



An assessment of appraisals for federal and state timber sales in Minnesota, U.S.A.

Sonia R. Bruck¹ · Michael A. Kilgore² · Jesse D. Henderson¹ · Gregory E. Frey¹

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Abstract

The frequency of tracts of timber offered for sale that do not receive any bids, also known as no-bids, is a concern for public land managers. No-bids can delay forest management and result in lost revenue to federal and state agencies. We used data collected by the USDA Forest Service (Forest Service) and the Minnesota Department of Natural Resources (MN DNR) to assess the impact of appraisal adjustments on the appraised value of federal and state timber tracts offered for sale in Minnesota and quantify the impact of appraisal characteristics on the likelihood of a sale. We found that Forest Service appraisers are adjusting appraisal values sufficiently to the point where buyers are indifferent between sales at different price points. However, MN DNR appraisers appear to not have had sufficient adjustments, because buyers are more likely to buy higher-valued sale offerings. This study is the first to assess adjustment factors on no-bid sales, as well as assess some sale characteristics that result in successive no-bids.

Study Implications

Successive no-bids are timber tracts that are put up for sale multiple times and repeatedly result in a no-bid. This trend results in lost time and revenue to the agency, more so than a no-bid that occurs only once. We are the first to assess characteristics of successive sales and discuss avenues for future research. Furthermore, we are the first to assess adjustment characteristics of sale offerings. Implications from these findings can provide insight for timber sale managers on how to adjust sale values to increase the likelihood of a final sale and reduce the likelihood of successive no-bids.

Keywords No-bid · Public forests · Timber sales · Timber auctions

✉ Sonia R. Bruck
sonia.bruck@usda.gov

¹ USDA Forest Service, Southern Research Station, Durham, NC, USA

² Center for Environment and Natural Resource Policy, University of Minnesota, St. Paul, MN, USA

Introduction

The frequency of tracts of timber offered for sale that do not receive any bids, also known as “no-bids,” is a concern for public land managers, since this can delay revenue and accomplishing forest management objectives. In Minnesota (MN), the forest products industry contributes an estimated 10.4 billion dollars and employs over 30,000 individuals in direct effects (Deckard 2023). A considerable portion of the wood fiber used by this industry is sourced from MN’s publicly owned forest lands, which account for 53% of all forest land and includes 2.6 million acres (1.1 million hectares) of National Forests (NFs) and 3.8 million acres (1.5 million hectares) of state-owned forests (Oswalt et al. 2019). Proceeds from timber sales on NFs are used as funding for land management practices, including improvements to forest health and ecosystem services, as well as PILT payments (payments in lieu of taxes). Revenue generated from state timber sales is used to support forest management activities, local units of government, and the state’s K-12 education system (Soulder and Fairfax 1996). Timber harvests on public land can create habitat for early successional species. Well-planned sale offerings can assist with wildfire hazard reduction and insect and disease prevention by reducing fuel loads and creating breaks across the landscape.

The appraisal process is an assessment of the value of timberland. The USDA Forest Service (Forest Service) seeks to achieve the sale of at least 85% of sales volume on first offer and are mandated to modify the appraisal process as necessary to achieve this standard (Forest Service 2022), meaning the sales target is less than 15% no-bid on first offering; although, managers aim to reduce no-bids as much as possible. Sale prep and re-advertisement requires an interdisciplinary effort between engineers, environmental planners, foresters, and timber markers. It takes multiple years of planning and preparation to offer a single timber sale on public land. Thus, when managers must re-offer and re-advertise sales, it can divert labor hours from other tasks such as preparing new sale offerings, increase administration, as well as leave standing timber vulnerable to risks (such as wildfire and invasive pests), and potential declining forest health conditions. This is a loss to the agency and ultimately the taxpayer. A memo from the Appraisals Issue of the Forest Products Modernization task declares that the Forest Service would like to, “*reduce the incidence of no-bid sales...through an appraisal system that can respond quickly to market conditions*” (USDA 2018). Assessments accounting for sales that are eventually sold after an initial no-bid, also called successive no-bids, are significantly lacking across the literature. In this article, we aim to assess appraisal adjustment factors and re-offered timber sales (successive no-bids) on public lands in MN.

No-bids are the result of a high appraisal price relative to the identified value of timber offered in the sale (Sendak 1991). Key variables influencing the likelihood of no-bids include wood processing mills holding large wood inventories, missing or weak timber markets, considerable operational and seasonal restrictions on timber permits, road construction requirements, long hauling distances, and low volumes or poor species mixes (Adams and Haynes 1989; Frey et al.

2023). Some literature has assessed timber auction design, including open versus sealed bid auctions (Athey et al. 2011; Kilgore 2023; Schuster and Niccolucci 1993), the impact of reserve price at sealed bid auctions (Carter and Newman 1998), and the competitiveness between open and set-aside timber for small businesses (Haynes 1979).

The appraisal value is the set minimum bid price for stumpage, also called the “reserve price” (Brown et al. 2013). When a timber stand is appraised, the advertiser may apply a “roll-back” factor, reducing the total price of the sale to increase bidding incentive to account for uncertainty in the appraisal process or to make sales more competitive in relation to surrounding markets (Huang and Buongiorno 1986). The appraiser can then apply “adjustment factors” to reflect surrounding market conditions and tract-specific characteristics. Adjustment factors can increase or decrease the final appraisal price, whereas roll-back factors typically only decrease the appraised price.

Timber tracts that are offered and receive no-bid are oftentimes later re-offered for sale with or without changes to the sale package. Even if eventually sold, public agencies and managers consider these re-offers no-bid sales. Schuster and Niccolucci (1991) assessed causes of federal timber no-bids in the Northern Region of the Forest Service from 1961 to 1988 and found that while about 7% of offerings were initially unsold, about 60% of the volume in unsold offerings were eventually sold within 15 months of the initial no-bid. This may have resulted in missed yearly timber targets, putting additional burden on managers to re-package and re-advertise sales. Nationally, from 2007 to 2020, approximately 10% of Forest Service offerings were initially unsold, and 78% of volume from those offerings eventually sold (Frey et al. 2024), although this varied by region and over time. For example, Region 4 (Nevada, Idaho, Utah, and Wyoming) had the highest average level of no-bids (18% no-bids from 2001 to 2021). In contrast, MN DNR has had significantly more no-bids in recent years. From 2021 to 2022, MN DNR had 32% of offered sales, and 35% of offered acres go no-bid (Table 2).

The bidding framework, advertised price, and details about the potential contract offered can significantly impact final sale price. Brown et al. (2013) used a paired bidding field experiment to determine how the appraisal price and contract duration affected the final bid price. They observed a reduction in contract duration from 5 to 2 years lowered average sale price by 3%, providing some evidence that changes in contract length could incentivize bidding. In interviews with timber sale program supervisors, Brown et al. (2012) found that reducing administrative constraints could reduce the frequency of no-bids.

Additionally, Leefers and Potter-Witter (2006) assessed sale characteristics and administrative factors that influenced final sale price in Michigan, Minnesota, and Wisconsin state and federal timber sales. They found that Forest Service sales received fewer bids per sale compared to state sales, possibly due to the fact that Forest Service sales were typically larger in size. Consequently, many small-scale operators may have been unable to bid (because the offered volume was too large for them to harvest), thereby reducing the potential pool of bidders.

Typically, assessments of unsold timber offerings have examined final bid price of surrounding tracts to quantify factors that lead to a no-bid (Leefers and Potter-Witter 2006; Barr and Perez-Garcia 2006). Buongiorno and Young (1984) and Niccolucci and

Schuster (1994) used statistical procedures to predict the high-bid value of a sale by evaluating the characteristics of nearby timber sales. Yet, stand characteristics are likely not the only reason why a no-bid occurs. Recent research has discussed more complex drivers of no-bids, including unforeseen factors such as severe weather and road closures, as well as institutional factors such as policies and regulations (Frey et al. 2023) and perceptions of timber sale managers and bidders (Bruck and Frey 2023).

Numerous stakeholders have pointed to poor appraisals as a major contributor to no-bid sales. Industry stakeholders were more likely to point to appraisals than any other single factor (Frey et al. 2024). In that context, this study aims to explore the linkages between the appraisal system and likelihood of sale. Unlike previous works, our dataset includes novel information on the price adjustment factors applied to Forest Service National Forest System (NFS) and Minnesota Department of Natural Resources (MN DNR) timber sale base prices. Furthermore, we determined which sales were re-offered and quantified the effect of re-offers on no-bid likelihood and appraisal price, which is a unique contribution to the literature.

