

# Integrating empirical evidence on forest landowner behavior in forest sector models

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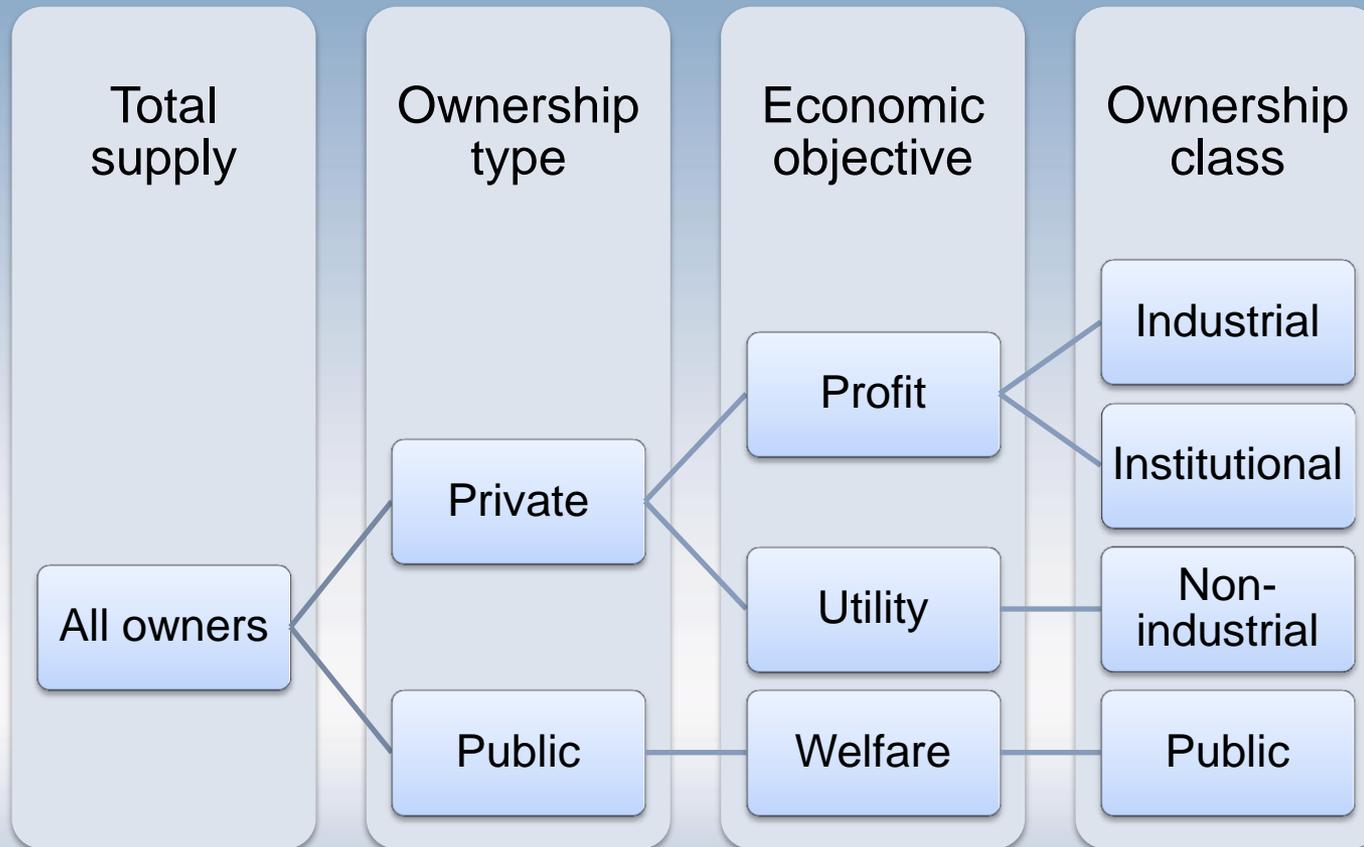
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# Why study forest owners?

