Analysis of New Zealand forest transactions 2011–2013

Bruce Manley

Abstract

Data from 27 New Zealand forest transactions were analysed and a model developed to predict crop value from the discounted stumpage revenue associated with the average stand in each forest that was sold in 2011–2013. Inputs to the model are average age (adjusted for species mix), total recoverable volume, harvest cost, distance to port and the proportion of pruned area. Parameters in the model are log price, pruned log price differential, unit transport cost and discount rate. Although the model explains 65% of the variation in crop value, it only predicts the value of 20 out of the 27 transactions to within $2,000/ha of the actual value.

Introduction

Respondents to the 2013 NZIF Discount Rate Survey were asked to provide information on the discount rates they used for forest valuation as well as the discount rates implied by recent transactions. Results were reported by Manley (2014). In addition, valuers were asked to provide information on recent transactions. This paper analyses these transactions. In particular, it attempts to develop an overall model to predict the value paid for each forest from underlying variables.

The approach taken parallels the study of Manley and Bell (1992), which analysed data from 12 transactions involving the cutting rights to state plantations. The model developed in that study predicted forest value as a function of the discounted net clearfell revenue less silvicultural and overhead costs. The model had parameters to represent transport cost and discount rate.

Method

Valuers were asked to provide information on transactions between mid-2011 and 2013:

- Average value ($/ha)
- Net stocked area (ha)
- Region
- Proportion of area in radiata pine
- Proportion of area pruned
- Average age[1]
- Average volume at age 30 years[2] (m^3/ha)
- Average harvesting cost ($/$m^3$ for logging, loading, roading and overheads)
- Distance to port.[3]

Most valuers provided the value of the tree crop. In some cases, the value included land value. Crop value was subsequently calculated by deducting land value from the forest value provided. Analysis was carried out using the R statistical package.

Results

Data was provided for a total of 27 transactions. These represent many, but not all, of the forests for which implied discount rates were reported in Manley (2014). Crop value ranged from $1,450/ha to $16,245/ha. The forests sold cover a range of maturity, proximity to port, harvest difficulty, productivity, species mix and silvicultural input (Table 1).

Table 1: Minimum, mean and maximum value for variables reported for the 27 transactions

	Minimum	Mean	Maximum
Crop value ($/ha)	1,450	6,636	16,245
Average age	4	17	32
Distance to port (km)	25	92	190
Harvest cost ($/m³)	19	38	50
Volume at age 30 (m³/ha)	380	618	814
Radiata pine proportion	0.76	0.96	1
Pruned area proportion	0	0.55	1

Adjustment to age

All blocks had at least 76% of the area in radiata pine. The remainder of the area was mostly Douglas-fir. To allow for longer rotation ages for this species, age was reduced by 15 years for the proportion of non-radiata pine area and an adjusted average age calculated. The

[1] Valuers were also asked for minimum and maximum age but this information was not consistently supplied.
[2] Some valuers provided volume at different ages. This was converted to a volume at age 30 on the basis of mean annual increment.
[3] Distance to port was asked for because it represents a more objective measure than distance to market.

assumption is that a non-radiata pine stand of a given age is equivalent in maturity (years to clearfelling) to a radiata pine stand that is 15 years younger.

Correlation of value with predictive variables

Average age is the only variable that is significantly correlated with value (Table 2). It explains 44% of the variation in value. The pruned area proportion explains 7% of the variation, while the other variables (on their own) explain less than 1% of the variation in value.

Table 2: Correlation coefficient r and r^2 for the relationship between value and potential explanatory variables

	Correlation coefficient (r)	r^2
Average age (adjusted)	0.667	0.445
Distance to port (km)	0.033	0.001
Harvest cost ($/m³)	0.047	0.002
Volume at age 30 (m³/ha)	0.094	0.009
Radiata pine proportion	−0.021	0.000
Pruned area proportion	0.262	0.069

While the relationship between value and age is significant there is a lot of unexplained variation (Figure 1). For example, six of the forests have an average age between 14 and 16 years and their value varies between $4,646/ha and $11,700/ha.

