Depreciation Rates for Australian Tractors and Headers - Is Machinery Depreciation a Fixed or Variable Cost?

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Seven different remaining value functions for tractors and harvesters were estimated using data from advertised prices for used farm equipment. The generalised Box-Cox model was used to nest six of the seven functions. The more complex Box-Cox function explained the data better, but simpler models such as the sum-of-the-years-digits, or double-square root models were no different and were easier to manipulate to estimate depreciation rates and costs. There were up to three components of depreciation, drive-away, age and use related, depending on functional form. Drive-away depreciation is the immediate loss in value of a machine due to purchase, in some models this depreciation was higher than either age or use related depreciation. When drive-away depreciation was treated as a separate cost or when there was no drive-away depreciation, due to functional form, age and use depreciation costs were approximately equal.

Introduction

Depreciation is the cost associated with capital equipment ownership to account for use, obsolescence, and, supposedly, as a means to save for the replacement of capital items. Typically, it is assumed that depreciation is a fixed cost. The rationale for this assumption is that the major component of depreciation is based on the age of the capital item and that use does not significantly affect the value of the item (Heady and Jensen 1954; James and Eberle 2000). However, it would be reasonable to assume that there are at least two factors that cause depreciation, age and use (Perry et al. 1990). The value of a machine can decline simply by sitting unused because of obsolescence of the technology embedded in the machine. Use causes depreciation, even in new machinery because of wear and tear on the components within the machine which could shorten the usable life of the machine. Therefore, it would be rational to decompose the depreciation cost into two cost elements, fixed, which would be age-related, and variable, which is use-related, when developing enterprise and whole farm budgets. With the variable component assigned pro-rata to the enterprises utilizing the machine and the fixed factor deducted from the operating profit. Many extension publications assume that the depreciation cost is a linear function of the initial purchase price, salvage value and expected life of the piece of machinery item (Anon 2004; Harris 2002). However, this method requires assumptions being made concerning the expected life of the equipment and the salvage value (Makeham and Malcolm 1993).

The remaining value (RV) function is an equation that allows researchers and extension workers to estimate the residual value of a piece of capital equipment using knowledge of initial cost, age, usage and other variables that may impact on value. These variables can include size, condition, power, manufacturer, and location of sale of machinery. One benefit of the RV function is that it is not necessary to make assumptions regarding the salvage value of the equipment (Dumler et al., 2000; Perry et al. 1990; Wu and Perry 2004). Therefore, machinery RV which is calculated as the

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current value as a percentage of the initial real cost, can be represented in general form as:

RV = *f* (age, usage, manufacturer, power, drive, size, condition, other factors) (1)

The range of functions used to calculate RV is varied. The American Society of Agricultural Engineers (ASAE) (in Siemens and Bowers 1999) suggests that the remaining value of farm machinery can be estimated using an exponential function as follows:

$$RV = \alpha(\beta)^{Age} \quad (2)$$

Where, in the ASAE standards, $\alpha = 0.68$ and $\beta = 0.94$ for tractors and headers (Siemens and Bowers 1999). This equation has been shown to be a poor estimator of remaining value due to the inflexibility inherent in the function caused by the fixed parameters (Wu and Perry 2004). Kruger and Logan (1980) concluded that the parameters of the ASAE model for American machinery were not applicable to Australian tractors.

Weersink and Stauber (1988) used a log-linear functional form to estimate the remaining value function for grain combines in Canada. This function fitted the data well, but there was no inclusion of other variables such as usage to determine if these other variables affected the remaining value. Other researchers have used linear, Cobb-Douglas, or exponential functions to estimate remaining value (Wu and Perry 2004). Each of the forms mentioned imposes restrictions on the ability of the data to explain depreciation rates over time. Hence, Perry et al. (1990) suggested the use of the Box-Cox flexible functional form as a means of allowing the data to more accurately capture the effects of different variables on depreciation rates and patterns. The general Box-Cox function is written as:

$$\frac{RV^{\lambda} - 1}{\lambda} = \beta_0 + \sum_i \beta_i \left(\frac{x_i^{\gamma_i} - 1}{\gamma_i}\right) + \sum_j \beta_j Z_j \quad (3)$$

