Factors Influencing Private Forest Owners’ Readiness to Perform Forest Management Services Within a Machinery Ring

Špela Pezdevšek Malovrh1,2 · Nike Krajnc2 · Matevž Triplat1,2

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Abstract
The cooperation of private forest owners has been recognized in many European countries, including Slovenia, as a key forest policy instrument to support sustainable management of private forests and implement policy objectives. In Slovenia, private forest owners have the opportunity to cooperate in machinery rings (an organised form of neighbourhood assistance as an association of farmers and private forest owners) to solve forest management related problems and more efficiently use of mechanization. The aim of this study is to determine the readiness of private forest owner to perform forest management services within machinery rings and to understand how property characteristics, forest management activities and owners’ socio-demographic characteristics influence their decisions. In 2020, a survey of machinery rings members (n=438) was conducted in which 24 machinery rings participated, representing 64.9% of the total number of machinery rings currently operating in Slovenia. The results show that only 18.3% of the machinery ring member perform forest management services within the machinery ring. A random utility model results showed that the readiness of private forest owners to perform forest management services within a machinery ring is influenced by forest property size and owners age. To motivate private forest owners to perform a forest management activity within a machinery ring more frequently, it is important to identify the profile of owners ready to perform services and provide a mix of innovative and supportive policy instruments to achieve the desired forest policy outcomes.

Keywords Private forest owners · Cooperation · Machinery ring · Forest management services · Logistic regression model

Extended author information available on the last page of the article
Introduction

Explaining and predicting the management behaviours and practices of private forest owners, or their willingness to perform various forest management activities based on different factors, is an increasingly important topic in forest policy and research arenas (UNECE 2020), especially as management objectives of private forest owners have changed considerably over the last two decades due to demographic, economic, and social changes (urbanization of lifestyles, disengagement from agriculture, economic restructuring) (Weiss et al. 2019). These changes have resulted in private forest owners lacking sufficient knowledge and experience in forest management to achieve financial and ecological sustainability (Lindroos et al. 2005; Rauch and Gronalt 2005; Sarvašová et al. 2015; Feliciano et al. 2017). Hence, private forest owners’ decisions regarding forest management are crucial for the timber supply and other forest-based ecosystem services that are increasingly demanded by European society and influence the future development of forest resources and the effectiveness of public policies (Juutinen et al. 2020).

Slovenia is one of the most forested countries in Europe, where private forest owners control a large part of forest resources (77.0% of forests are privately owned). The management of these forests is far from optimal due to the diversity of ownership and tenure (Pezdevšek Malovrh 2010). This diversity is reflected in a large number of owners (about 314,000) and co-owners (about 489,000). Forest property is small-scale: the average size of private forest property is about 3 ha and it is fragmented (3 forest estate parcels on average) (ZGS 2021). The management of private forests is further hindered by ongoing processes and changes in society, such as demographic, economic and social changes that have altered the interests, values and demands of private forest owners on their forests (Ficko and Bončina 2013; Kumer and Potočnik Slavič 2016; Kumer 2017). As a result, economic dependence on forests is decreasing, leading to the underutilization of forest resources. Only 71% of potential timber in Slovenian private forests is harvested and less than half of silvicultural work is carried out in accordance with forest management plans (ZGS 2021). Private forests are often managed primarily for timber production for the personal needs of owners (Ščap et al. 2021), but private forest owners typically have multiple objectives (Pezdevšek Malovrh et al. 2015).

The governments, not only in Slovenia but also across the world, have responded to concerns related to private forest management by offering a variety of policy instruments to tackle problems associated with small-scale forest (UNECE 2020). Among these, they have recognized cooperation and joint action by private forest owners as a key instrument to support sustainable management of private forests and to implement policy objectives (Sarvašová et al. 2015; Põllumäe et al. 2016). In response, in 2007 the Slovenian government established in its Forest Act the conditions for voluntary cooperation of private forest owners in two different organizational forms – private forest owners’ associations and machinery rings (Pezdevšek Malovrh and Avdibegović 2021). This cooperation should increase the efficiency of forest management and marketing of forest products and improve the efficient use of forest machinery, equipment, workforce and other production capacities (Pezdevšek Malovrh and Avdibegović 2021). However, the question arises whether these objec-
tives can be achieved with private forest owner’s using these organizational forms. Therefore, more knowledge is needed about the intentions of private forest owners to manage their forest and perform services to other owners within different organizational forms – which includes machinery rings.

