PREDICTING FORESTRY CONSULTANT PARTICIPATION BASED ON PHYSICAL CHARACTERISTICS OF TIMBER SALES

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ABSTRACT

The impacts of timber tract characteristics on the likelihood of participation by timber consultants are examined using a detailed data set on timber sales from North Carolina. General categories of determinants include tract values, the inherent uncertainty concerning tract values, and the costs of presale measurement (cruising) and contract enforcement services provided by consultants. Empirical results indicate that variables included as measures of inherent uncertainty and of presale measurement and contract enforcement costs have statistically significant impacts on consultant participation. Contrary to common wisdom, however, variables included to measure the impacts of tract value generally are not statistically significant.

Keywords: timber sales, forestry consultants, middleman participation.

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INTRODUCTION

Buyers and sellers rarely know the exact characteristics of goods being exchanged. This uncertainty motivates buyers to devote resources to obtaining information on — or measuring — the attributes of prospective purchases. In many situations, individual measurement by prospective buyers is duplicative and results in social waste. Further, the seller usually bears some portion of the costs associated with buyer measurement (often in the form of a lower transaction price) and therefore has an incentive to find ways to

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reduce buyer presale measurement activities. Sellers may, for example, make payment contingent on the levels of attributes revealed after the sale, offer warranties, supply free samples, or provide presale information on the attributes of the sale item.[1]

This paper examines these issues in the context of timber sales. The focus of the analysis is on the determinants of a timber seller's choice of whether to employ the services of a private timber consultant. These consultants provide presale information on the attributes of the timber tract being sold, as well as a number of other services that economize on the transaction costs associated with the sale of standing timber.

The effects of forestry consultants on timber sale prices have been examined in a number of studies (see, for example, Hardie & Wieland, 1987; Hubbard & Abt, 1989 and Munn & Rucker, 1994). In general, these studies have found increased timber sale prices associated with professional forestry assistance. There has, however, been much less attention directed to the topic of the present study — the determinants of consultant participation. The only previous study on this topic focused on the relationship between landowner characteristics and consultant participation in timber sales (see Larson & Hardie, 1989). The present study, by contrast, uses a data set on timber sales in North Carolina to examine a different set of determinants of consultant participation — the physical characteristics of timber tracts.

The results of our analysis have the potential to improve our understanding of the working of markets in general and of timber markets in particular. Our finding, for example, that an increase in the value of a tract *per se* does not lead to an increase in the use of consultants appears to contradict conventional wisdom in the industry. Additionally, in those instances — in the United States, as well as in other countries — where government agents compete with, or take the place of, private timber consultants, our analysis

[1] See Barzel (1982) and Williamson (1985) for discussions of these issues. It is well-documented that in certain instances sellers can actually bear the full costs of buyer presale measurement. See, for example, French & McCormick (1984), Leffler & Rucker (1991), and Leffler *et al*. (1996) and the sources cited therein.

may allow for improved resource allocation by helping to identify tracts where the services of such agents have the highest value.

Market Practices in the United States: a Brief Overview

In stumpage markets in the United States, when forest products firms buy standing timber from private landowners, the forest products firms typically employ professional foresters to procure the necessary raw materials for the mill. These professional foresters are experienced timber buyers, adept at determining timber volumes and other tract attributes and are well informed of current market prices and conditions. In contrast, many private landowners rarely sell timber, are unfamiliar with current market prices when they do sell, and lack the necessary forestry expertise to determine the timber volumes or other attributes of their tracts. As a consequence, landowners acting on their own are likely to be at a disadvantage when negotiating with buyers. Landowners have the option, however, of employing private forestry consultants to handle the sale of their timber. Like timber buyers, forestry consultants also are professional foresters, adept at determining timber volumes and other tract attributes and are well informed of current market prices and conditions.

When a consultant is employed by a landowner, the consultant typically prepares the tract for sale, estimates the quality and volume of timber, informs potential timber buyers of the upcoming timber sale and provides pertinent tract information, prepares a timber sale agreement that protects the interests of the landowner, sells the timber either by direct negotiation or sealed-bid auction, monitors the logging operation and enforces the contract specifications. In exchange, the consultant receives a fee, typically a fixed percentage of the gross sale price of the timber sale.[2]

The contractual arrangements between small landowners and buyers almost always specify the transfer of standing timber to the buyer, thereby making the buyer the re-

[2] A study of consultant fees in North Carolina found that the average fee was about 8.5% (Kronrad & Albers, 1983).

sidual claimant from harvesting activities.[3] Timber sales contracts usually provide the buyer with a relatively short period of time to complete harvesting operations — typically 24 months or less — and specify harvest levels in terms of "merchantable" timber or minimum diameters to be removed. Timber contracts also specify other performance criteria — related, for example, to road or post-harvest physical tract characteristics — as well as penalties for violations of contract provisions. Payment provisions on private contracts generally call for either lump sum (the buyer agrees to pay a stated amount regardless of the volume and composition of logs actually removed from the tract) or per unit (the buyer agrees to pay a specified amount per unit of logs removed from the tract) payment.