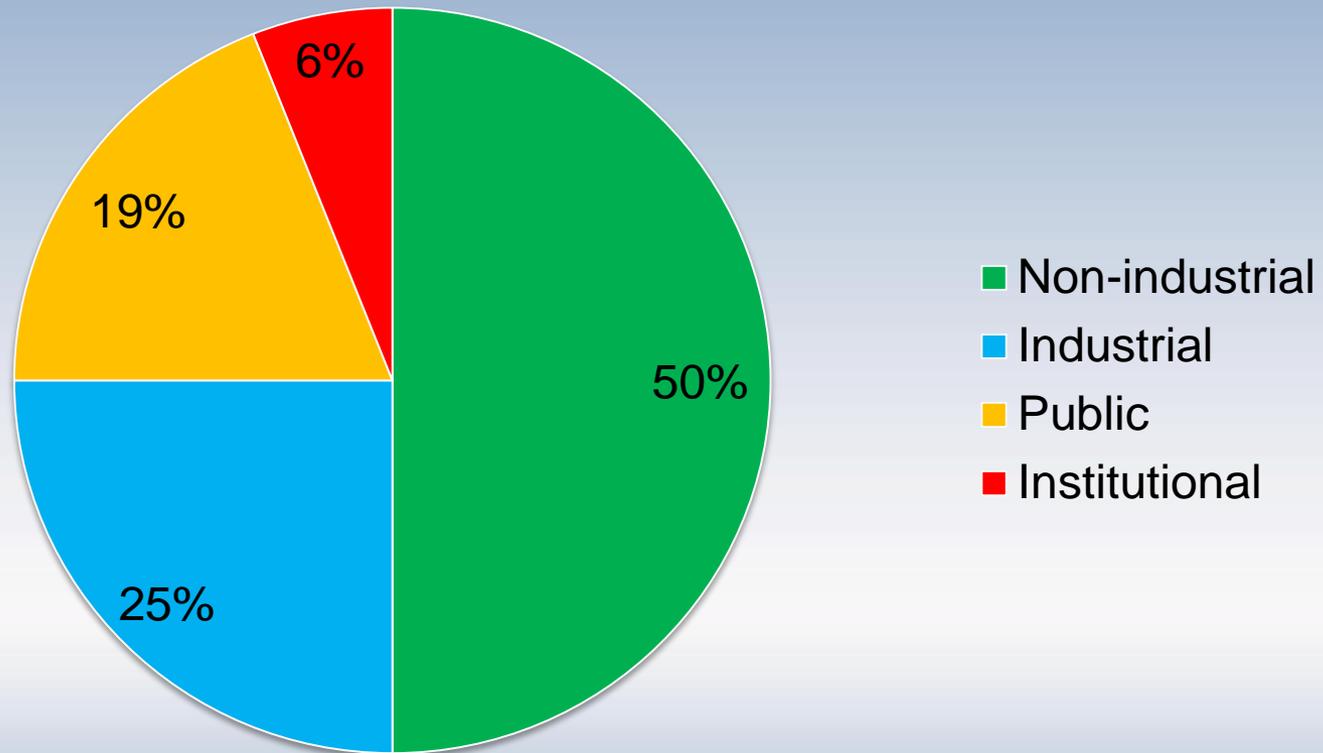
- Relevance for several issues:
  - Energy security – Sustainable energy supply
  - Environment – Reduction of GHG emissions
  - Economy – Competition about forest resources
- Research on the potential of bioenergy requires knowledge about the drivers of biomass supply
- Large-scale implementation of bioenergy requires knowledge about which policy tools could increase biomass supply

# Ownership classes



# Ownership classes

## Distribution of Swedish forest areal



*Source: Swedish Forest Agency (2012)*

# Economic theory

- Theory of the firm
  - Firms maximize profit from selling produced goods, e.g. sawtimber, pulpwood, woodfuel
- Distinct properties of forests and owners
  - Time perspective important for decisions on harvesting and management
  - Forest industry supply chains often vertically integrated
  - Institutional owners may hold forestland as complementary low-risk assets

# Economic theory

- Consumer theory
  - Non-industrial private forest owners often thought of as consumers rather than firms
  - They maximize their utility of their forestland and may utilize it as a source of income amongst other uses
- Welfare economics
  - Public owners maximize the welfare (aggregated utility) of the society
  - Public goods differ from private goods
  - Focus on goods that markets may fail to supply, e.g. clean environment, ecosystem services

# Empirical studies

- Over three decades of econometric studies on forest management decisions of landowners
  - Most studies focus on timber supply, but recent years also studies regarding residuals for bioenergy production
  - Most studies on non-industrial private forest (NIPF) owners in United States
  - Some studies use data on actual harvesting decisions, while many rely on hypothetical survey-based data

## Contribution of our study

- Previous reviews on non-industrial owners
  - Beach, Pattanayak et al (2005): Market drivers most frequently included but least frequently significant
  - Silver, Leahy et al. (2015): Parcel size, harvest price and education positive, absentee ownership and age negative (most freq. significant among 5+ citations)
- Contribution of this study
  - More quantitative approach covering higher number of studies and estimates
  - Broader scope including four ownership classes and including studies on residuals for bioenergy
  - Forest sector modeling perspective