Timber appraisal

The Forest Service uses a timber sale preparation process called the Gate System. The first three gates require an interdisciplinary effort between engineers, environmental planners, foresters, and timber markers to accurately plan and prepare sales. Gate 1 is the initial planning and feasibility assessment; Gate 2 includes project analysis and design; Gate 3 is when the timber sale preparation occurs. The next three gates are primarily overseen by contracting officers. Gate 4 is when a timber sale package is appraised and advertised; Gate 5 is when the bidding is opened, and the NF finds interested buyers; and Gate 6 is when the contract is awarded to the highest eligible bidder (Frey et al. 2024). MN DNR identifies tracts of timber for harvest, conducts public notice, and auctions timber for sale in generally the same gate procedure as Forest Service sales. Typically, in early December, MN DNR produces a calendar of the public timber auctions that will be held over the next 12 to 15 months. Public notices of timber auctions are made approximately 30 days before the date of each auction (MN DNR 2022a).

According to the National Forest Management Act of 1976, “the secretary of Agriculture, under such rules and regulations as he may prescribe, may sell at *not less than appraised value*, trees, portions of trees or forest products located on National Forest system lands.” Similarly, MN tracts also cannot be sold at less than the tract’s appraised value (MN DNR 2020b). Thus, accurate appraisal value is critically important for ensuring the sale of both NF and state timber.

Transactions evidence appraisal (TEA) is the most common appraisal method used by the Forest Service and MN DNR to estimate stumpage values (Haynes et al. 2016; Barron et al. 2015; MN DNR 2020b). Ideally, information would be available to compare the proposed sale to recent sales that are similar with respect to species, quality, tree diameter mix, product mix, terrain, distance from mill, road, and logging costs. TEA offers an approach to estimate fair market value using recent competitively sold timber from NFs or state-owned forests within a specific geographic area.

Furthermore, both NFS and MN DNR can apply a roll-back factor, or a discount, to the tract's base stumpage price. The state's timber sale manual indicates a normal roll-back factor represents a 15% reduction in the tract's base stumpage prices, although roll-back factors can range between 10% and 20% (MN DNR 2020b). The roll-back factor for NFS sales is typically 10–15% of the tract's base appraised price (Haynes et al. 2019). Of note, Forest Service sales in MN apply the roll back factor to the base period price, while other Forest Service regions across the country apply the roll-back to the predicted bid. The roll-back factor, if applied, always occurs before separate price adjustments.

After the roll-back factor, the appraiser has the discretion to further modify the tract's adjusted base stumpage prices to account for tract-specific characteristics such as road construction costs, distance to mills, stand density, operational constraints, and other stand-specific conditions. For MN DNR the MN timber sale and scaling manual provides criteria to foresters for making these adjustments. For example, the manual indicates a 10% discount is to be applied to the adjusted base stumpage prices when the tract is 76–100 miles from a consuming mill. Tract-specific price adjustments each typically range from a 10% premium to a 10–15% discount (MN DNR 2020b). Similarly, the NFS Region 9 Supplement to the Forest Service Handbook (FSH 2409.18 Chp. 40) details methods for calculating the adjustments. In the instance of haul costs, the appraiser calculates the adjustment to base period haul costs with a spreadsheet that uses factors including mileage, average running speed, standing time, truck owning and operating costs for the type of vehicle to be used, fuel price, volume per load (as influenced by accessibility and road weight limits). Adjustments are allowed for most cost categories up to $\pm 100\%$. Certain adjustment categories have limits (e.g., market adjustment limited to $\pm 25\%$), but these can be overridden by the Forest Supervisor. Thus, NFS generally allows for a wider range of adjustments to the price based on appraisal. How appraisers apply these adjustment factors could potentially influence the likelihood of no-bids. Appraisers have a deep knowledge of the surrounding market conditions and preferred stand characteristics. While there are general guidelines on how adjustments should be applied, the final adjustments are often made at the discretion of the appraiser.

Other mechanisms can be used to incentivize bidding, such as the provision of different contract types that focus on environmental or ecological goals, or the use of set aside contracts for certified small businesses. Both the Forest Service and MNDNR must have a proportion of “Small Business Set-Aside” (SBA) sales. Eligible individuals or companies for SBAs are those with 30 or fewer employees.¹ In the following section we discuss our estimation methods to quantify the impact of appraisal mechanisms.

¹ Sect. 15(a) of the Small Business Act authorizes small businesses (individuals or companies with 30 or fewer employees) to receive any contract which would, “assur[e] that a fair proportion of the total purchases and contracts for property and services for the Government in each industry category are placed with small-business concerns” and which would, “assur[e] that a fair proportion of the total sales of Government property be made to small-business concerns” (Federal Register 2016). Or simply, the Forest Service is required to offer sales to Small Businesses at a fair proportion of market-share at a competitive rate which accurately reflects the estimated transactions costs of eligible bidders. Businesses with 30 or more employees are not eligible to bid on SBA designated sales.

Methods

Probability of a Sale

We use logistic regression (logit model) (Cameron and Trivedi 2010), which distinguishes between the observed binary outcome, y , and an underlying continuous unobservable or latent variable y^* such that:

$$y^* = \mathbf{x}'\boldsymbol{\beta} + u$$

A sale is predicted if $y^* > 0$ and never sold predicted if $y^* \leq 0$. This defines a binary outcome:

$$y = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{if } y^* \leq 0 \end{cases}$$

We seek to estimate the conditional probability of a sale:

$$\begin{aligned} \Pr(y = 1) &= \Pr(\mathbf{x}'\boldsymbol{\beta} + u > 0) \\ &= \Pr(-u < \mathbf{x}'\boldsymbol{\beta}) \\ &= \Lambda(\mathbf{x}'\boldsymbol{\beta}) \end{aligned}$$

Where $\Lambda(\bullet)$ is the cumulative distribution function (c.d.f) of $-u$. We assume u is logistically distributed. We interpret the average marginal effects (AME) of the j th factor, which is computed as the average of all the marginal effects from each observation in the sample:

$$\frac{1}{N} \sum_{i=1}^N \{ \Lambda(\mathbf{x}'\boldsymbol{\beta}) \{ 1 - \Lambda(\mathbf{x}'\boldsymbol{\beta}) \} \beta_j \}$$

We also present the complementary log-log model (cloglog), which is typically used when one of the outcomes is relatively rare compared to the other. For Forest Service sales, most offered sales eventually sell. The complementary log-log is unlike the logit estimator in that the transformation is not symmetric (Long 1997, 2005; Long and Freese 2014). The complementary log-log model of a timber sale is:

$$\Pr(y = 1) = 1 - \exp(-\exp(\mathbf{x}'\boldsymbol{\beta}))$$

As for the logit model, the complementary log-log model is estimated by maximizing a log-likelihood function. We used the Hosmer-Lemeshow goodness of fit test to determine whether the fitted model adequately describes the observed outcome in the data (Hosmer and Lemeshow 1980).

Effect of no-bids on appraised sale value

We used a similar set of independent variables to estimate an OLS regression model to determine the relationship between no-bids on appraised sale value (p).

$$\ln p = \mathbf{x}'\boldsymbol{\beta} + \delta y + u$$

A dummy variable y represents whether or not the offering sold. The matrix $\mathbf{x}$ contains control variables for appraisal characteristics and surrounding employment in the forestry and logging industries and the dependent variable $\ln p$ represents the natural logarithm of per acre appraisal values. This linear regression model specifies an additive normally distributed error term u , which is assumed to be independent and identically distributed across the ranges of the x_j . The solutions $[\hat{\boldsymbol{\beta}}, \hat{\delta}]$ are obtained by minimizing the sum of squared errors (Cameron and Trivedi 2010).

Frequently, OLS models will include outcomes as the dependent variable with presumed causal factors as explanatory variables. In our case, we utilize an outcome variable, whether or not the timber offering sells, as an explanatory variable. The purpose here is to test for systematic differences in appraised prices between offerings that sell and those that do not sell. That is, after controlling for other factors known to shift appraised price up or down, we quantify if there some other systematic biases in appraisal.