Where RV is the remaining value, x_i and Z_j are two subsets of independent variables, one transformed and the other not. The transformation variables λ and γ_i are for the dependent and independent variables, respectively. Solving equation 3 for RV yields:

$$RV = \left[\lambda\left(\beta_0 + \sum_i \beta_i \left(\frac{x_i^{\gamma_i} - 1}{\gamma_i}\right) + \sum_j \beta_j Z_j\right) + 1\right]^{1/\lambda} \quad (4)$$

The value of the transformation variables can determine the type of depreciation function; when $\lambda = 1$ and $\gamma_i = 1$ depreciation is linear; when $\lambda = 0.5$ and $\gamma_i = 1$ the function replicates the sum-of-the-year's digits (SYD) form; $\lambda = 0$ and $\gamma_i = 0$ indicates that depreciation takes the Cobb-Douglas form; when $\lambda = 1$ and $\gamma_i = 0.5$ the square root function is assumed, and for $\lambda = 0.5$ and $\gamma_i = 0.5$ the function is a double square root. When λ and γ_i are estimated they have the following general properties, if $\lambda < 0$ and $\gamma_i \leq 1$ then depreciation rates are declining over time, if the opposite holds then depreciation rates are increasing over time (Wu and Perry 2004). In the case when $\lambda = 0$ or $\gamma_i = 0$ the function is estimated using the natural logarithm of RV or x_i.

The RV function provides an estimation of the value of a capital item but can also be utilized to estimate the depreciation rate and annual costs. Depreciation rate (RATE) in the general Box-Cox model is equal to (Wu and Perry 2004):

$$RATE = RV'(x_i) / RV \quad (5)$$

where, if we assume that the depreciation rate relates to one of the transformed variables;

$$RV'(x_i) = \left[\lambda \left(\beta_0 + \sum_i \beta_i \left(\frac{x_i^{\gamma_i} - 1}{\gamma_i} \right) + \sum_j \beta_j Z_j \right) + 1 \right]^{\frac{1-\lambda}{\lambda}} * \beta_i x_i^{\gamma_i - 1} \tag{6}$$

and;

$$RATE = \beta_i x_i^{\gamma_i - 1} * \left[\lambda \left(\beta_0 + \sum_i \beta_i \left(\frac{x_i^{\gamma_i} - 1}{\gamma_i} \right) + \sum_j \beta_j Z_j \right) + 1 \right]^{-1} \tag{7}$$

By using this equation it is possible to calculate annual depreciation costs for any transformed variable of interest. It is also possible to calculate the depreciation rate for non-transformed variables through manipulation of equation 4. This yields an equation similar except the numerator is β_j rather than $\beta_i x_i^{\gamma_i - 1}$.

The studies mentioned above have all utilized data from North America; no machinery depreciation studies have been undertaken using Australian data, except for the study of Kruger and Logan (1980) which was based on a set of 33 observations and only the exponential functional forms was tested. Also, none of the studies listed have explicitly answered the question: How do factors other than age affect the annual machinery depreciation costs for agricultural producers? These studies have provided parameter estimates, but have not shown how these models and parameters affect the fixed and variable costs of depreciation to the producer. The objective of this paper is to estimate remaining value functions for tractors and combine harvesters using data from Australia, to test a set of functional forms to determine which, if any, are better suited to the estimation of the fixed and or variable costs components for extension and research purposes, and to determine if depreciation is a fixed or variable cost or a combination of both.

Data

The data for the models estimated in this study are based on machinery dealer advertised prices for tractors and headers, less GST if GST was included in the advertised price, as GST is not included in the manufacturer's new list price. The data were obtained from search of internet sites of agricultural machinery dealers across Australia over the months of September to October 2004 and are summarised in Table 1. In previous studies actual sales price was used; however in this study actual sales prices were not available. The advertised prices include dealer mark-ups to cover warranty costs and repair expenses that could be or were incurred to get the machine to sale quality. Tests on the data show that reducing the advertised price by various percentages to capture mark-ups changed the remaining value by approximately the same percentage, indicating that the functions were changing the intercept value but not the slopes. Hence, the depreciation rates and costs are not affected by dealer mark-ups only the remaining value of the machine, this is consistent with the comments of Unterschultz and Mumey (1996)

Each observation for the harvester data set contained information on manufacturer, year of manufacture, total hours of use, front width, and price. Tractor data contained information on manufacturer, year of manufacture, total hours of use, engine power, type of drive (four-wheel, front wheel assist, or two wheel), and price. Tractors with attached equipment, such as front end loaders or fork lifts were

excluded from the data set. Data on other variables such as condition were not included as the data either included photographs from which it was difficult to discern condition or the dealer did not list the condition. Because of the need for a complete observation to contain the minimum information listed above, the number of potential data points was limited, as many advertisers did not include at least one piece of critical information, hence the small size of the data set.

