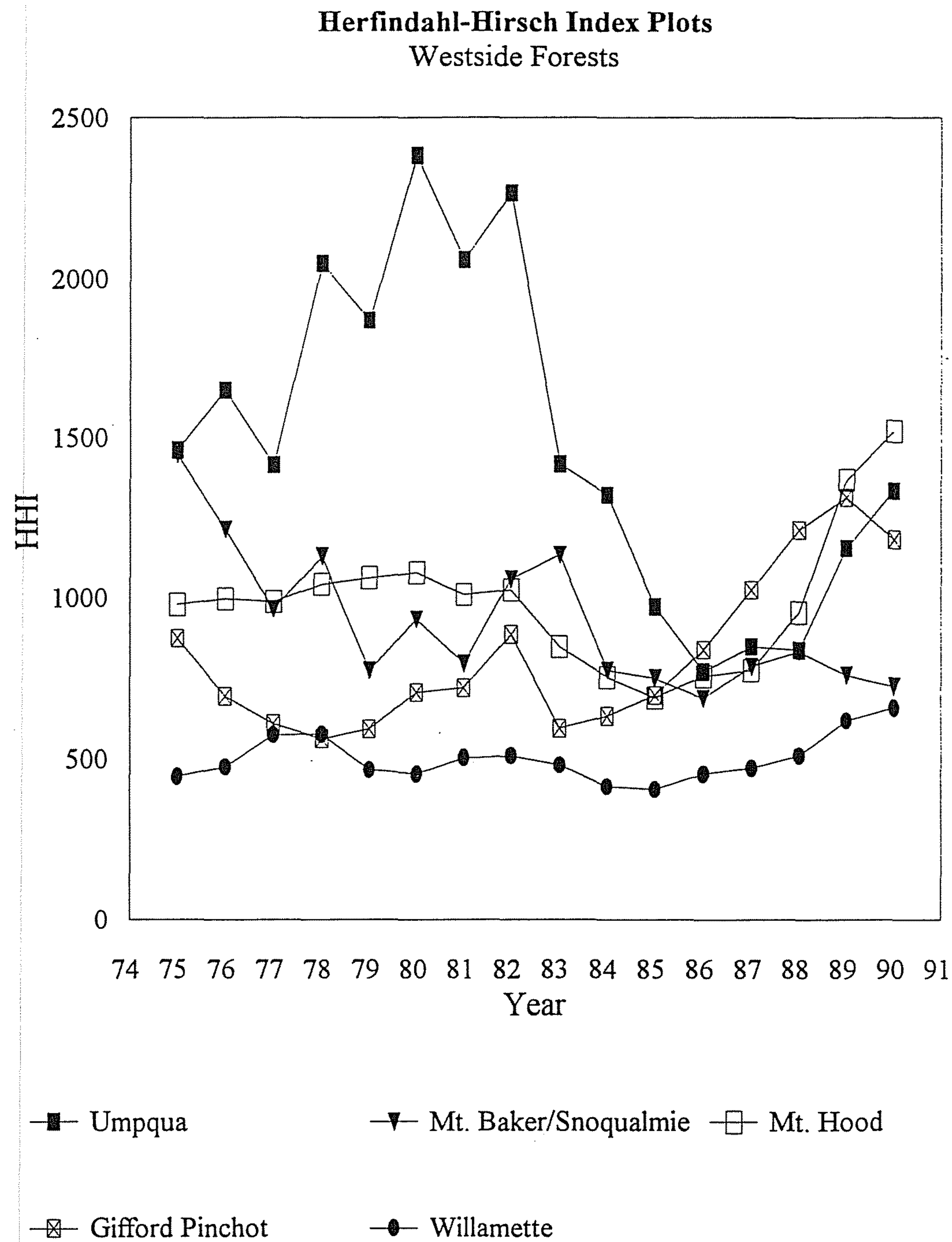
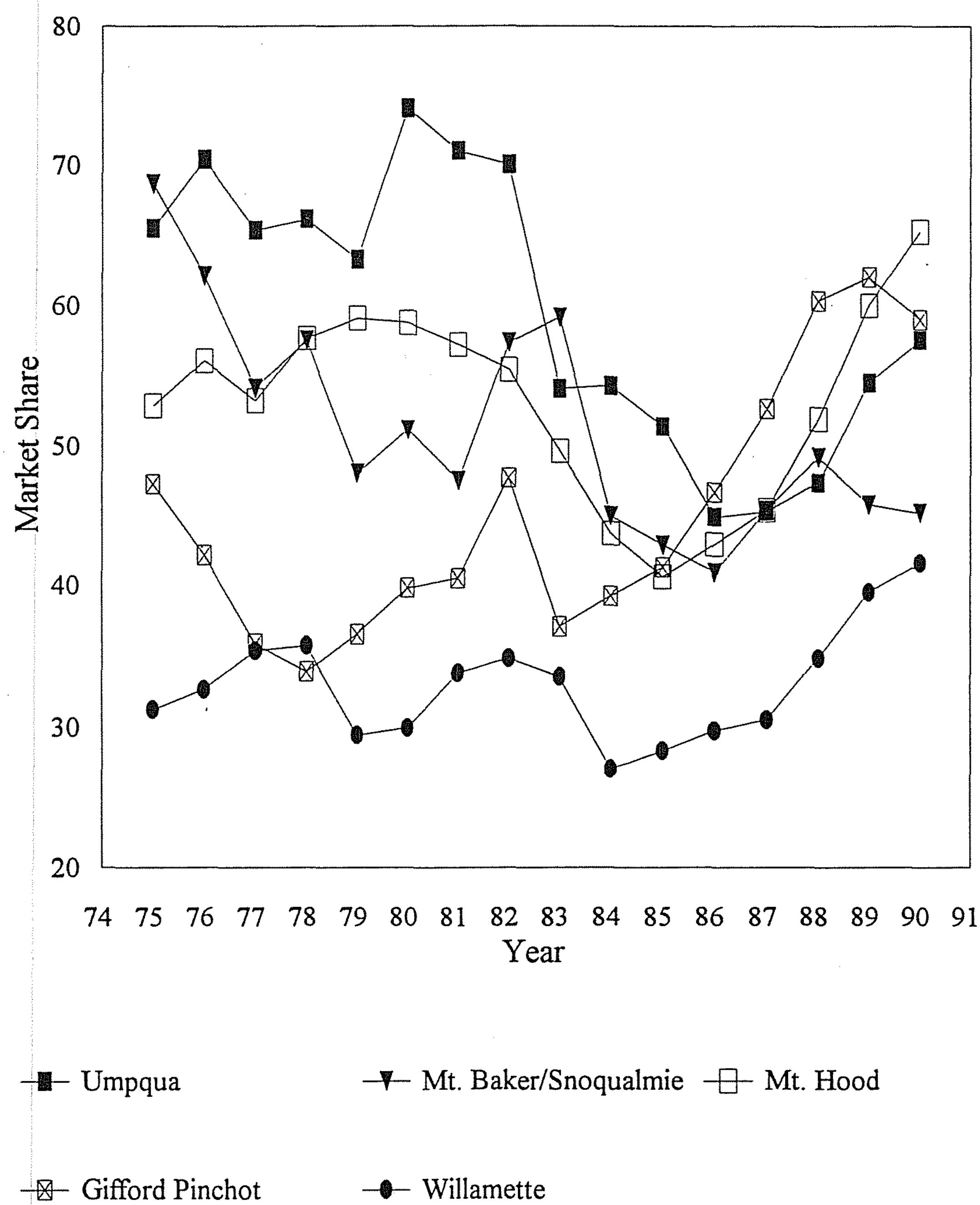

Herfindahl-Hirsch Index Plots
Westside Forests
2500
2000
1500
1000
500
0
HHI
74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
Year
Umpqua
Mt. Baker/Snoqualmie
Mt. Hood
Gifford Pinchot
Willamette

Figure 6

Four-Firm Concentration Ratio Plots
Westside Forests



An examination of the HHI and four-firm concentration ratio plots for the westside forests reveals that Willamette's HHI's and four-firm concentration ratios are constantly lower than the other forests' concentration measures, except for a single year when HHI's for Willamette and Gifford Pinchot are roughly equal. Although the Umpqua Forest stands out on the HHI plot as having extremely high HHI's relative to the other forests for the years prior to 1985, Umpqua does not look as strikingly different in the four-firm concentration ratio plots. Without knowing anything else about these two forests, one may hypothesize that Willamette contains the most competitive bidding in the westside group of forests and Umpqua appears to be the most susceptible to cooperative bidding.[30] In stage two of the multistage procedure Umpqua, Mt. Hood, Gifford Pinchot and Mt. Baker/Snoqualmie will be compared to Willamette via mean bid prices (controlling for tract and sale characteristics) and the price decomposition procedure to determine which forests are likely to contain cooperative bidding.

Market Concentration
Measurements of the Eastside Forests

The four-firm concentration ratio and HHI measurements for the eastside forest are calculated in the same manner as the westside forests' measurements and the plots are presented in Figures 7 and 8. As with the westside forests, the HHI and four-firm

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[30] A Forest Service contact suggested that one possible explanation for the extremely high HHI's for Umpqua is that a larger than normal proportion of sales in Umpqua took place in one ranger district (the Tiller district) during 1973–81. Because bidding was much more localized during that period of time, a few bidders won more sales than usual simply because the sales were located in their district. This concentration of sale location may cause the concentration estimates for Umpqua to be higher than if sale locations had been more widely dispersed.

concentration ratio plots look very similar in many respects. In both plots, for the years prior to 1981 the forests are more distinguishable, with Ochoco lying below the other forests, and Malheur having the highest concentration measurements. There also seems to be a grouping of the forests—Malheur and Wallowa/Whitman appear to be different from Ochoco and Umatilla.

Like the westside forest plots, the eastside forest plots indicate that dramatic market changes began occurring in the early 1980s. On the HHI plots around 1981 the concentration measurements for Malheur and Umatilla change noticeably. Malheur's concentration ratios plummet while Wallowa/Whitman's skyrocket. Later, around 1985, the concentration measures converge to the bottleneck shape seen in the westside forest plots. Whatever market phenomena were occurring (possibly timber crash related) seem to have affected both the eastside and westside forests at approximately the same time and in a similar manner.

Westside and Eastside Forests

Comparing the vertical axes of Figures 5 and 7, and Figures 6 and 8, we see that as a group the eastside forests are more concentrated than the westside forests. The differences in concentration between eastside and westside forests may stem from the structural differences in costs (as mentioned in Chapter 2) due, for example, to differences in the relative density of timber and hauling distances.