The Determinants of Consultant Participation

The extent of consultant participation in the timber sale process is determined by the interaction of factors that affect the demand for consultant services and factors that determine the supply of such services. Included among the factors that determine whether a consultant is hired are a timber sale's physical characteristics. Three different types of characteristics of a timber tract might be expected to influence landowners' decisions to seek professional forestry assistance and consultants' decisions to participate. First, are features of a timber tract that affect the intrinsic, or inherent, uncertainty with respect to the tract's true value.[4] Second, are attributes of a timber tract that affect the costs of the presale measurement (cruising) and contract enforcement services provided by consultants. Third, are attributes of a tract that affect its value. Each of these three types of characteristics is discussed below.

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[3] An alternative arrangement might be one in which the small landowner hires logging resources to cut his timber and then sells logs to the mill. Such an arrangement — which would make the landowner the residual claimant from harvesting activities — is extremely rare. See Rucker & Leffler (1991) for a discussion of the choice among these alternative ways of organizing production.

[4] By intrinsic or inherent uncertainty, we refer to the uncertainty concerning the value of a timber tract when no information on the characteristics of the tract is available, i.e., prior to a formal timber cruise by either the seller (or consultant acting as an agent for the seller) or prospective buyers.

The discussion of the first two types of characteristics below is based on research by Barzel (1982), French & McCormick (1984), and Williamson (1985) that examines the issue of presale measurement in a general context, and by Leffler & Rucker (1991), and Leffler *et al*. (1996) that examine the same issue, both in a general context and in the context of timber sales. This literature on transaction costs provides several insights relevant to the present analysis. In a general context, it is widely recognized that buyers' incentives to undertake presale measurement can be duplicative and that the costs of buyer measurement are borne — either in part or in total — by the seller. These costs provide sellers with the incentive to structure the conditions of the sale in ways that reduce buyers' incentives to measure.

It is also generally recognized that an increase in the level of uncertainty concerning the value of a good leads to an increase in the amount of presale measurement buyers will undertake.[5] This in turn increases the seller's incentives to develop methods for curtailing buyer measurement activities. One method by which the seller can reduce buyer measurement activities is by providing information to prospective buyers on the attributes of the sale good. There may, however, be a problem with the credibility of the information provided by the seller. He may have an incentive to provide biased information, particularly if he does not participate in the market frequently (Akerlof, 1970). Provision by the seller of such information will do little to diminish the measurement activities of buyers. In such situations, there is a role to be played by third party information providers who, as frequent participants in the market, have incentives to establish and maintain reputations for providing high quality information (Klein & Leffler, 1981). Such individuals may also provide other services that reduce the costs of transactions. In the context that is the focus of the present paper, timber consultants play the role of third party information providers, and also assist landowners in the negotiation and enforcement of timber sales contracts.

[5] For analyses of these issues in a standard market setting see, for example, Stigler (1961) and Barzel (1982). For analyses of the impacts on presale measurement of an increase in the level of uncertainty concerning a good's value in an auction setting, see Leffler *et al*. (1996) and Persico (1997).

Uncertainty as a Determinant of Consultant Participation

As indicated by the preceding discussion, as the inherent uncertainty concerning a tract's actual value increases, the landowner's incentive also increases to hire a timber consultant as a means of reducing the costs borne by the seller from buyer presale measurement. Further, most landowners sell timber infrequently and are relatively unskilled at estimating timber values. Timber buyers, on the other hand, are trained professionals who participate on a daily basis in the timber market and are better able than landowners to assess the value of heterogeneous timber tracts. As a consequence, landowners are at a greater disadvantage negotiating prices and contract terms with timber buyers as the inherent uncertainty regarding the tract's true value increases. The greater the uncertainty concerning a tract's value, therefore, the higher the probability that the landowner will seek assistance — essentially, an increase in inherent uncertainty increases the demand for consultant services.