Total hours of use was converted to average hours of use per year to reduce the possibility of multicollinearity affecting the estimates due to relatively high correlation between the age and total hours variables. The correlation coefficient for the age and total hours variables was 0.7784 and 0.5448 for the harvester and tractor data, respectively. Correlation coefficients for age and hours per year were -0.1524 (harvesters) and -0.3650 (tractors) indicating low to moderate correlation between the two variables.

The harvester data covered harvesters manufactured from 1990 through to 2003. Data was available for a small number of machines manufactured prior to this period, however because of the sparse nature of this data it was deemed unsuitable for the study. Tractor data covered the period 1989 through 2003. Again data were available for a small number of machines manufactured prior to 1989 but were not utilized for the same reason as for harvesters.

The harvester data set of 115 observations was dominated by two manufacturers, John Deere and Case. These two manufacturers accounted for 76 per cent of the harvester observations. Machines from three other manufacturers, New Holland, Allis-AGCO, and Massey Ferguson, completed the data set. List prices for the harvesters included in the data were obtained from the Power Farming harvest annual (Power Farming various dates). The tractor data set of 68 observations was again dominated by the same two manufacturers as before, in this particular set representing 71 per cent of observations. The remaining data represented six other manufacturers, Ford, New Holland, AGCO, JCB, Fiat, and Caterpillar. For both tractor and harvester sets some of these manufacturers have, over the period covered, merged; hence some brands may not now exist or are manufactured by one company rather than two or more, i.e. Ford, Case and New Holland. Each manufacturer was assigned a dummy variable from one to three, one and two representing the two largest manufacturers, respectively and group three capturing all other minor manufacturers.

List prices for tractors were obtained from the fourth edition of Power Farming every year from 1989 until 2004 to maintain consistency of recording time. Unterschultz and Mumey (1996) suggest that the manufacturer's list price not be used in an analysis of depreciation as the list price may be higher than actual market price for new machines due to marketing methods used by manufacturers. However, to accurately estimate depreciation a new price is needed and as list prices are available and easily accessible these are used in this study, and others such as Perry et al. (1990) and Cross and Perry (1995). The list prices were converted to real 2004 prices by weighting the list prices by the index of plant and machinery costs reported in ABARE (2003; 2004). The price index was adjusted such that 2004 was the base year, so that real list and current sales prices were in the same real values. Wu and Perry (2004) also included indices of farm income and interest rates in a multiyear

study of machinery depreciation, however as this current study covers one-year's data these variables are not necessary.

Results

Models

The general Box-Cox model was used as a basis for the harvester and tractor models estimated, the difference being that brand is excluded from the harvester model due to heteroscedasticity. The basic form of the Box-Cox model for this study was:

$$RV = \left[\lambda \left(\beta_0 + \beta_1 (\frac{AGE^{\gamma_A} - 1}{\gamma_A}) + \beta_2 (\frac{HPY^{\gamma_H} - 1}{\gamma_H}) + \beta_3 BRAND \right) + 1 \right]^{1/\lambda} \quad (8)$$

The models that can be derived from the Box-Cox functional form that were used in this study are: linear; Cobb-Douglas (C-D); sum-of-the-year's digits (SYD); square root (SQR); double square root (DSQR); and the Box-Cox transformation (BCT). The exponential function model as used by the ASAE was also modelled, however, in this study α and β were estimated using the same data as the Box-Cox models, rather than utilize the parameters as specified earlier. The ASAE model was included in the study to compare its performance against the other functional forms. All models were estimated using the PROC MODEL procedure in SAS (SAS 1999). Model comparison is based on goodness-of-fit statistics including adjusted R^2 and log of the likelihood function.