Figure 7

Herfindahl-Hirsch Index Plots
Eastside Forests

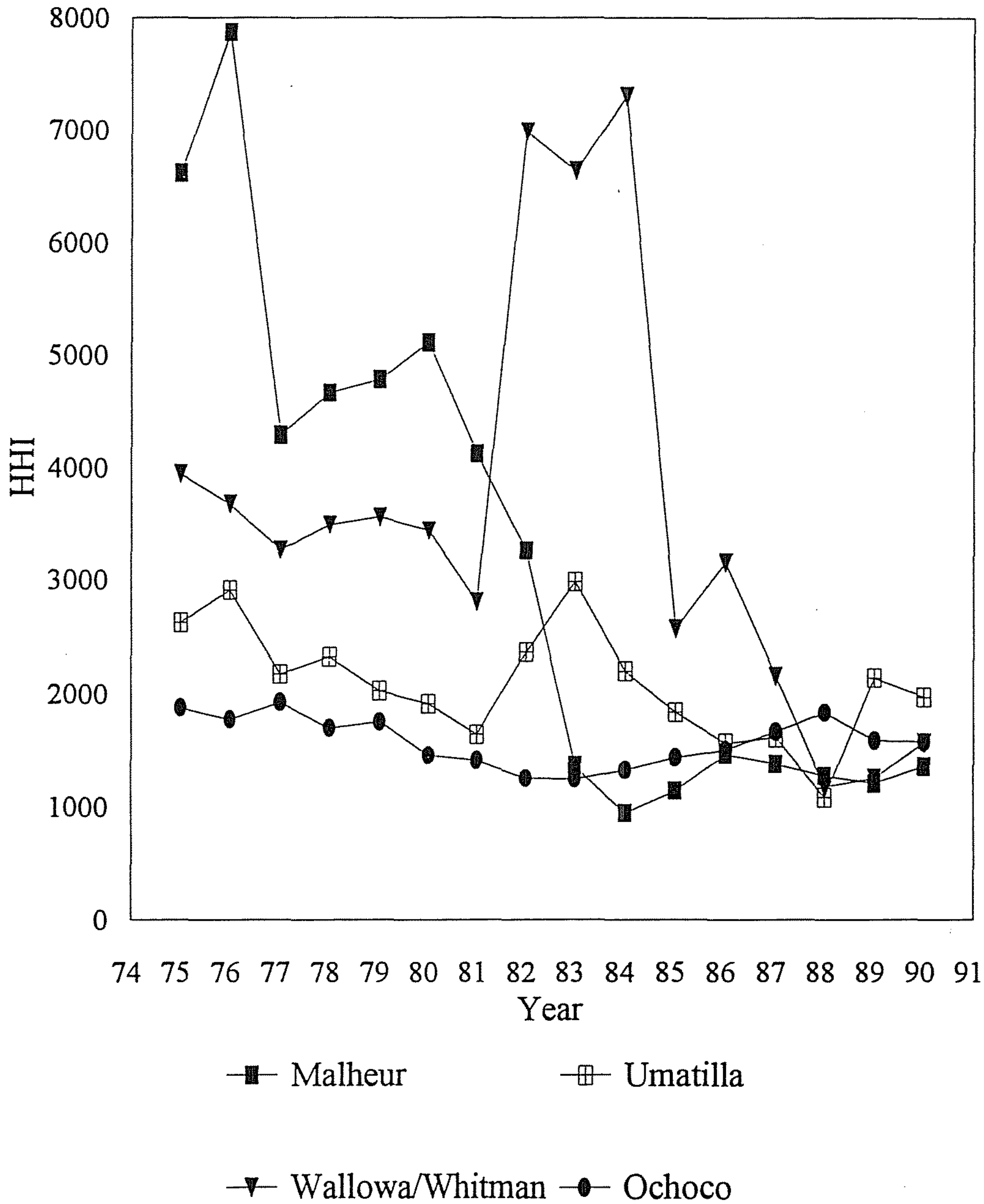
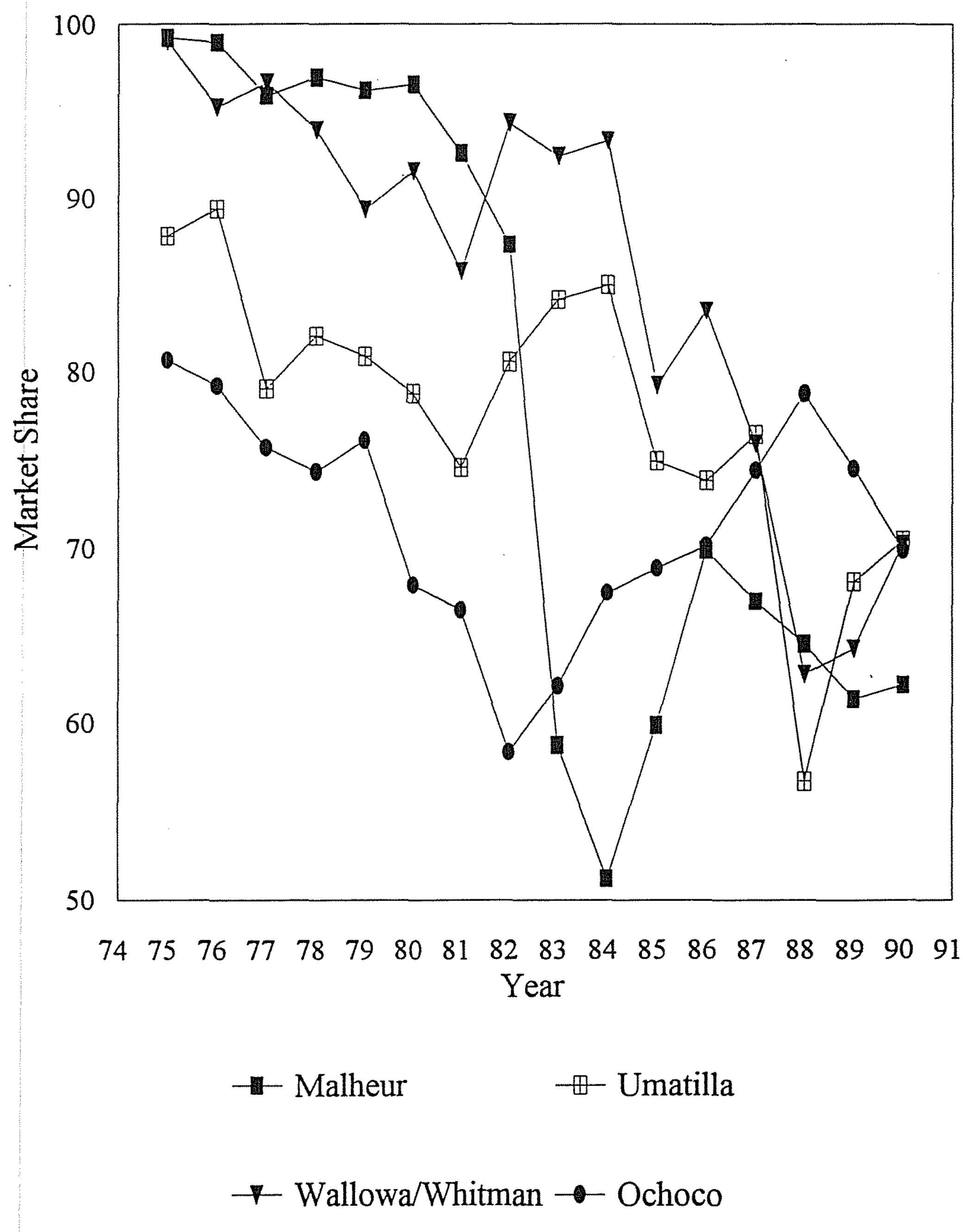


Figure 8
Four-Firm Concentration Ratio Plots
Eastside Forests



Based on the market concentration plots, the most stable period for the timber industry, within the time spanned by the data set, is 1973–81 for the westside forests and 1973–80 for the eastside forests (the early years). The years from 1981 or 1980 to 1985 are the years of the timber crash and contract restructuring by the Forest Service (the middle years). The years 1985–90 are the years following the upheaval in the timber industry (the later years). Because of all the market chaos during the middle years these years are not used in the remainder of the empirical analysis.

The early years and the later years are compared to see if these periods are structurally different from one another. This is done by running a regression explaining bid price per acre using a dummy variable to distinguish the later years from the early years.[31] The dummy variable is multiplicatively interacted with all of the regression variables and is also included as an intercept shifter. Variables used in this regression and later regression analyses are presented below in Table 1. A joint F-test shows that the later years are significantly different from the early years. Therefore the early years

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[31] The regression is run separately for eastside and westside forests.

(1973–81 for the westside forests and 1973–80 for the eastside forests) are analyzed separately from the later years.[32]

Separate regression results for the early and later years are presented below in Tables 2a and 2b for the westside forests and in Tables 3a and 3b for the eastside forests. If bidders believe that the Forest Service accurately estimates costs (*e.g.*, STMPTRCK, HAULCOSTS, ENVIRON, TEMPROADS), the estimated coefficients of the cost variables will equal negative one. If bidders believe the Forest Service underestimates costs, the cost variable coefficients will be less than negative one. If bidders believe the Forest Service overestimates costs, the cost variable coefficients will be greater than negative one. The coefficients of the volume of species variables are estimates of the value of an additional thousand board feet (mbf) of the given species. Based on the Tables 2a–3b, Ponderosa pine is the most valuable species per unit in the eastside forests and cedar is the most valuable species per unit in the westside forests.

[32] In a regression equation explaining bid price per acre, multiplicative interactive dummy variables for early years and later years are included in the regression to separate the data into three time periods. The middle years 1982–84 were years in which many contract revisions took place following the crash of 1980–81. The data are separated into three timber periods to account for structural market changes due to the timber market crash and contract changes. Using the data for either all of Zone 2 (the western half) of Region 6 or only the five forests along the western side of the Cascades, the adjusted R-square is approximately 0.80. Joint F-tests show that the "early years" variables and "later years" variables are significantly different from zero, indicating structural market differences among the early, middle, and later years of data.

Table 1. Definitions of Variables Used in Regression Analyses.

Variable Name	Definition
BID PRICE	Winning bid price (per acre)
NBIDDERS	Number of bidders
ORALAUCT	Dummy variable equal to one if auction is oral, zero otherwise
ACRES	Number of acres per sale.
CLENGTH	Contract length (in days)
LUMPSUM	Dummy variable to distinguish "lump sum" sales from scale sales
PRICEMETH	Dummy variable to distinguish escalated sales from flat rate sales
SALVDUM	Dummy variable equal to one if sales are salvage sales, zero otherwise
SBADUM	Dummy variable equal to one if sales are SBA set-aside, zero otherwise
BIDYEAR	Trend variable to distinguish the year in which a tract was auctioned
QUARTER1	Distinguishes sales auctioned in January, February, or March
QUARTER2	Distinguishes sales auctioned in April, May or June
QUARTER3	Distinguishes sales auctioned in July August, or September
ENVIRON	Environmental costs (per acre) of harvesting timber
STMPTRCK	Stump-to-Truck costs (per acre) of harvesting timber
HAULCOSTS	Hauling costs (per acre) of harvesting timber
TEMPROADS	Temporary road costs (per acre)
PCL	Purchaser credit limit (per acre); Acts as a proxy for permanent road costs
HAULMILES	Hauling distance (in miles)
VOLOTHER	Volume of "other" species (mbf per acre). Equals total volume minus volume of major species specified in the regression
CPAM	Volume of cull per acre material (mbf per acre)
DFPRICE*	Monthly Douglas fir price series ($ per mbf)
DFIRWEST*	Volume of western Douglas fir (mbf per acre)
WESTHEM*	Volume of western hemlock (mbf per acre)
CEDARS*	Volume of cedars (mbf per acre)
OTHERFIRS*	Volume of "other" firs (mbf per acre); firs other than Douglas fir
PPPRICE†	Monthly Ponderosa pine price series ($ per mbf)
DFIREAST†	Volume of eastern Douglas fir (mbf per acre)
PONDPINE†	Volume of Ponderosa pine (mbf per acre)
WHITEFIR†	Volume of white fir (mbf per acre)
JEFFPOND†‡	Volume of Jeffrey or Ponderosa pine (mbf per acre)

* Used only in regression with westside forest data.
† Used only in regressions with eastside forest data.
‡ Variable available until 1980.
Note: All variables in dollars are deflated using the producer price index for total industrial commodities listed in the Economic Report of the President.

Table 2a. Regression Results for the **Westside Forests, 1973–81.**†

Variable Name	Parameter Estimate	t-stat for Ho: Parameter = 0
INTERCEPT	8784.856	4.452**
NBIDDERS	315.447	16.008**
ORALAUCT	699.996	4.073**
ACRES	-0.960	-4.879**
CLENGTH	0.898	5.936**
LUMPSUM	899.064	2.006**
PRICEMETH	1958.684	5.759*
SALVDUM	63.751	0.433
SBADUM	-264.119	-1.994*
BIDYEAR	-209.437	-7.750**
QUARTER1	730.554	4.352**
QUARTER2	855.082	5.370**
QUARTER3	74.264	0.446
ENVIRON	0.794	4.640**
STMPTRCK	-1.480	14.151**
HAULCOSTS	2.784	11.919**
TEMPROADS	-1.542	-2.239*
PCL	0.909	10.286**
HAULMILES	-19.955	-5.724**
DFPRICE	25.038	15.038**
DFIRWEST	227.136	18.642**
WESTHEM	131.804	15.302**
CEDARS	275.459	17.475**
OTHERFIRS	135.377	10.030**
CPAM	31.299	2.109*

Adjusted R-squared: 0.8239
Mean of the dependent variable: 3244.56
† Bid price per acre is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level

Table 2b. Regression Results for the **Westside Forests 1985–90.**[†]

Variable Name	Parameter Estimate	t-stat for Ho: Parameter = 0
INTERCEPT	-120527.00	-25.217**
NBIDDERS	473.41	17.353**
ORALAUCT	430.40	-1.346
ACRES	0.000	-0.078
CLENGTH	0.403	-1.608
LUMPSUM	-91.639	-0.358
PRICEMETH	358.097	1.608
SALVDUM	-510.403	-2.365*
SBADUM	264.943	1.372
BIDYEAR	1356.979	21.658**
QUARTER1	2115.202	9.486**
QUARTER2	-166.537	-0.810
QUARTER3	-20.055	-0.107
ENVIRON	-2.809	-11.993**
STMPTRCK	-0.092	-0.782
HAULCOSTS	-0.476	-2.827**
TEMPROADS	1.212	1.316
PCL	0.828	6.979**
HAULMILES	-3.217	-0.942
DFPRICE	5.592	1.067
DFIRWEST	65.394	5.887**
WESTHEM	134.542	13.227**
CEDARS	201.108	6.134**
OTHERFIRS	118.763	9.417**
CPAM	233.337	17.246**