Data

Data for federal sales from 2003 to 2021 was gathered from the Forest Service Natural Resource Manager (NRM) Timber Information Manager (TIM) database and NFS Eastern Region (Region 9) District Automation Project (R9DAP or simply DAP) database. DAP contains forest, district, and sale-level variables, including final sale characteristics such as the appraisal adjustments made in the TEA process. However, if a timber offering was not sold on the first offer, and was re-offered later with modifications, DAP only saves the final (sold) characteristics and does not keep information about prior offering(s), except for original appraisal price and volume of timber offered. We were able to gather a limited amount of information about initial appraisals for timber sales. Namely, we were able to observe the initial volume in hundred cubic feet (CCF), total acres, and total advertised value of sale packages that went no-bid and were subsequently reoffered. The sales could have been eventually sold or could have remained unsold after the sale package changes. We inflation adjusted appraisal values to 2021 dollars using the consumer price index (CPI).²

The number of employees and business establishments were collected from the North American Industry Classification Systems (NAICS) for Wood Product Manufacturing (NAICS 321) and Forestry and Logging (NAICS 113), which are maintained by the United States Bureau of Labor Statistics (BLS) (BLS 2023). To

² Consumer Price Index provided by the Federal Reserve Bank of Minneapolis.

estimate total employment near a NF, the forest shape file boundaries were overlaid with county boundaries using ArcGIS Pro 3.2. A summation of total employment in each sector was taken for county boundaries that overlapped with Forest Service forests for concurrent time periods. We included the total employment in forestry and logging and paper, pulp, and lumber manufacturing sectors to control for time varying market conditions. On average, there were 3,039 individuals employed in NAICS 113, and 7,870 employed in NAICS 321 in the counties where the Chippewa and Superior NFs reside.

Additionally, we assess how appraisal zones may influence sales and appraised value (see Appendix 2). Appraisal zones, as defined by the Forest Service, divide each region, forest, and district by factors such as location of manufacturing facilities, haul distance, species yield and composition, timber quality, market competition, and logging methods. Over time the appraisal zones across the Forest Service have been consolidated, since the forest products industry has fewer larger facilities as compared to three decades ago (Haynes et al. 2016). For the Chippewa and Superior NFs there are three zones (9031, 9091, 9092).

The MN dataset consists of tracts of timber offered for sale at public auction by the MN DNR from January 2021 through January 2022. All data associated with each timber tract were obtained from publicly available records available on the MN DNR (2020c) website. To make the federal and state timber data as comparable as possible, only the state tracts that were located within 50 miles of the Superior and Chippewa NF boundaries were included in the analysis. The federal appraisal zones were associated with each state forest according to proximity.

To define no-bid, we described four categories for Forest Service sales (Frey et al. 2024). Category 1 was a sale that never sold; Category 2 was a sale where timber was offered, did not receive any bids at the first offering, changes were made to the sale terms, and the package was finally sold; Category 3 was a sale where timber was offered, did not receive any bids, and then was sold later with no changes made to the sale package; and Category 4 was a sale package where timber sold on the first offer. Importantly, we use the language “initial offer,” “re-offer,” and “final offer” to denote the number of times the timber sale package goes up for bid (Gate 5). At the “initial offer” stage sales have been appraised for the first time and are posted for bid opening. If the sale does not receive any bids, then it may be posted for “re-offer.” At “final offer” the sale was either sold, considered a no-bid, or not yet reoffered at the time of data collection. Lastly, we use “timber sale package” and “sale” interchangeably. The term “sold” means the sale was awarded to the highest eligible bidder. For state sales, we were unable to observe if the timber sale package was a category 2 or 3, we only know if it was put up for “re-offer” (with or without package changes) and if it was “sold” or “never sold.”

The binary definition of no-bid associates with the stakeholder’s perspective (Frey et al. 2023). Forest managers often consider category 1 to 3 as no-bid offerings, and category 4 is considered a sale. Re-advertisement can push timber sale timelines to future years, thus hindering the success of meeting yearly timber targets. Re-offers can create tradeoffs between re-managing old sales instead of offering new sales or conducting other work. A substantial amount of effort can go into offering a single sale. Thus, it is possible that even a low-level of never

sold and re-offers can be a large cost to the agency and taxpayers. Those primarily interested in administration and re-appraisal costs (i.e.: timber sale managers) may consider category 1 and 2 as no-bid and category 3 and 4, as a sale. On the Chippewa and Superior forests Forest Service sales sold without changes are uncommon, and it is not possible to know at this time how many are sold without changes on MN DNR lands. Finally, those most interested in land management practices to reduce fire hazard and conduct habitat management may consider a no-bid as category 1 and a sale as categories 2 through 4. While the income to agencies is important, timber sales are a primary way in which forest management is conducted to reduce fuel loads. When sales are left unsold, that biomass is not removed, which can affect the public via smoke impacts, loss of structures, and human life. We define a binary variable (sold or “never sold”), where categories 2, 3, and 4 constitute “sold” and category 1 constitutes a no-bid (aligning with stakeholders who may be primarily interested in the work eventually being completed). This is not to say that one perspective is superior to another, it is simply because most of the appraisal characteristics in the dataset are the characteristics observed at final offer.

In Table 1 (Forest Service) and Table 2 (MN DNR) we provide summary statistics for acres and values that went unsold or were reoffered. Never sold offerings were about 4.5% of all USFS acres and 2.1% of real value, adjusted to 2021 dollars. When considering the manager stakeholder perspective, combined never sold and re-offered sales constituted 11.2% of all USFS acres, and almost 6% of real value. For MN DNR never sold offerings were 30.1% of acres and 12.5% of value. From the manager stakeholder perspective, no-bids constituted 35.4% of acres and 15.0% of value equaling over 2 million dollars. In Appendix 1, we provide histograms of the timeseries acres and value for Forest Service that was never sold or re-offered from 2003 to 2021.

The dependent variable in all models of federal and state sales was appraised value per acre, not the final bid value. Appraised value is the price that the sale was advertised for at auction; we evaluate how the reserve price may influence bidding. Many of the independent variables are the same between the OLS and logit regression, except the reoffer variables are not included in the OLS regression (difference in original appraised price and volume) because we were primarily interested in how timber package changes impacted “no-bids.” We added a Small Business Set Aside (SBA) dummy and no-bid categories to the OLS regression. SBA was not included in the logit regression because all SBA sales in NFS dataset eventually sold. For MN DNR sales, all variables were the same for the logit and OLS regression, except for the addition of reoffer and SBA dummies. We include a reoffer binary, to proxy the categories identified for Forest Service sales. In Table 3, we describe the independent variables used in each of the regressions, the objective or purpose for including the variable, and the expected signs based on the literature. Furthermore, all data dates provided to us in fiscal year were converted to calendar year. The fiscal year for the Forest Service begins in October (For example: Fiscal Year Quarter 1 = October – December; Calendar year Quarter 1 = January–March). Data analysis was conducted in STATA, version 18.0 (StataCorp 2023).

There were some limitations to our study design, and some potential limitations to the interpretation of our findings. MN DNR sales were collected from one year,

Table 1 Summary of acres and value by sale category for Forest Service offerings. Categories “never sold,” “sold with changes,” and “sold without changes,” are considered no-bid sales

Sale Category	Forest Service Acres	Percent Forest Service Acres	Forest Service Nominal Value (USD)	Percent Forest Service Nominal Value	Forest Service Real Value (USD)	Percent Forest Service Real Value
Never sold	6,400.00	4.53%	\$1,148,238.75	1.43%	\$1,385,020.51	2.07%
Sold with changes	9,102.16	6.45%	\$2,133,975.23	4.04%	\$2,589,313.19	3.87%
Sold without changes	290	0.21%	\$22,825.25	0.04%	\$26,961.62	0.04%
Sold on first offer	129,231.10	91.57%	\$50,198,000.31	94.49%	\$62,967,348.15	94.03%
	Total acres offered	Total considered no-bid by USFS	Total offered value (Nominal)	Total offered value considered no-bid by USFS managers (Nominal)	Total offered value (Real)	Total offered value considered no-bid by USFS managers (Real)
	141,126.76	11.19%	\$52,810,353.45	5.51%	\$66,968,643.46	5.97%

Table 2 Summary of acres and value by sale category for MN DNR offerings. Categories “never sold” and “reoffer” are considered no-bid sales

Sale Category	MN DNR Acres	Percent MN DNR Acres	MN DNR Value	Percent MN DNR Value
Never sold	11,887.70	30.05%	\$1,770,005.00	12.54%
Reoffer	2,102.00	5.31%	\$343,342.00	2.43%
Sold	25569.2	64.64%	\$12,000,000.00	85.03%
	Total acres offered	Total considered no-bid by MN DNR	Total offered value	Total offered value considered no-bid by MN DNR managers
	39,558.90	35.36%	\$14,113,347.00	14.97%

and Forest Service sales were collected from eighteen years of observations. This was necessary because there were fewer federal sales offered in any one year. We collected 783 total observations for MN DNR and 585 total observations for Forest Service. On average, 34 sales were offered per year for Forest Service, compared to the 783 offered sales in one-year period of observations for MN DNR. We aimed to control for time dependent market factors by including NAICS employment variables in Forest Service sale regressions.

Additionally, we were not able to observe all characteristics of Forest Service sales after an initial no-bid and before re-offer, and none of the sale characteristics of MN DNR timber packages prior to reoffer. For Forest Service sales we were able to collect information on original advertised value and original total volumes, which are important components of sales that are typically changed after an initial no-bid occurs. There were some characteristics that we were unable to observe, namely contract length, and final rollback percentages.