Preliminary Models

Several preliminary models were tested using different sets of variables to determine which initial combination of variables best explained RV. The basic model for the harvester data included age and average hours of usage per year. When the brand variable was included in the harvester model, all models demonstrated high levels of heteroscedasticity based on White's χ^2 test which was statistically significant at 95% or greater (Greene 1993); hence for the harvester models the brand variable was excluded. Even though models with heteroscedasticity fitted better they were not used nor were models that were corrected for heteroscedasticity, as the objective was to have models that were simple to work with. Correcting for heteroscedasticity yields models, such as generalised least squares or weighted least squares (Judge et al. 1988) that are more complex to work with in estimating depreciation in the context of this study, due to the need to determine the effect of the correction method on the parameter estimates.

The tractor model differed slightly, in that brand was included and in this case did not lead to the problem of heteroscedasticity. Wu and Perry (2004) estimated models for tractors of 5 different horsepower levels, given the small data set used in this study this was not possible. Also, preliminary testing on the models estimated showed that horsepower was not a variable that significantly affected the remaining value of tractors.

Other models were tested; these included regressing RV on age, total hours, or hours per year individually, all these models yielded unsuitable results based on tests for heteroscedasticity or goodness-of-fit. Some of these results were expected, particularly with respect to the model of RV on age which is the typical model used in estimating depreciation. This model did not fit either set of data as well as the models

that included hours per year and brand as well as age. A model of RV and total hours was also an inferior fit to the models including age and hours per year, these models also exhibited high levels of heteroscedasticity using White's test ($P < 0.0001$).

Models of RV Function

The results derived from the general Box-Cox model for the harvester models, as shown in Table 2, suggest that the SYD, SQR, DSQR, and BCT functions explain the depreciation data better than do the simpler forms, such as the linear or the Cobb-Douglas, based on the log likelihood functions. There were no differences between the SYD, SQR, DSQR and BCT models in terms of likelihood ratio tests, which is in contrast to the results of Wu and Perry (2004) who found that the Box-Cox models were statistically different from all other functional forms in estimating depreciation of harvesters.

The set of functions that fitted the tractor data best were the BCT, DSQR and SQR models, with no statistical difference between these three functions, which again is counter to the results of Wu and Perry (2004). The linear, Cobb-Douglas and SYD models were comparable to each other in terms of likelihood ratio tests, but were poorer fits than the BCT, DSQR and SQR functions.

The ASAE model fitted the harvester data relatively well with goodness-of-fit statistics, measured by the adjusted R^2 and log-likelihood function, within comparable ranges of the other models. In the case of the tractor models the ASAE model fitted the data worst with the lowest adjusted R^2 and the lowest log-likelihood, indicating a poor fit. As the ASAE model can be nested in the general Box-Cox the model can also be compared to the others using the likelihood ratio test as the model. Likelihood ratio tests show that the ASAE model is significantly different to the SYD, SQR, DSQR, and BCT functions as well as the Cobb Douglas function for the harvester data, and different to all functions in the tractor models. The Cobb-Douglas function had the poorest fit of all the harvester models, based on adjusted R^2 and log likelihood, and was significantly different from all models including the linear model.

Although the BCT function fitted well in both sets of models, based on the likelihood ratio statistic and the adjusted R^2, the fit of individual parameters in the BCT models was relatively poor. In the harvester model only two parameters were statistically greater than zero based on the approximate *t*-values calculated by SAS, one at 95 per cent (β_2) and one at 90 per cent (λ). For the tractor model, three parameters, β_2, β_3, and λ, were statistically different from zero at 95 per cent for the first two and 90 per cent for λ.

Another problem that arose in the SQR, DSQR and BCT functions for both machine types was that the intercept for each of these functional forms was greater than one, implying that for the machine type studied it would be worth more used than it is new. Intercepts greater than one imply that the machinery appreciates after sale and this can lead to an underestimation of annual depreciation costs. The intercept terms for the linear, ASAE and SYD function are all less than one, which would be expected, as new machinery loses value as soon as it is sold (Perry et al. 1990), and implies that there is a fixed component of depreciation that is not affected by any variable except the sale of the piece of machinery.

