Precision Farming and Land Leasing Practices

By Marvin T. Batte

Abstract

Precision farming practices may influence precision farmers' preferences for alternative forms of land lease and the contract terms negotiated between landlord and tenant. This article discusses attributes of cash and share leases, the two primary lease types employed in Ohio, and suggests implications of precision farming for the choice of lease type. Evidence from the 1999 Ohio Precision Farming Survey may shed light on how precision farmers are controlling land through lease.

Precision farming (PF) is an emerging technology that allows farmers to better allocate inputs to specific cropland areas based on soil type, fertility levels, and other endowments of that site. Precision farming incorporates four technologies: remote sensing, geographic information systems (GIS), global positioning systems (GPS), and process control. Together these technologies allow the ability to repeatedly locate a position within a field, to make measurements regarding the particular attributes of that specific location, and to use these data to make input allocation decisions that are specific to that site. The consequence of reducing the scale of land area that is managed uniquely from a farm or field to a much smaller management zone or grid is to substantially reduce the number of cropped acres for which inputs are either over- or under-applied. This has significant implications for the magnitude of farm receipts, variable input costs, fixed investment costs, and profitability. Environmental benefits of VRT are thought to increase with increased fertility variability due to the relative increases in fertilizer use efficiency, as compared to the traditional single rate application method (Sunil, Weersink, Kachanoski, and Fox). Also, it is possible to directly incorporate environmental constraints or goals into the decision rules for variable input application, and thus impact environmental quality.

Precision farming practices may influence precision farmers' preferences for alternative forms of land lease and the contract terms negotiated between landlord and tenant. In the following article, attributes of cash and share leases will be discussed and implications of precision farming on the choice of lease type will be suggested. Evidence from the 1999 Ohio Precision Farming Survey will be presented that may shed light on the methods precision farmers use to lease land.

Marvin T. Batte holds the Fred N. VanBuren Professorship of Farm Management, Department of Agricultural, Environmental and Development Economics, at The Ohio State University. He received the B.S. degree from Eastern Kentucky University, M.S. from the University of Kentucky, and Ph.D. from the University of Illinois. His research and teaching address farm management, finance, and technology adoption.

Cash Leasing of Cropland

The cash lease is the simplest form of land lease, involving a cash payment for the use of farmland for a specific period of time. Beyond simplicity, the advantages of cash leasing are greater managerial freedom for the operator, the opportunity for the tenant to fully benefit from high quality management, and reduced record-keeping requirements. The first two of these advantages may be particularly attractive to the precision farmer. Precision farming is management intensive. Crop management decisions are made at the level of small grids or management zones within the field. Potentially, a number of inputs may be applied variably across the field, implying a large number of decisions. A landlord who wishes to be heavily involved in fertility management and other decisions may be a significant hindrance to the precision farmer. In this sense, the precision farmer may value the managerial freedom of the cash lease. Also, to the extent that precision farming adds to business profitability, the cash lease tenant can fully capture the benefits of the technology as the sole claimant of profits.

Simplicity often translates into weaknesses or disadvantages as well. One disadvantage of cash leasing of farmland is higher risk exposure (yield, price, and financial) relative to a share lease contract. Clearly, the nature of the share lease (payment is made in-kind) means that the commodity price and yield risks are shared between the landlord and tenant. Because the precision farmer may have additional investments in precision farming services or machinery, greater amounts of capital are at risk, and with everything else equal, greater financial risk. A second disadvantage is the potential that cash rents may rise over time due to the tenant's management ability. Cash leases are typically a function of the productivity of the land; to the extent that precision farming results in increased yields over time, the landlord and other farmers may attribute this increase to the land rather than to the increased (precision) management of the land, resulting in an upward bidding of the cash lease rate for the parcel. Finally, because the landlord does not share in the returns for production, there is not a direct incentive to make capital improvements, including application of drainage improvements or lime applications, investments that precision farming may identify as important.