# Review method

- Selection process
  - Systematic searches for relevant search terms in Web of Science, complemented with Google Scholar + references from articles
  - Criteria for 'overall significance': At least 5 inclusions, of which 50% statistically significant on 95% level, and sign test indicates significant effect on 95% level)
- Reviewed studies
  - Results from 36 studies with totally 146 estimates, i.e. on average 4 estimates per study, mostly U.S. studies on NIPF owners focusing on timber supply

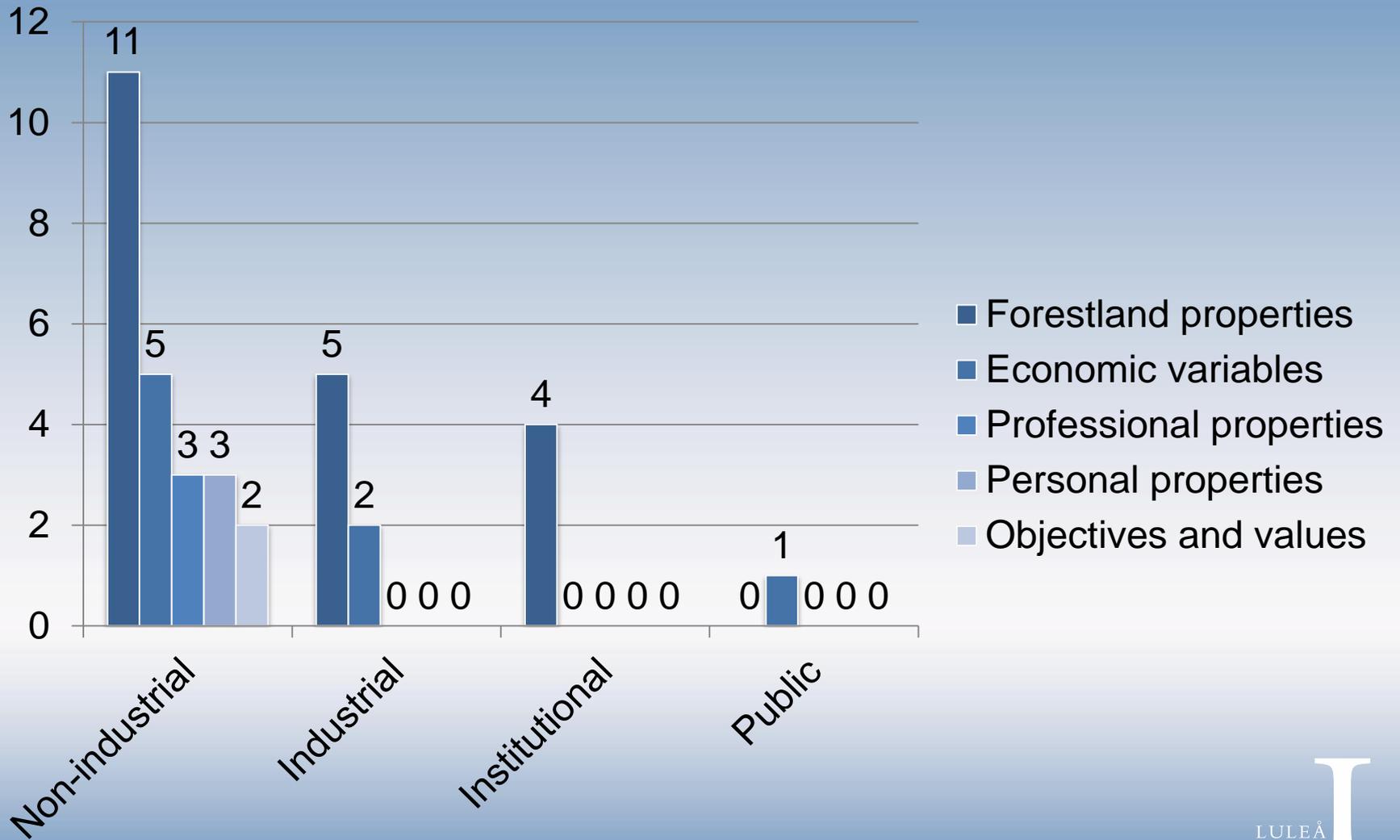
## Review method

- Estimates differ considerably among studies, motivating the use of meta-analysis to obtain more general knowledge
- For the empirical review we apply ‘vote counting’ method to identify the sign of impact for each determinant
- One ‘vote’ per estimated result (statistic test)
  - Risk for both type I (false positive) and type II (false negatives) errors
  - Consistent estimated sign of impact in several models indicates robustness of result

