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Trends in discount rates used for forest valuation in New Zealand

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Abstract

Background: The discount rate is a key input for estimating the market value of a forest. Data collected in surveys of forest valuers from 1997 to 2017 indicate a reduction in implied discount rate (IDR) over time with lower IDRs for larger forests. The purpose of this study was to formally analyse these trends.

Methods: There are three steps to the analysis:
1. Relationships were developed for the IDR data from 1997 to 2017;
2. Further relationships were developed for IDR data from 2009 to 2017 for which forest size (i.e. net stocked area) rather than just size class is available; and
3. Detailed forest transaction data from 2011 to 2017 were used to develop a model to estimate average crop value from key variables including discount rate. This process allowed an analysis to confirm whether or not trends in discount rate with time and forest size were significant.

Results: Analysis of the implied discount rate (IDR) revealed that the reduction over time is significant and that the discount rate for large forests (>10,000 ha) has declined more than for smaller forests. Analysis of data from 2009, for which forest size rather than size class is available, showed that forest area has a significant effect on IDR. Finally, the discount rate within the crop-value model, developed using transaction data collected since 2011, was found to vary with time and forest size; i.e. discount rate decreased as time or forest size increased.

Conclusions: Overall, it can be concluded that the discount rates implicit in New Zealand forest transactions have declined over time, with the scale of the reduction depending on forest size.

Keywords: crop value; discount rate; plantation forestry

Introduction

Discounted cashflow analysis has been widely used for forest valuation since Faustmann (1849) used it to estimate both the value of land and the value of the tree crop growing on that land. A key input to discounted cashflow analysis is the choice of discount rate. A common approach in New Zealand is to use the discount rate implied by recent transactions (Manley 2018). The implied discount rate (IDR) is estimated for a transaction as the discount rate that makes the NPV (Net Present Value) of the forecast cashflows of a forest crop equal to the transaction value.

In analysing forest transactions (i.e. forest sales), average value is sometimes used as a comparative measure to benchmark the market evidence (Manley 2016a). However, average value is influenced by many factors. The influence of average stand age on average crop value[i] for New Zealand forest transactions from 2011 to 2017 is shown in Figure 1. The variation at any age indicates that other factors are also important

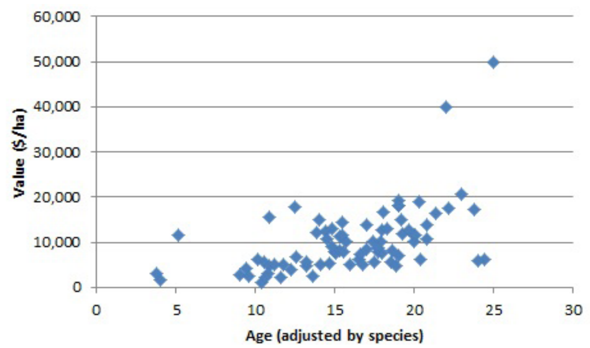

FIGURE 1: Average crop value for each of 78 New Zealand forest transactions between 2011 and 2017 (i.e. dataset 3) plotted against average stand age. Values are real $2017. Average stand age is adjusted for species mix.

determinants of value. Manley and Bell (1992) showed that crop value is a function of age, species composition, site productivity, past silvicultural investment, terrain, and distance to market. Given that no two forests are the same, average crop value of one forest only provides limited ability to estimate the value of another forest unless adjustments are made for the underlying determinants of forest value.

In New Zealand, IDR provides a better way to summarise transaction evidence in order to estimate the market value of forests. Keating (1990) reported the discount rates implicit in the sales price achieved in the sale of State plantations. Since then, the IDR rather than average value ($ ha^{-1}) has been the key statistic extracted from transaction information.

Forest valuers in New Zealand have been surveyed every two years about the discount rate they use to determine the market value of a tree crop (Manley 1998, 1999, 2001, 2003, 2005, 2007, 2010, 2012, 2014, 2016b, 2018). As part of these surveys, valuers were also asked for transaction information; in particular, their estimate of the discount rate implicit in the transaction price of recent forest sales[ii]. There is a large variation in reported IDRs (Figure 2).

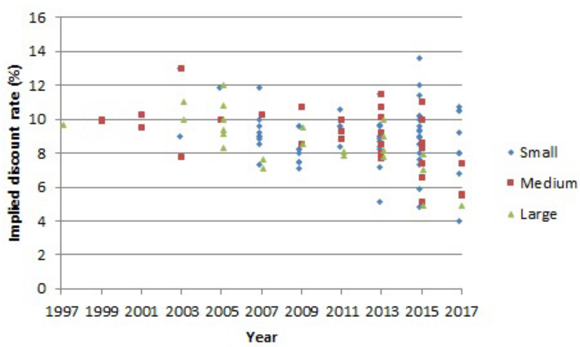

FIGURE 2: IDRs (applied to current rotation pre-tax cashflows) for transactions reported in each of the discount rate surveys. Forests are identified by size class (Small <1000 ha; Medium 1000 to 10,000 ha; Large >10,000 ha). [Figure 3 of Manley (2018)]

However, some trends in IDR are apparent:

- A reduction in IDR over time; and
- Lower IDRs for larger forests

Manley (2016a) analysed data from 27 New Zealand forest transactions between 2011 and 2013 and developed a model to predict the market value of the tree crop from the discounted stumpage revenue associated with the average stand in each forest that was sold. Inputs to the model (Model 1) 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 represent log price, pruned log price differential, unit transport cost and discount rate. The model has a residual standard error (RSE) of $2154 ha^{-1} (Table 1).