Share Leasing of Cropland

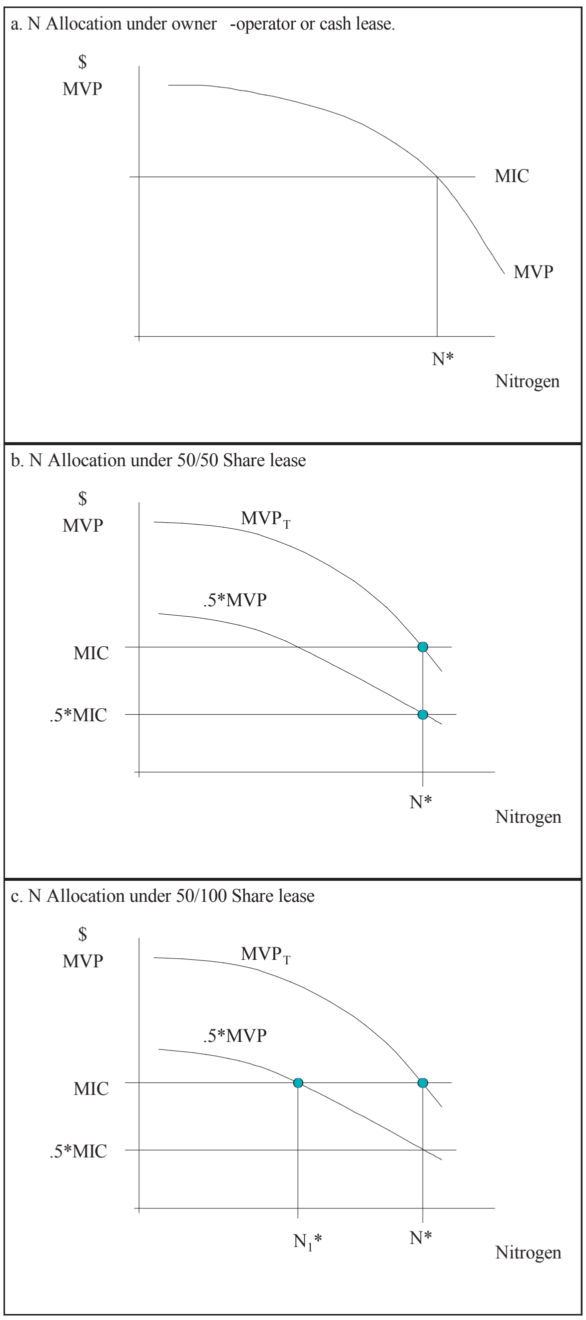
Share leases stipulate that the landlord will receive a specified share of the crops produced in exchange for the use of the land by the tenant. The landlord will typically also share the costs of inputs that vary directly with the level of production. There are a number of advantages and disadvantages of this lease method. Clearly, less operating capital is required with share leases because the landlord provides a share of the operating inputs. Similarly, because the lease is paid with a share of the crop, production and price risks are shared with the landlord. The landlord does have a vested interest in the outcome of production, and thus has an incentive to assist in the best management of the system. Because the precision farming system is information intensive, a knowledgeable landlord may be able to contribute significantly with information about soil types, drainage characteristics, or other information that might be useful in management zone definition or identification of input allocation improvements on individual field locations. However, there is a strong tension between this advantage and what is probably the greatest disadvantage of the share lease -- the loss of managerial freedom. As indicated earlier, precision farming implies a great number of decisions to be made, potentially with many decisions required for each identified management zone. A share lease landlord who is not informed of the science of site-specific management can become a substantial impediment to the precision farmer.

The design of the share lease can have an important consequence on the incentives for correct input allocation. The following are generally regarded as principles to guide the development of the share lease:

1. Variable expenses that increase yields should be shared in the same percentage as the crop is shared.
2. Share arrangements should be adjusted to reflect the effect of new technology.
3. Landlord/tenant should share returns in same proportion as they contribute resources.
4. Tenants should be compensated at lease end for undepreciated long-term inputs.