A variety of previous studies have attempted to understand why private forest owners engage in forest management. Amacher et al. (2004), for example, provide a review of empirical studies on the behaviour of private forest owners. In addition, many typologies of private forest owners that segment according to their forest management objectives have been developed (Ficko et al. 2019) to provide an understanding of the diversity of owners’ attitudes, beliefs, management objectives and behaviours. Previous studies have mainly focused on the timber harvesting decisions of private forest owners and show that their decisions depend on market prices, landowner type, bequest motives, the forest property size, environmental preferences, management objectives, and a range of socio-demographic and forest management characteristics (e.g., Kuuluvainen et al. 1996; Amacher et al. 2003; Conway et al. 2003; Novais and Canadas 2010; Kuuluvainen et al. 2014; Poje et al. 2016; Heinonen et al. 2020). Beach et al. (2005) conducted a comprehensive review of econometric studies on private forest management, where variables affecting forest management behaviour were divided into four categories: market drivers, policy variables, owner characteristics, and plot and resource conditions. They found that in the “market driver” category, a timber price variable was most frequently included in the models, followed by interest rate. They also found relatively few studies that include the “policy variables” category. In contrast, many studies include owner characteristics, such as income, education level, age, and owner proximity. In the “plot and resource conditions” category, property size and growing stock are the most common variables included in the models.

The above-mentioned studies have provided important information on how different factors influence the private forest owners’ harvesting behaviour and harvesting rates, which means they usually consider only one management practice. Few studies have examined multiple forest management activities or practices simultaneously (Joshi and Arano 2009; Aguilar et al. 2014; Feliciano et al. 2017; Juutinen et al. 2020). However, these studies only explain how individual private forest owners behave and fail to explain how private forest owners behave when they cooperate; whether they are ready to perform forest management services to other owners and what are the factors influencing their decisions.

The aim of this study is to identify private forest owner’s readiness to perform forest management services within machinery rings as one of the organizational forms of machinery cooperation among private forest owners in Slovenia. Machinery rings are an organised form of neighbourhood assistance as an association of farmers and private forest owners that enable private forest owners to overcome cost-inefficient forest management and more efficiently utilization of mechanization. Moreover, this study also tries to understand how certain factors, such as property characteristics, forest management activities and socio-demographic characteristics of owners, influence their readiness. The results of this study could provide a useful basis for forest policy actors to develop supportive policy instruments (i.e., innovative support schemes and advisory services to encourage forest owners to engage) to encourage
private forest owners to perform forest management services within machinery rings in order to increase machinery utilization, enhance social innovations and achieve ambitious national and international policy goals related to climate, sustainability and energy.

**Overview of Private Forest Owners’ Cooperation in Machinery Rings in Slovenia**

The cooperation of private forest owners in Slovenia in the form of machinery rings is an important starting point to enable private forest owners to overcome cost-inefficient forest management and to use mechanization more efficiently. The economic benefits of participation in machinery rings are reflected in higher utilisation of machinery and resulting reductions in costs, higher productivity and quality of work, and the opportunity to generate additional income by working on other members’ farms or forests. The social benefits of participation in machinery rings are related to work safety and thus a reduction in the number of accidents, participation and offering help in labour during the holiday and peak seasons and improving social relations among neighbours and thus improving the quality of life (Pezdevšek Malovrh et al. 2012, 2022).

Slovenian legislation regulates machinery rings operations. The Agriculture Act (Article 110) (Agriculture Act 2008) stipulates that in order to make use of agricultural and forestry machinery and equipment, workforce and other production capacities more efficiently, agricultural holdings, farm holders and forest owners may establish a machinery ring through which they may carry out services with agricultural and forestry machinery. Under this Act, a machinery ring is a legal entity under private law established under the Act regulating associations, primarily to provide information on agricultural and forestry machinery, promote the provision of such services, and link providers and recipients of such services. Therefore, the machinery rings are organised under the Association Act and in legal transactions use the name “Association for Neighbourhood Assistance - Machinery Ring” (Pezdevšek Malovrh et al. 2022).

The members are persons (including private forest owners) and holders of agricultural holdings. Members offer available capacity of their own machinery or workforce to other members and gets payment at a previously agreed upon price in the Catalogue of Cost of Agriculture and Forestry Machinery. Machinery rings are responsible to provide information and services for its members (Pezdevšek Malovrh et al. 2022).