Results

Table 4 presents the descriptive statistics for the Forest Service sale variables. Most offered sale packages on the Chippewa and Superior NF eventually sold (96%). On average, volume per acre for reoffered sales decreased by a very small margin (-0.09 CCF/acre), advertised value of the sale increased after changes ($\$5.78$ /acre), and the market adjustment reduced the appraised price by 11%, while the operations adjustment reduced the appraised price by 3%. Furthermore, aspen (*Populus* spp.) for pulp and bolts were on average 7 CCF/acre, while pine (*Pinus* spp.) sawtimber was on average 2 CCF/acre for a typical sale package. Additionally, approximately 41% of sales included a salvage component. Approximately 4% of timber packages never sold (category 1), 8% were reoffered with package changes (category 2), 0.3% were reoffered with no package changes (category 3), and 88% were sold on the first offer (category 4) for Forest Service sales. About 7% of sales were designated as SBA for Forest Service.

Table 3 Predictors of a sale and appraised value per acre. Cells with "NA" are independent variables not added to the logit/cloglog estimations. We expected adjustments (haul, road, operations, and market) and package changes (volume and value) to potentially have a positive or negative effect. If adjustments are increased or decreased sufficiently, we would expect the bidders may be indifferent between sales, and thus the baseline hypothesis may be zero. Adjustments have a direct effect on the minimum bid price (appraisal value), so a negative adjustment would decrease the appraisal and a positive adjustment would increase the appraisal. The sale package changes after an initial no-bid (volume and value differences) are unique to this study. Sale package changes may also be positive or negative depending on if the volumes and values are increased or decreased after an initial sale offering. We list primary literature that applies the other independent variables to predict sale outcomes under "references," and the expected coefficient signs based on reference findings

Variable	Objective	Expected Sign (logit/cloglog)	Expected Sign (OLS)	Reference
Total Sale Acres	Efficiencies in harvesting	+	+	Leefers and Potter-Witter 2006; Kilgore 2023
Sale Category 1	Observed bidding choice	NA	-	Frey et al. 2023; Frey et al. 2024; Bruck and Frey 2023
Sale Category 2	Observed bidding choice	NA	-	Frey et al. 2023; Frey et al. 2024; Bruck and Frey 2023
Sale Category 3	Observed bidding choice	NA	-	Frey et al. 2023; Frey et al. 2024; Bruck and Frey 2023
Sale Category 4	Observed bidding choice	NA	+	Frey et al. 2023; Frey et al. 2024; Bruck and Frey 2023
Aspen Pulp CCF/acre	Preferences at mill	+/-	+	Cubbage et al. 1989; Huebschmann et al. 2004; Leefers and Potter-Witter 2006; Huang and Buongiorno 1986; Kilgore 2023
Low Value Pulp CCF/acre	Preferences at mill	+/-	+	Cubbage et al. 1989; Huebschmann et al. 2004; Leefers and Potter-Witter 2006; Huang and Buongiorno 1986; Kilgore 2023
Pine Pulp CCF/acre	Preferences at mill	+/-	+	Cubbage et al. 1989; Huebschmann et al. 2004; Leefers and Potter-Witter 2006; Huang and Buongiorno 1986; Kilgore 2023
Pine Saw CCF/acre	Preferences at mill	+/-	+	Cubbage et al. 1989; Huebschmann et al. 2004; Leefers and Potter-Witter 2006; Huang and Buongiorno 1986; Kilgore 2023
Haul Adjustment	Efficiencies in harvesting	+/-	+/-	Kilgore 2023
Road Adjustment	Efficiencies in harvesting	+/-	+/-	Kilgore 2023
Operations Adjustment	Efficiencies in harvesting	+/-	+/-	Kilgore 2023
Market Adjustment	Efficiencies in harvesting	+/-	+/-	Kilgore 2023

Table 3 (continued)

Variable	Objective	Expected Sign (logit/cloglog)	Expected Sign (OLS)	Reference
Volume Difference	Observed changes to sale package	+/-	+/-	Unique to this study
Value Difference	Observed changes to sale package	+/-	+/-	Unique to this study
Employment NAICS 113; NAICS 321	Employment in forestry	+	+	Abt 2013
Salvage	Preferences at mill	-	-	Gerbert et al. 1998
SBA	Restrictions on bidder	NA	-	Gerbert et al. 1998; Leefers and Potter-Witter 2006
Qtr 1	Yearly workflow for loggers	+	+	Leefers and Potter-Witter 2006
Qtr 2	Yearly workflow for loggers	+	+	Leefers and Potter-Witter 2006
Qtr 3	Yearly workflow for loggers	+/-	+/-	Leefers and Potter-Witter 2006
Qtr 4	Yearly workflow for loggers	-	-	Leefers and Potter-Witter 2006
Appraisal Zone 9031	Efficiencies in harvesting	+	+	Huang and Buongiorno 1986
Appraisal Zone 9091	Efficiencies in harvesting	+	+	Huang and Buongiorno 1986
Appraisal Zone 9092	Efficiencies in harvesting	-	-	Huang and Buongiorno 1986

Table 4 Descriptive Statistics for Forest Service NFS sales (n=585)

Variable	Description	Mean	Std. Dev	Min	Max
Appraised Value/Acre adjusted to 2021 dollars	Value of the timber sale package at final appraised value per acre.	469.850	410.410	4.389	3263.026
Total Sale Acres	Total acres in the sale package	241.242	147.205	1.000	752.000
Sold	Dummy variable indicated sold (1) or unsold (0). Sum of categories 2–4 below.	0.961	0.195	0.000	1.000
Category 1	Timber was offered, but never sold.	0.039	0.195	0.000	1.000
Category 2	Timber was offered, did not receive any bids at the first offering, changes were made to the sale terms (for example, a larger or smaller tract of land was offered), and was subsequently sold.	0.075	0.264	0.000	1.000
Category 3	Timber was offered, did not receive bids, and was then sold later with no changes made to the sale terms.	0.003	0.058	0.000	1.000
Category 4	Timber was sold at the first offer.	0.882	0.323	0.000	1.000
Aspen Pulp CCF/acre	Quaking and bigtooth aspen and balm of gilead pulp and bolts (no sawtimber found in the database).	6.813	5.592	0.000	33.727
Low Value Pulp CCF/acre	All non-pine and aspen species (pulp and bolts). This includes red and sugar maple, basswood, red, bur, northern pin, and white oak, paper and yellow birch, ash, ironwood, tamarack, white cedar, balsam fir, black and white spruce.	5.642	4.347	0.000	40.335
Pine Pulp CCF/acre	Red, white, and jack pine pulp and bolts	1.709	2.801	0.000	23.402
Pine Saw CCF/acre	Red, white, and jack pine sawtimber	1.348	3.016	0.000	41.294
Haul Adjustment	Haul cost adjustment as a percentage of the base price	-5.295	44.660	-956.790	52.602
Road Adjustment	Road cost adjustment as a percentage of the base price	-3.314	14.66	-100.158	189.506
Operations Adjustment	Operations cost adjustment as a percentage of the base price	-3.033	11.663	-71.529	34.568
Market Adjustment	Market cost adjustment as a percentage of the base price	-10.99	15.859	-93.42	41.724
Volume Difference	The difference in original volume per acre and new volume per acre in CCF after a no-bid occurs.	-0.089	1.020	-14.556	0.000
Value Difference	The difference in the original advertised value per acre and the new advertised value per acre in USD after a no-bid occurs.	5.784	45.445	-84.874	608.199
Employment NAICS 113	Total employment in "Forestry and Logging" in the county(s) in which the National Forests reside.	3038.832	1266.344	1129	5540

Table 4 (continued)

Variable	Description	Mean	Std. Dev	Min	Max
Employment NAICS 321	Total employment in "Paper, Pulp, and Lumber Manufacturing Sector" in the county(s) in which the National Forests reside.	7870.026	3618.541	1306	17,028
Salvage	Dummy variable if salvage comprises any component of the sale.	0.405	0.491	0.000	1.000
SBA	Timber appraisals performed specifically for small business set aside (SBA)	0.067	0.250	0.000	1.000
Qtr 1	If the sale was advertised in quarter 1 of the calendar year.	0.209	0.407	0.000	1.000
Qtr 2	If the sale was advertised in quarter 2 of the calendar year.	0.202	0.402	0.000	1.000
Qtr 3	If the sale was advertised in quarter 3 of the calendar year.	0.409	0.492	0.000	1.000
Qtr 4	If the sale was advertised in quarter 4 of the calendar year.	0.181	0.386	0.000	1.000
Appraisal Zone 9031	Dummy variable if the Forest and District was in Appraisal Zone 9031	0.477	0.500	0.000	1.000
Appraisal Zone 9091	Dummy variable if the Forest and District was in Appraisal Zone 9091	0.338	0.474	0.000	1.000
Appraisal Zone 9092	Dummy variable if the Forest and District was in Appraisal Zone 9092	0.185	0.388	0.000	1.000