Figure 1 demonstrates the importance of the first principle. Panel A describes the allocation of a variable input (nitrogen fertilizer) in the production of a crop. The marginal value product (MVP) curve indicates the value of output produce by each additional unit of input. This curve is consistent with a production function that increases at a decreasing rate with more N. The optimal amount of N to apply in this case (N*) is that associated with the equality of MVP and the marginal input cost (MIC) for N. This suggests that the profit maximizing farmer will continue to apply N as long as the value created from the last unit applied at least equals the cost of the input. Note that this is the case of the owner operator, who faces 100 percent of the input costs and realizes 100 percent of the yield. It is also the case for the cash lease operator because this operator also pays 100 percent of costs and receives all outputs.

Figure 1: Profit maximizing level of nitrogen fertilizer under three lease scenarios.



Panel B of Figure 1 illustrates input allocation in the case where the landlord and tenant share yields and all variable costs in the same ratios (50 percent to each in this example). MVP_T represents the total (to both parties) marginal value produced by the nitrogen fertilizer, and .5*MVP represents the marginal value of output earned by the tenant. Similarly, the cost of the input (N) is shared between operator and landlord on a 50 percent each basis. Thus, the MIC for the tenant is one-half of the total MIC (.5*MIC). The profit-maximizing tenant will apply N to the point where .5*MVP = .5*MIC. Panel B illustrates that this is the same allocation of nitrogen, N*, that would be made by the owner-operator.

Panel C of Figure 1 illustrates the consequences when operator and landlord share costs and returns in different proportions. In the example, the tenant receives 50 percent of yield (thus the .5*MVP curve is appropriate), but must pay all costs of the variable input (MIC). Hence, the profit maximizing N input is determined by the point of equality of the .5*MVP and MIC curves. This implies N_1* units of nitrogen fertilizer will maximize the tenant's profits. Although this is the best input allocation under these lease terms, profits to landlord and tenant combined are greater in Panel B.

There are several implications for precision farmers. Clearly, output increasing variable inputs such as fertilizers should be shared between landlord and tenant. Also, the costs of variable application of the inputs, and any associated costs such as costs of grid soil sampling to support the variable application of inputs, should also be shared in the same manner as is yield.

The second principle is that share arrangement should periodically be adjusted to reflect the effects of new technology. If a new yield-increasing technology is adopted, equity between participants would suggest that the lease terms be altered so that operator and landlord share the costs associated with the technology. If the new technology is essentially one of input substitution, e.g., herbicides substituted for mechanical tillage, then the costs of the new technology should be borne by the party originally responsible for that input. Finally, if the new technology both increases yields and substitutes for other inputs, terms of the lease should be negotiated to have some but not full sharing of the costs of the new technology.

The third principle suggests that landlord and tenant should share costs and yields in the same proportion that they contribute resources. For example, the costs faced by the operator are relatively constant whether farming poor or high quality soils. However, the costs faced by the landlord increase with the value of the land, which generally is a strong function of land quality. Thus as land quality increases, the share earned by the landlord typically increases. Similarly, the precision farmer may be contributing more to the production process in the form of increased capital equipment (precision farming tools) and managerial inputs than non-precision farmers. Over time, precision farmers may seek to negotiate leases with greater shares to the tenant than are common in the area, thus reflecting the higher value contributed to production.

Finally, the fourth principle suggests that tenants should be compensated at lease end for undepreciated long-term inputs. In the case of precision farming, data costs for grid soil sampling and testing, variable rate lime application fees and material costs, and similar items represent durable investments. Precision farmers may wish to negotiate a lease that provides for a prorated reimbursement for such investments, should the landlord choose not to renew the lease.

Evidence from the 1999 Precision Farming Survey

The 1999 Ohio Precision Farming Survey was administered by mail to a representative sample of all Ohio farmers. In March 1999, 2,500 farmers were contacted. Responses were received from 1,351 producers, 782 of whom were actively farming and completed the survey. The characteristics of the sample respondents matched closely the age and size distributions of the 1997 Census of Agriculture.