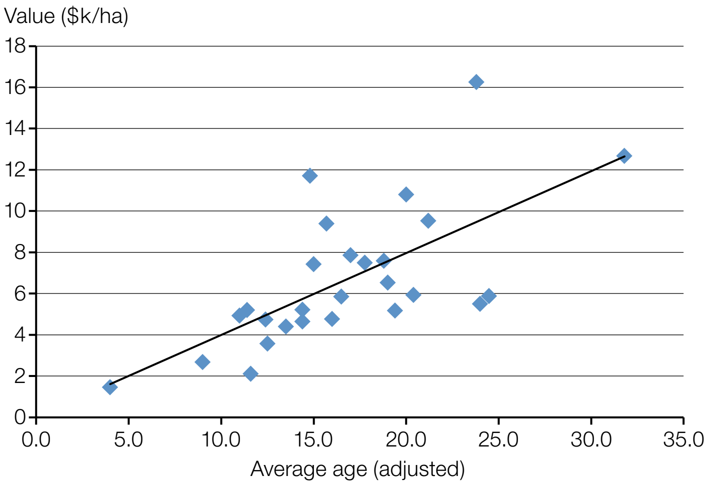

Figure 1: Crop value ($/ha) of the 27 forests sold graphed against average age

An initial attempt was made using multiple linear regression to estimate value from the explanatory variables (Table 3). The model has a residual standard error (RSE) of 2502 and an R^2 value of 57%. However only the coefficient for average age is significant, so consequently a linear model was developed to estimate value from only average age. This model has an RSE of 2547 and an R^2 value of 44%.

Table 3: Regression coefficient and p-value for the relationship between crop value and potential explanatory variables. P-value gives the level of significance of each coefficient (e.g. needs to be less than 0.05 for the coefficient to be significant at the 5% level)

	Regression coefficient	p-value
Intercept	−62.7	0.994
Average age (adjusted)	431.6	0.0001
Distance to port (km)	−13.6	0.328
Harvest cost ($/m³)	−104.1	0.242
Volume at age 30 (m³/ha)	8.6	0.113
% radiata pine	−1903.7	0.828
% pruned	2424.7	0.085

Model based on expectation value

Manley and Bell (1992) developed a model based on the expectation value approach to forest valuation:

Value ($/ha) = discounted stumpage revenue
– discounted annual costs
– discounted silvicultural costs

A similar approach is attempted here. However given that there is only one forest that is aged under nine years, there was insufficient data to consider a silvicultural costs term. Stumpage revenue can be expanded:

Stumpage revenue = at-port revenue
– transport cost
– harvest cost

$= (\beta_1 - \beta_2 * \text{distance to port} - \text{harvest cost}) * \text{volume}_{30}$

Where β_1 = at-wharf price ($/m³)
β_2 = unit transport cost ($/m³/km)

The discount factor for stumpage revenue:

discount factor = $1/(1+\beta_3)^{30\text{-Age}}$

Where β_3 = discount rate
Age = adjusted average age

Consequently a non-linear model was tested:

$$\text{Value} = [(\beta_1 - \beta_2 * \text{distance to port} - \text{harvest cost}) * \text{volume}_{30}] / (1+\beta_3)^{30\text{-Age}} \quad \text{(Model 1)}$$

Where β_1, β_2 and β_3 are parameters to represent at-wharf price, unit transport cost and discount rate.

Regression coefficients for price and discount rate are significant, but not for transport cost (Table 4). Model 1 has an RSE of 2662 and an R^2 value of 42%.

Table 4: Regression coefficients for Model 1

		Regression coefficient	p-value
At-wharf price ($/m³)	β_1	70.30	<<0.001
Transport cost ($/m³/km)	β_2	0.031	0.478
Discount rate	β_3	0.081	<<0.001

Model 1 was extended to take into account pruning. Additional revenue from pruned forests was estimated as β_4 * pruned * 0.25 * $volume_{30}$ where the parameter β_4 represents the price premium paid for pruned logs. It is assumed that 25% of the volume from any stand that has been pruned will be in pruned log grades. This volume is scaled by the percentage of the forest that has been pruned. This leads to Model 2:

$$Value = [(\beta_1 + \beta_4 * pruned * 0.25 - \beta_2 * distance\ to\ port - harvest\ cost) * volume_{30}] / (1+\beta_3)^{30-Age}$$

Model 2 (Table 5) has an RSE of 2154 and an R^2 value of 64%. All coefficients are significant.