Tract characteristics that reflect such differences in uncertainty include the proportion of sawtimber on the tract and the total volume of timber on the tract. Forests in the North Carolina area from which we obtain our data contain hardwoods such as maple or oak, pine sawtimber, "chip-and-saw," and pulpwood timber. Maple, oak, or pine sawtimber can yield sawmill products with a substantial variance in value depending upon the particular characteristics of the individual trees.[6] In contrast, chip-and-saw and pulpwood timber yield primarily low value products such as pulp stock and fire wood with little variance by tree characteristic. We therefore predict that, *ceteris paribus*, consultants are more likely to be involved in the sale of timber tracts with higher proportions of the highly variable hardwood and pine sawtimber.

Holding the tract's expected composition constant, a larger volume implies a larger variance and greater uncer-

[6] This variation in value is typified by the following examples of recent hardwood market prices: The average price of first and second grade oak is \$1110/mbf as compared with \$485/mbf for #2a common; first and second grade hard maple is \$1445/mbf as compared with \$475/mbf for #2a common. See *Weekly Hardwood Review* (1997).

tainty concerning a tract's true value.[7] Such an increase in uncertainty suggests the prediction that an increase in volume will increase the likelihood of consultant participation.

Measurement and Enforcement Costs as Determinants of Consultant Participation

Differences in presale measurement (cruising) costs and in the contract enforcement costs borne by landowners and their agents also are predicted to affect the likelihood that consultants will be involved in the sale of a timber tract. Holding other tract characteristics (including volume) constant, an increase in the density of timber on a sale tract reduces the number of (fixed radius) plots that must be cruised to conduct a given percentage cruise.[8] On a higher density tract, in other words, the same number of trees can be evaluated with less movement from plot to plot. The implied decrease in the costs of cruising essentially increases the supply of consultant services. An increase in density is thus predicted to result in an increase in the likelihood of consultant involvement.

An increase in the costs of preparing a sale site and monitoring the terms of the timber sale agreement will increase the likelihood that a landowner will seek the assistance of a timber consultant. Thinning and other types of partial cut sales typically require marking of the trees to be cut and monitoring of the buyer's activities to assure that only the marked trees are harvested. We predict, therefore, that as a result of an increase in the demand for consultant services, consultants are more likely to be involved with partial cut sales than with clear cut sales.

[7] To see that an increase in volume increases variance, consider a tract with one tree whose perceived size and quality are such that the expected value of the tract is \$110, and that prospective buyers' perceptions are that the actual value of the tract is either \$100 or \$120, both with probability of 0.5. Now, suppose the number of trees on the tract doubles to two. Assuming that the expectations concerning the second tree are identical to the first (i.e., holding composition constant), the tract now has an expected value of \$220 with potential realized values of \$200 with probability 0.25, \$220 with probability 0.50, and \$240 with probability 0.25. The variance of the tract thus increases from 100 to 200 with the increase in volume. We address below (and test the possibility empirically) that the increase in value that accompanies, for example, an increase in volume affects consultant involvement.

[8] An increase in density holding volume constant requires that the size of the tract (in acres) be allowed to decrease. Accordingly, in our empirical analysis, our regressions do not include a tract size variable.

Value as a Determinant of Consultant Participation

From the perspective of the presale measurement and transaction costs model that provides the basis for the predictions discussed above, a change in the value of a tract, per se, should not affect the likelihood of consultant participation. To see this, consider two tracts with expected values of $1,000 and $1,000,000. Suppose that the level of uncertainty concerning the value of the tracts is the same — the actual value may be either $100 above the expected value or $100 below the expected value, both with probability of 0.5. The incentives for presale measurement and the demand for the services of a consultant should be the same for the two tracts — a variance preserving shift in the value distribution of a timber tract is predicted to have no impact on consultant involvement.[9]

We find the logic of the preceding discussion to be compelling. There are, however, at least three alternative explanations for why a change in value (holding constant the uncertainty concerning a tract's value) may affect the probability of consultant participation. The first explanation relates to the role of the number of potential bidders for a tract. The number of potential bidders — it might be argued — will increase as the potential profitability of the tract increases. For purposes of this paper, we define potential profitability from the perspective of a buyer to be the profits that could be made if he did not have to pay anything for the tract.[10] As the number of potential bidders increases, the costs to the landowner of identifying the buyer with the highest valuation increase. This, in turn, increases the probability that a landowner will seek assistance from consultants, whose costs of identifying potential bidders and accurately estimating each bidder's valuation generally are lower than the landowners' due to consultants' market expertise and knowledge concerning potential bidders.