The first machinery rings were established in Slovenia in 1994. So far, 45 machinery rings have been established. But today (January 2022) 37 machinery ring with 6,343 members are active and cover practically the whole country. The machinery rings are mainly active in agriculture; only three are mostly active in forestry and seven are partly active in forestry. In 2020, machinery ring members performed on average about 113,000 h of services (work), which correspond to an average of 17.8 h of services per member (Dolenšek 2021).
Research Methods

Survey Method

Within the project “Development of indicators and methodology for monitoring of forest contractors” a structured questionnaire was developed by the research team to collect data on machinery ring operations and their members. The questionnaire consisted of 22 questions divided into three sections: (1) members and their socio-economic characteristics; (2) performance of forest management activities and (3) availability of forest mechanization. The data from the first and second section were analysed in this study. The questionnaire was pre-tested in May 2019 in a machinery ring – Machinery ring Gorjan. Based on the pre-tests, the questionnaire was revised by the project research team to make the questions as understandable and precise as possible.

The survey was conducted during the annual general meetings of the machinery rings. Due to COVID-19, some annual general meetings were cancelled and others were moved to online platforms. Therefore, 24 machinery rings participated in the survey, representing 64.9% of the total number of machinery rings currently operating in Slovenia (Fig. 1).

The questionnaire was distributed to all members present at the annual general meetings. Part of the respondents (n=32) were surveyed at the general assembly meeting of the Machinery ring association of Slovenia. A total of 529 questionnaires

Fig. 1 Machinery rings distribution in Slovenia
were completed from March to August 2020. First, the members of the machinery rings were asked if they are forest owners and if they provided services in the forests. Only those who answered yes to at least one of the exclusion questions were asked to complete the questionnaire (n=438) and their responses constitute the data used in this study.

**Theory Behind the Econometric Modelling Method**

Private forest owners’ decisions to perform forest management services within the machinery rings in this study assumed to be based on their utility maximization as found in some previous studies on private forest owners management behaviour (Shivan and Mehmood 2012; Poje et al. 2016). To consider the uncertainties surrounding the decision-making processes of private forest owner to unobserved alternatives, unobserved individual attributes, and measurement errors (Manski 1977; Lynch et al. 2002), a random utility model was used to determine the factors that influence private forest owner’s readiness to perform a forest management services within a machinery ring.

Given the information from previous studies on the factors influencing private forest owner’s readiness to perform forest management services, the utility function can be expressed as follows:

\[ U_i = f(x_i) + \epsilon \]

where \( U_i \) is the utility received by private forest owners from providing forest management services within the machinery ring; \( x_i \) is a vector of property characteristics (PROP), forest management activities (MANACT), and owners’ socio-demographic characteristics (SOCIODEM) and \( \epsilon \) is the random error term.

Because the dependent variable “private forest owners’ performance of forest management services within the machinery ring (PERF)” was converted to a binary scale in this study, logistic regression was applicable to estimate the model parameters (Field 2009). Logistic regression is based on the cumulative logistic probability function and estimates the probability of an action given a set different variable (Pindyck and Rubinfeld 1981). In binary logistic regression, the probabilities of each outcome are specified as follows:

\[ \ln \left( \frac{P(Y = 1 | x_1, x_2, \ldots, x_p)}{1 - P(Y = 1 | x_1, x_2, \ldots, x_p)} \right) = \text{logit}P(Y = 1) = \beta_0 + \beta_1x_1 + \cdots + \beta_px_p \]

where \( P \) is the probability that an owner is performing services within the machinery ring, \( x \) denotes the values of the independent variables and \( \beta \) denotes the model coefficients. Maximum likelihood estimation was used to estimate values for model parameters from 1 to \( p \).

The specific binary logit model used in the study is:
\[ \text{PERF} = \beta_0 + \beta_1 \text{PROP} + \beta_2 \text{MANACT} + \beta_3 \text{SOCIODEM} + \epsilon \]

**Variable Definitions and Predicted Influence on Private Forest Owners’ Readiness to Perform Services Within Machinery Ring**

The dependent variable (PERF) for the selection equation was binary, taking the value “1” if private forest owners perform forest management services within the machinery ring and “0” if not. Using Beach et al. (2005) definition for variable categorization, the independent variables used in the model were divided into three categories: forest property characteristics, performance of forest management activities in their own forests, and socio-demographic characteristics. A total of 12 variables were included in the model. The definitions and coding system for all variables are presented in Table 1.