Table 5: Regression coefficients for Model 2

		Regression coefficient	p-value
At-wharf price ($/m³)	β_1	68.15	<<0.001
Pruned log price premium ($/m³)	β_4	75.38	0.002
Transport cost ($/m³/km)	β_2	0.103	0.019
Discount rate	β_3	0.086	<<0.001

A similar approach was taken to account for species. Marginal revenue from non-radiata pine forests was estimated as β_5 * other * $volume_{30}$

Where other = (1 – radiata pine proportion)

The parameter β_5 represents the marginal price (premium or discount) paid for non-radiata pine logs.

Model 3:

$$Value = [(\beta_1 + \beta_4 * pruned * 0.25 + \beta_5 * other - \beta_2 * distance\ to\ port - harvest\ cost) * volume_{30}] / (1+\beta_3)^{30-Age}$$

Model 3 (Table 6) has a an RSE of 2202 and an R^2 value of 64%. It implies that the average price for other species (predominantly Douglas-fir) is $4.69 less than the average unpruned price for radiata pine. However this coefficient is not significant, so consequently Model 2 is the preferred model.

An attempt was also made to include annual overhead costs in the model using the approach of Manley and Bell (1992). However the model developed was not significant and not logical – an annual revenue of $310/ha/year was implied rather than an annual cost.

Table 6: Regression coefficients for Model 3

		Regression coefficient	p-value
At-wharf price ($/m³)	β_1	68.29	<<0.001
Pruned log price premium ($/m³)	β_4	74.66	0.003
Other species price differential	β_5	–4.69	0.886
Transport cost ($/m³/km)	β_2	0.103	0.022
Discount rate	β_3	0.085	<<0.001

Model 2 performance

Model 2 predicts the value of 20 of the 27 transactions to within ±$2,000/ha (Figure 2). However there are three outliers for which the model under-predicts by more than $2,000/ha and four outliers for which the model over-predicts by more than $2,000/ha. For one of the forests that had value underestimated, existing infrastructure and access to diverse markets could be a factor. However no common patterns could be observed in the outlier groups.

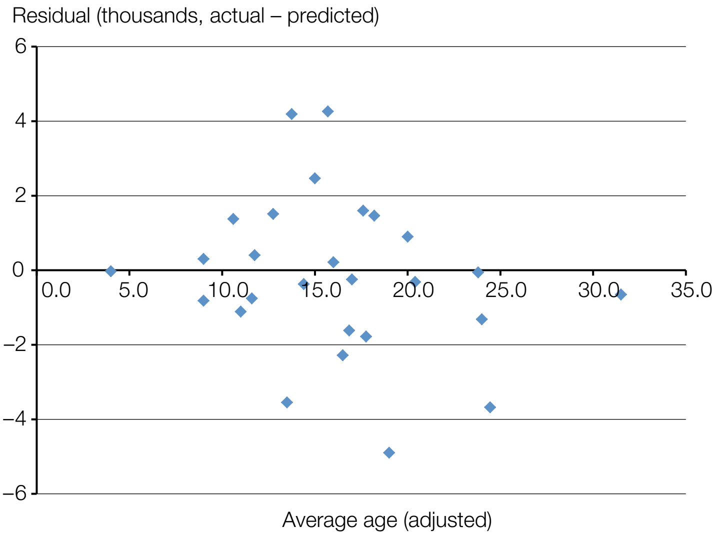

Figure 2: Residuals (calculated as actual value minus predicted value) plotted against adjusted average age

The wide distribution of residuals in Figure 2 is not surprising given the range of implied discount rates reported in Manley (2014). Implied discount rates reported for New Zealand forests varied between 5.1% and 11.5%. Using a model such as Model 2 with an 'average' discount rate of 8.6% will result in crop value being poorly estimated in some cases.