The potential profitability — or value — of a tract, and hence, the number of potential bidders is determined by

[9] Leffler *et al*. (1996) find empirical support for this prediction in a similar context, finding that a change in value has no effect on cruising intensity. For a derivation of this prediction in the context of a formal auction model, see Persico (1997).

[10] Note that by this definition, potential profitability and the value of the tract are equivalent.

such factors as the market value of the logs to be removed from the tract, harvesting costs, the type of sale (clearcuts, partial cuts, or salvage sales), and the quality of the timber. For example, as harvesting costs increase, the value of the tract decreases, thereby reducing the number of potential bidders. Similarly, salvage sales are typically more costly to harvest than clearcuts and consequently, fewer loggers are willing to bid on such sales. Finally, as the quality of the timber increases, so does its value and hence the number of potential bidders.

The second possible explanation for why consultants are more likely to participate on higher value sales is a supply-based explanation offered to us by industry observers and participants. It is suggested that because consultants typically are paid a constant percentage of gross sale revenues, their incomes will increase proportionately with a tract's gross sale revenues even though many timber sales preparation and marketing costs increase less than proportionately with value.[11] If consultants' commission rates stay constant, then their net returns will increase with tract value and they will be more willing to participate in the sale of higher value tracts.

Although this argument presents a testable prediction, it also implies that consultants earn economic profits on higher value tracts. In the presence of competition among consultants, however, such profits will tend to be competed away. In fact, in an ongoing survey of Mississippi forestry consultants, a significant proportion of the consultants surveyed indicated that they reduce their commission rates on larger, higher value tracts. Such reductions are consistent with competitive behavior among consultants.[12] If, in fact, this competition is sufficient to eliminate profits on higher value sales, then this explanation for why consultant participation is expected to increase with value is not valid.

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[11] See, for example, Avery and Burkhart (1983).

[12] About 35 percent of the consultants responding to date have indicated that they reduce their commission rates on larger, higher value tracts. The survey does not provide details (1) on whether consultants who do not vary their commission rates specialize in certain types, or value categories, of sales or (2) on how successful consultants with different pricing practices are at obtaining tracts.

A third possible explanation for why an increase in value may lead to increased consultant participation relates to wealth effects. If landowners with larger, more valuable tracts have greater wealth and income, and if consultant services are a normal good, then an increase in the value of the sale tract will lead to an increase in the likelihood of consultant participation.

The preceding arguments suggest that the probability of consultant participation is a function of the tract's characteristics. In a related work, Larson & Hardie (1989) examine the effect of acquiring information (defined as consultant assistance or obtaining a stumpage inventory) on timber sales revenues and find that seller characteristics such as income and intent of timberland ownership influence a landowner's decision to seek additional information.

In contrast, the present paper focuses on the probability of consultant participation as a function of the sale's physical characteristics. An empirical model of the determinants of the probability of consultant participation is estimated below using a data set that includes detailed tract information for consultant and non-consultant sales.

DATA AND EMPIRICAL SPECIFICATIONS

Data

The data set consists of information on 298 North Carolina timber sales collected from timber buyers throughout the state. Of the total, 105 were handled by consultants and the remaining 193 were sold without consultant assistance. For a detailed description of the data and collection procedures, see Munn (1993).

Empirical Specification

The probability of consultant participation for a given timber sale is modeled as a function of the tract's physical characteristics: percentage of the volume in high variance commodities, total volume, timber density, type of sale, access conditions, timber quality, and geographic location. These characteristics determine the tract's value. With the exception of the geographic location variables (which we include to control for any omitted variables — market conditions or tract characteristics — that differ systematically among the geographic regions from which our sample of timber sales was obtained) these characteristics fall into the three categories discussed above. The empirical model we estimate is:

$$P(Consult_i) = f(\%Sawtimber_i, Volume_i, Density_i, Partial\ Cut_i, \\ Good\ Access_i, High\ Quality_i, Salvage_i, Value_i, \\ Piedmont_i, Mountain_i)$$

$P(Consult_i)$ = probability a consultant will represent the sale. *Consult* is a dummy variable for consultant participation (1 if a consultant handles the sale, 0 otherwise).