| Variable | Definition | Coding system | Expected correlation |
|----------|------------|---------------|---------------------|
| PERF     | Owners’ performance of services within machinery ring | 1 – perform services, 0 – do not perform services | / |
| **Property characteristics (PROP)** | | | |
| PROSIZE  | Property size | Continuous variable | (+) |
| FPROSIZE | Forest property size | Continuous variable | (+) |
| **Forest management activities (MANACT)** | | | |
| REFOR    | Management activity - reforestation | 1 – Do not perform activities, 2 – Perform activities by themselves or with a help of family members, 3 – Perform activities otherwise | (+) |
| SILPRO   | Management activity - silvicultural and protection work | 2 – Perform activities by themselves or with a help of family members | (+) |
| RFELL    | Management activity - regular felling | 3 – Perform activities otherwise | (+) |
| SFELL    | Management activity - sanitary felling | 3 – Perform activities otherwise | (+) |
| SKID     | Management activity - timber skidding | | |
| TRANS    | Management activity - timber transportation | | |
| **Socio-demographic characteristics of owners (SOCIODEM)** | | | |
| AGE      | Age of forest owners in years | Continuous variable | (-) |
| EDU      | Level of education | 1 – primary school or less, 0 – others | (-) |
| FARM     | Status of farmer | 1 – yes, 0 – no | (+) |
The first category of variables “property characteristics (PROP)” included two variables related to the physical size of the property, namely the property size (PROSIZE) and forest property size (FPROSIZE). The variable PROSIZE was a continuous variable indicating how many hectares of land (agricultural and forest land) the respondent owned. The variable FPROSIZE was a continuous variable indicating how many hectares of forest land the respondent owned. It was expected that these variables would be a positive predictor of private forest owners’ readiness to perform forest management services within the machinery ring, as large-scale forest owners have often been identified as active forest managers who favour the economics-centred forest management (Zhang and Mehmood 2001; Beach et al. 2005; Joshi and Arano 2009; Feliciano et al. 2017; Ščap et al. 2021). According to their economics-centred forest management, they are more economically oriented and better equipped with mechanization, and therefore more ready to perform services to other owners (Lindroos et al. 2005; Feliciano et al. 2017). In addition, there are some optimal sizes that determine the economics of scale. High average per hectare forest management costs on smaller properties are the main obstacle to overcome under-productivity. Therefore, only owners with larger forest properties can consider forest management as profitable (Toscani and Sekot 2015).

The second category of variables “forest management activities (MANACT)” included six variables that captured the forest management activities that owners performed in their forests themselves or with the help of family members. This category included management activities such as reforestation (REFOR), silvicultural work and forest protection (SILPRO), regular felling (RFELL), sanitary felling (SFELL), timber skidding (SKID), and timber transportation (TRANS). According to previous studies (Dennis 1989; Conway et al. 2003; Majumdar et al. 2008; Joshi and Arano 2009) it was difficult to predict the sign of the MANACT variable because some studies have shown that the active management behaviour of private forest owners is much less predictable than that of industrial owners due to the multiple ownership objectives (Feliciano et al. 2017). In this study, all variables related to owners’ forest management activities were expected to be a positive predictor of private forest owners’ readiness to perform forest management services within a machinery ring, as it was assumed that private forest owners who have been previously engaged in forest management activities already have experience and the necessary equipment and see this as a good opportunity to earn extra money. All variables were coded as 1 if the private forest owners did not perform harvesting activities, 2 if they performed them themselves or with the help of a family member and 3 if they performed them otherwise.

The third category of variables, “socio-demographic characteristics of owners (SOCIODEM)”, included three variables: age (AGE), education (EDU), and status as farmer (FARM). The continuous variable AGE was expected to be a negative predictor of private forest owners’ readiness to perform forest management services within the machinery ring as, older owners are generally less receptive to active forest management, and forest work is considered as one of the most physically demanding jobs (Conway et al. 2003; Joshi and Arano 2009; Poje et al. 2016). Older owners were more likely to own forest for amenity purposes rather than maximizing financial returns from it (Zhang et al. 2005). The variable EDU was also expected to be a nega-
tive predictor of owners’ readiness to perform forest management services within the
machinery ring, given a likely concern of less educated forest owners for economic-
centred forest management, representing the owners who pursue mostly economic
goals and search for innovative business models (Feliciano et al. 2017). The variable
EDU was coded 1 for those private forest owners with a primary school education
or less and 0 otherwise. The FARM variable was expected to be a positive predictor
of owners’ readiness to perform forest management services within the machinery
ring, because owners who are farmers are more traditionally orientated toward forest
management practices (Juutinen et al. 2020) and have mechanization that can be used
in both agriculture and forestry.