Discussion

Model interpretation

Model 2 explains 64% of the variation in forest value using a model structure that is based on the discounted stumpage revenue of the average stand in each forest. The model parameters can be compared with industry practice:

- The discount rate parameter of 8.6% is broadly comparable with the average implied discount rate of 8.9% (for pre-tax cashflows) reported in the 2013 survey (Manley, 2014).
- Average at-wharf prices for unpruned logs during 2011 to 2013 were $80–100/m^3, certainly higher than the calculated price coefficient of $68/m^3.[4]
- Pruned log prices were $40–50/m^3 higher than average unpruned log prices during 2011 to 2013, lower than the $75/m^3 premium estimated.
- Unit transport costs are typically higher than $0.10/m^3/km, for example, the AgriFax log price report for June 2013 implies a unit transport cost of $0.13/t/km.

Some of these differences will reflect the assumptions made, for example, the assumption that all logs are transported to the port will result in an over-estimation of transport distance for many forests. The lower unit cost estimated in the model may be compensating for this. Similarly the pruned log premium assumes a pruned log percentage of 25%. A higher percentage would result in a reduced coefficient. However in many cases the pruned log percentage would be lower than 25% and result in an even higher pruned log price differential in the model.

Other species

Although the price differential estimated for other species in Model 3 was not significant, use of an age adjustment means that the relative maturity of non-radiata pine species is captured in Model 2. When Model 2 was re-estimated using raw (i.e. unadjusted) average age, the RSE increased from 2154 to 2286 and R^2 decreased from 64% to 59%. This confirms that adjusting age to reflect species mix is warranted. Figure 3 shows the effect on RSE of varying the age reduction for other species. It shows that the minimum RSE would be achieved with an age reduction of 16 years for other species. The reduction of 15 years adopted in this analysis gives only a small increase in RSE.

Comparison with 1992 analysis

Manley and Bell (1992) developed a model that explained 93% of the variation in market value of 12 transactions. In contrast, the model developed in this study explains only 64% of the variation in value of 27 transactions. There are probably four main reasons for this:

- The explanatory variables were derived by the authors using a consistent approach in Manley and Bell (1992). In contrast, data was provided by six forest valuers in this study.

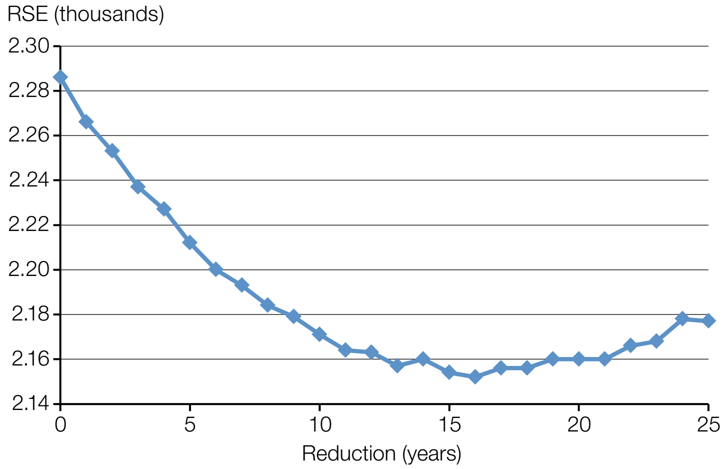

Figure 3: Effect on model fit (residual standard error – RSE) of varying the age reduction for other species from 0–25 years. The underlying model is Model 2, with average age calculated using different age reductions for the proportion of non-radiata pine species

- There was a single seller in the 1990 transactions.
- In 1990, the cost of using land was standardised as a Crown Forest Licence rental.
- Due to limited transaction evidence, reserve prices calculated by the Crown played a large role in the 1990 sale and purchase negotiations. These were calculated using a standard approach and calibrated using initial transactions. The 2011–2013 transactions involved many different buyers and sellers, all with a wide range of perceptions about forest value and motivations for sale or purchase.

Acknowledgements

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References

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Bruce Manley is Head of School at the School of Forestry at the University of Canterbury in Christchurch. Email: bruce.manley@canterbury.ac.nz.

[4] Prices are derived from an analysis of AgriFax prices done as part of Management Case Study 2014 by final year BForSc students.