Table 5 describes the MN DNR sale variables data. On average, more state sales went unsold (about 32%), as compared to Forest Service sales. Additionally, the average sale was 51 acres and final appraised value (inflation adjusted to 2021 dollars) was about \$470 per acre. Typically, aspen comprised the largest component of MN DNR sale packages, followed by low value species (non-pine and non-aspen species for pulp and bolts). Pine sawtimber made up the lowest percent of state timber sale packages at only 0.9 CCF/acre on average. Like the Forest Service sale data, we include adjustment percentages. On average, haul adjustments were increased by 0.43% from the base price, while road (0.48%), operations (2.93%), and market adjustments (5.65%) were decreased from the base price. Most MN DNR tracts were offered for sale in quarter two of the calendar year (April-June), closely followed by quarter one (January-March). Additionally, 72% of MN DNR sales fell near the Forest Service appraisal zone 9031. About 6% of MN DNR sales were re-offered. Exactly 33 MN DNR sales were re-offered and “never sold,” and 12 sales were re-offered and “sold,” at the time of data collection. We were unable to observe if there were any changes made to MN DNR sales after initial appraisal and no-bid, thus we were unable to add volume or appraisal value changes as we do in the Forest Service regressions. Finally, approximately 66.5% of MN DNR sales were designated SBA.

Table 6 reports the logit model results for the Forest Service or MN DNR timber sale data. The Hosmer-Lemeshow goodness of fit test was not statistically significant for the Forest Service or MN DNR models, indicating the logit is an appropriate estimation strategy for both forest ownership types (Hosmer-Lemeshow Chi-squared=5.85 Forest Service and 1.44 MN DNR). The logit model for Forest Service sales correctly classified 96% of the observations. However, the model poorly predicted the “never sold” timber sale packages because of the low number of observations, which made up only 4% of the dataset. Thus, we also present the complementary log-log model estimates for the Forest Service sales. For the MN DNR sales, 48% of all observations were classified as “never sold.” Therefore, the complementary log-log estimation strategy would have been unsuitable. The logit model correctly predicted 84% of the MN DNR observations. For all regressions, the number of observations was 585 for Forest Service sales, and 783 for MN DNR sales.

In Table 6, we present the logit average marginal effects (AMEs) with robust standard errors for the federal and state timber sale models. The binary dependent variable is “sold” or “never sold” for Forest Service and MN DNR regressions. Columns A and B represent Forest Service sales for the logit and complementary log-log models, respectively. Column C presents the logit estimates for MN DNR sales.

For Forest Service (column A of Table 6), we found that increasing the total sale area by 10% increases the probability of a sale by 0.001 probability points. Furthermore, a CCF/acre increase in low value pulpwood on the tract and a CCF/acre increase in pine sawtimber increases the probability of a sale by 0.004 probability points and 0.013 probability points, respectively. Moreover, an additional employee in the forestry and logging sector (NAICS 113) increases the probability of a sale by 0.007 probability points. There is some statistical evidence that if the sale was offered in quarter 4, as compared to quarter 1, the probability of sale increased by 0.04 points.

The estimates for the complementary log-log model differed slightly from the logit Forest Service estimation (column B of Table 6), but the goodness of fit

Table 5 Descriptive statistics for MN DNR sales (n=783)

Variable	Description	Mean	Std. Dev	Min	Max
Appraised Value/Acre	Value of the timber sale package at final appraised value per acre.	424.158	412.599	6.405	4340.909
Total Sale Acres	Total acres in the sale package	50.522	46.032	2.100	442.8
Reoffer	Timber was offered, did not receive any bids at the first offering, and was subsequently reoffered with or without package changes.	0.057	0.233	0.000	1.000
Sold	Timber was offered and subsequently sold on first offer or reoffer, with or without package changes	0.676	0.468	0.000	1.000
Aspen Pulp CCF/acre	Quaking and bigtooth aspen and balm of gilead pulp and bolts (no sawtimber found in the data-base).	9.043	9.028	0.000	39.623
Low Value Pulp CCF/acre	All non-pine and aspen species (pulp and bolts). This includes red and sugar maple, basswood, red, bur, northern pin, and white oak, paper and yellow birch, ash, ironwood, tamarack, white cedar, balsam fir, black and white spruce.	6.567	5.747	0.000	30.784
Pine Pulp CCF/acre	Red, white, and jack pine pulp and bolts	1.95	4.765	0.000	37.292
Pine Saw CCF/acre	Red, white, and jack pine sawtimber	0.917	4.756	0.000	61.045
Haul Adjustment	Haul cost adjustment as a percentage of the base price	0.434	5.334	-35.000	10.000
Road Adjustment	Road cost adjustment as a percentage of the base price	-0.484	7.639	-15.000	10.000
Operations Adjustment	Operations cost adjustment as a percentage of the base price	-2.93	4.305	-15.000	0.000
Market Adjustment	Market cost adjustment as a percentage of the base price	-5.646	15.275	-90.000	0.000
SBA	Timber appraisals performed specifically for small business set asides (SBA).	0.665	0.472	0.000	1.000
Qtr 1	If the sale was advertised in quarter 1 of the calendar year.	0.312	0.463	0.000	1.000
Qtr 2	If the sale was advertised in quarter 2 of the calendar year.	0.436	0.496	0.000	1.000
Qtr 3	If the sale was advertised in quarter 3 of the calendar year.	0.038	0.192	0.000	1.000
Qtr 4	If the sale was advertised in quarter 4 of the calendar year.	0.215	0.411	0.000	1.000
Appraisal Zone 9031	Dummy variable if the Forest and District was in Appraisal Zone 9031	0.719	0.45	0.000	1.000
Appraisal Zone 9091	Dummy variable if the Forest and District was in Appraisal Zone 9091	0.174	0.379	0.000	1.000
Appraisal Zone 9092	Dummy variable if the Forest and District was in Appraisal Zone 9092	0.107	0.31	0.000	1.000

Table 6 Logit and cloglog model results for Forest Service and MN DNR sales

Dependent Variable = Sold	LOGIT Forest Service: Average Marginal Effect (A)	Robust Std. Error	CLOGLOG USFS: Average Marginal Effect (B)	Robust Std. Error	LOGIT MN DNR: Aver- age Marginal Effect (C)	Robust Std. Error
Total Sale Acres (ln)	0.013**	0.006	0.016**	0.006	0.098***	0.016
Aspen Pulp CCF/acre	0.001	0.001	0.001	0.001	0.029***	0.002
Low Value Pulp CCF/acre	0.004*	0.003	0.004**	0.002	0.004	0.003
Pine Pulp CCF/acre	0.004	0.004	0.003	0.003	0.028***	0.004
Pine Saw CCF/acre	0.013**	0.006	0.014**	0.005	0.020***	0.004
Haul Adjustment	0.000	0.000	0.000	0.000	0.009**	0.003
Road Adjustment	0.000	0.001	0.001	0.000	0.009***	0.002
Operations Adjustment	0.000	0.001	-0.001	0.001	0.011***	0.003
Market Adjustment	0.000	0.000	0.001	0.000	0.002**	0.001
Employment NAICS 113 (ln)	0.069**	0.029	0.056**	0.021		
Employment NAICS 321 (ln)	-0.023	0.017	-0.020*	0.012		
Volume Difference	0.004	0.007	0.007	0.006		
Value Difference	0.005	0.005	0.007	0.005		
Salvage (binary)	0.001	0.018	-0.002	0.012		
Qtr 2	0.002	0.025	-0.009	0.021	-0.011	0.028
Qtr 3	0.002	0.024	-0.003	0.017	0.144**	0.065
Qtr 4	0.037*	0.021	0.026	0.018	-0.025	0.035
Appraisal Zone 9091	-0.002	0.019	-0.009	0.016	-0.103**	0.035
Appraisal Zone 9092	-0.041	0.029	-0.042**	0.022	-0.168***	0.048
Statistical Significance	* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (bolded indicates statistical significance)					
Observations	585		585		783	
Wald Chi2	64.020		49.520		204.010	
Log pseudolikelihood	-75.214		-73.3		-262.163	
Pseudo R ²	0.224		Prob > Chi2 = 0.000		0.469	

measure between the model outcomes is negligible (indicating that the logit is just as robust as the complementary log-log). Similar to the logit, we found that total sale acres, low value pulpwood, pine sawtimber, and employment in NAICS 113 are all statistically significant and increase the probability of a sale. However, offering a sale in quarter 4 is not statistically significant in the complementary log-log estimation. We found that total employment in NAICS 321 reduced the likelihood of a sale in the cloglog, yet was not statistically significant in the logit estimation. Sales offered in appraisal zone 9092 are more likely to go unsold, compared to sales offered in appraisal zone 9031.