$\%Sawtimber_i$ = percent of the total volume that is sawtimber — predicted to have a positive estimated coefficient because of greater inherent uncertainty associated with the value of sawtimber as compared to pulpwood,

$Volume_i$ = total volume of all timber commodities (thousands of cords) — predicted to have a positive estimated coefficient because increases in total volume increase inherent uncertainty.

$Density_i$ = volume (cords) per acre — predicted to have a positive estimated coefficient because an increase in density reduces cruising costs and increases the supply of consultant services. Also, an increase in density may reduce logging costs and increase the value of the tract — holding volume constant, an increase in density means a decrease in the sale area, resulting in shorter skidding distances.

$Partial\ Cut_i$ = partial cut dummy (1 for partial cut sales, 0 otherwise) — predicted to have a positive estimated coefficient because associated increases in sale preparation and monitoring costs increase the demand for consultant services.[13]

$Good\ Access_i$ = access dummy variable (1 if both access and logging conditions are rated as good or better, 0 otherwise)

[13] Although there may be differences in harvesting costs associated with partial cut sales (relative to clear cuts) we have no value-related prediction for this variable due to the number of different types of sales included in this category — first thinning, high grading, etc. — whose effects on harvesting costs relative to clearcuts may vary.

— predicted to have a positive estimated coefficient because of the associated decrease in logging costs and consequent increase in value.

High Quality$_i$ = quality dummy variable (1 if excellent, 0 otherwise) — predicted to have a positive estimated coefficient because better quality timber has higher value.

Clear Cut$_i$ = clearcut dummy (1 for clearcut sales, 0 otherwise) — omitted variable.

Salvage$_i$ = salvage dummy (1 for salvage sales, 0 otherwise) — predicted to have a negative estimated coefficient because salvage timber is associated with high logging costs and/or poor quality timber relative to clearcuts thereby reducing value.

Log Value$_i$ = first of two proxies for the value of the tract ($1000) — predicted by alternative models discussed in the preceding section to have either a positive or a zero estimated coefficient. This measure of value is the sum across species of the estimated volume of each species multiplied by the corresponding contemporaneous delivered log prices. (The source for delivered log prices is *Timber Mart South*, various issues.) This measure does not control for either logging costs or differences in log qualities across tracts.

Stumpage Value$_i$ = second of two proxies for the value of the tract ($1000) — predicted by alternative models discussed in the preceding section to have either a positive or a zero estimated coefficient. The principle underlying this measure of value comes from standard auction theory, which suggests that on average the winning bid approaches the true value of the tract as the number of bidders becomes large. Accordingly, a bid price equation was estimated for the timber tracts in our sample that included the natural logarithm of the number of bidders as one of the explanatory variables. We then estimated the tract's "true" value as the predicted value from this regression using the estimated coefficients, the tract's actual characteristics, and a "large" number of bidders (virtually identical results were obtained with either 10 or 20 bidders — the maximum number of bidders in our sample is 11). The "value" in this discussion is the stumpage value — the difference between the value of the delivered logs and the costs of transforming standing timber into logs at the mill.

$Coastal_i$ = dummy for coastal region sales (1 if coastal plain, 0 otherwise) — omitted variable.

$Piedmont_i$ = dummy for piedmont region sales (1 if piedmont, 0 otherwise) — no prediction.

$Mountain_i$ = dummy for mountain region sales (1 if mountain, 0 otherwise) — no prediction.

Because the estimated model includes a constant term, the dummy variables for clearcut sales and coastal region sales are omitted to allow inversion of the X'X matrix. The coefficients on *Partial Cut* and *Salvage* therefore are interpreted as differences from clearcut sales in the probability of consultant participation and the coefficients on *Piedmont* and *Mountain* are interpreted as differences from the probability of consultant participation for coastal plain sales.

Results and Discussion

The probability that a sale is handled by a consultant is estimated by maximum likelihood based on a normal cumulative density function (probit regression). Summary statistics for the full sample of 298 sales are reported in Table 1.[14] The results of three different probit regression specifications are reported in Table 2. Model 1 uses the full data sample and does not include either *Log Value* or *Stumpage Value*. Model 2 includes *Log Value* and Model 3 includes *Stumpage Value*.[15] With these value variables included, the estimated coefficients on *%Sawtimber* and *Volume* can be interpreted as measures of the effects on consultant participation of increasing inherent uncertainty, holding value constant. For each of the three models, likelihood ratio test statistics indicate rejection (at the 0.01 level), of the null hypothesis that the explanatory variables are jointly zero, thereby lending support to our specification of the factors that determine whether consultants are used.