Adoption rates for various precision farming components differed greatly (Figure 2). The four most frequently adopted precision farming practices were georeferenced grid soil sampling and the variable rate application of phosphorus and potassium fertilizers, and lime. The least frequently adopted practices included georeferenced field scouting for weeds, pests and disease, aerial field photography, and variable rate application of pesticides. Overall, about 24 percent of the surveyed farmers had adopted at least one of the thirteen listed precision farming practices.

Figure 2: Adoption of precision farming technologies by Ohio farmers.

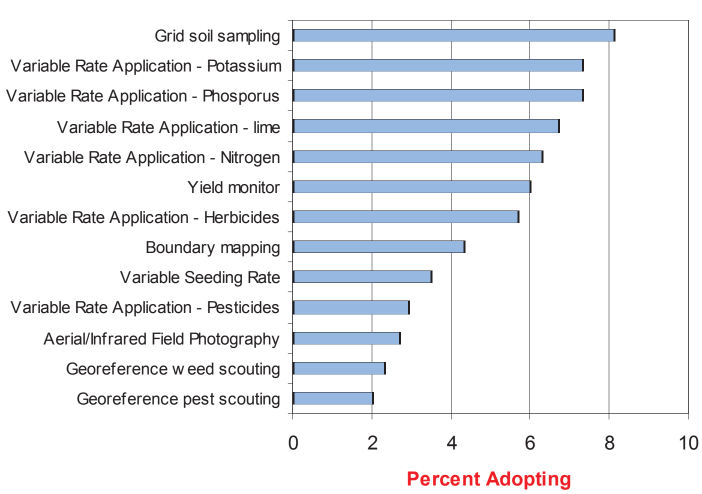


Table 1: Farmer and farm business characteristics for precision farming adopters and non-adopters.

	PF[a]	Non-PF[a]	
Number of observations	139	627	
Operator age	50.6	53	* *
Percent with post-high school education	38.4	38.1	
Percent of land that is leased	55.1	39.5	* * *
Farm size (acres)	810.4	462.4	* * *
Percent of farms with livestock	54.1	57.8	
Livestock sales as a percent of total gross sales	26	32.7	*
Business organization form			
Sole proprietorship (%)	70.8	80.1	
Partnership (%)	23.4	14.2	
Corporation (%)	5.1	4.3	
Other (%)	0.7	1.3	
Percent full time farmers	72.2	66	
Debt to asset ratio (%)	18.5	16.3	
Farm business gross income	$381,151	$187,025	
Net farm income	$70,603	$21,280	

* One, two, and three asterisks indicate a difference in the means that is significant at the 0.1, 0.05, and 0.01 probability levels, respectively.

a PF - Precision farming adopters. Non-PF - Precision farming non adopters.

There were important differences between the precision farming and non-precision farming groups (Table 1). Precision farmers were defined as those who had adopted at least one of the practices identified in Figure 2. Precision farmers were younger (50.6 vs. 53.0 years), they had a greater reliance on leased land, and they were less likely to have a livestock enterprise in the business; those precision farming operators with livestock also tended to receive a smaller percentage of total gross receipts from livestock. Farm size was substantially larger for the precision farming adopters, with an average farm size about 350 acres larger than for the non-adopters. There was no significant difference in the level of formal education between the two groups. These results conform to those of Khanna, Epouhe, and Hornbaker who found that adopters of precision farming tend to be younger, more educated, full time farmers, and operate larger sized farms.