TABLE 1. Parameter estimates for Model 1 developed by Manley (2016a) for 2011 to 2013 transactions.

	Parameter	Estimate	P-value
At-wharf price ($ m^{-3})	a	68.15	<<0.001
Pruned log price premium ($ m^{-3})	b	75.38	0.002
Transport cost ($ m^{-3} km^{-1})	c	0.103	0.019
Discount rate	d	0.086	<<0.001

RSE = $2154 ha^{-1}

$$\text{Value} = [(a + b^* \text{ Pruned} * 0.25 - c * \text{Distance to port} - \text{Harvest cost})^*\text{Volume}_{30}] / (1+d)^{30-\text{Age}}$$

(Model 1)

Where:

- Value is average tree crop value ($ ha^{-1}). In cases where the transaction involved land as well as the tree crop, land market value was deducted.
- Pruned is proportion of forest area that has been pruned. It is assumed that pruned logs make up 25% of the volume from a pruned crop.
- Distance to port is distance to nearest port (km).
- Harvest cost is average harvesting cost ($ m^{-3}) including logging, loading, roading and overheads).
- $Volume_{30}$ is total recoverable volume (m^3 ha^{-1}) at age 30 years.
- Age is average forest age adjusted so that age is reduced by 15 years for the proportion of non-radiata pine area. This adjustment allows for the longer rotation age of these other species which are mostly Douglas-fir.

The coefficients (Table 1) can be considered to represent:

a = at-wharf price ($ m^{-3})
b = premium paid for pruned logs ($ m^{-3})
c = unit transport cost ($ m^{-3} km^{-1})
d = discount rate

With an extended data set available for 2011 to 2017, this model provides an alternative framework for analysing trends in discount rate evident from transaction information.

The purpose of this paper was to formally analyse trends in IDR. This was done using two different approaches: direct analysis of IDRs and analysis of crop value with IDR embedded within the valuation model. There were three steps to the analysis:

1. Relationships were developed for the IDR data from 1997 to 2017;
2. Further relationships were developed for IDR data from 2009 to 2017 for which net stocked area (rather than just size class) is available; and
3. Detailed forest transaction data from 2011 to 2017 were used to develop a model to estimate average crop value from key variables including discount rate. This provides a complementary approach to confirm whether trends in the discount rate with time and forest size are statistically significant.

It is important to differentiate this analysis from previous work that postulated that the discount rate used to value an investment should reduce over time; i.e. that the cashflows for an investment should be discounted at a variable rate, with a successively lower rate used for distant cashflows. Arguments for this, as summarised by Price (2011), include: (i) this is the way in which humans actually discount (Henderson & Bateman 1995); (ii) present generations are entitled to discount their own consumption, but not that of future generations (Kula 1981); and (iii) when discount rate is uncertain, future cashflows should be discounted at lower rates (Newell & Pizer 2003). In contrast, in the analysis reported here a constant discount rate is used in valuing the future cashflows for a specific tree crop with only the current rotation considered. Trends in the discount rate recognised by the market over time are evaluated.

Methods

Three sets of data were used, one for each of the three steps to the analysis. The first dataset was the full set of IDR data from 1997 to 2017. The second dataset was the subset for which net stocked area (rather than just size class) was available. The third dataset was the subset for which detailed forest data is available.

Data came from the 11 surveys of forest valuers carried out between 1997 and 2017. In each survey, all known valuers active in the valuation of New Zealand plantations were surveyed. Although the response rate was always high (near 100%) the IDR dataset did not include all transactions as some forests, particularly smaller forests, had been sold without subsequent analysis of IDR by any of the respondents.

1. IDR data from 1997 to 2017

Data were available from the surveys of forest valuers for 119 transactions: 63 small forests, 33 medium forest and 23 large forests. The available data consisted of:

- Year of transaction.
- Valuers' estimates of IDR (applied to pre-tax cashflows for the current rotation) for each transaction. The average IDR for each transaction was used in the analysis.
- Forest size class (Small/Medium/Large) for each transaction. *(Small <1000 ha; Medium 1000 to 10,000 ha; Large >10,000 ha).*

Data were analysed (using the R non-linear least squares function - nls) for trends in discount rate over time allowing for potential differences with forest size class. The general structure of the model initially used was:

$$R = e - [\exp(f*T) - 1] \qquad \text{(Model 2)}$$

Where:

- R is implied discount rate applied to pre-tax cashflows
- T is time (years since 1997)

In this model, e is the estimated discount rate at T=0. If there is no trend with time, f=0 and R=e for all values of T.