Similar to Forest Service sales (column C of Table 6), we found that increasing sale acres for MN DNR lands by 10% increases the probability of a sale by 0.01 probability points. Furthermore, a CCF/acre increase in aspen pulp, pine pulp, or pine saw on the tract increases the probability of a sale by 0.03, 0.03 and 0.02 probability points, respectively. Unlike the Forest Service models, all four adjustment factors are statistically significant in the MN DNR model. An increase in haul, road, operations, and market adjustments all increase the probability of sale. This means that higher-priced timber (larger positive price adjustments), are more likely to sell than lower priced timber. This is likely because higher priced timber has preferred stand-features, and thus appraisers are adjusting upward to account for favored characteristics (i.e.: sales that are more likely to sell are adjusted upwards). This suggests that appraisers may not be using adjustment factors to their full potential, such that buyers are indifferent to adjustments.

Operations adjustments have the largest effect as compared to the other adjustment factors, and timber sales in quarter 3 have a higher probability of selling than the other three quarters. Finally, MN DNR sales offered in appraisal zones 9091 and 9092 have a higher probability of going unsold, as compared to sales in appraisal zone 9031.

In Table 7, we present the OLS estimates with appraised value per acre (natural log) as the dependent variable for the Forest Service (column D) and MN DNR (column E) sales. The R-squared values (goodness of fit measure) for Forest Service and MN DNR OLS regressions are acceptable, at 0.79 and 0.86, respectively. For Forest Service timber packages, sale categories are not statistically significant at the 10% level. This suggests that timber offerings that are sold are not systematically appraised differently than those that are never sold, when controlling for other factors affecting appraisal.

For the MN DNR timber sales, if the tract sold the appraised value is 26.6% higher than unsold tracts. This suggests that MN DNR timber offerings at higher prices are correlated with higher sales percentage, consistent with the idea that purchasers are willing to bid on tracts that have a higher appraised price. For example, sales that are sold on average have 1.2 CCF per acre of pine sawtimber, compared to unsold sales that have 0.3 CCF per acre of pine sawtimber; sold sales have on average 11.9 CCF per acre of aspen, compared to 3.2 CCF per acre of aspen. Thus, it is possible that higher prices are associated with both better stocking density and higher-value wood products. Reoffered sales for MN DNR timber packages are not statistically significant at the 10% level.

However, we found opposite effects of total sale acres on appraised value, where a 1% increase in sale acres on Forest Service land is associated with a 0.07% increase in appraised value per acre, but a 1% increase in sale acres on MN DNR lands would

Table 7 OLS model results for Forest Service and MN DNR sales

Dependent Variable = Appraised value per acre (ln)	Forest Service: Coefficient Value (D)	Robust Std. Error	MN DNR: Coefficient Value (E)	Robust Std. Error
Category 2	0.115	0.124		
Category 3	0.792	0.874		
Category 4	0.164	0.114		
Reoffer			-0.021	0.062
Sold			0.266***	0.041
Total Sale Acres (ln)	0.070**	0.032	-0.066***	0.019
Aspen Pulp CCF/acre	0.070***	0.005	0.065***	0.003
Low Value Pulp CCF/acre	0.070***	0.007	0.046***	0.003
Pine Pulp CCF/acre	0.087***	0.009	0.078***	0.009
Pine Saw CCF/acre	0.064***	0.012	0.090***	0.009
Haul Adjustment	0.009***	0.001	0.011***	0.003
Road Adjustment	0.014***	0.003	0.013***	0.002
Operations Adjustment	0.034***	0.002	0.004	0.003
Market Adjustment	0.014***	0.002	0.020***	0.001
Employment NAICS 113 (ln)	0.688***	0.076		
Employment NAICS 321 (ln)	0.311***	0.061		
Salvage (binary)	-0.077*	0.043		
SBA (binary)	0.130**	0.052	0.100***	0.033
Qtr 2	-0.025	0.058	0.038	0.031
Qtr 3	-0.030	0.051	0.055	0.082
Qtr 4	-0.144**	0.064	-0.011	0.033
Appraisal Zone 9091	0.241***	0.057	0.094***	0.029
Appraisal Zone 9092	-0.150**	0.073	-0.084*	0.051
Constant	-3.669***	0.751	4.680***	0.095
Statistical Significance	* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (bolded indicates statistical significance)			
Observations	585	783		
F(21, 563)	69.49	219.010		
Prob > F	0.000	0.000		
R-Squared	0.788	0.863		
Root MSE	0.456	0.348		

result in a 0.07% decrease in appraised value per acre. Additionally, for MN DNR, a sale package designated as an SBA sale is associated with an increase in appraised value by 10% and 13% for Forest Service. SBA sales can limit competition, since they exclude larger operators. It seems that public land managers may be offering more desirable sales to smaller operators, as evidenced by a larger appraisal value for SBA offerings.

Moreover, adding timber volume per acre regardless of species/product grouping increased the appraised value per acre for both Forest Service and MN DNR sales. Pine sawtimber (MN DNR) and pine pulpwood (Forest Service) stocking had the largest effect. A CCF/acre increase in pine sawtimber per acre raises appraised value by 9% on MN DNR lands and a 6.4% increase in appraised value on Forest Service lands. Similarly, a CCF/acre increase in pine pulpwood per acre raises appraised value by 7.8% on MN DNR lands and 8.7% on Forest Service lands. Additionally, for Forest Service sales, if a haul adjustment increases by 1% point, then there would be an expected 0.9% increase in appraised value per acre on Forest Service lands, but a 1.1% increase on MN DNR lands. A similar percentage point increase in a road adjustment would generate an expected 1.4% increase in appraised value per acre on Forest Service lands, and a 1.3% increase on MN DNR lands. A percentage point increase in an operations adjustment raises appraised value per acre on Forest Service lands by 3.4%, on average. A percentage point increase in a market adjustment raises appraised value per acre on Forest Service lands by 1.4%, on average, and raises appraised value per acre on MN DNR lands by 2%, on average. In general, similar coefficient signs and magnitudes were found for MN DNR sale adjustments.

Employment in NAICS 113 and 321 are positive and statistically significant for Forest Service sales. A 1% increase in forestry and logging employment (NAICS 113) raises appraised value per acre on Forest Service lands by 69%, and an increase in paper, pulp, and lumber manufacturing employment (NAICS 321) raises appraised value by 31%, on average. This suggests that more activity in the forest sector is correlated with higher appraised prices, perhaps a result of greater bidding competition amongst loggers and downstream manufacturers. Sales in appraisal zone 9091 were appraised significantly higher, and sales in appraisal zone 9092 were appraised significantly lower, than those in 9031 (omitted zone). Finally, for Forest Service lands, sales offered in quarter 4 were appraised 14.4% lower than those in quarter 1.

Discussion

To the best of our knowledge, no other studies have quantified the relationship between appraisal price and no-bid timber sales on state and federal lands or assessed the impacts of re-offered sales on appraisal price and no-bids. We compare the key results of our study to prior literature, keeping in mind that our dependent variable for the OLS regression is unique. Leefers and Potter-Witter (2006) found that sale area, sale volume, and road construction and reconstruction were not statistically significant predictors of a winning bid price. We found that total acres offered was a statistically significant predictor of whether or not an offering sells in both the Forest Service and MN DNR binary regressions. We found total sale acres is relatively inelastic (Es: Forest Service logit=0.013 and MN DNR logit=0.098), meaning there is a very small change in the probability of a sale for a marginal change in acreage. Yet, the magnitude of the correlation is larger for MN DNR sales, as compared to Forest Service sales. This is likely because Forest Service sales were larger on average (241 mean acres for Forest Service and 51 mean acres for MN DNR).

Leefers and Potter-Witter also found that mean sale size for Michigan state sales was 63 acres and mean sale size for Forest Service sales was 263 acres. They hypothesized that smaller sales, not designated as SBA, may attract more bidders since varying sizes of operators could compete, which may stand true in MN, as well.