[14] A table of pairwise correlation coefficients is available on request from the authors. For the most part, these correlations are relatively small. The only three correlations larger than 0.50 are between *Volume* and *Log Value* (0.983), *Volume* and *Stumpage Value* (0.932) and between *Log Value* and *Stumpage Value* (0.930).

[15] Because for some sales in our sample, values for these two variables are missing, the sample sizes for Models 2 and 3 are somewhat smaller than for Model 1.

Table 1. Summary Statistics for Variables Used in Regression Analysis.

Variable	# of Obs.	Mean	Std. Dev.	Minimum	Maximum
Consult	298	0.352*		0	1.000
%Sawtimber	298	61.913	31.886	0	100.000
Volume (1000 cords)	298	1.105	1.391	0.015	12.910
Density (cords/acre)	298	22.397	15.244	0.184	118.710
Partial Cut	298	0.215*		0	1.000
Good Access	298	0.389*		0	1.000
High Quality	*298*	*0.151**		*0*	*1.000*
Salvage	298	0.044*		0	1.000
Log Value ($1000)	267	65.108	82.224	1.543	734.019
Stumpage Value ($1000)	268	47.516	60.016	1.728	473.627
Piedmont	298	0.359*		0	1.000
Mountain	298	0.141*		0	1.000

* For each of these 0–1 dichotomous variables, the mean represents the proportion of the sales in the sample with a value of one. The standard deviations for these variable are omitted because they provide no information beyond that provided by the means.

In all three of the models, the estimated coefficients for *%Sawtimber* and *Volume* are positive and significant indicating that, as predicted, increases in inherent uncertainty do increase the probability of consultant participation in timber sales. Similarly, the estimated coefficients for *Density* and *Partial Cut* are positive and significant, as predicted by the measurement and enforcement costs explanation discussed above.

The variables included to measure the impacts of changes in the value of the tract (holding constant the level of inherent uncertainty) tend not to be significant. In Model 1, although the estimated coefficient on *Salvage* is negative and significant at an α level of 0.10, neither of the coefficients on *Good Access* or *High Quality* are significant. In Model 2, which adds *Log Value* to the specification in Model 1, similar results are obtained as in the first model, and the estimated coefficient on *Log Value* is not significant. For both Models 1 and 2, likelihood ratio tests fail to reject (at an α level of 0.10) the null hypotheses that the value variables are jointly equal to zero. Model 3 includes *Stumpage Value* and (because a tract's stumpage value is the difference between delivered log values and logging costs) omits the other variables included as measures of value (*Salvage*, *Good Access*, *High Quality*, and *Log Value*). In this specification, while the estimated coefficients on the two inherent uncertainty variables and the two measurement/enforcement cost variables are all significantly different from zero, the estimated coefficient on *Stumpage Value* does not even have the positive sign predicted by the arguments presented in the final portion of the preceding section.[16]

The estimated coefficients on the two regional dummy variables indicate a tendency for consultant participation to be lower in the mountain region than in the coastal plains.

Table 2 displays the estimated partial effects of the statistically significant explanatory variables for each of the three models.[17] For a continuous variable like *Density*, this partial effect indicates (for Model 2) that an increase of one standard deviation in this variable (about 15 cords per acre) increases the likelihood of consultant participation by about seven percentage points. Similarly, for a binary variable like *Salvage*, the partial effect of changing from a clear cut to a salvage sale (that is, changing the variable's value from 0 to 1) is to reduce the likelihood of consultant participation by about twenty one percentage points. The partial effects displayed indicate that the statistically significant variables in our specifications are also economically important in determining consultant participation on timber sales.

A common interpretation of a probit model in the current context is that it predicts consultant participation if $X'\beta > 0$ (or equivalently, if the predicted probability of consultant participation is at least 0.50), where X is the matrix of observed characteristics and β is the vector of regression coefficients.[18] Table 3 presents information on the performance of the three estimated regression models that is

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[16] It is notable that the very high pairwise correlations between both *Volume* and *Log Value*, and *Volume* and *Stumpage Value* suggest the possibility that our proxies for total value are providing essentially the same information as is provided by *Volume*. Recall, however, that multicollinearity does not cause bias in either the parameter estimates or the estimated standard errors of the parameters. The p-values reported in Table 2 are therefore appropriate indicators of the significance of these variables.