The brand coefficient in the tractor models was positive and significant. This indicates that brand somewhat ameliorates the negative impacts of age and usage on the remaining value. The impact of brand on the RV can be quite large given the magnitude of the coefficient.

Depreciation rates

Utilizing equation seven to estimate the depreciation rate for each functional form's transformed variables yielded a range of depreciation rates. The annual average age related depreciation rate for harvesters varied from 4.59 per cent to 12.46 per cent, and average usage depreciation rate ranged from 0.03 per cent to 0.10 per cent. Depreciation rates for tractors followed similar ranges with age depreciation from 4.03 per cent to 12.23 per cent and usage from 0.02 per cent to 0.09 per cent. The average depreciation rates across machines types and functional forms were consistent, meaning that similar rates are estimated for the different machine types using the same functional form.

In this study only average annual depreciation rates are reported, due to space limitations. However, it must be remembered that the most depreciation rates are not constant across age or usage rates. Wu and Perry (2004) showed that the linear and the SYD forms have increasing depreciation rates over time. This is not intuitively obvious, particularly for the linear function as the linear function has constant depreciation cost. The reason for the increasing depreciation rate is that the constant, β_i is divided by a declining remaining value, therefore the depreciation rate increases over time. This effect can be observed more clearly in equation 6, the numerator is constant at β_i as $x^{\gamma-1} = 1$, and the denominator is declining as age or usage increases. For all other functional forms reported in this study the age depreciation rates are declining over time as expected. Usage depreciation rates followed similar patterns to the age functions.

Depreciation costs

Estimating annual depreciation costs using the remaining value functions derived is possible using several easily accessible pieces of information; the new price of the piece of machinery, expected usage and age. In this study we will use a simple case study to demonstrate the calculations and effects of different functional forms on annual depreciation costs. The case study will use a new harvester with a price of $322 000. It is assumed the harvester will be used for four years then traded for a newer model and usage of 400 hours per year. Using textbook straight-line depreciation method over four years with a trade-in value of 50 per cent of new value or $161 000, the estimated the annual depreciation cost is calculated to be $40 250 per year. In this paper only a header example is shown, however, it is possible to follow similar logic for calculating tractor depreciation using the parameters estimated.

Beginning with the linear model; the estimated remaining value of the harvester is $177 766, implying that the total depreciation over four years is $144 234. This depreciation cost is made up of three components; the fixed component due to sale (what will be termed here the drive-away depreciation), the age factor, and usage element. Given that the intercept term for the linear model is 0.8179, the drive-away depreciation is $58 633; this is incurred in the first year of ownership in addition to the age related and use caused depreciation costs. The age depreciation cost is $46 961, and usage depreciation costs are $38 640. Adding the three components together

yields an annual average depreciation cost of $36 058, which is less than the $40 250 estimated by the straight-line method. In this case the total fixed costs are $105 594 and the variable costs are $38 640, or $26 398 fixed and $9 660 variable costs per annum over the four years or a ratio, fixed to variable, of 2.73:1. Alternatively, the drive-away depreciation costs could be incurred in the first year, leaving the annual fixed cost at $11 740 and annual variable costs of $9 660. In the second case the ratio is now reduced to 1.22:1.

The total depreciation costs over four years for the SYD and DSQR models are $143 972 and $148 043, respectively. Of the $143 972 depreciation in the SYD model, $42 819 is drive-away depreciation incurred in year one, $53 870 is total age-related depreciation, and $47 276 is total use-caused depreciation, yielding $96 696 in fixed depreciation costs and $47 276 in variable costs, and an annual depreciation charge of $35 993, implying annual average costs of $24 174 fixed and $11 819 variable. The fixed to variable cost ratio is approximately 2:1. Again, this could be recalculated to incur the drive-away depreciation in year one, which gives average annual fixed depreciation of $13 467 and variable depreciation of $11 819, a fixed to variable ratio of 1.13:1.