## Review method

- On the plus side: Vote counting is a simple and straight forward method to sum up results from studies representing a substantially larger number of observations than any single study
- On the minus side: Results rely on strong assumptions, e.g. does not control for heterogeneity between the counted studies
- Where sample size is sufficient, such bias can be evaluated by observing differences between subgroups of the included studies

# Results: Overview



## Results: Non-industrial owners

Economic variables	Sign of impact	Number of inclusions	Significance rate
Price at harvest decision	Positive ***	57	70%
Wealth of landowner	Positive ***	16	69%
Debts of landowner	Positive ***	6	67%
Price before harvest decision	Negative ***	18	67%
Price after harvest decision	Negative ***	5	80%

## Results: Non-industrial owners

Forestland properties	Sign of impact	Number of inclusions	Significance rate
Areal	Positive ***	73	62%
Volume	Positive ***	45	84%
Volume squared	Negative ***	8	100%
Share of pine	Positive ***	13	69%
Integrated farm	Positive ***	9	78%
Volume growth	Positive (*)	9	67%
Volume growth squared	Negative ***	6	100%
Artificial	Positive ***	6	100%
Site quality	Positive ***	5	80%
Slope	Negative ***	9	56%
Structures	Negative ***	8	50%

## Results: Non-industrial owners

Professional properties	Sign of impact	Number of inclusions	Significance rate
Management plan	Positive **	12	50%
Membership	Positive **	7	71%
Professional forester	Positive ***	6	83%
Personal properties			
Age	Negative ***	66	58%
Objectives and values			
Supports/aware of bioenergy	Positive ***	20	50%
Amenity values	Negative ***	21	57%
Indifferent owner	Negative ***	6	83%
No harvest intentions	Negative ***	5	80%

## Results: Industrial owners

Economic variables	Sign of impact	Number of inclusions	Significance rate
Price at harvest decision	Positive ***	9	89%
Price after harvest decision	Negative ***	5	100%

Forestland properties	Sign of impact	Number of inclusions	Significance rate
Volume	Positive ***	10	80%
Artificial	Positive ***	6	67%
Volume growth	Positive ***	6	50%
Slope	Negative ***	6	83%
Coastal plain	Negative ***	6	67%

## Results: Public and institutional owners

Economic variables (public owners)	Sign of impact	Number of inclusions	Significance rate
Price at harvest decision	Positive ***	5	80%

Forestland properties (institutional owners)	Sign of impact	Number of inclusions	Significance rate
Volume	Positive ***	12	67%
Artificial	Positive ***	12	67%
Slope	Negative ***	12	50%
Coastal plain	Negative ***	12	50%

## Results: Comparison of estimated signs

- For private industrial and non-industrial owners
  - Supply increases with price in current period and decreases with price in other periods
  - Supply increases with timber volume and artificial plantation, and decreases with slope of forest
- Same results indicated for institutional and public owners but not significant based on criteria
  - Due to the low number of studies for institutional and public owners, vote counts do not provide sufficient data for comparison between ownership classes

## Results: Comparison of elasticities

- A better approach to identify differences between ownership classes could be to compare estimated supply elasticities
- Advantage of comparisons within same study, as many sources of heterogeneity is controlled for
  - E.g. Zhang et al. (2015) estimated timber price elasticities of 4.24 for industrial owners and 2.55 for non-industrial owners, over a 6-year period. For institutional owners, values ranged from inelastic (0.68 for REITs) to 5.34 (TIMOs).

# Conclusions

- In general, the empiric evidence of landowners make sense from an economic point of view
  - Economic variables including forestland properties constitute the most frequent determinants to harvesting decisions
  - NIPF owners respond to economic incentives, but also other factors, suggesting that small-scale owners behave like consumers rather than firms
  - However, propensity to harvest increases with determinants related to scope and quality, suggesting profit-seeking behavior increases with more productive forestland

## Conclusions

- From a modeling perspective, results suggest that landowner behavior can be integrated in forest sector models using detailed micro-level data on forestland
- To which extent modeling bias can reduce from a more accurate representation of landowner behavior depends on the impact of the determinants identified in this study, which is a suggestion further studies on this topic

## Conclusions

- From a policy perspective, results suggest that policy tools could increase the supply of biomass as forestland owners respond to price incentives
- Results also suggest a research gap as more knowledge is needed about particularity public and institutional owners