Adjusted R-squared: 0.7177
Mean of the dependent variable: 6619.78
† Bid price per acre is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.00 1 level

Table 3a. Regression Results for the **Eastside Forests 1973–80.**†

Variable Name	Parameter Estimate	t-stat for Ho: Parameter = 0
INTERCEPT	5779.240	5.514**
NBIDDERS	107.407	8.180**
ORALAUCT	-144.709	-2.372*
ACRES	0.003	0.822
CLENGTH	-0.062	-1.148
LUMPSUM	-36.159	-0.487
PRICEMETH	-75.565	-1.223
SALVDUM	-21.811	-0.353
SBADUM	262.716	3.464**
BIDYEAR	-89.168	-6.193**
QUARTER1	130.720	1.955*
QUARTER2	72.565	1.184
QUARTER3	61.994	1.045
ENVIRON	1.047	2.937**
STMPTRCK	-0.116	-0.888
HAULCOSTS	0.012	0.039
TEMPROADS	0.229	0.098
PCL	0.316	1.965*
HAULMILES	-0.678	-0.516
PPPRICE	4.588	7.825**
DFIREAST	122.228	5.435**
PONDPINE	255.775	24.443**
JEFFPOND	241.015	10.709**
WHITEFIR	72.690	3.311**
VOLOTHER	44.587	7.247**
CPAM	59.041	1.044

Adjusted R-squared: 0.7983
Mean of the dependent variable: 786.11
† Bid price per acre is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level

Table 3b. Regression Results for the **Eastside Forests 1985–90.**†

Variable Name	Parameter Estimate	t-stat for Ho: Parameter = 0
INTERCEPT	11448.000	-12.484**
NBIDDERS	75.704	9.524**
ORALAUCT	-39.586	-0.491
ACRES	0.003	0.439
CLENGTH	0.043	0.871
LUMPSUM	-107.064	-1.611
PRICEMETH	24.734	0.470
SALVDUM	-28.368	-0.561
SBADUM	76.696	1.621
BIDYEAR	122.902	11.170**
QUARTER1	-58.639	-1.221
QUARTER2	-81.716	-1.566
QUARTER3	11.909	0.251
ENVIRON	-2.298	-8.904**
STMPTRCK	-0.121	-1.252
HAULCOSTS	-0.063	-0.451
TEMPROADS	-8.663	-3.182**
PCL	-0.201	-1.415
HAULMILES	0.231	0.400
PPPRICE	1.894	1.785
DFIREAST	82.390	9.217**
PONDPINE	270.688	43.106**
WHITEFIR	78.290	11.715**
VOLOTHER	87.802	18.437**
CPAM	8.011	1.709

Adjusted R-squared: 0.9227
Mean of the dependent variable: 1055.14
† Bid price per acre is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level

Empirical Results of the Second Stage of the Multistage Procedure

In stage two of the multistage procedure the forests that are more prone to noncompetitive bidding behavior are compared to the forest that is least prone to noncompetitive behavior as determined by the first stage of the multistage procedure. Mt. Baker/Snoqualmie, Gifford Pinchot, Mt. Hood and Umpqua are compared to Willamette in the westside group, and Wallowa/Whitman, Umatilla and Malheur are compared to Ochoco in the eastside group. The differences in mean bid prices between forests are compared using the two statistical methods discussed in Chapter 3. The first method compares bid price means calculated from data restricted to have certain tract or sale characteristics, and the second method is the price decomposition procedure. Both methods allow us to control for tract and sale characteristics so that the differences in mean bid prices are a reflection of differences in competition between the forests being compared.

Analysis of the Difference in Mean Bid Prices

Results for the Westside Forests. In the HHI and four-firm concentration ratio plots of the first stage, Willamette, based on being the least concentrated forest, is predicted to have the most competitive bidding of any westside forest, followed by Mt. Baker/Snoqualmie, Mt. Hood, Gifford Pinchot, and finally Umpqua. Based on the concentration measurements alone, one would predict, *for sales with similar* *characteristics*, the bid price per mbf or per acre of timber to be higher in Willamette than in the other forests.

To test the above hypothesis, bid price means are compared while controlling for an important tract characteristic by restricting the data to sales where Douglas fir comprises at least 70 percent of the timber on a tract. The mean bid prices of the other forests are compared to Willamette's to see whether Willamette's mean bid price per mbf is significantly greater than the mean bid price per mbf in the four other forests. The mean bids per mbf in each forest are calculated using data samples of two consecutive years at a time.[33] If the HHI's reflect relative competition, then the ratio of the mean bid price per mbf in Umpqua, Mt. Hood, Gifford Pinchot, or Mt. Baker/Snoqualmie to the mean bid price per mbf in Willamette will be less than one. A relative ranking of the competitiveness of bidding across forests may also be obtained from these ratios.

The results listed in Table 4a reveal that in fifteen out of twenty comparisons of the other four forests to Willamette, the mean bid price in Willamette is greater, with ten of the differences in means significantly greater than zero. In five instances, other forests' means are greater than Willamette's, but the differences are not significant at the 5 percent level.

The results in Table 4a substantiate the hypothesis formed from the HHI and four-firm concentration ratio plots that Willamette contains the most competitive bidding. No clear ranking of competitiveness of bidding among Umpqua, Mt. Baker/Snoqualmie,

[33] The bid prices are deflated using the monthly producer price index for total industrial commodities listed in the Economic Report of the President (1974–91).

Gifford Pinchot or Mt. Hood is apparent however. Controlling for only one tract and sale characteristic (percentage of Douglas fir on a tract) may not be enough to isolate differences in competitiveness of bidding between forests from differences in tract and sale characteristics.

The mean bid prices are also calculated and compared on a per-acre basis. When comparing bids per acre, however, it is important to control for density of the timber. An acre with only five mbf is likely to receive a lower bid than an acre with thirty mbf. The data are split into two groups; sales with less than twenty mbf per acre and sales with at least twenty mbf per acre. Twenty mbf is chosen as the dividing number because it is roughly the mean value in the sample.

The results of the analysis on a per-acre basis using sales with at least twenty mbf per acre are comparable to the analysis a per mbf basis.[34] The results are presented in Table 4b. In eighteen out of twenty comparisons of the four other forests to Willamette, Willamette's mean is significantly greater than the other forests' means. In only one out of twenty comparisons was Willamette's mean bid price less than another forest's mean, but the difference is not significant. For one two-year period Mt. Baker/Snoqualmie has only one observation so a comparison of means is not possible.

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[34] The mean bid per acre results for sales with less than twenty mbf per acre are inconsistent and not very comparable to the mean bid per mbf results. Out of twenty comparisons of the four other forests to Willamette, eight of the mean bid prices in other forests are less then Willamette's, however, only two of the differences are significant. Twelve out of twenty bid price means are greater than Willamette's, but again, only two of these differences are significant.

Table 4a. Bid per MBF Comparisons Using Sales with at Least 70 Percent Douglas Fir in the Westside Forests.

Years 1974–75 Willamette Mean = $373.42; 59 Observations			
Forest Compared to Willamette†	Mean Bid/MBF in $	Ratio of Forest's Mean to Willamette's Mean*	Is Mean Bid/MBF Significantly Different from Willamette's?■
Mt. Baker/Snoqualmie (4)	178.36	0.48	Yes
Gifford Pinchot (31)	298.14	0.80	Yes
Mt. Hood (21)	288.22	0.77	Yes
Umpqua (43)	265.92	0.71	Yes
Years 1977–78 Willamette Mean = $327.09; 123 Observations			
Forest Compared to Willamette	Mean Bid/MBF in $	Ratio of Forest's Mean to Willamette's Mean	Is Mean Bid/MBF Significantly Different from Willamette's?
Mt. Baker/Snoqualmie (9)	332.77	1.02	No
Gifford Pinchot (38)	269.51	0.82	Yes
Mt. Hood (42)	259.97	0.79	Yes
Umpqua (131)	330.91	1.01	No
Years 1981–82 Willamette Mean = $186.23; 141 Observations			
Forest Compared to Willamette	Mean Bid/MBF in $	Ratio of Forest's Mean to Willamette's Mean	Is Mean Bid/MBF Significantly Different from Willamette's?
Mt. Baker/Snoqualmie (18)	174.88	0.94	No
Gifford Pinchot (37)	167.15	0.90	No
Mt. Hood (48)	136.71	0.73	Yes
Umpqua (155)	192.26	1.03	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Willamette's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 4a (cont.). Bid per MBF Comparisons Using Sales with at Least 70 Percent Douglas Fir in the Westside Forests.

Years 1985–86 Willamette Mean = $130.90; 114 Observations			
Forest Compared to Willamette†	Mean Bid/MBF in $	Ratio of Forest's Mean to Willamette's Mean*	Is Mean Bid/MBF Significantly Different from Willamette's?■
Mt. Baker/Snoqualmie (13)	127.85	0.98	No
Gifford Pinchot (43)	133.50	1.02	No
Mt. Hood (23)	134.99	1.03	No
Umpqua (229)	120.65	0.92	Yes
Years 1989–90 Willamette Mean = $309.98; 152 Observations			
Forest Compared to Willamette	Mean Bid/MBF in $	Ratio of Forest's Mean to Willamette's Mean	Is Mean Bid/MBF Significantly Different from Willamette's?
Mt. Baker/Snoqualmie (17)	294.25	0.95	No
Gifford Pinchot (58)	224.66	0.72	Yes
Mt. Hood (48)	304.30	0.98	No
Umpqua (141)	274.33	0.88	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Willamette's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 4b. Bid per Acre Comparisons Using Sales with at Least 70 Percent Douglas Fir and 20 MBF/Acre in the Westside Forests.

Years 1974–75 Willamette Mean = $17,435; 27 Observations			
Forest Compared to Willamette†	Mean Bid/Acre in $	Ratio of Forest's Mean to Willamette's Mean*	Is Mean Bid/Acre Significantly Different from Willamette's?■
Mt. Baker/Snoqualmie (1)	19,416	1.11	—
Gifford Pinchot (10)	10,179	0.58	Yes
Mt. Hood (11)	18,619	1.07	No
Umpqua (10)	11,702	0.67	Yes
Years 1977–78 Willamette Mean = $15,543; 47 Observations			
Forest Compared to Willamette	Mean Bid/Acre in $	Ratio of Forest's Mean to Willamette's Mean	Is Mean Bid/Acre Significantly Different from Willamette's?
Mt. Baker/Snoqualmie (6)	14,654	0.94	No
Gifford Pinchot (13)	10,276	0.66	Yes
Mt. Hood (19)	10,889	0.70	Yes
Umpqua (58)	14,295	0.92	No
Years 1981–82 Willamette Mean = $7,291; 42 Observations			
Forest Compared to Willamette	Mean Bid/MBF in $	Ratio of Forest's Mean to Willamette's Mean	Is Mean Bid/Acre Significantly Different from Willamette's?
Mt. Baker/Snoqualmie (5)	6,860	0.94	No
Gifford Pinchot (15)	5,738	0.79	No
Mt. Hood (20)	7,025	0.96	No
Umpqua (44)	6,715	0.92	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Willamette's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 4b (cont.). Bid per Acre Comparisons Using Sales with at Least 70 Percent Douglas Fir and 20 MBF/Acre in the Westside Forests.

Years 1985–86 Willamette Mean = $9,567; 86 Observations			
Forest Compared to Willamette†	Mean Bid/Acre in $	Ratio of Forest's Mean to Willamette's Mean*	Is Mean Bid/Acre Significantly Different from Willamette's?■
Mt. Baker/Snoqualmie (9)	7,364	0.77	No
Gifford Pinchot (26)	7,724	0.81	No
Mt. Hood (14)	6,466	0.68	Yes
Umpqua (49)	5,553	0.58	Yes
Years 1989–90 Willamette Mean = $19,503; 100 Observations			
Forest Compared to Willamette	Mean Bid/Acre in $	Ratio of Forest's Mean to Willamette's Mean	Is Mean Bid/Acre Significantly Different from Willamette's?
Mt. Baker/Snoqualmie (11)	18,422	0.94	No
Gifford Pinchot (31)	11,648	0.60	Yes
Mt. Hood (14)	19,128	0.98	No
Umpqua (56)	12,101	0.62	Yes

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Willamette's mean bid/mbf < 1.
■ Significantly different at the .05 level.