Huebschmann et al. (2004) found that total pine sawtimber volume, and average sawtimber volume per tree were significant and positive predictors of final sale price, likely because efficiencies in harvesting costs exist when there are larger trees with more volume per tree and higher stocking (Cubbage et al. 1989). Evidence from across the literature suggests that the more softwood pine and sawtimber offered, the higher the final bid value will be, as well as the likelihood of being sold. Leefers and Potter-Witter (2006) found that the percentage of Michigan state sales in eastern white pine sawtimber increased the final bid price more than red pine sawtimber and red pine pulpwood, while federal sales received the highest increase in price for red pine sawtimber, as compared to eastern white pine sawtimber and spruce pulpwood. We found that increasing pine sawtimber volume per acre across all of our model estimations significantly increased the probability of being sold. For Forest Service sales, increasing low value pulpwood volume per acre increased the probability of a sale. Higher aspen pulpwood and pine pulpwood volumes per acre marginally increased the probability of MN DNR sales. This indicates that packages with higher volume per acre have a higher probability of being sold and have a higher appraised value.

Huang and Buongiorno (1986) found that on the Chequamegon NF in Wisconsin, increased hardwood pulpwood and haul distance decreased the value of a sale. Intuitively, we found that volume of softwood sawtimber increased the value of the sale, more than softwood pulpwood and hardwood sawtimber. Gerbert et al. (1998) found that designation as SBA or salvage decreased appraisal price. Conversely, we found SBA significantly increased appraised value for MN DNR and Forest Service sales. Salvage did decrease appraisal value for Forest Service offerings. The mean value per acre of SBA sales for Forest Service offerings was \$754.31, and non-SBA sales was \$444.17 per acre (inflation adjusted).

Additionally, Forest Service sales were more likely to be sold if offered in quarter four (October-December) than quarter one (January-March), but at a lower appraised price. In comparison, Leefers and Potter-Witter (2006) found that Forest Service sales offered in Michigan from July-September decreased final bid price, while state sales offered January – March and April – June decreased final bid price. Typically, the best time to harvest in MN for many lowland-dominant species are during the winter months, for both agencies, to protect the soil from compaction and erosion. It is possible that NFS is offering timber at an attractive rate to incentivize bidding at the end of the calendar year. Loggers may be occupied at the end of the year conducting harvest on tracts that they've previously purchased and do not have time to make bids on new tracts.

Next, we provide some insights not previously discussed in the literature. We found that advertised value per acre decreased in only four sales after an initial no-bid. This is counter to what we may have expected, since it is commonly thought that

the reserve price decreases by making additional changes to adjustment appraisal factors after an initial no-bid. One explanation is that NFS employees are changing the composition of the sale once reoffered to be more appealing for purchasers, thus not significantly changing volume per acre, but increasing price of a sale with a higher percentage of valuable species (e.g., removing salvage and replacing with sawtimber). This finding could be further explored by discussing typical tactics with sale managers that they use to increase bidding incentives.

Furthermore, in contrast to much of the literature, we were able to explore the effect of adjustment factors on appraisal price and likelihood of a sale for federal and state timber. We found that the adjustment factors were positive and significantly increased the probability of sale for MN DNR tracts, but not Forest Service tracts. Yet, on average, the adjustment factors were a higher percentage of each sale for Forest Service, as compared to MN DNR. For example, the market adjustment for Forest Service was 11% compared to 6% for MN DNR sales. In addition, there was not a statistically significant correlation between sale category and appraised price for Forest Service, but there was a positive correlation between sale and appraised price for MN DNR. Further, the pseudo R-squared for Forest Service logit model was substantially lower than for MN DNR data, suggesting that there are more observable differences between offerings that sell and don't sell for MN DNR whereas Forest Service have no-bids occurring more randomly. This may be a function of the differing time periods we are comparing. Combined, these results suggest that Forest Service appraisers adequately adjust the price, increasing or decreasing the appraised price to the point where buyers are indifferent between sales at different price points. MN DNR appear not to have sufficient adjustments to prices since buyers are more likely to buy higher-valued sales (and less likely to buy lower-priced sales). This suggests that the deviation from the mean of the actual value of the timber is greater than the premium or discount applied by the appraiser.

Forest Service and MN DNR appraisal values were lower per acre in 9092 and higher in 9091 (in and around Superior NF), compared to 9031 (Chippewa NF). For Forest Service sales, about 48% were offered in 9031, 34% in 9091, and 18% in 9092. About 11% of MN DNR sales was offered in 9092, and 17% of sales was offered in 9091, leaving 72% offered in 9031. Timber tracts located in appraisal zone 9092 were less likely to sell than tracts located in appraisal zone 9031 for both Forest Service (complementary log-log) and MN DNR sales (4.2% less likely for Forest Service and 16.8% less likely for MN DNR tracts). This is likely because zone 9092 is located in extreme northeastern Minnesota, which is not as easy to access as zone 9031. We used employment in the forest sector as an indication of market demand for roundwood products over time, which are strongly linked (Abt 2013). We found for Forest Service sales that more employment in NAICS 113 (forestry and logging) increased likelihood of a sale, and more employment in 113 as well as 321 (paper,

pulp, lumber) increased appraised value of the sale. We have not found the inclusion of appraisal zones or employment indicators in previous literature on this topic.

For Forest Service sales, we were able to observe some of the changes to sale packages, including initial appraisal value and volume, which has not been explored in previous literature. We found that the difference in appraised value and changes to sale volume are not statistically significant, meaning there must be something else about the timber package that is changed to entice bidders. This could include changing the type of species composition offered in the sale, such that the sale has a lower volume but higher value species. Further, other unobservable characteristics may have led to a final sale. For example, nearby mills may have been at capacity at first offer and at re-offer demanded more stumpage.

Conclusion

This study was the first to quantify the effect of adjustment factors (haul, road, operations, and market adjustments) on the likelihood of a sale and effect on appraisal price for federal and state timber offerings. Those along the sale offering chain must use their time to re-work and re-advertise sales, when they could be accomplishing other tasks and working on future sale offerings. Price adjustments can be used by managers to incentivize bidding. Our findings suggest that Forest Service appraisers are adjusting the appraised price such that buyers are indifferent between sales at different price points. However, MN DNR appraisers may not be adjusting prices sufficiently such that buyers are indifferent (approximately 32% of sales are not sold on first offer), as each price adjustment factor is positively correlated with the probability of sale. This may be due to the limitations MN DNR places on adjustment factors. The standard deviations on adjustment factors for MN DNR are clustered more tightly around the mean than Forest Service sales, further suggesting that MN DNR is more constrained than Forest Service in the amount they are able to adjust sale packages.

Despite these differences, the study found most timber packages resulted in a final sale for Forest Service offerings. On average, 11% of offered Forest Service acres are considered no-bid, and 9% of offered sales. However, there are some years where they do not meet the goal of 15% or fewer no-bids (Appendix 1). This analysis can provide insight into those factors which can be adjusted during the appraisal process during years when no-bids are likely to occur. In general, Forest Service is offering up fewer larger sales per year as compared to MN DNR, which may result in fewer no-bids on Forest Service lands comparatively. It is also possible that MN

DNR packages will sell at a later time, after receiving an initial no-bid, which we were unable to observe due to our limited dataset. However, as discussed, re-offers are still considered no-bids by public land managers.

We suggest a couple of avenues for future research. Putting together timber sale packages involves multiple disciplines, including engineers, environmental planners, foresters, and timber markers, among others. Staff shortages within Forest Service and MN DNR may lead to longer sale-package preparation timelines, which may result in changing stand condition (e.g., increased tree mortality) or market conditions that make them less desirable by the time they are offered for sale. While we were able to quantify some institutional factors (e.g., price adjustments), we suggest further exploration of institutional constraints, including attrition of employees and policy rules, and the impact they may have on no-bids.

Currently, there is no available data that quantifies the labor hours it takes to curate a timber sale package on federal or state lands. Future studies could measure the labor hours it takes to advertise and re-advertise sales and match the associated pay-scale for the accompanying labor hours. It would be useful to quantify the difference in labor hours associated with each of the sale categories, as well as evaluate the heterogeneity that may occur across different regions.

Recent policies, such as the Wildfire Crisis Strategy, via the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), aim to increase the scale and pace of forest health treatments in order to reduce wildfire risk to communities (Forest Service, *accessed* 2024). In accordance, part of the mission is to remove and sell more timber across National Forests. Federal sales are relatively infrequent, as compared to state sales, which may contribute to the lower frequency of timber packages that were never sold historically in MN. However, if the Forest Service increases the number of sale offerings, no-bids may become a larger issue than they are currently if appraisal factors are not adequately addressed.

Our study is the first to attempt to quantify the effect of sale package changes and re-offers on no-bid sales. However, we were only able to observe some of the re-offer characteristics of Forest Service sales, and none of the re-offer characteristics of MN DNR (2023) sales. Having information on all changes that are made to a no-bid timber tract at each successive reoffer, particularly species volume changes, would be enable an assessment of what attributes are most influential in increasing the probability of sale. Having such information can help employees work towards reducing the number of re-offers, which would positively impact an agency's timber sale staff workload as well as its ability to accomplish its forest management objectives through timber harvesting. Finally, data on the amount of time it takes employees to re-work or re-appraise sales could more thoroughly capture the impact of re-offers.