Table 2 provides information about the relative usage of ownership, cash leasing, and share leasing by precision farming adopters and non-adopters. Precision farmers less frequently own their entire farmland base; only 13 percent of the precision farmers owned all land farmed versus nearly 30 percent for the non-precision farming group. For both groups, equal percentages controlled leased land with a single lease type; 41 percent of the operators in both groups employed only cash leasing of land, and about 10 percent only share leasing. However, the precision farming group was much more likely to be engaged in both cash and share leasing activities, with 36 percent of the precision farmers operating land using both methods. The lower panel of Table 2 indicates the average percentages of land controlled using each method for the two groups. Precision farmers used significantly larger percentages of leased land than non-adopters (55.1% versus 39.4% for non precision farmers). Even though both producer groups were more reliant on cash leasing, precision farmers made relatively greater use of share leasing than did non-adopters - 32 percent (17.7/55.1) of the leased acreage farmed by precision farmers was share leased, versus only 28 percent for the non-adopters.

Respondents who cash leased were asked to "identify a particular tract that is representative of all tracts you cash lease" and to answer various questions addressing the terms of the lease and the relationship between the landlord and tenant. Hence, the numbers reported in the following are not an average for all cash leased tracts for a farmer, but those for a specific contract. Precision farmers paid significantly higher cash rental rates than did non-adopters ($76.9 versus $65.6), and leased land from a greater number of landlords (Table 3). Precision farmers also indicated higher average yields for corn, soybeans and wheat than did non-adopting farmers. These relationships also held true when the analysis was restricted to cornbelt counties, and therefore these differences do not appear to be the result of location differences within the state. The higher yield results could be an indication that precision farming does raise

Table 2: Land control methods used by Ohio precision farmers and non-precision farmers.

	PF[a]	Non-PF[a]	
Percent of Farmers who:			
Operated only <u>owned</u> land	13	29.8	
Operated some cash leased land	41	41.2	
Operated some share leased land	10.1	10	
Operated both cash and share leased land	36	19	
Percent of land base that is:			
Owned	44.9	60.5	***
Cash leased	37.4	28.4	***
Share leased	17.7	11	***

** One, two, and three asterisks indicate a difference in the means that is significant at the 0.1, 0.05, and 0.01 probability levels, respectively.*
a PF – Precision farming adopters. Non-PF – Precision farming non adopters

Table 3: Cash lease rates, number of landlords, and crop yields for Ohio precision and non-precision farmers.

	PF[a]	Non-PF[a]	
Cash rent ($/tillable acre)	76.9	65.6	***
Number of landlords	4.7	3.8	*
Average leased acreage per landlord	109.4	95.1	
Crop yields (bu/ac)			
Corn	136.2	127.1	***
Soybeans	45.4	43.3	***
Wheat	60.6	55.9	***

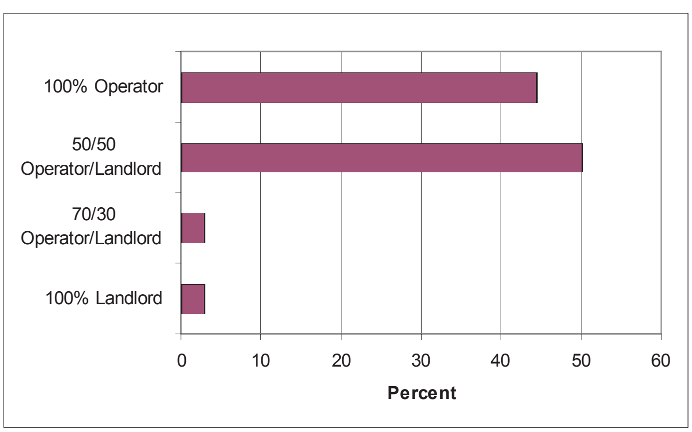
** One, two, and three asterisks indicate a difference in the means that is significant at the 0.1, 0.05, and 0.01 probability levels, respectively.*
a PF – Precision farming adopters. Non-PF – Precision farming non adopters

average yields, that precision farming adopters are typically better managers, that they tend to select more productive land for rental, or that they simply have better yield data due to yield monitors and are reporting more accurate (and higher) yield estimates.