For the DSQR model, given that the intercept is greater than one, any remaining value functions that yielded intercepts greater than the initial purchase were truncated to the purchase price otherwise they were left as calculated. As the DSQR model does not have an intercept less than one there is no drive-away depreciation and only age and use depreciation costs are calculated. These costs are $73 367 and $74 676, respectively. This is a split of near equal proportion of fixed and variable costs and the proportions of fixed and variable costs remain relatively constant across all years. However, because of the nature of the DSQR function a large depreciation cost is incurred in the first year then depreciation costs decline over time. In this case the initial year depreciation cost, assuming a four year life, is 54 per cent of the total depreciation cost; the proportions of the depreciation cost in years two, three and four, are 19 per cent, 15 per cent, and 12 per cent, respectively. These proportions yield annual depreciation costs of $79 943, $28 128, $22 206, and $17 765 in years one, two, three and four, respectively, and an average annual cost of $37 010, with $18 342 age-related and $18 669 use-caused.

Discussion

Given the poor fit of individual parameters in the BCT model and that there is no significant difference between the BCT model and more simpler models such as the DSQR or the SQR, it is suggested that depreciation be calculated using one of these simpler models. Because of the complexity of the BCT function, Wu and Perry (2004) suggested and estimated a series of reduced form double-square-root models. However, in the current study either the DSQR or SQR models would be appropriate models to use as both are comparable to the BCT model in terms of adjusted R^2 and likelihood ratio tests.

One problem that does manifest itself when attempting to calculate annual depreciation rates using the remaining value method and the models estimated, other than the linear function, is separating age and use related depreciation because of the functional forms and the interdependence of the two parameters. Although the more complex forms fit the data better, the simpler functions, i.e. linear or SYD, are more

tractable to handle when estimating annual depreciation costs. As shown above the annual depreciation for the DSQR model is high in the first year, and then diminishes over time, whereas for the linear model the annual depreciation cost is constant over time, even though the depreciation rate is increasing.

Although, a high cost is also generated if the drive-away depreciation cost of the linear and SYD models is treated as a separate component. When drive-away depreciation is included as a separate component in the depreciation costs or in the case of the DSQR model, a high first year cost, the depreciation costs demonstrate a type of accelerated depreciation. The SYD model is already a type of accelerated depreciation function as depreciation costs are high in earlier years of ownership and decline over time. Neither the traditional straight-line method nor the DSQR are considered accelerated methods, but, in the case of the straight-line model with drive-away depreciation separate, and the high depreciation costs in year one of the DSQR model, it would be reasonable to allow that accelerated depreciation does occur in these models.

One objective of this research was to determine if depreciation was a fixed or variable cost or a combination. The research results suggest that depreciation is a combination of both. The ratio of fixed to variable deprecation varies from 2.73:1 to approximately 1:1. The major influence on this ratio was the drive-away depreciation cost. In the straight-line and SYD models drive-away depreciation accounted for 40.6% and 29.7% of the total loss in value in the harvester case. In the tractor example, drive-away depreciation accounted for 36.2% of the loss in value of the machine. Assuming drive-away depreciation is incurred in the first year of ownership and separated from the age and use depreciation components, then the ratio of fixed to variable costs approaches 1:1, depending on the model.

The drive-away component of depreciation raises some questions concerning the implications of depreciation on farm management and investment decisions. If drive-away depreciation is incurred as a separate component within the calculation of net farm income in the year it is incurred the impact of NFI and other financial indicators would be significant. In the example used in this study, the drive-away component of the straight-line model is $58 633, which is $21 575 higher than the average total annual depreciation cost, when this component is incurred as an age-related cost, and would reduce NFI by this amount. This reduction in NFI could then affect the timing of investments in capital equipment as a producer would need to time capital purchases to coincide with years of higher NFI to reduce the impact of the higher depreciation charge on profit measures of the farm business.

Conclusions

The objectives in this paper were to estimate depreciation functions for Australian farm machinery; to determine if any of the functional forms were fitted the data better than the others utilized; and to determine whether machinery depreciation was a fixed or variable cost or a combination of both. In the current study, although the Box-Cox transform model fitted better in the harvester data and was second best fit for the tractor data, based on adjusted R^2 and log-likelihood statistics, the overall fit of these models was no better than other simpler forms, this is in contrast to the results of Wu and Perry (2004). Also, the fit of individual parameters in both Box-Cox models was poor with relatively few significant parameters. However, the results of

the current study are consistent with the suggestion of Wu and Perry (2004) that the DSQR or SYD models are the reasonable alternatives for the Box-Cox model, with one or both being not significantly different from the Box-Cox model in both data sets.