This model form was chosen because it allowed for the general trends evident in Figure 2 and it subsequently allowed for a simple comparison between different size classes with only a single coefficient (f) changing.

2. IDR data from 2009 to 2017

Data were available for 70 transactions: 43 small forests, 19 medium forest and 8 large forests. The available data consisted of:

- Year of transaction.
- Valuers' estimates of IDR (applied to pre-tax cashflows for the current rotation) for each transaction. Again, the average IDR for each transaction was used in the analysis.
- Forest size (net stocked area in hectares (NSA)) for each transaction.

This dataset is a subset of the 1997 to 2017 dataset. Initially the same analysis was conducted as for the 1997 to 2017 dataset. Subsequently, forest size was included in the model as a continuous variable.

3. Transaction data from 2011 to 2017

Data were available for 78 transactions. The available data consisted of:

- Year of transaction.
- Crop value ($ ha^{-1}).
- Forest size (net stocked area – NSA in hectares) for each transaction.
- Proportion of area in radiata pine.
- Proportion of area pruned.
- Average age.
- Average volume at age 28 years (m^3 ha^{-1}).
- Average harvesting cost ($ m^{-3} for logging, loading, roading and overheads).
- Distance to nearest port (km).

Both the crop value and harvesting cost were converted to real $June 2017 using PPI (Producer Price Index, Outputs level 1, All industries).

The model developed by Manley (2016a) for 2011 to 2013 data was re-estimated using all data. The main change was to assume a harvest age of 28 years rather than 30 years. This was done to better reflect current practice. Subsequent steps allowed for:

- Changes in real price over time.
- Trends in discount rate with time and forest size.

Of the 78 transactions, 58 were included in the IDR dataset for 2009 to 2017; i.e. those transactions from 2011 to 2017 for which an IDR was provided for current rotation pre-tax cashflows. Some survey respondents provided transaction details but IDR data only for post-tax cashflows or multiple rotations. Other respondents provided details for some transactions but not IDRs.

Results

1. IDR data from 1997 to 2017

The initial model evaluated was Model 2 and the initial discount rate level was estimated as 10.3% (Table 2). The trend for a reducing discount rate over time was significant. The Residual Standard Error (RSE) was 1.65%.

TABLE 2. Parameter estimates for Model 2 fitted to data from 1997 to 2017.

Parameter	Estimate	P-value
e	10.311	<<0.001
f	0.0596	<<0.001

RSE = 1.65%

Model 3 was evaluated to determine whether there are different trends over time for the three different forest size groups. In this model, the parameter f corresponds to the medium forest size. Parameter g is not significant (Table 3) indicating that there is no significant difference in trends in discount rate over time between small and medium forests. The difference in discount rate trends between medium and large forests (parameter h) is only marginally significant; i.e. not significant at the 5% probability level but significant at the 10% probability level. RSE is 1.60%.

TABLE 3. Parameter estimates for Model 3 fitted to data from 1997 to 2017.

Parameter	Estimate	P-value
e	10.453	<<0.001
f	0.0657	<<0.001
g	-0.00963	0.226
h	0.0177	0.059

RSE = 1.60%

$$R = e - [\exp((f + g * Small + h * Large) * T) - 1] \quad \text{(Model 3)}$$

Where: Small and Large are dummy variables that take on the value of 1 if the forest is in that size class, and 0 otherwise.

Making the small forest size the base case in Model 3 (with dummy variables for medium and large) confirmed that there was no significant difference in trend between small and medium forests but that the difference between small and large forests was significant (P=0.002). Consequently Model 4 was developed in which small and medium forests were pooled. The pooled small/medium group was significantly different from the large group (P=0.003). RSE is 1.61% (Table 4).

TABLE 4. Parameter estimates for Model 4 fitted to data from 1997 to 2017.

Parameter	Estimate	P-value
e	10.453	<<0.001
f	0.0657	<<0.001
h	0.0243	0.003

RSE = 1.61%

$$R = e - [\exp((f + h * Large) * T) - 1] \quad \text{(Model 4)}$$

Where: Large is a dummy variable that takes on the value of 1 if the forest is in that size class, and 0 otherwise.

A variation of Model 4 was analysed in which large forests were allowed to have a different level of initial discount rate. This was done by replacing e by the expression e + i*Large. However, the coefficient i was not significant (P=0.65). Consequently, Model 4 was chosen as the preferred model. Estimates from Model 4 show the trends in discount rate over time with a lower discount rate for large forests (Figure 3).