In both the bid price per mbf and bid price per acre analyses, we control for tract characteristics to guarantee that bid prices are being compared on similar sales. In both cases, only sales with at least 70 percent Douglas Fir are used in the calculations, and for the bid per acre analysis the data are also restricted to sales with at least twenty mbf per acre. A problem with making inter-forest comparisons using a simple comparison of means is that there are a large number of tract and sale characteristics to control. For example, means can be compared for sales on which the primary species is hemlock, or on which Douglas Fir plus hemlock equals at least 70 percent of the total volume of timber, etc. The price decomposition procedure, whose results are presented below, solves the problem of controlling for many variables simultaneously.

Results for the Eastside Forests. From the concentration measurements of the first stage of the multistage procedure Ochoco stands out as being the most competitive, followed by Umatilla, Wallowa/Whitman, and Malheur. The comparison of mean bid prices is performed to see if Ochoco has the highest mean bid price and to possibly provide a competitive ranking of the remaining forests.

The analysis of mean bid prices for the eastside forests is performed in the same fashion as the analysis of the westside forests. Mean bid prices per mbf and per acre are again computed for five two-year sample periods. The mean bid prices on the per-mbf basis are calculated using only sales whose timber volume is composed of at least 70 percent Ponderosa pine (the most prevalent species in eastern Oregon and Washington.). The results are displayed in Table 5a.

Out of fifteen mean bid price comparisons made to Ochoco, twelve mean bid prices per mbf are less than Ochoco's—eight of them significantly different at the 5 percent level. Only three comparisons have mean bid prices greater than Ochoco's and none of them are statistically significant. There doesn't appear to be any pattern or consistent ranking among the other forests compared to Ochoco, but the results support the hypothesis that Ochoco contains the most competitive bidding of the eastside forests.

Mean bid price comparisons are also performed on a per-acre basis. Again the data set is restricted to sales with at least 70 percent Ponderosa Pine volume. In addition, we control for timber density. The data are divided into sales with at least four mbf per acre and sales with less than four mbf per acre. Four mbf is used as the dividing point because it is roughly the mean density. First, sales with at least four mbf per acre are used to compute and compare mean bid prices. The results are presented in Table 5b. Twelve out of fifteen mean bid price comparisons show Ochoco has a higher mean bid price per acre, but only five of the differences are statistically significant. Three comparisons indicate Ochoco has a lower average bid price than the forest being compared to it, but none of the differences are significant. In two instances there are forests with only one observation so the significance of the results could not be tested.

The results using sales with less than four mbf per acre (presented in Table 5c) are for the most part similar to the results using sales with at least four mbf per acre, only they are weaker. The restrictions imposed on the data set result in fewer observations per forest, so in four instances forests have no observations. Many of the problems associated with the comparisons of means (*e.g.*, few observations and the inability to control for several tract and sale characteristics) can be alleviated by using the price decomposition procedure.

Table 5a. Bid per MBF Comparisons Using Sales with at Least 70 Percent Ponderosa Pine in the Eastside Forests.

Forest Compared to Ochoco†	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean*	Is Mean Bid/MBF Significantly Different from Ochoco's?■
Years 1974–75 — Ochoco Mean = $94.13; 10 Observations			
Malheur (4)	54.29	0.58	Yes
Umatilla (31)	32.10	0.34	No
Wallowa/Whitman (21)	49.66	0.53	No
Years 1977–78 — Ochoco Mean = $370.49; 26 Observations			
Forest Compared to Ochoco	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/MBF Significantly Different from Ochoco's?
Malheur (35)	240.33	0.65	Yes
Umatilla (14)	141.79	0.38	Yes
Wallowa/Whitman (28)	136.61	0.37	Yes
Years 1981–82 — Ochoco Mean = $140.29; 41 Observations			
Forest Compared to Ochoco	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/MBF Significantly Different from Ochoco's?
Malheur (48)	97.97	0.70	Yes
Umatilla (2)	152.82	1.09	No
Wallowa/Whitman (17)	380.06	2.71	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Ochoco's mean bid/mbf <1.
■ Significantly different at the .05 level.

Table 5a (cont.). Bid per MBF Comparisons Using Sales with at Least 70 Percent Ponderosa Pine in the Eastside Forests.

Years 1985–86 Ochoco Mean = $177.88; 52 Observations			
Forest Compared to Ochoco†	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean*	Is Mean Bid/MBF Significantly Different from Ochoco's?■
Malheur (37)	174.31	0.98	No
Umatilla (3)	124.68	0.70	No
Wallowa/Whitman (12)	91.63	0.52	Yes
Years 1989–90 Ochoco Mean = $255.65; 35 Observations			
Forest Compared to Ochoco's	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/MBF Significantly Different from Ochoco's?
Malheur (35)	284.35	1.11	No
Umatilla (14)	227.26	0.89	Yes
Wallowa/Whitman (28)	190.39	0.74	Yes

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Ochoco's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 5b. Bid per Acre Comparisons Using Sales with at Least 70 Percent Ponderosa Pine and 4 MBF/Acre in the Eastside Forests.

Years 1974–75 Ochoco Mean = $745; 5 Observations			
Forest Compared to Ochoco†	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean*	Is Mean Bid/Acre Significantly Different from Ochoco's?■
Malheur (4)	360	0.46	No
Umatilla (2)	148	0.20	No
Wallowa/Whitman (1)	421	0.57	—
Years 1977–78 Ochoco Mean = $2,707; 16 Observations			
Forest Compared to Ochoco	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/Acre Significantly Different from Ochoco's?
Malheur (18)	2,764	1.02	No
Umatilla (3)	1,326	0.49	Yes
Wallowa/Whitman (5)	928	0.34	Yes
Years 1981–82 Ochoco Mean = $1,435; 22 Observations			
Forest Compared to Ochoco	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/Acre Significantly Different from Ochoco's?
Malheur (26)	961	0.67	No
Umatilla (1)	1,710	1.19	—
Wallowa/Whitman (2)	420	0.29	Yes

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Ochoco's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 5b (cont.). Bid per Acre Comparisons Using Sales with at Least 70 Percent Ponderosa Pine and 4 MBF/Acre in the Eastside Forests.

Years 1985–86 Ochoco Mean = $1,423; 25 Observations			
Forest Compared to Ochoco†	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean*	Is Mean Bid/Acre Significantly Different from Ochoco's?■
Malheur (37)	1,707	1.20	No
Umatilla (3)	801	0.56	No
Wallowa/Whitman (4)	726	0.51	Yes
Years 1989–90 Ochoco Mean = $2,540; 24 Observations			
Forest Compared to Ochoco's	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/MBF Significantly Different from Ochoco's?
Malheur (39)	1,869	0.74	Yes
Umatilla (2)	2,297	0.90	No
Wallowa/Whitman (3)	1,220	0.48	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Ochoco's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 5c. Bid per Acre Comparisons Using Sales with at Least 70 Percent Ponderosa Pine and Less than 4 MBF/Acre in the Eastside Forests.

Years 1974–75 Ochoco Mean = $129; 5 Observations			
Forest Compared to Ochoco†	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean*	Is Mean Bid/Acre Significantly Different from Ochoco's?■
Malheur (4)	180	0.84	No
Umatilla (0)	—	—	—
Wallowa/Whitman (0)	131	1.01	No
Years 1977–78 Ochoco Mean = $583; 10 Observations			
Forest Compared to Ochoco	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/Acre Significantly Different from Ochoco's?
Malheur (17)	391	0.67	No
Umatilla (11)	181	0.31	Yes
Wallowa/Whitman (23)	211	0.36	Yes
Years 1981–82 Ochoco Mean = $159; 19 Observations			
Forest Compared to Ochoco	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/Acre Significantly Different from Ochoco's?
Malheur (16)	135	0.85	No
Umatilla (0)	—	—	—
Wallowa/Whitman (15)	1,175	7.39	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Ochoco's mean bid/mbf < 1.
■ Significantly different at the .05 level.

Table 5c (cont.). Bid per Acre Comparisons Using Sales with at Least 70 Percent Ponderosa Pine and Less than 4 MBF/Acre in the Eastside Forests.

Years 1985–86 Ochoco Mean = $188; 12 Observations			
Forest Compared to Ochoco†	Mean Bid/Acre in $	Ratio of Forest's Mean to Ochoco's Mean*	Is Mean Bid/Acre Significantly Different from Ochoco's?■
Malheur (15)	222	1.23	No
Umatilla (0)	—	—	—
Wallowa/Whitman (8)	140	0.74	No
Years 1989–90 Ochoco Mean = $500; 7 Observations			
Forest Compared to Ochoco's	Mean Bid/MBF in $	Ratio of Forest's Mean to Ochoco's Mean	Is Mean Bid/MBF Significantly Different from Ochoco's?
Malheur (11)	358	0.72	No
Umatilla (0)	—	—	—
Wallowa/Whitman (5)	281	0.56	No

† Number of observation in parentheses.
* Expectation: ratio of forest mean bid/mbf to Ochoco's mean bid/mbf < 1.
■ Significantly different at the .05 level.

The Price Decomposition Procedure

A detailed discussion of the price decomposition procedure was presented in Chapter 3. The price decomposition procedure decomposes the difference in mean bid prices between two markets (forests) into two components using regression analysis. One component measures the difference in bid prices between forests due to differences in tract and sale characteristics (DDC), and the other measures the difference in bid price between forests due to differences in *valuations* of tract and sale characteristics (DDVC). The latter reflects the difference in the competitiveness of bidding between forests. The price decomposition is a more comprehensive estimation technique than the simple comparison of bid price means because it can control for several tract and sale characteristics simultaneously without reducing the size of the usable data set.

The price decomposition regression equations (equation 2.5 and 2.6 from Chapter 3) are estimated for the eastside and westside forests. All of the westside forests are compared to Willamette, and all of the eastside forests are compared to Ochoco (*i.e.*, Willamette and Ochoco act like Market B in the example in Chapter 3). Unlike the previous mean bid price comparisons, which are performed on both a per-mbf and per-acre basis, the mean bid price differences in equations 2.5 and 2.6 are calculated solely on a per-acre basis. The per-acre basis is chosen over the per-mbf basis because some of the regression coefficients are easier to interpret on a per-acre basis[35]. The tract and sale

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[35] The interpretation of the coefficients on species is more straightforward in a regression explaining bid per acre than in a regression explaining bid per mbf. In the bid per acre specification the coefficient on volume of a species per acre (holding acres constant) is the marginal value of another mbf of that species (plus the marginal value of increasing tract density, which is likely to be relatively small). This coefficient should be roughly equal to estimates of market stumpage values. In a regression explaining bid per mbf, where species are measured as the percentage or proportion of total volume, the coefficient of a species (mbf/total volume in mbf) is interpreted as the change in bid price per mbf given a change in the relative proportion of species. If the volumes of species are directly entered into the equation (in mbf), then the coefficient on a species is the change in average bid price per mbf if an additional mbf of that species is added to the tract. No market prices exist to provide an indication of the "accuracy" of the coefficient estimates in either of the last two regression specifications.

characteristics that form the X matrix used in the price decomposition regression equations are listed in Table 1.[36]

Results for the Westside Forests. The price decomposition procedure was applied to the westside forests for the years 1973–81. These early years are selected for analysis because the timber market was the most stable during that period of time (relative to the remaining time covered by the data set) and the differences in the level of competitive bidding among forests are probably the most distinguishable during this period. The price decomposition results for the westside forests are shown in
Table 6.

From Table 6 we can see that Mt. Baker/Snoqualmie, Gifford Pinchot and Umpqua all have mean bid prices less than Willamette's, while Mt. Hood has a mean bid price that is greater than Willamette's. Mt. Hood's higher mean bid price may seem contradictory to the market concentration results and most of the comparisons of mean bid prices, however, Mt. Hood's DDC measurements are significantly greater than zero. The positive DDC's indicate that (on average) Mt. Hood's timber sales have characteristics that are more desirable than those in Willamette, so Mt. Hood should be expected to have a higher mean bid price.