There is one problem that arises from using the more complex models, such as the DSQR or even the sum, and that is the calculation of annual depreciation costs due to usage and age, due to the interaction of these two factors on the remaining value of the harvester or tractor. When calculating annual use and age depreciation costs the simpler models are easier to manipulate to determine these costs.

In this study a relatively small data set was used to estimate the remaining value functions, and the data covered one year's supply of used tractors and harvesters. The size of the data set may have contributed to the heteroscedasticity present in the harvester models when brand was included in the models. A larger data set may have alleviated this problem as there would be more observations for each brand of harvester included in the models. The size of the tractor data set also reduced the ability to estimate models of tractors of different engine capacity or drive types.

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Table 1: Summary of data for harvester and tractor models.

Harvesters (n = 115)	Mean	Std Dev	Minimum	Maximum
Age (years)	6.25	2.76	1	14
Total Hours	1873.03	942.29	250	5 232
Average hours per year	305.81	93.49	131.63	795.80
Current value	$175 826	$53 604	$70 000	$331 818
Front width[a]	32	3	25	36
Real new list price	$335 817	$39 124	$253 009	$456 769
Remaining value	0.5181	0.1245	0.1987	0.7895
Tractors (n = 68)				
Age (years)	7.26	3.50	1	15
Total Hours	4218.72	2633.82	600	13422
Average hours per year	633.99	306.90	133	1500
Current value	$88 668	$41 932	$24 000	$250 000
Horsepower	220.81	97.58	60	425
Real new list price	$171 409	$63 617	$51 049	$326 591
Remaining value	0.5173	0.1381	0.2463	0.8935

[a] Width is measured in feet as this is how they are marketed due to importation from North America.

Table 2: Parameter estimates, goodness of fit statistics and depreciation rates for harvesters.

	Parameters			**Goodness of Fit**		**Average Annual Depreciation Rate**	
Model	β_0	β_1	β_2	Adj R^2	Log-likelihood	Age (%)	Usage (%)
Linear	0.8179**[a]	-0.0365**	-0.0002**	0.6327	134.0205	7.40	0.05
ASAE	0.7947**	0.9310**		0.6334	134.1272	11.56	
Cobb Douglas	0.8547**	-0.2934**	-0.1383**	0.5959	128.5276	12.46	0.10
Sum of the Years Digits	-0.1377**	-0.0525**	-0.0003**	0.6504	136.8640	4.59	0.03
Square Root	0.9207**	-0.0871**	-0.0047**	0.6627	138.9155	7.72	0.06
Double Square Root	0.0188**	0.1183**	0.0064**	0.6617	138.7541	7.38	0.05
Box Cox Transform	44.6099	-0.0830	-48.2158**	0.6674	139.7222	7.62	0.07
	λ	γ_A	γ_H				
	0.6252*	0.6730	-1.0722				

a ** Indicates significant at $P \leq 0.05$, * indicates significant at $P \leq 0.10$.

Table 3: Parameter estimates, goodness of fit statistics and depreciation rates for tractors.

	Parameters				Goodness of Fit		Average Annual Depreciation Rate	
Models	β_0	β_1	β_2	β_3	Adj R^2	Log-likelihood	Age (%)	Usage (%)
Linear	0.8349**[a]	-0.0335**	-0.0002**	0.0297**	0.6957	78.5685	6.26	0.03
ASAE	0.7779**	0.9427**			0.5386	64.4122	9.58	
Cobb Douglas	2.7613**	-0.3375**	-0.2145**	0.0151**	0.7054	79.6689	12.23	0.09
Sum of the Years Digits	-0.0944**	-0.0505**	-0.0003**	0.0432**	0.7235	81.8179	4.03	0.02
Square Root	0.9864**	-0.0898**	-0.0048**	0.0355**	0.7562	86.0986	7.38	0.04
Double Square Root	0.0971	-0.1265**	-0.0070**	0.0507**	0.7689	87.9159	8.29	0.05
Box Cox Transform	0.4037	-0.1452**	-0.0454	0.0595**	0.7600	86.6424	7.40	0.05
	λ	γ_A	γ_H					
	0.3261	0.4802*	0.2219					

[a] ** Indicates significant at $P \leq 0.05$, * indicates significant at $P \leq 0.10$.