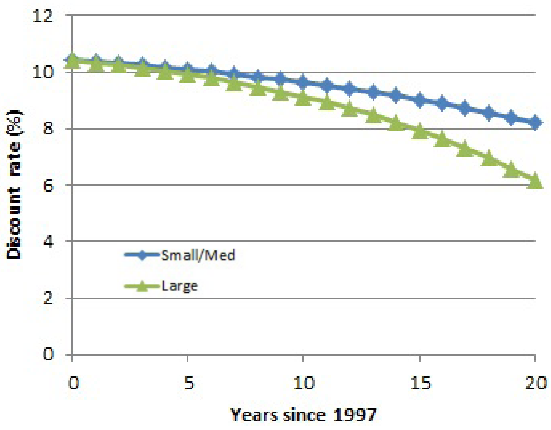

FIGURE 3: Estimates of IDR over time for different forest size classes using Model 4 fitted to data from 1997 to 2017.

2. IDR data from 2009 to 2017

When the 2009 to 2017 dataset was used, the time variable (T) represented the number of years since 2009. When fitted to this dataset, Model 2 had an RSE of 1.79% (Table 5). The trend with time was significant.

TABLE 5. Parameter estimates for Model 2 fitted to data from 2009 to 2017.

Parameter	Estimate	P-value
e	9.690	<<0.001
f	0.150	<<0.001

RSE = 1.79%

Model 3 allowed for different trends for each size class. This resulted in a model with an RSE of 1.71% (Table 6). There was no significant difference in trends between medium and large forests (P=0.22) but the difference between small and medium forests was marginally significant (P=0.08). Using small rather than medium as the base in Model 3 showed that the difference between small and large forests was significant (P=0.008).

TABLE 6. Parameter estimates for Model 3 fitted to data from 2009 to 2017.

Parameter	Estimate	P-value
e	9.648	<<0.001
f	0.177	<<0.001
g	-0.0684	0.081
h	0.0462	0.217

RSE = 1.71%

Again, there were indications of different trends in discount rate over time for different forest size classes. As net stocked area (NSA) was available for transactions in the 2009 to 2017 dataset, it was possible to treat forest area as a continuous variable rather than using discrete size classes. Here, the natural logarithm of NSA was used to scale the effect of time (Model 5). This model reduced RSE to 1.67% (Table 7). Both model coefficients e and f were significant although residuals are large. There was no strong pattern when model residuals were plotted against ln(NSA) (Figure 4). Model estimates show trends over time for forests of different size (Figure 5). Forest area varied from 30 ha to 61,000 ha in the dataset used.

TABLE 7. Parameter estimates for Model 5 fit to data from 2009 to 2017.

Parameter	Estimate	P-value
e	9.617	<<0.001
f	0.0212	<<0.001

RSE = 1.67%

$$R = e - [\exp(f*\ln(NSA)*T)-1] \quad \text{(Model 5)}$$

A variation of Model 5 allowing the initial level of the discount rate to vary with forest size was tested. This was done by replacing e by the expression e + i*ln(NSA). However, the coefficient i was not significant (P=0.88).

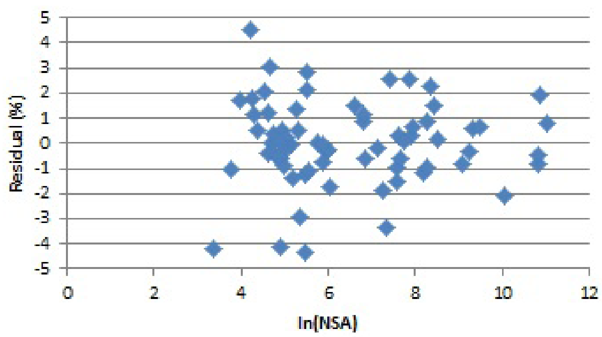

FIGURE 4: Residuals (Actual – Predicted) for Model 5 (fitted to data from 2009 to 2017) plotted against ln(NSA).

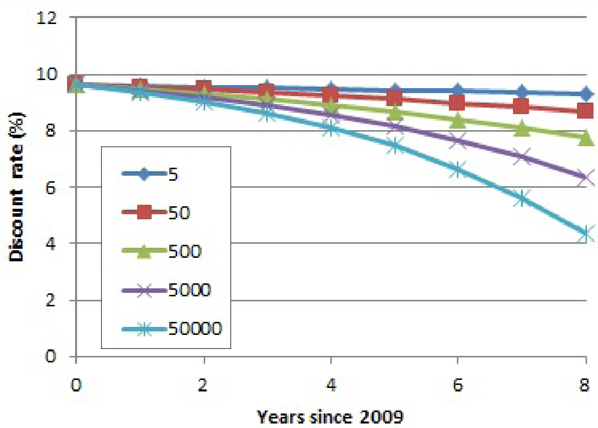

FIGURE 5: Estimates of IDR over time for five different forest sizes using Model 5 fitted to data from 2009 to 2017.

An alternative approach was to model the effects of forest size and time as additive rather than multiplicative (Model 6). The result for this model was not as good as for Model 5 with an RSE of 1.71% (Table 8). Nevertheless the coefficients for both ln(NSA) and T were significant.

R = e – [exp(f*ln(NSA)+g*T)-1]

(Model 6)

TABLE 8. Parameter estimates for Model 6 fitted to data from 1997 to 2017.