Model Building

The model building procedure proposed by Hosmer and Lemeshow (2000) was fol-
lowed. In the first stage, the assumption of linearity in the logit was verified by using
the univariate loess smoothed scatter plot method, which showed that all independent
variables met the assumption of linearity and were therefore continuously scaled in
the models. In the second stage, multivariate logistic regression analysis with the
Enter method was used to estimate the coefficients and standard error. Testing for sta-
tistical significance of the regression coefficients in the model was performed using
the Wald’s test at a significance level of 0.05 (Hosmer and Lemeshow 2000). Before
running the analysis, the data were assessed for logistic regression assumptions like
linearity and multicollinearity. In addition, the data were checked to reduce the prob-
lem of coefficients with unreasonably large standard errors, using multiway cross
Tabulation of all categorical independent variables with the dependent variable.
The linearity assumption has been tested for continuous variables by looking at
whether the interaction term between the predictor and its log transformation is sig-
nificant. All interactions had significance values greater than 0.05 indicating that the
assumption of linearity of the logit has been met for all continuous variables. The
multicollinearity was tested using variance inflation factors (VIFs). The VIFs for the
independent variables were less than 5, with an average VIF of 1.6. For statistical
analysis, IBM SPSS Statistics, version 25, was used (IBM 2021).

Results

Basic Characteristics of the Machinery Rings Members and Their Performance of
Forest Management Services Within the Machinery Rings

The sample represents 438 members of machinery rings, most of whom are male
(98%), mainly with high school education (64.6%). The main occupation is agricul-
ture, as 68.6% of the surveyed member have the status of farmer, of which 28.4%
have registered subsidiary activity on their farm. The average age of the surveyed
machinery ring member is 50 years (the range is 18 to 82 years). The surveyed mem-
ers of the machinery rings own a total of 11.100 ha of land, of which 6.241 ha is
forested. The average size of the owned properties is 27.2 ha (the range is 1.0 to
322,0 ha). They own an average of 15,2 ha of forest (the range is 0,5 to 150,0 ha) (Table 2).

| Characteristics of surveyed machinery ring members and their properties |
|-------------------------------------------------|------------------|
| Gender                                         | Share of surveyed members (%) |
| Male                                           | 98,0              |
| Female                                         | 2,0               |
| Age (average age 50 years)                     |                   |
| <30 years                                      | 11,3              |
| 30–45 years                                    | 23,9              |
| 45–60 years                                    | 42,5              |
| 60–75 years                                    | 20,7              |
| >75 years                                      | 1,6               |
| Level of education                             |                   |
| Primary school                                 | 16,1              |
| Secondary school                               | 64,6              |
| University education                           | 19,1              |
| Status of farmer                               |                   |
| Yes                                            | 68,6              |
| No                                             | 31,4              |
| Registered subsidiary activity on their farm   |                   |
| Yes                                            | 28,4              |
| No                                             | 71,6              |
| Size of forest property (average 15,2 ha)      |                   |
| <1 ha                                          | 4,4               |
| 1–5 ha                                         | 23,3              |
| 5–10 ha                                        | 25,5              |
| 10–30 ha                                       | 35,4              |
| >30 ha                                         | 11,4              |

| Amount of forest services performed by surveyed machinery ring members |
|-----------------------------------------------------------------------|
| Type of services                                                      | Share of surveyed members (%) | Total amount of services performed | Average amount of services performed |
|-----------------------------------------------------------------------|--------------------------------|-----------------------------------|-------------------------------------|
| Timber harvesting with chainsaw (m³)                                  | 14,8                          | 32.044,50                         | 414,27                              |
| Timber skidding (m³)                                                  | 12,3                          | 34.250,00                         | 634,26                              |
| Wood fuel production (stacked m³)                                    | 8,7                           | 2.723,00                          | 71,66                               |
| Silvicultural and protection work (ha)                                | 5,3                           | 89,20                             | 3,87                                |
| Timber transportation (m³)                                            | 5,3                           | 9.810,00                          | 426,52                              |
| Wood chips production (bulk m³)                                       | 2,1                           | 10.990,00                         | 1.221,11                            |
| Wood chips transportation (bulk m³)                                   | 1,1                           | 1.420,00                          | 284,00                              |
| Timber harvesting with harvester (m³)                                  | 0,9                           | 10.166,00                         | 2.541,50                            |
Among the surveyed members of the machinery rings, the performance of forest management activities by themselves or with the help of family members predominates. Only a small proportion of the surveyed machinery ring members uses neighbourhood assistance (machinery rings) to perform the work. Only 18.3% of the surveyed machinery ring members provide forestry services through the machinery ring, but their scope of services is not insignificant (Table 3). In 2019, the surveyed machinery ring members most frequently performed service was timber harvesting