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[36] NBIDDERS and ORALAUCT (listed in Table 1) are not included in the X matrix of the price decomposition procedure because they are variables that reflect the level of competition. If NBIDDERS and ORALAUCT were included in the X matrix, they would become part of the DDC measurements rather than the DDVC measurements that are supposed to reflect differences in the competitiveness of forests.

Table 6. Price Decomposition Results for the **Westside Forests, 1973–81.**

Bid Price Difference Due to . . .		Characteristics		Valuation of Characteristics	
Forest Compared to Willamette	Average Price Difference (per acre)	DDC	DDC'	**DDVC**	**DDVC'**
Mt. Baker/Snoqualmie	-1667.79	-403.93**	-201.81	-1263.87**	-1949.60**
Gifford Pinchot	-1559.08	-85.72	396.58	-1473.36**	-1955.66**
Mt. Hood	536.11	861.35**	1678.25**	-325.24	-1142.14**
Umpqua	-572.96	-284.25**	-288.71	-133.62*	-439.34**

* Indicates variable is significantly different from zero at .10 level.
** Indicates variable is significantly different from zero at .05 level.

Note:

$$= \left(\bar{X}_{\text{Forest Y}} - \bar{X}_{\text{Willamette}}\right)\beta_{\text{Willamette}}$$

$$DDC' = \left(\bar{X}_{\text{Forest Y}} - \bar{X}_{\text{Willamette}}\right)\beta_{\text{Forest Y}}$$

$$DDVC = \bar{X}_{\text{Forest Y}}\left(\beta_{\text{Forest Y}} - \beta_{\text{Willamette}}\right)$$

$$DDVC' = \bar{X}_{\text{Willamette}}\left(\beta_{\text{Forest Y}} - \beta_{\text{Willamette}}\right)$$

As previously stated, the DDVC's are the useful measures for studying competitiveness of bidding. All of the westside forests have negative DDVC measurements when compared to Willamette, and all but one of the DDVC measurements are significantly less than zero. This may suggest that bidding is less competitive in the other westside forests than in Willamette. Of the four westside forests, Gifford Pinchot and Mt. Baker/Snoqualmie stand out as having the most negative DDVC measurements.

These two forests are examined in the third stage of the multistage procedure for further indications of noncompetitive bidding.[37]

Results for the Eastside Forests. The price decomposition procedure is applied to the eastside forests using only data from the years 1973–80 (for the same reasons indicated in the westside forest discussion—stability of the timber market). The eastside price decomposition results are presented in Table 10.

From Table 7 one can see that the mean bid prices in Malheur, Umatilla, and Wallowa/Whitman are less than Ochoco's. All of the DDC measures are significantly less than zero, with one exception. The negative DDC values reveal that Ochoco has better tracts in terms of characteristics than the three other eastside forests. The negative DDC values help to explain some of the negative differences in mean bid prices, but in all cases negative DDVC values also account for part of the difference in mean bid prices. Wallowa/Whitman followed by Malheur have the most negative values of DDVC. These forests are examined in the next stage for further evidence of noncompetitive bidding.

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[37] The values of DDVC for Umpqua are the lowest of the westside forests compared to Willamette. This is surprising considering Umpqua had by far the highest concentration measures of the westside forests. This may be a case where the caveats concerning market concentration in Chapters 2 and 3 apply. Umpqua is concentrated, however, (according to stage two) bidding is relatively competitive.

Table 7. Price Decomposition Results for the **Eastside Forests, 1973–80.**

Bid Price Difference Due to . . .		Characteristics		Valuation of Characteristics	
Forest Compared to Ochoco	Average Price Difference (per acre)	DDC	DDC'	**DDVC**	**DDVC'**
Malheur	-558.34	-186.31	-295.26**	-372.03**	-263.07**
Umatilla	-934.70	-701.18**	-845.79**	-153.53**	-88.91**
Wallowa/Whitman	-1242.59	-738.99**	-592.22**	-503.60**	-650.37**

* Indicates variable is significantly different from zero at .10 level.
** Indicates variable is significantly different from zero at .05 level.

Note: $= \left(\bar{X}_{\text{Forest Y}} - \bar{X}_{\text{Ochoco}}\right)\beta_{\text{Ochoco}}$

$$DDC' = \left(\bar{X}_{\text{Forest Y}} - \bar{X}_{\text{Ochoco}}\right)\beta_{\text{Forest Y}}$$

$$DDVC = \bar{X}_{\text{Forest Y}}\left(\beta_{\text{Forest Y}} - \beta_{\text{Ochoco}}\right)$$

$$DDVC' = \bar{X}_{\text{Ochoco}}\left(\beta_{\text{Forest Y}} - \beta_{\text{Ochoco}}\right)$$

Empirical Results of the Third Stage of the Multistage Procedure

In this stage the forests identified in the first two stages as the most likely to contain noncompetitive bidding are examined for further indications of whether noncompetitive bidding might be present in those forests. As explained in Chapter 3, one way to determine whether noncompetitive bidding is occurring is to compare the impact of additional regular bidders have on bid price to the impact of additional nonregular bidders. Finding that additional nonregular bidders have a greater impact than additional regular bidders constitutes evidence that noncompetitive bidding is occurring. Finding that additional nonregular bidders do not have a greater impact on bid price than regular bidders suggests that bidding is competitive. To measure the relative effects of regular versus nonregular bidders, the nonlinear regression specified in Chapter 3 is applied to the forests of interest. That nonlinear specification is

$$BidPrice = \alpha_0 + \beta_0 (R + \lambda N)^{\gamma} + \sum_{i=1}^{k} \beta_i X_i + \epsilon.$$

Recall that if λ is greater than one, then additional nonregular bidders have more of an impact on bid price than additional regular bidders. In instances where the nonlinear regression results may appear ambiguous, two linear regression specifications are estimated to provide additional information. From Chapter 3 those linear specifications are

$$BidPrice = \beta_0 + \beta_1 R + \beta_2 N + \beta_3 RN + \sum_{i=4}^{k} \beta_i X_i + \epsilon$$

and

$$BidPrice = \beta_0 + \beta_1 BIDDERS + \beta_2 PCTN + \sum_{i=3}^{k} \beta_i X_i + \epsilon.$$

Before these regression equations can be estimated for the selected forests, regular and nonregular bidders must be defined for each forest.

Defining Regular versus Nonregular Bidders

Regular bidders are bidders that bid frequently in a market area (in this case forest). For each forest regular bidders will be defined as bidders who bid on at least a specified percentage of sales, and the remaining bidders will be the nonregular bidders.[38] Determining the percentage of sales that defines a regular bidder is problematic. Would a regular bidder be one who bid on at least 20 percent of sales? Ten percent? Five percent? Because there is no theoretically correct critical percentage of sales, several different percentages are used in the analysis and the sensitivity of the results to the definition of regular bidders is examined.[39]

Nonlinear Regression Results for the Westside Forests

The nonlinear regression specification is estimated for Gifford Pinchot, Mt. Baker/Snoqualmie, and Willamette. Gifford Pinchot and Mt. Baker/Snoqualmie are the forests selected for further examination by the first two stages of the multistage procedure, and Willamette is included in the nonlinear analysis as a benchmark to see how the

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[38] The Forest Service data include a maximum of twelve bidders for each sale (ranked according to their bids), so if an observation has twelve bidders, the actual number of bidders is unknown. Twelve-bidder sales are eliminated from the nonlinear estimation process because of the problems those observations cause in estimating regular bidders. This may result in a loss of information (especially in Willamette where twelve-bidder sales account for twenty-one percent of the sales), but the listing of bidders according to the percentage of sales on which they bid would have been biased otherwise.

[39] The choices of the percentages used below to define regular bidders are based on the distribution of the percentages of times bidders bid in a forest and are somewhat subjective. Also, because the distribution of the percentage of times bidders bid is quite different for each forest, the choices of the percentages used to define regular bidders will also vary for each forest.

nonlinear regression specification performs on the forest identified above as having the most competitive bidding among the westside forests. The nonlinear regressions are estimated separately for the early and later years of data and the results are presented in Tables 8a through 10b. The tables include the estimates of λ (the coefficient of nonregular bidders), β_0 (the coefficient of regular plus nonregular bidders) and γ (which indicates the curvature of the nonlinear function).[40] The residual sum of squares is also included to identify the definition of regular bidders that best fits the data. The total number of sales in a forest (for either the early or later years) is included near the top of each table so that the number of sales on which regular bidders bid can be easily determined. For example, the total number of sales in Gifford Pinchot for the early years is 687, so a regular bidder who bids on at least 10 percent of sales bids on a minimum of 68.7 sales (or 69 sales by rounding).

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[40] Gamma (γ) is empirically restricted to be less than one based on auction theory. When the SAS statistical program estimates γ to be very close to one, it rounds the value to one. Limited nonlinear analyses were performed with γ unrestricted and the nature of the results are the same as those with γ restricted.

Table 8a. **Gifford Pinchot, 1973-1981.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0$ (Regular + λNonregular)$^\gamma$ + $\beta_1 X_1$ + ...

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 687								
	2%	3%	4%	5%	6%	10%	12%	15%	19%
λ	1.38 (0.25)	1.45* (0.24)	1.50* (0.22)	1.48* (0.22)	1.42* (0.23)	1.40* (0.22)	1.37 (0.26)	1.91* (0.38)	2.30* (0.59)
β_0	477.24 (283.20)	466.37 (275.87)	444.53 (267.28)	445.78 (269.41)	446.72 (272.34)	442.57 (268.53)	424.13 (262.08)	349.58 (219.47)	292.48 (189.46)
γ	1.00 (0.22)	1.00 (0.22)	1.00 (0.22)	1.00 (0.22)	1.00 (0.22)	1.00 (0.22)	1.00 (0.22)	1.00 (0.21)	1.00 (0.20)
Residual Sum of Squares†	2,464,799	2,457,726	2,447,741	2,449,714	2,456,589	2,457,376	2,463,381	2,424,548	2,410,602

•Standard errors in Parentheses. * Significantly Different from 1 at .05 level. † In thousands, rounded to the nearest thousand. Note: γ was restricted to be < 1 based on auction theory.

Table 8b. **Gifford Pinchot, 1985-1990.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0$ (Regular + λNonregular)$^\gamma$ + $\beta_1 X_1$ + ...

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 476						
	2%	3%	5%	8%	10%	17%	25%
λ	0.54 (0.30)	0.43* (0.26)	0.80 (0.25)	0.85 (0.24)	1.41 (0.36)	2.45* (0.86)	1.48 (0.40)
β_0	464.17 (403.55)	486.40 (404.14)	452.56 (426.84)	448.65 (427.36)	733.01 (778.53)	1161.66 (1295.47)	377.48 (419.13)
γ	1.00 (0.37)	1.00 (0.33)	1.00 (0.36)	1.00 (0.36)	0.76 (0.35)	0.55 (0.29)	0.96 (0.37)
Residual Sum of Squares†	2,469,824	2,459,280	2,478,437	2,478,927	2,475,094	2,448,057	2,468,774

•Standard errors in Parentheses. * Significantly Different from 1 at .05 level. † In thousands, rounded to the nearest thousand. Note: γ was restricted to be < 1 based on auction theory.

Table 9a. **Mt. Baker/Snoqualmie, 1973-1981.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0(\text{Regular} + \lambda\text{Nonregular})^{\gamma} + \beta_1 X_1 + \ldots$

Regression Parameter•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 658								
	2%	3%	4%	5%	6%	7%	8%	9%	11%
λ	2.27* (0.43)	1.92* (0.40)	2.18* (0.50)	2.90* (0.77)	2.34* (0.60)	3.80* (1.36)	4.01* (1.41)	4.97 (2.25)	10.69 (12.32)
β_0	260.74 (230.65)	319.76 (300.25)	465.00 (452.17)	464.50 (464.50)	820.56 (820.56)	1633.03 (1896.26)	3520.85 (5112.68)	2102.78 (2733.28)	413.49 (590.67)
γ	1.00 (0.32)	0.93 (0.32)	0.78 (0.30)	0.73 (0.74)	0.60 (0.29)	0.38* (0.23)	0.24* (0.22)	0.32* (0.22)	0.56* (0.21)
Residual Sum of Squares†	2,783,290	2,822,901	2,807,007	2,761,885	2,810,262	2,763,752	2,761,253	2,747,564	2,735,155

• Standard errors in parentheses. * Significantly Different from 1 at .05 level. † In thousands, rounded to the nearest thousand. Note: γ was restricted to be <1 based on auction theory.