Parameter	Estimate	P-value
e	10.585	<<0.001
f	0.110	<<0.001
g	0.084	<<0.001

RSE = 1.71%

3. Transaction data from 2011 to 2017

The initial step was to re-estimate the coefficients of the model developed by Manley (2016a) to predict the market value of the tree crop from the discounted stumpage revenue associated with the average stand in each forest that was sold. The model (Table 9) has an RSE of \$4269 ha^{-1}. All four coefficients are significant.

The a and b coefficients of Model 7 are estimates of log prices over the period 2011 to 2017. However, over this period log prices increased (Figure 6). Consequently, the PF Olsen Log Price Index (converted to real \$June 2017 and rebased so that June 2017 equals 1) was included in the model (Model 7). This addition resulted in a better model with the RSE reducing to \$3518 ha^{-1} (Table 10).

Value = [(a*LPI + b* LPI*Pruned * 0.25 – c * Distance to port – Harvest cost)*$Volume_{28}$] / $(1+d)^{28-Age}$

(Model 7)

Where LPI is the PF Olsen log price index in real \$June 2017 rebased so that \$June 2017 equals 1.

TABLE 9. Regression coefficients for Model 1 fitted using data from 2011 to 2017. The model form is identical to Manley (2016a) except that a rotation age of 28 years rather than 30 years is assumed.

	Parameter	Estimate	P-value
At-wharf price (\$ m^{-3})	a	96.90	<<0.001
Pruned log price premium (\$ m^{-3})	b	87.04	<<0.001
Transport cost (\$ m^{-3} km^{-1})	c	0.209	<<0.001
Discount rate	d	0.104	<<0.001

RSE = \$4269 ha^{-1}

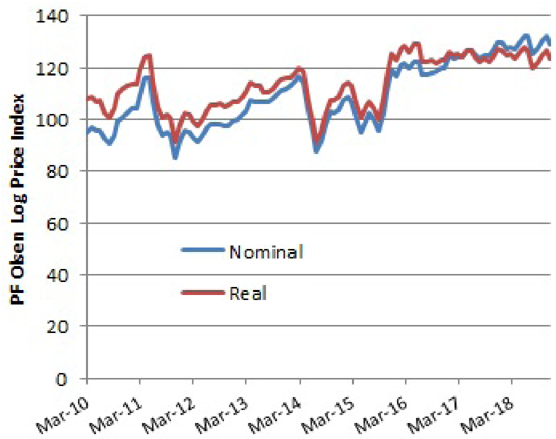

FIGURE 6: PF Olsen Log Price Index (in nominal \$ and real \$June 2017) from March 2010 to December 2018. This Index is based on prices for log grades "weighted in proportions that represent a broad average of log grades produced from a typical pruned forest with an approximate mix of 40% domestic and 60% export supply" [Source PF Olsen]. Conversion to real \$June 2017 was done using PPI (Producer Price Index, Outputs level 1, All industries).

TABLE 10. Regression coefficients for Model 7 fitted using data from 2011 to 2017.

	Parameter	Estimate	P-value
At-wharf price (\$ m^{-3})	a	95.53	<<0.001
Pruned log price premium (\$ m^{-3})	b	82.39	<<0.001
Transport cost (\$ m^{-3} km^{-1})	c	0.155	<<0.001
Discount rate	d	0.085	<<0.001

RSE = \$ 3518 ha^{-1}

The final step was to allow for the discount rate to vary with time and forest size. Based on the findings of the previous section, the parameter d was replaced by the expression used in Model 7:

e – [exp(f*ln(NSA)*T)-1]

(used in Model 8 to replace parameter d in Model 7)

where T is years since 2009.

All coefficients in this model (Model 8) are significant and the RSE is further reduced to \$3069 ha^{-1} (Table 11). The residuals do not exhibit any strong patterns when plotted against ln(NSA), year or age (Figures 7, 8 and 9). Model estimates show the trends over time for forests of different sizes (Figure 10). Forest area varied from 10 ha to 132,000 ha in the dataset used.

TABLE 11. Regression coefficients for Model 8 fitted using data from 2011 to 2017. This model allows for discount rate to vary with forest size over time.

	Parameter	Estimate	P-value
At-wharf price ($ m^{-3})	a	97.14	<<0.001
Pruned log price premium ($ m^{-3})	b	97.34	<<0.001
Transport cost ($ m^{-3} km^{-1})	c	0.1764	<<0.001
Base discount rate	e	0.121	<<0.001
Discount rate adjuster	f	0.0009051	<<0.001

RSE = $ 3069 ha^{-1}

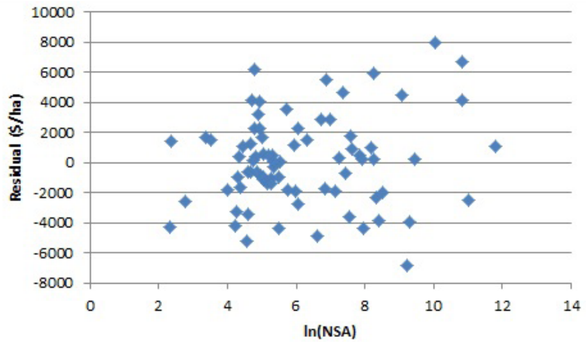

FIGURE 7: Residuals for Model 8 (fitted to data from 2011 to 2017) plotted against ln(NSA).