Table 4  Logit estimates for the factors influencing owners’ performance of services within machinery ring

|                | B    | S.E.  | Wald | df | p   | Exp(B) |
|----------------|------|-------|------|----|-----|--------|
| Constant       | 0.333| 1.066 | 0.098| 1  | 0.754| 1.396  |
| PROSIZE        | -0.002| 0.007 | 0.049| 1  | 0.824| 0.984  |
| FPROSIZE       | 0.022| 0.011 | 3.996| 1  | 0.046| 1.022  |
| REFOR          |      |       |      |    |      |        |
| Do not perform activities | 0.402| 0.849 | 0.224| 1  | 0.636| 1.494  |
| Perform activities by themselves or with a help of family members | 1.065| 0.845 | 1.587| 1  | 0.208| 2.900  |
| Perform activities otherwise |        |       | 4.290| 2  | 0.117|        |
| SILPRO         |      |       |      |    |      |        |
| Do not perform activities | -1.360| 0.965 | 1.986| 1  | 0.159| 0.257  |
| Perform activities by themselves or with a help of family members | -1.431| 0.948 | 2.277| 1  | 0.131| 0.239  |
| Perform activities otherwise |        |       | 2.284| 2  | 0.319|        |
| RFELL          |      |       |      |    |      |        |
| Do not perform activities | -0.385| 0.833 | 0.214| 1  | 0.644| 0.680  |
| Perform activities by themselves or with a help of family members | -0.111| 0.777 | 0.020| 1  | 0.887| 0.895  |
| Perform activities otherwise |        |       | 0.395| 2  | 0.821|        |
| SFELL          |      |       |      |    |      |        |
| Do not perform activities | 0.662| 0.969 | 0.467| 1  | 0.495| 1.938  |
| Perform activities by themselves or with a help of family members | 0.389| 0.875 | 0.197| 1  | 0.657| 1.475  |
| Perform activities otherwise |        |       | 0.580| 2  | 0.748|        |
| SKID           |      |       |      |    |      |        |
| Do not perform activities | -0.305| 0.925 | 0.109| 1  | 0.742| 0.737  |
| Perform activities by themselves or with a help of family members | 0.108| 0.841 | 0.017| 1  | 0.898| 1.114  |
| Perform activities otherwise |        |       | 0.629| 2  | 0.730|        |
| TRANS          |      |       |      |    |      |        |
| Do not perform activities | 0.257| 0.389 | 0.437| 1  | 0.508| 1.293  |
| Perform activities by themselves or with a help of family members | -1.063| 0.486 | 4.778| 1  | 0.290| 0.346  |
| Perform activities otherwise |        |       | 5.854| 2  | 0.540|        |
| AGE            |      |       |      |    |      |        |
| Do not perform activities | -0.028| 0.012 | 5.693| 1  | 0.017| 0.972  |
| Perform activities by themselves or with a help of family members | -0.231| 0.423 | 0.298| 1  | 0.585| 0.794  |
| Perform activities otherwise |        |       | 0.158| 2  | 0.625| 0.854  |
with a chainsaw (14.8%), followed by timber skidding (12.3%) and wood fuel production (8.7%).

**Results of logistic regression model**

The estimates of the binary logistic regression model for the private forest owners’ readiness to perform forest management services within the machinery ring are presented in Table 4. The Chi-squared test on the log-likelihood ratio indicates that the model was significant ($\chi^2 = 29.343; p = 0.031$). The model correctly classified 81.8% of the cases.

The results revealed that only two of the 12 independent variables have a significant influence on the private forest owners’ readiness to perform forest management services within machinery rings, namely forest property size (FPROSIZE) and age (AGE) (Table 4). The direction of the relationship between the variables and dependent variable was consistent with the hypotheses. Surprisingly, active performance of various forest management activities did not influence the private forest owner’s readiness to perform forest management services within the machinery ring (all variables were statistically insignificant).

The variable FPROSIZE was positive, indicating that the large-scale private forest owners were more likely to be ready to perform forest management services within the machinery rings. On the other hand, the direction of the variable AGE was negative, indicating that the readiness to perform services within machinery rings decreased with the age of the owner.

**Discussion**

Private forest owners and their forests are an important source of forest-related ecosystem services, and as a result, there is a significant interest in understanding their forest management activities and behaviour.

Previous studies have largely sought to understand why private forest owners engage in forest management (Amacher et al. 2004) and typically consider single management practices of private forest owners’ (Kuuluvainen et al. 1996, 2014; Amacher et al. 2003; Conway et al. 2003; Novais and Canadas 2010; Poje et al. 2016; Heinonen et al. 2020) rather than multiple forest management practices at the same time (Joshi and Arano 2009; Aguilar et al. 2014; Feliciano et al. 2017; Juutinen et al. 2020). However, these studies have shown that private forest owners’ forest management decisions depend on different factors, but failed to explain how private forest owners behave when they cooperate, whether they are ready to perform different forest management services to members, and what factors influence their decisions. This study was initiated to investigate the private forest owners’ readiness to perform forest management services within the machinery rings and to understand how certain factors such as property characteristics, forest management activities, and socio-demographic characteristics influence their readiness.