Table 9b. **Mt. Baker/Snoqualmie, 1985-1990.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0(\text{Regular} + \lambda\text{Nonregular})^{\gamma} + \beta_1 X_1 + \ldots$

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 390							
	4%	5%	6%	8%	9%	10%	14%	22%
λ	0.50* (0.24)	0.49* (0.20)	0.58* (0.50)	0.75 (0.24)	2.47 (1.31)	0.98 (0.35)	0.96 (0.41)	Would
β_0	426.38 (400.38)	447.80 (410.93)	442.60 (436.31)	409.08 (444.33)	9870.56 (36335.48)	335.96 (430.21)	363.09 (446.10)	Not
γ	1.00 (0.38)	1.00 (0.37)	1.00 (0.40)	1.00 (0.42)	0.11 (0.33)	1.00 (0.45)	1.00 (0.45)	Converge
Residual Sum of Squares†	1,828,605	1,821,234	1,831,217	1,841,951	1,840,647	1,846,241	1,846,197	

• Standard errors in parentheses. * Significantly Different from 1 at .05 level. † In thousands, rounded to the nearest thousand. Note: γ was restricted to be < 1 based on auction theory.

Table 10a. **Willamette, 1973-1981.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0$ (Regular + λNonregular)$^{\gamma}$ + $\beta_1 X_1$ + ...

Regression Parameter•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Totals Sales = 1192								
	2%	3%	4%	5%	6%	8%	10%	12%	15%
λ	1.56 (0.45)	1.58 (0.45)	1.31 (0.38)	1.24 (0.36)	1.25 (0.39)	1.03 (0.30)	1.38 (0.53)	1.28 (0.54)	0.79 (0.64)
β_0	381.03 (558.01)	549.90 (837.44)	609.19 (947.62)	759.84 (1217.85)	680.25 (1073.28)	604.04 (880.48)	831.30 (1430.58)	604.30 (975.21)	570.18 (727.98)
γ	0.72 (0.47)	0.59 (0.44)	0.57 (0.45)	0.51 (0.44)	0.53 (0.45)	0.58 (0.44)	0.46 (0.44)	0.55 (0.45)	0.79 (0.42)
Residual Sum of Squares†	3,741,739	3,737,151	3,745,908	3,747,478	3,747,325	3,749,523	3,747,074	3,747,896	3,747,983

• Standard errors in Parentheses. † In thousands, rounded to the nearest thousand.

Table 10b. **Willamette, 1985-1990.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0$ (Regular + λNonregular)$^{\gamma}$ + $\beta_1 X_1$ + ...

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder Bid: Total Sales = 908						
	3%	5%	6%	8%	10%	12%	20%
λ	0.68 (0.21)	1.07 (0.23)	0.96 (0.20)	0.75 (0.16)	0.78 (0.16)	1.12 (0.23)	0.73 (0.17)
β_0	684.64 (540.83)	630.71 (558.64)	650.41 (436.31)	709.50 (568.19)	711.04 (573.75)	601.07 (556.32)	781.44 (617.82)
γ	1.00 (0.29)	1.00 (0.32)	1.00 (0.32)	1.00 (0.30)	1.00 (0.30)	1.00 (0.32)	1.00 (0.29)
Residual Sum of Squares†	12,398,624	12,435,599	12,437,060	12,400,950	12,408,269	12,431,621	12,404,752

• Standard errors in Parentheses. † In thousands, rounded to the nearest thousand. Note: γ was not allowed to be < 1 based on auction theory.

Gifford Pinchot. The nonlinear results for Gifford Pinchot are shown in Tables 8a and 8b. In the early years, for all of the different definitions of regular bidders, all of the estimates of λ are greater than one, and most of the estimates are *significantly* greater than one. Based on the bidding model of Chapter 3, this suggests that noncompetitive bidding was occurring in Gifford Pinchot in the early years.

The results in Table 8b suggest that the noncompetitive bidding diminished in the later years. With one exception, none of the estimates of λ for different definitions of regular bidders are significantly greater than one. Two definitions of regular bidders produced contradictory results, however. When the criterion for regular bidders is that they bid on at least 3 percent of sales, λ is significantly less than one, however when the criterion for regular bidders is that they bid on at least 17 percent of sales, λ is significantly greater than one. The two alternative linear regression specifications are applied to the two definitions of regular bidders that produced contradictory results. The results from the linear regression specifications are presented in Table 11.

Table 11. **Gifford Pinchot.** Linear Regression Results (1985–90).

	Linear Equation 1	Linear Equation 2
Percentage of Sales on which a Regular Bidder Must Bid	$\frac{\partial Bid\,Price}{\partial R} - \frac{\partial Bid\,Price}{\partial N}$	Coefficient of PCTN (Percentage of Nonregular Bidders)
3%	410.27*	1.90
17%	-2697.95*	19.16*

* Statistically significant at the .05 level.

The linear regression results for regular bidders who bid on at least 3 percent of sales indicate regular bidders have more of an impact on bid price than nonregular bidders, while the linear regression results for regular bidders who bid on at least 17 percent of sales indicate that nonregular bidders have more of an impact than regular bidders, or that cooperative bidding is occurring. The linear regression results thus are consistent with the results obtained using the nonlinear regression specification for the corresponding definition of regular bidders. They do not, however, eliminate the ambiguity of the nonlinear results.

To decide which definition of regular bidders is better, bidders who bid on at least 3 percent or 17 percent of sales, one may be guided by the residual sum of squares (RSS). The lower the value of the RSS, the better the regression explains the variation of the dependent variable (bid price per acre). Because the only change in the nonlinear regression analyses is the definition of regular bidders (and thus nonregular bidders because N equals number of bidders minus R), the lower the RSS, the better the corresponding definition of regular bidders fits the data. According to the RSS in Table 8b, the best fitting definition of regular bidders (empirically) are those who bid on at least 17 percent of sales. The corresponding λ is significantly greater than one, indicating noncompetitive bidding may be present in the later years as well, however the coefficients for the "seventeen percent" definition of regular bidders appear rather abnormal, suggesting the estimates might not be reliable.[41]

Mt. Baker/Snoqualmie. The nonlinear regression results for Mt. Baker/Snoqualmie are found in Tables 9a and 9b. The estimated values of λ are strikingly large in the early years, and almost all are significantly greater than one, suggesting noncompetitive bidding was occurring. Like Gifford Pinchot, the possible noncompetitive bidding appears to have diminished in the later years. Only one of the estimates of λ is greater than one in the later years, and it is not significant.

Linear regression analysis is employed for three of the definitions of regular bidders; when regular bidders bid on at least 11 percent of sales in the early years (because of the large standard error of λ), 9 percent of sales in the later years (because results appear anomalous), and 22 percent of sales in the later years (because the nonlinear estimates did not converge). The linear regression results are shown below in Table 12. All of the linear regression results in Table 12 suggest that the nonregular bidders had a greater impact on bid price than regular bidders. The linear regression results provide further evidence that noncompetitive bidding was present during the early years and during the later years for the definitions of regular bidders tested.

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[41] Using the RSS's to indicate the most appropriate definition of regular bidders is questionable in some cases. Frequently the lowest RSS in Tables 8a–10b and 13a–15b correspond to estimated coefficients that appear inconsistent with those in the remainder of the table—the coefficients may be very large or small, and/or have large standard errors.

Table 12. **Mt. Baker/Snoqualmie.** Linear Regression Results (1973–81 and 1985–90).

	Linear Equation 1	Linear Equation 2
Percentage of Sales on which a Regular Bidder Must Bid	$\frac{\partial Bid\,Price}{\partial R} - \frac{\partial Bid\,Price}{\partial N}$	Coefficient of PCTN (Percentage of Nonregular Bidders)
11% $_{(1973–1981)}$	-445.08*	25.14*
9% $_{(1985–1990)}$	-226.06†	23.39*
22% $_{(1985–1990)}$	-427.69*	26.92*

* Statistically significant at the .05 level. † Statistically significant at the .10 level.

The overall picture for the later years is unclear. The nonlinear and linear results when regular bidders are bidders who bid on at least 9 percent or 22 percent of sales seem inconsistent with the other results of Table 9b. The RSS statistic indicates that regular bidders are better defined when they are bidders who bid on fewer sales, and for those definitions of regular bidders the estimates of λ indicate bidding is competitive.

Willamette. The nonlinear results for Willamette can be found in Tables 10a and 10b. Though virtually all of the estimates of λ are greater than one in the early years, none are significantly greater than one. We cannot say nonregular bidders have a significantly greater impact on bid price than regular bidders, thus the bidding in Willamette appears to be competitive. In the later years most of estimates of λ are less than one and none are significantly greater than one, so bidding may have become even more competitive. None of the results for different definitions of regular bidders stand out as being ambiguous or contradictory, therefore the linear regression equations are not estimated for Willamette's analysis.

Nonlinear Regression Results for the Eastside Forests

Wallowa/Whitman and Malheur were the eastside forests selected earlier for further examination, so they, along with Ochoco, are analyzed using the nonlinear regression specification. The first two stages indicate Ochoco is the most competitive forest of the eastside group, so it will serve as benchmark in the nonlinear analysis as Willamette did for the westside forests. Nonlinear regression results can be found in Tables 13a through 15b. Again, the two linear specifications are estimated when the nonlinear results are ambiguous.

Table 13a. **Wallowa/Whitman, 1973-1980.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0\,(\text{Regular} + \lambda\text{Nonregular})^{\gamma} + \beta_1 X_1 + \ldots$

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 253				
	2%	3%	6%	8%	22%
λ	5.00 (8.97)	1.45 (2.79)	0.59 (1.31)	0.01* (0.11)	Would
β_0	10.46 (42.29)	10.45 (67.97)	15.60 (90.93)	395.82 (7156.01)	Not
γ	0.92 (1.40)	1.00 (2.87)	1.00 (3.16)	0.05 (0.97)	Converge
Residual Sum of Squares	9,331,278	9,415,328	9,413,879	9,302,084	

● Standard errors in parentheses. Note: γ was restricted to be < 1 based on auction theory; λ was restriced to be > 0.01 for estimation purposes.

Table 13b. **Wallowa/Whitman, 1985-1990.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0\,(\text{Regular} + \lambda\text{Nonregular})^{\gamma} + \beta_1 X_1 + \ldots$

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 241					
	3%	4%	5%	9%	14%	15%
λ	0.32* (0.28)	0.08* (0.24)	Would	0.25* (0.19)	0.26* (0.14)	Would
β_0	150.46 (181.59)	79.93 (62.29)	Not	124.85 (103.74)	152.35 (112.46)	Not
γ	0.61 (0.49)	0.96 (0.43)	Converge	0.76 (0.43)	0.76 (0.43)	Converge
Residual Sum of Squares	13,104,504	12,964,190		12,933,748	12,832,183	

• Standard errors in Parentheses. * Significantly Different from 1 at .05 level.

Table 14a. **Malheur, 1973-1980.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0$ (Regular + λNonregular)$^\gamma$ + $\beta_1 X_1$ + ...

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 208						
	2%	11%	12%	14%	16%	25%	53%
λ	0.26 (0.74)	0.01* (0.60)	0.01* (0.52)	0.76 (0.57)	1.68 (1.19)	1.22 (0.79)	0.55 (0.45)
β_0	98.72 (168.58)	110.25 (132.17)	121.26 (128.02)	256.63 (623.48)	290.18 (839.55)	237.22 (615.93)	136.55 (249.92)
γ	1.00 (0.80)	1.00 (0.58)	1.00 (0.51)	0.59 (0.90)	0.47 (0.85)	0.58 (0.90)	1.00 (1.12)
Residual Sum of Squares	36,865,587	36,327,978	35,643,053	36,951,953	36,833,947	36,963,470	36,925,097

• Standard errors in parentheses. * Sifnifcantly different from 1 at .05 level. Note: γ was restricted to be < 1 based on auction theory; $0.01 < \lambda < 5$ for estimation purposes.

Table 14b. **Malheur, 1985-1990.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0$ (Regular + λNonregular)$^\gamma$ + $\beta_1 X_1$ + ...

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 286					
	3%	5%	10%	15%	30%	50%
λ	2.86* (1.08)	2.44 (0.92)	2.47 (1.00)	2.12 (1.05)	1.36 (0.68)	1.51 (1.09)
β_0	40.16 (63.26)	39.88 (73.03)	36.80 (70.05)	33.80 (70.14)	40.62 (88.48)	34.93 (80.76)
γ	1.00 (0.57)	1.00 (0.65)	1.00 (0.67)	1.00 (0.71)	1.00 (0.78)	1.00 (0.79)
Residual Sum of Squares	27,202,375	27,441,552	27,420,920	27,682,615	27,952,945	27,951,824

• Standard errors in Parentheses. * Significantly Different from 1 at .05 level. Note: γ was restricted to be < 1 based on auction theory; and $0.01 < \lambda < 5$ for estimation purposes.