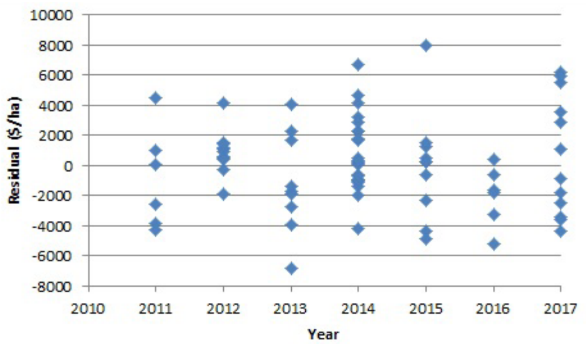

FIGURE 8: Residuals for Model 8 (fitted to data from 2011 to 2017) plotted against year.

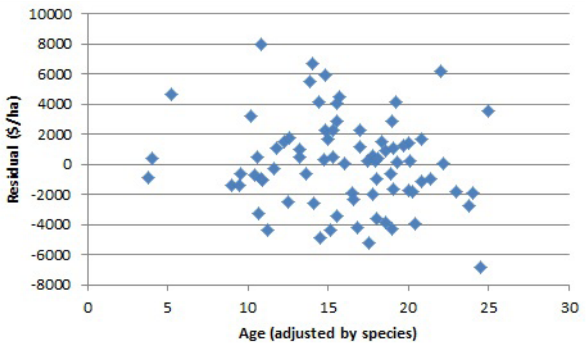

FIGURE 9: Residuals for Model 8 (fitted to data from 2011 to 2017) plotted against Adjusted Age (i.e. average forest age adjusted for species mix).

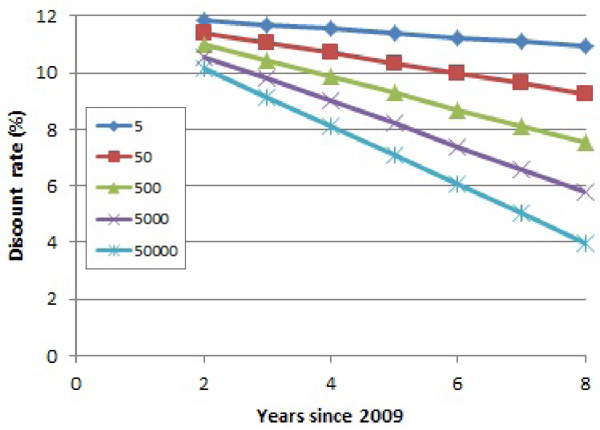

FIGURE 10: Estimates of IDR over time for five different forest sizes using Model 8 fitted to data from 2011 to 2017.

Discussion

IDR model

Analysis using data from 1997 to 2017 revealed that trends in discount rate over time were significant and provided a strong indication of a forest size effect. The forest size effect was clear once area was introduced as a continuous variable using the 2009 to 2017 dataset. The effects of size and time (i.e. years since 2009) can be modelled as being either multiplicative or additive. The former approach produced a better model and was adopted here.

Valuation model

Applying Model 1 to 2011 to 2017 transaction data increased RSE to $4269 ha^{-1} compared to $2154 ha^{-1} when only 2011 to 2013 data were used in the earlier Manley (2016a) study. However, improvements were made by:

- Including the log price index – RSE reduces to $3518 ha^{-1}.
- Allowing discount rate to vary with time and forest size – RSE further reduces to $3069 ha^{-1}.

The model structure determines the discounted stumpage revenue of the average stand in each forest allowing for changes in real log price and discount rate over time. A comparison of the model parameters with typical industry values revealed that:

- The value for at-wharf price (parameter a) was $95.53 m^{-3} in Model 7 and $97.14 m^{-3} in Model 8. Average at-wharf prices for unpruned logs in 2017 were $110–120 m^{-3}. Including lower priced pulplogs or chiplogs reduced this to a level closer to the estimated model parameters.
- Pruned log prices were typically $50–60 m^{-3} higher than average unpruned log prices. The pruned log price premium implicit in transaction information ($82.39 m^{-3} in Model 7 and $97.34 m^{-3} in Model 8) was greater than this.
- The unit transport cost ($0.15 m^{-3} km^{-1} in

model 7 and 0.18 m^{-3} km^{-1} in Model 8) aligned well with the value of \$0.15 t^{-1} km^{-1} used in the AgriHQ June 2017 report.

- The discount rate of 8.5% estimated for Model 7 is higher than the average reported IDR of 7.6% for 2016–17 in Manley (2018).