The results showed that regardless of the forest management activities, members of the machinery rings largely perform it by themselves or with the help of family
members. These results are consistent with those from other countries, which have shown that small-scale private forest owners generally perform forest management activities by themselves (Lindroos et al. 2005; Ni Dhubháin et al. 2007, 2010; Stanislovaitis et al. 2015; Ščap et al. 2021). Moreover, members of the machinery rings very rarely use the help of neighbourhood assistance to perform forest management services in their forests – most often, this happens in the transport of timber. The situation is similar regarding the performance of forest management activities within the machinery rings. Only 18.3% of machinery ring members provide forestry services through the machinery rings, but their scope of services is not insignificant (Pezdevšek Malovrh et al. 2022). These results raise concerns about whether cooperation in machinery rings increases the efficiency of forest management and the efficient use of machinery capacities, work force, and other production capacities in private forests, as envisaged in the strategic documents and the Slovenian Forest Act.

While examining the management activity of private forest owners as a service in different organizational forms is a valuable indication of how owners behave, it does not always coincide with what forest policy decision-makers would like to achieve. Previous studies have shown that private forest owners manage their forests and offer services to others according to their own preferences (Pezdevšek Malovrh et al. 2010; Heinonen et al. 2020) with respect to different factors (Beach et al. 2005; Blanco et al. 2015).

The results of our study coincide with the conclusions of many studies dealings with the management behaviour of private forest owners (for an overview see e.g., Beach et al. 2005; Blanco et al. 2015), showing that two factors influence readiness to perform forest management services within the machinery rings: forest property size and owner age.

Forest property size is one of the most commonly used variables in forest management studies (Beach et al. 2005; Silver et al. 2015). Despite findings that the relationship between the forest management activities performance level (especially harvesting) and property size is not straightforward (Stordal et al. 2008), most studies have confirmed the positive effect of forest property size on performing forest management activities (Beach et al. 2005) and show that forest property size is one of the strongest predictors of management behaviour (Conway et al. 2003; Eggers et al. 2014; Butler et al. 2020). The positive effect of forest property size on the performance of services within the machinery rings was also confirmed in our study. Considering the likelihood of private forest owner activity, it has been pointed out that activity in a given period is higher among large-scale owners because large properties provide greater diversity of stand conditions and more area available for various forest management activities (Cleaves and Bennett 1994). Moreover, many studies have shown that the pursuit of income through forest management is strongly related to the size of forest property, and only large-scale private forest owners consider income as a top priority (Lidestav and Ekström 2000; Stanislovaitis et al. 2015). Small-scale forest owners do not consider forest management to be financially rewarding because income from forests is sporadic and limited (Ni Dhubháin et al. 2010). Therefore, forest property size determines the economic expectation of private forest owners in terms of forest management activities and service performance. For members of machinery rings, the forest already has an important economic function and by per-
forming services for other members they pursue additional income and improved machinery utilization.

In addition to forest property size, many socio-demographic factors were significant in predicting private forest owner’s management decisions in previous studies (Kuuluvainen et al. 1996; Joshi and Arano 2009; Kline et al. 2020), one of them being the age of the owner. Results showed that the readiness to perform services within machinery rings decreased with owner age. Younger owners were more likely expected to perform forest management services within the machinery rings. One possible reason for this is that older private forest owners are more likely to make bequest decisions about their property and that their age makes them less able to perform physically demanding forest work, leading to passiveness in forest management and service performance (Karppinen, 2012). The average age of the respondents in this study was 50 years (48.8% of them were below 50 years), which is slightly younger than the average Slovenian private forest owner (according to Ščap et al. 2021, the average Slovenian private forest owner is 54 years old and 44.0% are in the age group of 50 to 60 years). Thus, the half of the respondents might be inclined to perform forest management services within the machinery ring. This indicates to forest policy makers that they need to make a shift from regulatory instruments to voluntary motivational measures. Motivating private forest owners through various campaigns and incentive measures can be one of the most effective ways to encourage owners to become active, as shown in other studies (Vokoun et al. 2010; Wilkes-Allemann et al. 2021). This can be achieved if and when private forest owners who are already members of machinery rings see that the policy measures offered to them better cater to achieving their primary objectives while also opening up possibilities for financial return from the performing forest management services. Apart from economic benefits of participation in machinery ring also the social ones are important. Social benefits are related to work safety, participation and offering help in labour during the holiday and peak seasons and improving social relations among neighbours and thus improving the quality of life (Pezdevšek Malovrh et al. 2012, 2022).