Tables 4 and 5 provide information regarding differences in share leasing between precision farming adopters and non-adopters. Again, farmers were asked to provide information for a particular tract of share-leased land. The most substantial finding is that there are no statistically significant differences in the share of yield accruing to the operator for these two groups (Table 4). Crop shares are essentially equal for the groups, ranging from 52 to 56 percent of the yield to the operator. Also, there were no significant differences in the crop yields reported for the two groups, and no statistically significant difference in the number of landlords per operator for the precision farming and non-precision farming groups.

Likewise, there is no statistically significant evidence of a difference in the operator's share of variable input or application cost between adopter and non-adopter groups (table 5). For both groups, the variable inputs were generally shared at approximately the same percentage as yield was shared. However, the operator tended to pay a somewhat higher percentage of application costs - typically about three-quarters of the cost of application - with the exception of lime which was shared more similarly to yields.

Figure 3: Operator/landlord sharing of VRT application and grid soil sampling for share lease contracts.



Surveyed precision farmers who share-leased land were specifically asked how the operator and landlord shared costs of grid soil sampling and variable rate application of fertilizers and lime. Results are presented graphically in Figure 3. The most common arrangement (50% of responses) was that the operator and landlord shared these costs on a 50 percent each basis. However, the other large group (45%) indicated that the operator paid 100 percent of grid soil sampling and VRT application costs. The other five percent had the landlord paying either 70 or 100 percent of these costs. It is possible

Table 4: Share lease yield sharing, crop yields, and number of landlords, Ohio precision farmers and non-precision farmers

	PF[a]	Non-PF[a]	
Number of landlords	2.6	2.3	
Average leased acreage per landlord	138.7	108.5	*
Crop yield share to operator	Percent to operator		
Corn	54.9	55.7	
Soybeans	52.9	53.3	
Wheat	52.6	52.2	
Crop yields	Bu/acre		
Corn	134.9	131.6	
Soybeans	44.4	44.3	
Wheat	59.3	57.4	

** One, two, and three asterisks indicate a difference in the means that is significant at the 0.1, 0.05, and 0.01 probability levels, respectively.*
a PF – Precision farming adopters. Non-PF – Precision farming non adopters

Table 5: Farmer and operator sharing of input material and application costs under share leasing contracts, Ohio precision farmers and non-precision farmers.

	PF		Non-PF	
Crop Expense share (%)	material	application cost	material	application cost
	Percent paid by operator			
Seed	58.8	82.4	58.6	77.6
Nitrogen fertilizer	59.1	74.1	57.7	72.8
Phosphate and Potassium fertilizer	60.5	71.7	56.9	71.3
Lime	47.2	51	50.6	59.8
Burndown herbicides	60.4	74	59.2	73.4
pre-emergence herbicides	58.3	74	59.1	73.5
post-emergence herbicides	58.9	76.9	59.4	74
Insecticides	58.2	72.3	57.2	71.4
Combining costs charged landlord	Dollars per acre			
Corn	17.96		16.64	
Soybeans	17.72		17.07	
Wheat	16.58		16.03	

** One, two, and three asterisks indicate a difference in the means that is significant at the 0.1, 0.05, and 0.01 probability levels, respectively.*
a PF – Precision farming adopters. Non-PF – Precision farming non adopters

that these latter cases are associated with land lease among family members or other unusual circumstance.

Multiple Regression Analysis

In order to understand the impact of precision farming adoption on lease terms while controlling for differences in other parameters, a multivariate regression approach is used. The primary hypothesis to be tested is that cash and share lease payment rates are identical for precision farming adopters and non-adopters. A multivariate analysis is used to allow other contract parameters to be controlled and thus to avoid bias in the *ADOPT* coefficient.