The general conclusion is that the parameter estimates are realistic given that Models 7 and 8 are simplifications. For example, they consider only discounted stumpage revenue and ignore annual overhead costs and land rents. An attempt was made to include annual costs in the model but the associated parameter was not significant. One interpretation of the pruned log price coefficient is that the market for forests recognises a greater premium for pruned logs than is evident in the current log market. The coefficient was calculated assuming that 25% of the volume of a pruned stand will be extracted as pruned logs. The pruned log price coefficient will vary inversely with the assumed proportion decreasing or increasing.

Comparison of two different approaches

Initially IDR is the dependent variable used for modelling in Models 2 to 6. At the final stage, in Models 7 and 8, crop value is the dependent variable with the model structure including a term to represent the discount rate. These two distinct approaches are discussed below.

In calculating IDRs, valuers make assumptions about future volumes, prices and costs. The IDR is the balancing variable in making the NPV of future cashflows equate to the known transaction value. Consequently, the estimated IDR depends on the assumptions made about future volumes (harvesting strategy and yields), prices and costs. If different valuers have different views about these factors, they will generate different IDRs for the same transaction. This variation is evident in the published survey results.

The alternative approach uses average crop value as the dependent variable and predicts it based on:

- Maturity (current age relative to a target rotation age of 28 years).
- Species composition (proportion of area in species other than radiata pine).
- Site productivity (volume at age 28).
- Past silvicultural investment (proportion of area pruned).
- Terrain/harvest difficulty (average harvesting cost).
- Distance to market.

Model inputs were provided by valuers. Again, there was some variation in these inputs between valuers. However, this approach does not rely on valuers' inputs on two key variables:

- Log price. This is an output from the model.
- Harvesting strategy. Harvest age is fixed at age 28 years.

There are differences between approaches in the coefficients estimated for discount rate. The e coefficient was 9.6 (Table 7) for Model 5 (IDR model) and 12.1 (Table 11) for Model 8 (average crop value model). The latter model estimated a greater impact of forest size on discount rate (Figure 10) compared to the IDR model (Figure 5).

Trends in discount rates

The consistent findings from the three elements of this study are that the reduction in discount rate over time is statistically significant and that the impact of forest size is also significant. The effect of forest size on discount rate revealed by analysis of the 1997 to 2017 IDR data (Figure 3) was muted because only size class data were available. Differences became greater once forest area was included as a continuous variable (see Figures 5 and 10). The greatest differentiation with forest size was exhibited in the analysis of transaction data for 2011 to 2017 (Figure 10).

The purpose of the models was to document past trends. Although the models contain significant coefficients they only partially explain the variation in IDR or crop value - model residuals are large. The models should not be used to forecast future discount rates as past trends are unlikely to be a good predictor of the future.

Limitations

The exponential functional form was chosen to model reductions in discount rate because it allows for the pattern of reduction apparent in Figure 2. The variant used (Model 2) is simple with only two coefficients, one for level and another that, when multiplied by time, gives the rate of change. In the extension to Model 5, the rate of change is also determined by ln(NSA). An inherent limitation is that for a given forest size, the rate of change is set and the reduction in discount rate increases with time. This is evident in Figure 5 where, for example, the reduction between years 7 and 8 is greater than the reduction between years 6 and 7.

Conclusions must also be tempered by the limited number of large-forest transactions in the datasets. For example, the dataset of 2011 to 2017 transactions includes only eight large forests over 10,000 ha: four 2011–13 transactions, three 2014–15 transactions and one 2016–17 transaction. The four transactions since 2014 have considerable leverage over the specific results obtained.

Implications for forest valuers

Given the limitations of model form and data, together with the large model residuals, forest valuers should not use the models developed here to set discount rates. The ultimate determinant of discount rates for New Zealand plantations will continue to be the market. Forest valuers are attempting to mimic the market when they act for buyers and sellers in a transaction or when they estimate the fair value of a tree crop for company reporting. The key message for forest valuers is that the market is recognising lower discount rates for larger forests.

Discount rates declared in financial reporting

Discount rates being used for financial reporting have tended to decline since 2013 (Figure 11). The companies shown are all large (>10,000 ha) apart from Invercargill City Forests, Sunchang Forestry NZ and Te Waihou Plantations, all of which are of medium size (1000 to 10,000 ha). The discount rates shown are those used by the independent forest valuer in determining crop value. There have been different trends for individual companies with discount rates not declining for some but markedly for others. The discount rates used in 2010 to 2012 are lower than those indicated by the IDR model while those in recent years are higher than shown in Figure 5 or Figure 10. Overall the reductions have not been at the same rate indicated by the reductions in IDRs for medium/large companies.

Comparison to Sewall survey

US forest valuation company James W. Sewall Company regularly carries out its own survey of discount rates. In the Sewall Investor Survey, active investors are asked "What is the 'base' discount rate (real, pre-tax, before TIMO fees & expenses) required for successful bids on generic timberland investments in the U.S. now?" Respondents are subsequently asked to "Provide the discount rate premium over the U.S. base rate" for a range of international forest investments including New Zealand pine. Since 2011, the average discount rate has declined for both US timberland and New Zealand pine (Figure 12). Again the reduction is not as steep as that indicated by the analysis of IDRs.