Since the age distribution of private forest owners in Slovenia, as in many other European countries, is strongly biased toward the elder, and since many of them are long-tenure forest owners, it is evident that there will be a growing number of so-called “new” forest owners in the upcoming years (UNECE 2020). These owners will be with short-term or no experience in forest management and might bring some needs for development of new services (Erlandsson 2013). Based on that, it can be concluded that there is a business opportunity for younger members of the machinery rings to generate additional income in the future by providing services within the machinery rings, as previous studies have shown that there is a trend toward increased outsourcing of forest management activities and decrease of family work is expected among new private forest owners (Novais and Canadas 2010; Andersson and Keskitalo 2019).

The results of this study found no significant influence of private forest owners’ performance of forest management activities in their forest on the performance of forest management services within the machinery rings. This is surprising as previous studies have shown that private forest owners who actively managed their forests were engaged in multiple activities (Joshi and Arano 2009). One possible explana-
tion is that machinery ring members became a member because of the cooperation of agricultural machinery, which was the basic idea of machinery rings. Therefore, the current tax legislation also encourages cooperation among farmers (agricultural holdings) than cooperation among private forest owners in machinery rings. Farmers are also more likely to have the time, skills, and equipment needed to undertake forest operations (UNECE 2020). The most recent representative survey of private forest owners showed that only 9% of the surveyed owners have agricultural holdings (Ščap et al. 2021), which explains why only a small part of the services within machinery rings is performed by private forest owners.

As with all studies, this study has limitations. During data collection, it was not possible to draw a random sample of machinery ring members because the COVID-19 epidemic restricted face-to-face general annual meetings of machinery rings. Therefore, only members present at the general annual meetings who agreed to participate in the study were included in the sample, implying that the sample was self-selected. Therefore, the sample could be subject to selection bias and possible systematic sampling coverage error. The possibility of including 64.9% of the total number of machinery rings currently operating in Slovenia in this study, and all forestry-orientated machinery rings minimize the inconsistency of the data and possible sources of error. However, these aspects should be considered when generalizing to the population of machinery rings. It should also be noted that the survey did not include some questions that might be useful to explain further private forest owners’ readiness to perform forest management services, e.g., forest management objectives, property acquisition, forest property fragmentation, income, occupation, co-ownership. This was mainly because the main objective of the research was to obtain an overview of the management activities of private forest owners and the services performed within the machinery rings. Expanding the number of factors, especially from the policy group, would be necessary in future studies to better understand how private forest owners respond to various policy measures and whether their forest management behaviour coincides with government objectives. An interesting topic for future research is the inclusion of profitability and other economic variables such as services and timber prices in the random utility model.

This study also has potential implications for other countries where small-scale private forest owners lack efficient utilization of owned machinery. The study has shown that machinery ring members are a complex and diverse group of private forest owners. Consequently, the success of machinery rings depends on the provision of relevant forest management services and the interest of their members. Younger and large-scale private forest owners were more likely to perform forest management services within the machinery ring, which may have implications for this group’s tailoring policies, programs, and services.

**Conclusions**

This study examined the readiness of private forest owners to perform forest management services within machinery rings and the factors (property characteristics, forest management activities, and socio-demographic characteristics of owners) that influ-
ence their decisions. A random utility model was developed based on the survey data of machinery rings members.

Machinery ring members most frequently perform forest management activities themselves or with the help of family members. Only 18.3% of machinery ring members perform forest management services within machinery rings, but their scope of services is not insignificant. The most frequently performed forest management services where those related to timber harvesting and skidding. The model’s results showed that the readiness of private forest owners to perform forest management services within a machinery ring was influenced by forest property size and the age of the owner. Large-scale private forest owners were more likely ready to perform forest management services within a machinery ring. On the other hand, readiness to perform services within a machinery ring decreased with owner age.

To motivate private forest owners to manage their forest actively and to encourage them to perform forest management services within a machinery ring more frequently, forest policy makers must provide a holistic approach of innovative and supportive policy instruments to achieve the desired forest policy outcomes. Because cooperation among owners is recognized as a key instrument to support sustainable management of private forests and to achieve policy objective it is important to continue work on strengthening the cooperation among private forest owners and to develop new communication tools and incentive measures to engage the diverse group of small-scale private forest owners.

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Declarations

Conflicts of Interest The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.
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Authors and Affiliations

Špela Pezdevšek Malovrh1 · Nike Krajnc2 · Matevž Triplat1,2

Špela Pezdevšek Malovrh
spela.pezdevsek.malovrh@bf.uni-lj.si

1 Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Večna pot 83, 1000 Ljubljana, Slovenia

2 Department for Forest Technique and Economics, Slovenian Forestry Institute, Večna pot 2, 1000 Ljubljana, Slovenia