Appendix 1

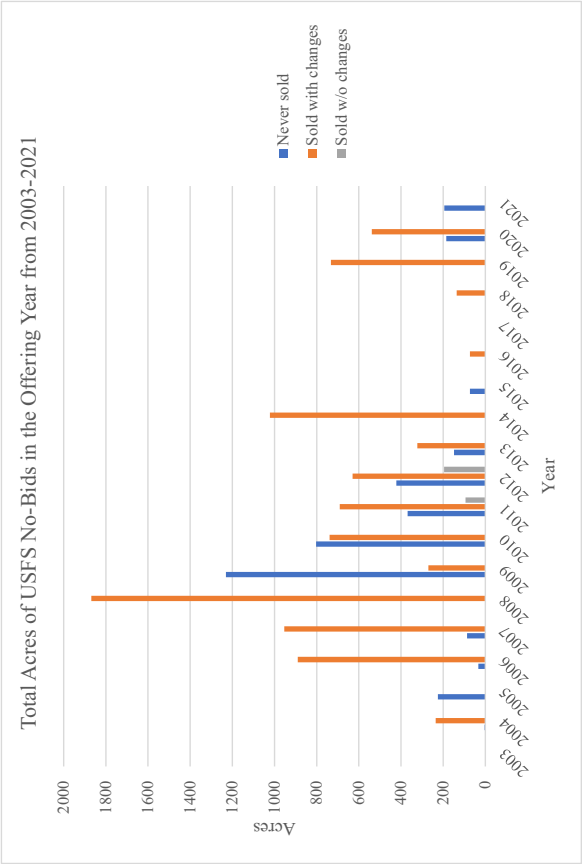


Fig. 1 Total acres of no-bid offerings from 2003-2021 on the Chippewa and Superior National Forests (Forest Service)

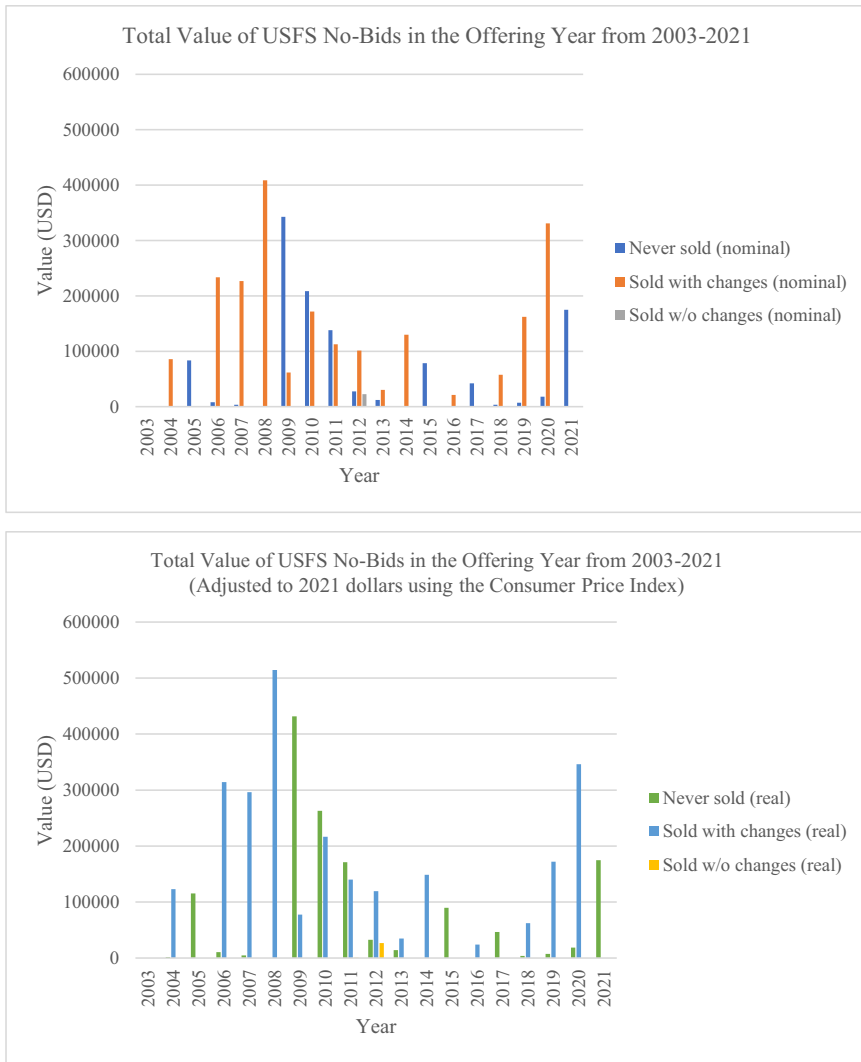


Fig. 2 Total value of no-bid offerings from 2003-2021 on the Chippewa and Superior National Forests (Forest Service), shown in real and nominal values

Appendix 2

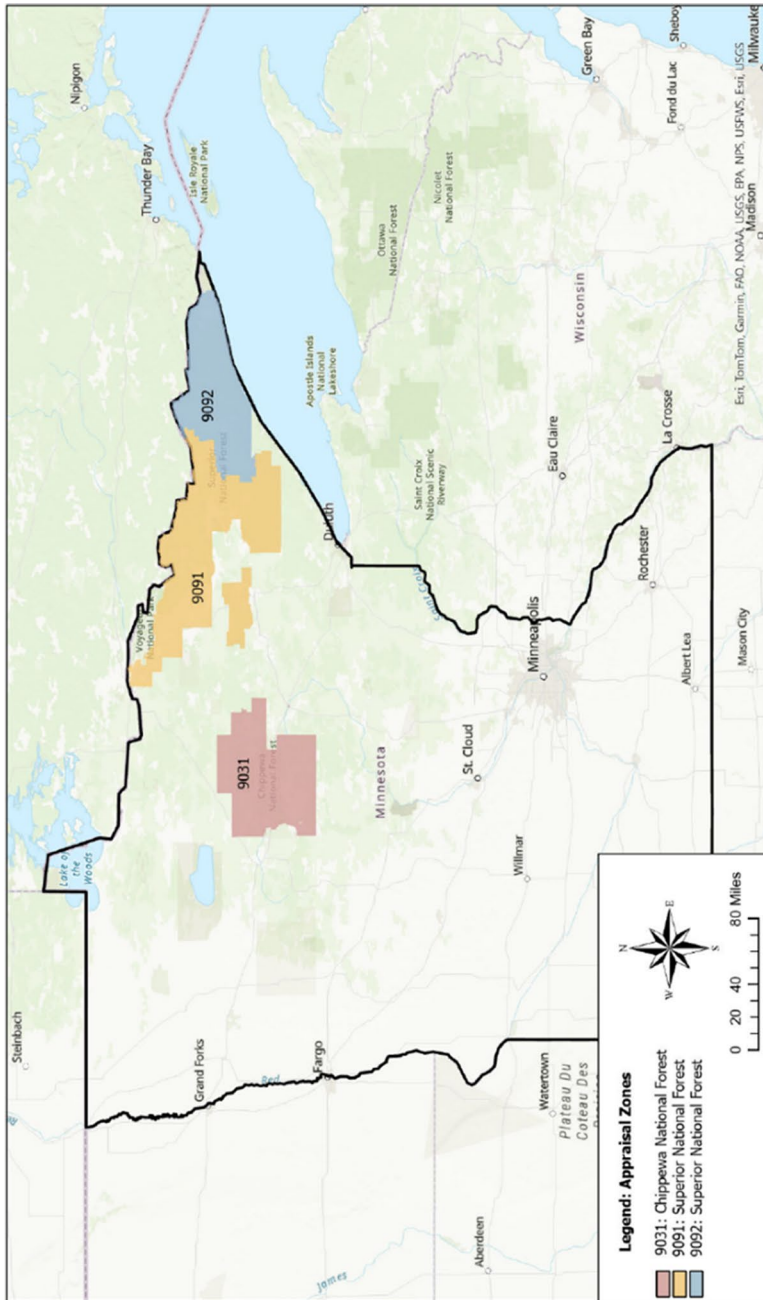


Fig. 3 Map of Federal appraisal zones in Minnesota on the Chippewa and Superior National Forests. The Chippewa National Forest has one appraisal zone (9031), while the Superior National Forest is split into two appraisal zones (9091 and 9092) (ESRI 2017)

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Declarations

Competing interests None

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