[17] See Greene (1997, pp. 876–880) for a discussion of how such partial effects are calculated.

[18] See, for example, Judge *et al*. (1985, p. 768) or Maddala (1992, pp. 334).

TABLE 2. DETERMINANTS OF CONSULTANT PARTICIPATION IN PRIVATE TIMBER SALES.

Probit estimation results for three different models. Each model is designed to estimate the effects of various factors on the probability that a timber consultant will participate in private timber sales. The dependent variable in each of the models is a dichotomous variable assigned a value of one if a consultant participated in a given sale, and zero otherwise.

	MODEL 1			MODEL 2			MODEL 3		
VARIABLE	COEF.	P-VALUE[a]	PARTIAL EFFECT[b]	COEF.	P-VALUE[a]	PARTIAL EFFECT[b]	COEF.	P-VALUE[a]	PARTIAL EFFECT[b]
Constant	–1.396	0.0001	–	–1.405	0.0001	–	–1.593	0.0001	–
%Sawtimber	0.006	0.0228	0.071	0.008	0.0056	0.091	0.011	0.0007	0.127
Volume	0.270	0.0001	0.139	0.639	0.0335	0.336	0.619	0.0030	0.329
Density	0.014	0.0097	0.079	0.012	0.0236	0.067	0.009	0.0649	0.051
Partial Cut	0.316	0.0812	0.120	0.347	0.0808	0.131	0.423	0.0431	0.162
Good Access	0.030	0.8518	–	–0.080	0.6476	–	–	–	–
High Quality	0.123	0.5977	–	0.111	0.6610	–	–	–	–
Salvage	–0.970	0.0718	–0.270	–0.906	0.0982	–0.210	–	–	–
Log Value	–	–	–	–0.007	0.2712	–	–	–	–
Stumpage Value	–	–	–	–	–	–	–0.008	0.1089	–
Piedmont	0.069	0.6985	–	0.016	0.9363	–	–0.032	0.8633	–
Mountain	–0.421	0.1206	–	–0.683	0.0415	–0.214	–0.677	0.0422	–0.217
Log Likelihood		–170.27			–151.97			–153.61	
# of observations		298			267			268	

[a]p-values are for one-tailed tests of significance for the first four variables, all of which have predicted algebraic signs from the transaction costs and measurement costs model. All other p-values are for two-tailed tests of significance.

[b]Partial effects are calculated at the sample means of the explanatory variables. For each continuous variable, the partial effect shown is the change in the probability of consultant participation that results from a change of one standard deviation in the explanatory variable. For each binary variable, the partial effect shown is the change in the probability of consultant participation that results from a change in the explanatory variable from zero to one. Partial effects are calculated only for estimated coefficients with the predicated algebraic signs and with p-values less that 0.10.

based on this interpretation. For the sake of brevity, the discussion that follows focuses on the performance of Model 2. The discussion for the other two models would not differ in any substantive manner.

By the standard interpretation above, Model 2 correctly predicts consultant participation for 192 (153 + 39) out of 267 sales in the sample, a success ratio of 0.72. To assess the usefulness of the model, consider that without the model, one could simply predict that all sales will be nonconsultant sales and have a success ratio of 0.64 · (170/267). Using the model to predict consultant participation

Table 3. Predicted versus Actual Outcomes.

Performance measures (predicted vs. actual outcomes) for each of the models estimated in Table 2.

Model 1

Actual Outcome	Predicted Outcome 0	Predicted Outcome 1	Total	% Correct
0	177	16	193	92
1	65	40	105	38
Total	242	56	298	
% Correct	73	71		

Model 2

Actual Outcome	Predicted Outcome 0	Predicted Outcome 1	Total	% Correct
0	153	17	170	90
1	58	39	97	40
Total	211	56	267	
% Correct	73	70		

Model 3

Actual Outcome	Predicted Outcome 0	Predicted Outcome 1	Total	% Correct
0	150	21	171	88
1	59	38	97	39
Total	209	59	268	
% Correct	72	64		

results in a 23 percent reduction in the error rate (from 97 to 75) relative to simply predicting all sales to be nonconsultant.

Using the standard interpretation, there is an interesting difference in the predictive accuracy for consultant and nonconsultant sales. From Table 3, the model correctly predicts no consultant participation for 153 of the 170 nonconsultant sales in the sample, a success ratio of 0.90. Also, the mean predicted probability of participation for nonconsultant sales is 0.305, well below 0.50, as might be expected.