Table 15a. **Ochoco 1973-1980.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0\,(\text{Regular} + \lambda\text{Nonregular})^{\gamma} + \beta_1 X_1 + \ldots$

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 142				
	2%	4%	21%	53%	63%
λ	2.06 (1.15)	1.78 (0.88)	1.50 (0.63)	1.84 (0.60)	1.87 (0.82)
β_0	209.77 (309.45)	219.84 (333.85)	231.13 (394.45)	218.86 (355.85)	190.90 (329.18)
γ	1.00 (0.62)	1.00 (0.64)	1.00 (0.72)	1.00 (0.63)	1.00 (0.66)
Residual Sum of Squares†	52,521,462	52,831,776	53,095,782	51,676,977	52,318,977

• Standard errors in Parentheses. * Significantly Different from 1 at .05 level. † In thousands, rounded to the nearest thousand. Note: γ was restricted to be < 1 based on auction theory.

Table 15b. **Ochoco, 1985-1990.** Key Nonlinear Regression Parameter Estimates for the Nonlinear Equation:
Bid Price (per acre) = $\alpha_0 + \beta_0\,(\text{Regular} + \lambda\text{Nonregular})^{\gamma} + \beta_1 X_1 + \ldots$

Regression Parameters•	Minimum Percentage of Sales on which a Bidder Must Bid to be Considered a Regular Bidder: Total Sales = 136					
	2%	11%	12%	20%	34%	52%
λ	5.00 (6.81)	0.01 (0.96)	0.01 (0.78)	0.40 (1.01)	1.35 (2.49)	5.00 (19.70)
β_0	26.63 (133.62)	47.93 (148.79)	54.74 (149.28)	41.68 (217.89)	26.23 (219.65)	11..24 (94.50)
γ	1.00 (1.77)	1.00 (1.31)	1.00 (1.15)	1.00 (2.15)	1.00 (3.04)	1.00 (1.92)
Residual Sum of Squares	23,760,463	24,053,736	23,916,713	24,189,764	24,231,551	23,891,156

• Standard errors in Parentheses. * Significantly Different from 1 at .05 level. Note: γ was restricted to be < 1 based on auction theory, and $0.01 < \lambda < 5$ for estimation purposes.

Wallowa/Whitman. The nonlinear results for Wallowa/Whitman are presented in Tables 13a and 13b.[42] The estimates of λ in the early years range from .01 to five.[43] None of the estimate of λ are significantly greater than one, so even though the estimates of λ vary substantially, one cannot say cooperative bidding was occurring in Wallowa/Whitman based on the nonlinear regression results. The same is true for the later years. Apart from the two instances where the nonlinear regression program would not converge, the estimates of λ are all significantly less than one, and unlike the early years' results, the estimates do not range widely. Because all the estimates of λ are significantly less than one in the later years, the bidding situation in Wallowa/Whitman appears to be one in which regular bidders have a cost advantage.

The linear regression specifications are estimated for the three definitions of regular bidders where the nonlinear regression program did not converge (when regular are bidders who bid on at least 22 percent of sales in the early years, and on at least five and 15 percent of sales in the later years) and when regular bidders are bidders who bid on

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[42] It should be noted that, on average, fewer different definitions of regular bidders are tested for the eastside forests. This is due to there being considerably fewer bidders in the eastside forests than in the westside forests. The frequency distribution of the percentages of times bidders had bid is much more discontinuous for the eastside forests than for the westside forests.

[43] These are the lower and upper bounds placed on the estimates of λ. The nonlinear regression program will not run if the estimate of λ reaches zero, and five is chosen as the upper bound on λ to save computer time. It seems reasonable to believe that if the estimate of λ reaches five either the nonregular bidders are having a much greater impact on bid price than regular bidders, or there is something peculiar about that particular definition of regular bidders that causes instability in the estimates.

at least 2 percent of sales in the early years (because of the large estimate of λ and its large standard error). The linear regression results presented in Table 16 confirm the findings in tables 13a and 13b that bidding was competitive in Wallowa/Whitman for both the early and later years.

Table 16. **Wallowa/Whitman.** Linear Regression Results (1973–80 and 1985–90).

	Linear Equation 1	Linear Equation 2
Percentage of Sales on which a Regular Bidder Must Bid	$\frac{\partial Bid\,Price}{\partial R} - \frac{\partial Bid\,Price}{\partial N}$	Coefficient of PCTN (Percentage of Nonregular Bidders)
2% (1973–1980)	-53.24	0.75
22% (1973–1980)	19.89	-0.78
5% (1985–1990)	45.38	-.042
15% (1985–1990)	33.30	0.01

* Statistically significant at the .05 level.

Malheur. The nonlinear regression results for Malheur are presented in Tables 14a and 14b. None of the estimates of λ in the early years are significantly greater than one, indicating bidding behavior was competitive in the early years. In the later years, though one of the estimates of λ is statistically significantly greater than one, the bidding appears less competitive.

The linear regression equations are applied to two definitions of regular bidders in the later years—regular bidders who must bid on at least 3 percent and 10 percent of sales. The "three-percent" definition of regular bidders was chosen to see if the nonregular bidders would have a significantly greater impact on bid price than regular bidders, and the "ten-percent" definition of regular bidders was chosen to see if perhaps the greater impact of nonregular bidders indicated by the nonlinear regression results would be significant in the linear regression specifications. The results are below in Table 17.

Table 17. **Malheur**. Linear Regression Results (1985–90).

	Linear Equation 1	Linear Equation 2
Percentage of Sales on which a Regular Bidder Must Bid	$\frac{\partial Bid\,Price}{\partial R} - \frac{\partial Bid\,Price}{\partial N}$	Coefficient of PCTN (Percentage of Nonregular Bidders)
3%	280.98*	1.93
10%	-4.13	1.30

* Statistically significant at the .05 level.

The linear results when regular bidders are bidders who bid on at least 3 percent of sales contradict the nonlinear regression results by showing that regular bidders have more of an impact on bid price than nonregular bidders. The linear regression results when regular bidders are bidders who bid on at least 10 percent of sales also confirm that bidding is competitive. The implications of the results of the linear and nonlinear regression analyses are unclear. Only one estimate of λ from the nonlinear regression analysis is significant, but the large size of the estimates suggests bidding behavior in the later years is at least suspicious.

Ochoco. The nonlinear regression results for Ochoco are presented in Tables 15a and 15b. Ochoco supposedly contains the most competitive bidding of the eastside group of forests, but all the estimates of λ for the early years are greater than one. None of the coefficients are significantly greater than one, so like Willamette, we cannot reject the hypothesis that bidding in Ochoco is competitive. A similar conclusion is suggested for the later years where none of the estimates for λ are significantly greater than one.

Linear regression results for the two instances in the later years are the estimates of λ equal five are presented in Table 18.

Table 18. **Ochoco.** Linear Regression Results (1985–90).

	Linear Equation 1	Linear Equation 2
Percentage of Sales on which a Regular Bidder Must Bid	$\frac{\partial Bid\,Price}{\partial R} - \frac{\partial Bid\,Price}{\partial N}$	Coefficient of PCTN (Percentage of Nonregular Bidders)
2%	-170.36	5.49
52%	-81.65	3.67

* Statistically significant at the .05 level.

The linear regression results, which provide no evidence that nonregular bidders have a significantly greater impact on bid price than regular bidders, support the nonlinear results and suggest that bidding in Ochoco is competitive in the later years.

This completes the empirical analyses of the three stages of the multistage procedure. The implications of the results obtained are discussed in Chapter 5, along with a possible extension of the multistage procedure.

CHAPTER 5

CONCLUSIONS AND EXTENSIONS

This thesis develops a procedure for identifying market areas where bidding is least competitive. A potential use for the procedure is to allow antitrust resources to be focussed more efficiently. The multistage procedure developed in this thesis is applied to five forests west of the Cascade Mountains (westside forests) and to four forests east of the Cascade Mountains (eastside forests) in Oregon and Washington over the time period 1973–90.

Measures of market concentration used in the first stage of the procedure are the Herfindahl-Hirsch Index (HHI) and four-firm concentration ratios. These suggest that the Willamette Forest may contain the most competitive bidding of the westside forests followed by the Gifford Pinchot, Mt. Baker/Snoqualmie, Mt. Hood, and Umpqua forests. For the eastside forests, the market concentration measures indicate the Ochoco Forest may contain the most competitive behavior followed by the Umatilla, Wallowa/Whitman, and Malheur forests. Plots of the market concentration measures show that market concentration appears to change dramatically in the early 1980s, possibly in response to the timber crash that occurred during that same period of time.

The comparisons of bid price means and the price decomposition procedures of the second stage support the first-stage findings that Willamette and Ochoco have the most competitive bidding of the westside and eastside forests. The price decomposition procedure indicates that Gifford Pinchot and Mt. Baker/Snoqualmie are the least competitive of the westside forests, and that Malheur and Wallowa/Whitman are the least competitive of the eastside forests.

A bidding behavior model developed in Chapter 3 reveals that an innovative way to test for the presence of noncompetitive bidding is to determine whether nonregular bidders have a greater impact on bid price than regular bidders. A greater impact on bid price by nonregular bidders suggests noncompetitive bidding.

Westside nonlinear and linear regression results in stage three show that nonregular bidders had a greater impact on bid price than regular bidders in Mt. Baker/Snoqualmie and Gifford Pinchot during 1973–81. This suggests that noncompetitive bidding may have been occurring in those forests during that period of time. Antitrust investigations, however, are necessary to confirm these results. For the time period following the crash of the timber market, 1985–90, regression results show that bidding in Mt. Baker/Snoqualmie was mostly competitive. The results for Gifford Pinchot are somewhat mixed, but tend to show that the apparent noncompetitive bidding of the earlier time period diminished. For both periods tested, bidding in Willamette (the competitive benchmark) appears competitive.

The nonlinear and linear regression results for Wallowa/Whitman and Malheur do not support the first- and second-stage findings that bidding may have been noncompetitive in those forests. During both time periods tested, 1973–80 and 1985–90, bidding in Wallowa/Whitman, Malheur, and Ochoco (the competitive benchmark) appears competitive. The increase in the estimated coefficients of nonregular bidders during the later years for Malheur (contrary to the trend of a decreasing impact of additional nonregular bidders on bid price in other forests), however, suggests that further examinations of bidding practices in Malheur may be warranted.

A potential fourth stage of the multistage procedure is to examine whether the alleged noncompetitive behavior identified in stage three is alleviated by the entry of additional competitive bidders. Outside bidders may be drawn to the market by the positive profits produced by on-going cooperative bidding. If there is entry by competitive outside bidders, and if such entry has the effect of increasing expected bid prices, then the problems created by cooperative bidding are temporary and may not warrant costly Forest Service corrective measures.

An examination of Gifford Pinchot and Mt. Baker/Snoqualmie was performed to see whether the positive profits in those forests in the early years (implied by the results of the multistage procedure) caused outside bidder entry. To obtain a measure of profits, a regression explaining bid price per acre was run separately for Mt. Baker/Snoqualmie and Gifford Pinchot. The residuals from the regression act as measures of profit per acre.[44] Next, the mean number of bidders per sale per quarter in each forest was regressed on lagged average profits per quarter to see whether changes in profits were responsible, in

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[44] If a residual is negative, then the actual bid price per acre is lower than the predicted bid price per acre, so profits are positive. Profits per sale are estimated as -1 (residuals × number of acres).

part, for changes in the average number of bidders.[45] Analyses were done using lagged profits per acre and lagged profits per mbf as independent variables.

The OLS results are not very strong for either Gifford Pinchot or Mt. Baker/Snoqualmie.[46] Very rarely are the coefficients of lagged profits per quarter significant, and when they are significant, the coefficients are often negative—contradicting the hypothesis that positive profits should increase the average number of bidders in a market. Similar analyses were performed for each district in both forests and the results are virtually the same as the analyses done on a forest basis.