Why the decline in discount rate over time?

The reduction in IDR over time has been driven by the supply and demand for plantations by the international investment community. Medium and large New Zealand plantations have been actively sought when put up for sale. In many cases purchasers have been pension funds, often investing via TIMOs (Timber Investment Management Organisations). Since 2010, the total TIMO forest area has plateaued (Figure 13). As noted

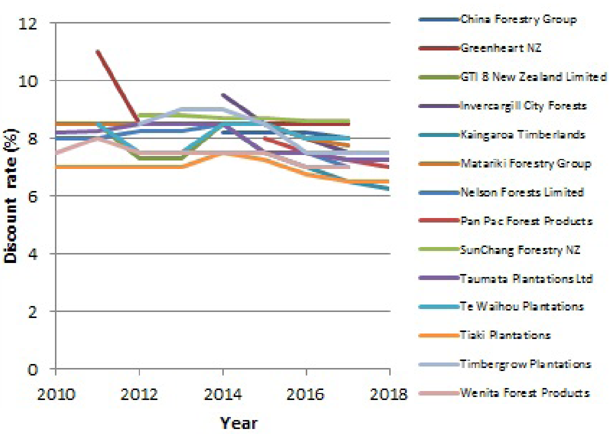

FIGURE 11: Discount Rates Declared in Financial Reporting for some New Zealand-registered companies with annual reports in the public domain. All rates are applied to current rotation pre-tax cashflows.

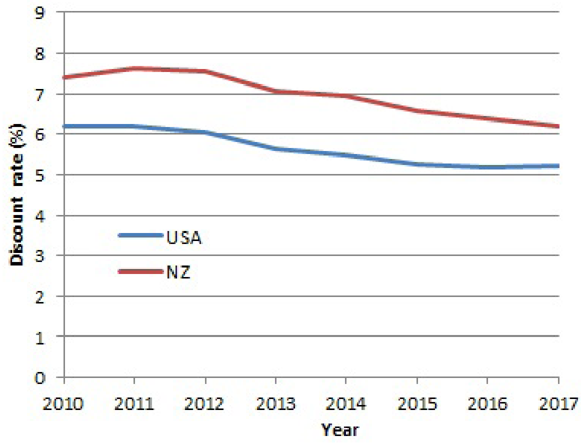

FIGURE 12: Average discount rates for USA and New Zealand from James W. Sewall surveys of forest investors. Source: James W. Sewall Company

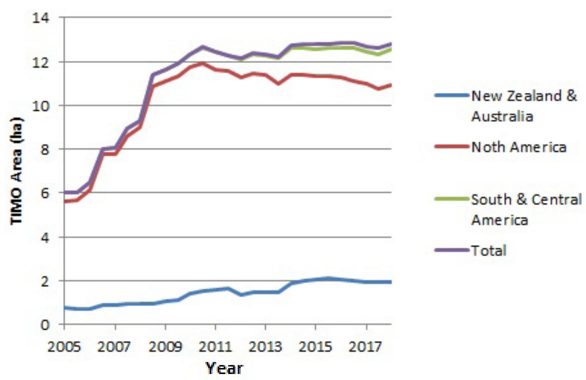

FIGURE 13:TIMO forest area under management. Source: TimberLink LLC.

by New Forests (2017), "A significant proportion of the high-quality timberland estates in US, Australia and New Zealand is already in institutional ownership....". It is also stated that "With rising allocations to real asset investments and a finite pool of such investments, institutional investors will increasingly seek to hold high-quality assets in their portfolio."

Purchasers in New Zealand have not only been pension funds or TIMOs. Wood processors and log traders have also purchased forests to guarantee their supply chain. As a consequence, there has been an increasing demand for a limited area of investment-grade plantations. In recent years, medium as well as large forests have had multiple parties seeking to buy them. The demand for medium to large plantations in New Zealand has led to higher prices being paid for them with a consequent reduction in IDR.

Conclusions

The three steps in the analysis all produce results with a similar pattern. Initial analysis using IDR data from 1997 to 2017 reveals that the reduction in discount rates over time is significant and that the discount rate for large forests (>10,000 ha) has reduced more than for smaller forests. Analysis of data from 2009, for which forest area rather than area class is available, shows that forest area has a significant effect on IDRs. Finally, detailed transaction data collected since 2011 are used to develop a model to predict crop value from the average stand in each forest. Discount rates estimated by this model are found to vary with time and forest size; i.e. the discount rate decreases as time or forest size increases.

Overall, it can be concluded that the discount rates implicit in New Zealand forest transactions have reduced, with the scale of the reduction depending on forest size.

Ethics approval
Not applicable.

Consent for publication
Not applicable.

Availability of data
Please contact the author for further information.

Competing interests
The author declares that he has no competing interests.

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Endnotes
[i] Crop value is the value of the tree crop and excludes the value of the land.

[ii] In the surveys valuers were asked for implied discount rates for both pre-tax and post-tax cashflows. Only the former was considered in this analysis.