In contrast, the model correctly predicts consultant participation for 39 of the 97 consultant sales in the sample, a success ratio of only 0.40. Further, the mean predicted probability of participation for nonconsultant sales is 0.47, which is less than the commonly specified threshold value of 0.50. Based on this interpretation, it would appear that our model does not do very well at predicting when consultants will be used.

Consider the following situation, however.[19] Suppose a probit model is estimated using 100 observations of which 90 are nonconsultant sales with values of zero for the dependent variable and 10 are consultant sales with values of one for the dependent variable. Suppose further that when the model is estimated, the 90 zero-value observations have predicted probabilities between 0.01 and 0.30, whereas the 10 one-value observations have predicted probabilities between 0.31 and 0.46. Based on the standard interpretation above, the model does not correctly predict any of the 10 observations with values of one. Clearly, however, the fact that *all* of the one-valued observations have predicted probabilities that are greater than *any* of the zero-valued observations suggests that the model is providing useful information on the one-value observations. A threshold value of 0.50 is arbitrary and in the preceding example yields very different conclusions concerning the performance of the model than would a threshold value of, say, 0.31.

Given the preceding, consider alternative measures of the performance of our specification of Model 2. The discussion in the preceding paragraph indicates that a useful measure of performance might be the simple correlation between the predicted probabilities and the actual value of the 0–1 dependent variable. For Model 2, this correlation is 0.411, which is significantly different from zero at an level of 0.0001. Further, a t-test rejects (at an α level of 0.01) the null hypothesis that the mean predicted probabilities of consultant participation are equal for consultant and nonconsultant sales.[20]

[19] The point made in the following discussion is similar to one made by Greene (1997, pp. 892–893).

[20] As indicated earlier in the text, these mean predicted probabilities are 0.305 for nonconsultant sales and 0.47 for consultant sales. The t-statistic for this test is 6.82.

With respect to the "poor" performance of the model in predicting sales in which consultants will be involved, the model's performance looks better when the observations with the highest predicted probabilities are considered. Of the 56 observations with predicted probabilities greater than 0.50, for example, 39 of them, or 70 percent, were consultant sales. Alternatively, given that there are 97 consultant sales in our sample, what proportion of the 97 sales with the highest predicted probabilities were consultant sales? Fifty-three of these 97 sales, or 55 percent of them, are consultant sales. Based on these figures, it can be argued that the estimated models do provide useful information for identifying consultant as well as nonconsultant sales.

Concluding Comments

Larsen & Hardie (1989) demonstrated that seller characteristics influence whether or not landowners elect to hire a consultant to handle their timber sales. The present study demonstrates that tract characteristics also play an important role. The likelihood of consultant participation is found to be significantly affected by characteristics of sale tracts that reflect differences in the level of inherent uncertainty and in the costs of presale measurement (cruising) and contract enforcement. A common claim in the timber industry is that timber consultants are more likely to participate in the sale of higher valued tracts. Several explanations were discussed in Section II for why this claim might be true. Our empirical results, however, do not support the prediction that *ceteris paribus* an increase in value increases the likelihood of consultant participation. This result is consistent with a measurement cost-based explanation of consultant participation on timber sales. We suggest that the seemingly mistaken industry claim is the result of a high correlation between value and inherent uncertainty. High volume sales and sales with large sawtimber components have both high values and high levels of inherent uncertainty. Our empirical results suggest that it is the high uncertainty on these sales — and not the high value, per se — that causes increased consultant participation.

A useful extension of this paper would be to collect and analyze a data set that includes information on both seller characteristics and physical characteristics of sale tracts.

Such an analysis would address potential criticisms of both the present paper and the earlier work by Larson and Hardie related to the possibility of omitted variable bias. Whereas our analysis omits information on seller characteristics, Larson and Hardie's work omitted information on tract characteristics.

We believe the analysis in this paper has the potential to enhance our understanding of how markets work—for goods in general, as well as for tracts of standing timber. Real estate agents and employment services represent familiar examples of third party information providers in other market settings who are hired by buyers or sellers to assist with the sale of heterogeneous goods and services with uncertain value. Our findings with respect to the impacts of changes in the level of uncertainty concerning value and in enforcement costs may provide insights into the factors that determine whether information providers are hired in such settings.

Finally, as we suggested in the introduction, in those instances where government agents substitute for private timber consultants, our analysis might help to identify those tracts where the value of the agents' services are the greatest.

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