Cash Lease Model

For the cash lease model, the cash payment per tillable acre was used as the dependent variable. Independent variables included various measures of contract terms and attributes of the tenant's farm. Specifically, the model was:

CashPayment = B0 + B1 Adopt + B2 FarmSize + B3 TractSize + B4 Relative + B5 Development + B6 Buildings + B7 VariableRent +B8 Cornbelt + ei

where:

- CashPayment is the dollar payment to the landlord per tillable acre leased,
- Adopt is one if the farmer is a precision farming adopter and zero otherwise,
- FarmSize is the number of acres the tenant farms,
- TractSize is the number of tillable acres in the leased parcel,
- Relative is 1 if the tract is owned by a relative and 0 otherwise,
- Development is 1 if the parcel is located in an area of high development pressure and is 0 otherwise,
- Buildings is 1 if buildings are included with the lease and is 0 otherwise,
- VariableRent is 1 if the lease contains a variable rent clause that allows cash lease rate to vary with crop yield or price and is 0 otherwise, and
- Cornbelt is 1 if the parcel is located in the corn belt region of Ohio and is 0 otherwise.

Table 6: Regression of cash lease contract parameters on cash lease payment per tillable acre.

Variable	Estimate	Pr > |t|
Intercept	47.90911	0.0001
Adopt	7.60974	0.0302
FarmSize	0.00678	0.0061
TractSize	0.02024	0.0315
Relative?	6.28127	0.0653
Development	-3.1522	0.3021
Buildings	4.06261	0.2061
VariableRent	-5.01358	0.4027
Cornbelt	24.24492	0.0001
N	390	
Model F Statistic	17.73	0.0001
R-Square	0.24	
Adjusted R-Square	0.22	

Regression results for the cash lease model are reported in Table 6. The model was significant at the 0.01 level of probability as indicated by the model F-value. The model explained 22 percent of the variation in cash lease payment per tillable acre as indicated by the adjusted R-Square statistic.

The primary hypothesis to be tested is that there is no difference in the cash lease payments per tillable acre for precision farming adopters and nonadopters. This hypothesis is rejected: the regression coefficient for *Adopt* is statistically different from zero at the 0.05 probability level. The estimated regression coefficient suggests that, with all other parameters constant, the precision farmers paid $7.61 per acre more than did non-adopters.

There are a number of other parameters that are expected to impact the cash lease payment rate. To avoid bias in the estimation of the PF *Adoption* parameter, these variables were also included as explanatory variables. *FarmSize* was statistically significant and indicated that the cash lease payment per acre increased with farm size. Although significant, the size of the impact was not large, indicating that the cash lease payment increased by $0.70 per acre for each hundred acre increase in the tenant's farm size. Size of the leased tract was also statistically significant and positive. The estimated regression coefficient suggests that cash lease payment increased by $0.02 per acre for every one-acre increase in the size of the tract ($2.00 per 100 acre increase in *TractSize*). Model results also suggested that if the landlord is a relative, cash lease payment is significantly impacted. The estimated regression coefficient indicates that cash lease payments increased by $6.28 per tillable acre in those cases where there was a familial relationship between landlord and tenant.

Ohio can be divided into two regions: a glaciated, highly productive region that is typical of Midwestern corn belt agriculture; and a non-glaciated region that is less suited to row crop production. To account for potential differences in these regions, the *Cornbelt* variable was included. The parameter estimate was statistically significant and positive, suggesting that cash lease payments were about $24.24 per acre higher in the corn belt region, with all other variables held constant. The presence of development pressure, the presence of buildings on the leased parcel, and the presence of a variable lease clause were not statistically significant determinants of lease payment.

Share Lease Model

A multivariate regression model also was formulated to evaluate share lease contract terms for precision farming adopters and nonadopters. The specific model was:

YieldShare% = B0 + B1 Adopt + B2 FarmSize + B3 TractSize + B4 Relative + B5 Development + B6 Buildings + B7 HarvestCharge + B8 HaulCharge + B9 Cornbelt + ei

where:

- YieldShare% is the percentage of crop yields earned by the operator,
- HarvestCharge is 1 if the tenant charges the landlord for harvesting the crop and is 0 otherwise,
- HaulCharge is 1 if the tenant charges the landlord for hauling the crop to market and is 0 otherwise, and
- Adopt, FarmSize, TractSize, Relative, Development, Buildings, and Cornbelt are as defined in the cash lease model.