The weak results of the regression testing bidder entry may indicate that either bidder entry did not occur in response to changes in profits, or that the regression specification used to obtain measures of profits is incorrect. The regression specification used in the bidder entry analysis was tested by estimating a bid regression using three years of Olympic Forest sales data including the "Up and Adam" sale that was sold noncompetitively (see Chapter 2). The regression indicated that profits for the Up and Adam sale were approximately $230,000 and ranked ninth out of 174 sales on a forest basis and third out of 65 sales on a ranger district basis. Recall from Chapter 2 that Astoria Plywood (a defendant) had originally intended to pay up to $275,272 above the

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[45] Five regressions were run for each forest with profits lagged from one to five quarters. The first regression included only profits lagged one quarter as an independent variable. The second included profits lagged one and two quarters, and so on.

[46] See the appendix for regression results.

Forest Service reserve price. This provides a measure of support for the regression specification used to obtain the measures of profit.[47]

The multistage procedure implemented in this thesis shows that overall, for the forests identified as noncompetitive, bidding became more competitive in the later years (1985–90) and any noncompetitive bidding that was occurring in the early years (1973–81) diminished. Should a time ever arise when noncompetitive behavior is believed to be prevalent, the Forest Service may wish to take the following steps to mitigate cooperative bidding: (1) reduce a noncompetitive coalition's ability to police itself by concealing bidders's identities or by using sealed-bid auctions or (2) lessen the loss of government revenue from noncompetitive bidding by raising the reserve price of timber tracts.[48, 49]

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[47] Similiar analyses using the noncompetitive sales from the two cases *United States v. Champion International et al.* and *United States v. Walker* were not performed because the sale dates did not correspond to the period of time spanned by the data available for this thesis.

[48] See Froeb and McAfee (1988) for more details.

[49] It is recognized that raising the Forest Service reserve price increases the probability that tracts will go unsold (*e.g.*, Froeb and McAfee [1988]);. A study by Schroeter and Smith (1994) suggests that *lowering* the Forest Service reserve price may result in higher expected revenue. Schroeter and Smith's study, however, only examined sealed-bid auctions in one forest between 1987 and 1990 where bids took the form of lump-sum amounts to be paid to the government (resulting in 94 observations).

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APPENDIX

EXAMINING BIDDER ENTRY

EXAMINING BIDDER ENTRY

A potential fourth stage of the multi-stage procedure is to examine whether profits created by the alleged noncompetitive bidding in Mt. Baker/Snoqualmie and Gifford Pinchot (1973–91) increased bidder entry. To test the relationship between profits and bidder entry, the mean number of bidders per sale per quarter is regressed on average profits per quarter. Profits are calculated using the residuals of regressions explaining bid price. (The bid price regression results for Mt. Baker/Snoqualmie and Gifford Pinchot are listed in Tables A-1 and A-3.) Separate regression analyses are performed for each forest using average profits per acre (PROFACR) and per mbf (PROFMBF) lagged up to five quarters. The number of periods PROFACR and PROFMBF are lagged is indicated by the number immediately following the variable names. For example, PROFACR3 is average profit per acre lagged three quarters.

The results of the bidder entry regressions for Mt. Baker/Snoqualmie are listed in Tables A-2 and A-3, and the results for Gifford Pinchot are listed in Tables A-5 and A-6. The regression results for Mt. Baker/Snoqualmie and Gifford Pinchot are weak. The coefficients are rarely significant and when they are significant, they are negative—contradicting the hypothesis that profits increase bidder entry. The regression coefficients may indicate that either bidder entry was not responsive to profits or the regression specification used to obtain measures of profits is incorrect. The bid price regression was run on three years of data including the noncompetitive "Up and Adam" sale (see Chapter 2), the regression indicates the Up and Adam had the ninth highest profits in the Olympic Forest and the third highest profits in its ranger district. This lends support to the regression specification used to obtain profits.

Table A-1. **Mt. Baker/Snoqualmie, 1973–81.** Bid Price Regression Results†

Variable Name	Parameter Estimate	t-stat for Ho: Parameter = 0
INTERCEPT	-2569.388	-0.640
NBIDDERS	295.147	8.582**
ORALAUCT	-86.477	-0.290**
ACRES	-2.690	-4.154**
CLENGTH	1.416	3.881**
LUMPSUM	219.500	0.091
PRICEMETH	657.088	0.455
SALVDUM	82.179	0.305
SBADUM	-542.106	-1.666
BID YEAR	-39.627	-0.736
QUARTER1	43.395	0.135
QUARTER2	145.891	0.475
QUARTER3	-109.379	-0.354
ENVIRON	-0.389	-1.242
STMPTRCK	-1.350	-6.598**
HAULCOSTS	-0.460	-0.841
TEMPROADS	-0.299	-0.387
PCL	0.749	4.882**
HAULMILES	-15.536	-1.735
VOLOTHER	470.255	3.854**
CPAM	30.785	0.828
DFPRICE	21.607	7.387**
DFIRWEST	379.698	24.211**
WESTHEM	225.524	12.045**
CEDARS	392.282	15.242**
OTHERFIRS	242.223	11.362**

Adjusted R-squared: 0.892
Mean of the dependent variable: 5561.46
† Bid price per acre is the dependent variable.
** Variable is significantly different from zero at the 0.001 level

Table A-2a. **Mt. Baker/Snoqualmie 1973–81.** Market Entry Regression Results †
(per MBF Basis)

Variable Name	Parameter Estimate	Standard Error	t-stat for Ho: Parameter = 0	Adjusted R-Squared
Regression 1				
INTERCEPT	6.098	0.260	23.332**	0.079
PROFMBF1	-0.006	0.003	-1.822	
Regression 2				
INTERCEPT	6.092	0.266	22.879**	0.109
PROFMBF1	-0.004	0.004	-1.237	
PROFMBF2	-0.004	0.004	-1.343	
Regression 3				
INTERCEPT	6.002	0.265	22.645**	0.128
PROFMBF1	-0.001	0.005	-0.152	
PROFMBF2	-0.002	0.004	-0.673	
PROFMBF3	-0.007	0.004	-1.905	
Regression 4				
INTERCEPT	5.875	0.261	22.487**	0.166
PROFMBF1	-0.002	0.005	-0.457	
PROFMBF2	0.003	0.005	0.584	
PROFMBF3	-0.004	0.004	-1.171	
PROFMBF4	-0.007	0.004	-1.987	
Regression 5				
INTERCEPT	5.750	0.258	22.328**	0.096
PROFMBF1	-0.003	0.005	-0.619	
PROFMBF2	0.002	0.004	0.380	
PROFMBF3	0.001	0.005	0.270	
PROFMBF4	-0.005	0.004	-1.360	
PROFMBF5	-0.006	0.004	-1.720	

Mean of the dependent variable: 6.13
† Mean number of bidders per quarter is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level.

Table A-2b. **Mt. Baker/Snoqualmie 1973-81.** Market Entry Regression Results†
(per Acre Basis)

Variable Name	Parameter Estimate	Standard Error	t-stat for Ho: Parameter = 0	Adjusted R-squared
Regression 1				
INTERCEPT	6.133	0.275	22.281**	-0.02
PROFACR1	-0.000	0.000	-0.526	
Regression 2				
INTERCEPT	6.129	0.291	21.056**	-0.06
PROFACR1	-0.000	0.000	-0.369	
PROFACR2	-0.000	0.000	-0.382	
Regression 3				
INTERCEPT	6.034	0.288	20.889**	-0.05
PROFACR1	0.000	0.000	0.093	
PROFACR2	0.000	0.000	0.148	
PROFACR3	-0.000	0.000	-1.250	
Regression 4				
INTERCEPT	5.920	0.276	21.478**	0.02
PROFACR1	-0.000	0.000	-0.168	
PROFACR2	0.000	0.000	0.819	
PROFACR3	-0.000	0.000	-0.630	
PROFACR4	-0.000	0.000	-1.834	
Regression 5				
INTERCEPT	5.792	0.241	24.001**	0.130
PROFACR1	-0.000	0.000	-0.786	
PROFACR2	0.000	0.000	0.738	
PROFACR3	0.000	0.000	0.299	
PROFACR4	-0.000	0.000	-1.282	
PROFACR5	-0.000	0.000	-2.222*	

Mean of the dependent variable: 6.13
† Mean number of bidders per quarter is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.05 level.

Table A-3. **Gifford Pinchot, 1973-81.** Bid Price Regression Results†

Variable Name	Parameter Estimate	t-stat for Ho: Parameter = 0
INTERCEPT	24707.000	7.664**
NBIDDERS	499.034	12.433**
ORALAUCT	239.583	0.791
ACRES	-1.274	-3.276**
CLENGTH	0.408	1.505
LUMPSUM	453.491	0.901
PRICEMETH	347.693	0.222
SALVDUM	348.728	1.490
SBADUM	338.721	1.310
BID YEAR	-419.623	-9.404**
QUARTER1	531.281	1.940*
QUARTER2	711.597	2.877
QUARTER3	258.585	0.972
ENVIRON	-0.252	-0.590
STMPTRCK	-1.816	-8.595**
HAULCOSTS	-0.117	-0.255
TEMPROADS	-0.530	-0.488
PCL	0.813	3.327**
HAULMILES	-13.569	-1.593
VOLOTHER	255.926	2.079*
CPAM	-107.611	-3.042**
DFPRICE	24.643	8.453**
DFIRWEST	434.331	27.251**
WESTHEM	339.595	16.732**
CEDARS	376.834	18.198**
OTHERFIRS	320.347	17.858**

Adjusted R-squared: 0.892
Mean of the dependent variable: 5561.46
† Bid price per acre is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level.

Table A-4a. **Gifford Pinchot, 1973-81.** Market Entry Regression Results[†]
(Per MBF Basis)

Variable Name	Parameter Estimate	Standard Error	t-stat for Ho: Parameter = 0	Adjusted R-Squared
Regression 1				
INTERCEPT	5.626	0.347	16.221**	-0.036
PROFMBF1	-0.001	0.007	-0.180	
Regression 2				
INTERCEPT	5.505	0.295	18.641**	0.121
PROFMBF1	0.008	0.007	1.194	
PROFMBF2	-0.016	0.007	-2.381	
Regression 3				
INTERCEPT	5.638	0.284	19.834**	0.186
PROFMBF1	0.010	0.006	1.617	
PROFMBF2	-0.017	0.007	-2.473*	
PROFMBF3	-0.003	0.006	-0.501	
Regression 4				
INTERCEPT	5.618	0.300	18.746**	0.166
PROFMBF1	0.012	0.007	1.727	
PROFMBF2	-0.019	0.008	-2.455*	
PROFMBF3	-0.000	0.008	-0.026	
PROFMBF4	-0.006	0.007	-0.766	
Regression 5				
INTERCEPT	5.720	0.284	20.107**	0.291
PROFMBF1	0.009	0.007	1.321	
PROFMBF2	-0.016	0.008	-2.045*	
PROFMBF3	-0.001	0.007	-0.078	
PROFMBF4	0.001	0.008	0.079	
PROFMBF5	-0.013	0.007	-1.767	

Mean of the dependent variable: 5.55
† Mean number of bidders per quarter is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level.

Table A-4b. **Gifford Pinchot, 1973-81.** Market Entry Regression Results†
(per Acre Basis)

Variable Name	Parameter Estimate	Standard Error	t-stat for Ho: Parameter = 0	Adjusted R-Squared
Regression 1				
INTERCEPT	5.605	0.348	16.126**	-0.031
PROFACR1	0.000	0.000	0.393	
Regression 2				
INTERCEPT	5.502	0.284	19.389**	0.203
PROFACR1	0.000	0.000	1.862	
PROFACR2	-0.001	0.000	-2.805*	
Regression 3				
INTERCEPT	5.651	0.271	20.881**	0.284
PROFACR1	0.001	0.000	2.131*	
PROFACR2	-0.001	0.000	-3.009	
PROFACR3	-0.000	0.000	-0.601	
Regression 4				
INTERCEPT	5.639	0.285	19.818**	0.276
PROFACR1	0.001	0.000	2.256*	
PROFACR2	-0.000	0.000	-3.035*	
PROFACR3	-0.000	0.000	-0.059	
PROFACR4	-0.000	0.000	-0.961	
Regression 5				
INTERCEPT	5.743	0.274	20.922**	0.366
PROFACR1	0.000	0.000	1.808	
PROFACR2	-0.000	0.000	-2.329*	
PROFACR3	-0.000	0.000	-0.490	
PROFACR4	0.000	0.000	0.068	
PROFACR5	-0.001	0.000	-1.591	

Mean of the dependent variable: 5.55
† Mean number of bidders per quarter is the dependent variable.
* Variable is significantly different from zero at the 0.05 level.
** Variable is significantly different from zero at the 0.001 level.