Regression results for the cash lease model are reported in Table 7. The model was significant at the 0.01 level of probability as indicated by the model F-value. The model explained 23 percent of the variation in share lease percent to operator.

The primary hypothesis to be tested is that there is no difference in the lease shares of crop yield for precision farming adopters and non-adopters. This hypothesis cannot be rejected: the regression coefficient for *Adopt* is statistically different from zero only at the 0.26 probability level. Hence, the conclusion is that there is no difference in the percentage allocation of crop yield accruing to the operator for precision farming adopters and non-adopters.

Several other variables were found to be significant determinants of share lease terms. Farm size was highly significant. The regression coefficient was -0.004, suggesting that a hundred acre increase in tenant's farm size is associated with a 0.4 percentage point reduction in the share of crop yields going to the tenant. Hence, larger farmers are apparently competing for leased land by increasing the percentage that they are willing to "pay" to the landlord.

Also significant at the 0.05 probability level were *HaulCharge* and *HarvestCharge*. These regression coefficient estimates suggest that *if* the landlord pays the tenant for hauling the landlord's grain to market (or paying a fee for crop harvest), the amount of the tenant's share is reduced by 5.97% (8.57%).

Table 7: Regression of share lease contract parameters on sharing of crop yields.

Variable	Estimate	Pr > |t|
Intercept	67.71356	0.0001
Adopt	1.97547	0.2546
FarmSize	-0.00362	0.0175
TractSize	-0.00188	0.6979
Relative?	0.33367	0.8397
Development	-0.06312	0.9683
Buildings	-2.76409	0.076
HarvestingCharge	-8.57033	0.0001
HaulingCharge	-5.96867	0.001
Cornbelt	0.19365	0.909
N	195	
Model F Statistic	7.42	0.0001
R-Square	0.26	
Adjusted R-Square	0.23	

Thus, even though the landlord is apparently paying for these services, this charge is being offset at least in part by an increase in the share of crop accruing to the landlord.

Summary

Choice of land lease method can be an important decision for farmers. Those farmers who have adopted precision farming technologies may differ from non-adopters in how these lease types may suite their operations. Managerial freedom may be particularly important due to the complexity of the decision environment for these farmers.

Results from the 1999 Ohio Precision Farming Study suggested that precision farmers do make heavier use of leased land, probably in large part due to their much larger farm sizes. The precision farmers were much less likely to be full owners than were non-precision farming adopters, and were much more likely to use both cash and share lease land control methods. Furthermore, they tend to make somewhat heavier use of the cash lease method than do non-adopters.

Precision farmers who cash leased land paid significantly more per acre for the lease than did non-precision farming adopters - about $7.60 per acre based on the regression model results. Average leased parcel size was somewhat larger for the precision farmers. Yields also were somewhat higher for the precision farmer group.

Even though principles for efficient lease design might suggest that precision farming adoption should ultimately result in changes in the way operators and landlords share yields and/or costs, there is no evidence of such a change at this early stage of adoption. For share lease contracts, there was no statistically significant evidence that the sharing of either yields or costs were different between the precision farming and non-precision farming groups.

References

Breece, Donald J. and D. Lynn Forster. "Crop Share Leasing in Ohio." *Ohio State University Extension Factsheet*, FR-0005-01, November 2001.

Khanna, Madhu, Onesime Faustin Epouhe, and Robert Hornbaker. 1999. "Site-Specific Crop Management: Adoption Patterns and Incentives." *Review of Agricultural Economics*, Vol. 21(2):455-472.

Sunil, Thrikawala, Alfons Weersink, Gary Kachanoski, and Glenn Fox. 1999. "Economic Feasibility of Variable-Rate Technology for Nitrogen on Corn." *American Journal of Agricultural Economics,* Vol. 81:914-927.