Updating Corn Program Payment Yields: Are Farm Operators Differentially Affected?

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Crop yields which determine farm income deficiency payments have been frozen at 1981-1985 levels since 1986. Data from a longitudinal survey of Ohio farm operators are analyzed to evaluate whether updating payment yields will differentially affect farm operators. Results of the analysis imply that farm operators who operate larger farms, live in counties with higher yields, and have higher fertilizer and pesticide expenses per acre of corn will benefit more. In addition, low (high) existing payment yields are understated (overstated) relative to updated payment yields.

The *Food Security Act of 1985* froze crop program payment yields, which in part determine farm income deficiency payments, at 1981–1985 levels (Glaser, p. 32). During debate on the *Food, Agriculture, Conservation, and Trade Act of 1990* (*FACTA 1990*), farm lobbyists argued that these program payment yields should be updated to reflect a continuing improvement in actual crop yields. Primarily because of budgetary concerns, Congress did not mandate that payment yields be updated; but the Secretary of Agriculture was given discretionary power to update payment yields (*FACTA 1990*).

While the policy debate has focused on budgetary cost, updating program payment yields also may have differential impacts among farm operators. For example, updating payment yields may benefit large farm operators more than small farm operators because large farm operators may adopt new, yield improving technology more quickly. A review of the literature finds no study of differential impacts among farm operators. Therefore, this study uses data from a longitudinal survey of Ohio farm operators to examine if updating corn program payment yields results in differential impacts among farm operators.

Calculation of payment yields and the data used in this study are discussed in the next two sections. Then, key characteristics of the farm and farm operator are identified for a regression analysis of the relationship between updated payment yield and the identified characteristics. Based on the analysis, conclusions are drawn concerning differential impacts among farm operators from updating payment yields.

Determination of Payment Yield

Since passage of the *Food Security Act of 1985*, a farm's program payment yield is calculated by averaging the yearly payment yields established for the 1981 through 1985 crop years, after eliminating the high and low payment yields (USDA, 1990). Payment yield equals the average of a farm's proven yield for the five previous crop years based on grain slips, measured bins, and certified or determined acres. For example, the payment yield for 1981 equals the average of a farm's proven yields for the 1976 through 1980 crops. If proven yields are not available, a farm's payment yield is the average payment yield for similar farms in the area as judged by the county's Agricultural Stabilization and Conservation Service (ASCS) committee (USDA, 1986).

According to *FACTA 1990*, the Secretary of Ag-

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riculture has the discretionary option to update payment yields beginning with the 1991 crop year. The updated yields would be calculated by using "the farm program payment yield for the 1986 crop year and the actual yield per harvested acre with respect to the 1987 and subsequent crop years" (*FACTA 1990*, Section 505 (c) (2)). As with the existing payment yield, the updated payment yield would equal the average of the relevant yields for the preceding five crop years after eliminating the high and low yields.

Data

The data used in this study are taken from the Ohio Farm Household Longitudinal Survey for 1987, 1988, and 1990 (no survey was conducted for 1989). Each survey collected data from a sample of approximately 1000 Ohio farm operator households during the spring of the following year. Some households in the surveys participated in earlier surveys (the first longitudinal survey was in 1986); other households were randomly selected replacements. Thus, some of the sampled households provide a set of continuous data on a farm for each of the three years used in this analysis.

The sampled households were asked about the production and financial characteristics of their farming operation as well as the financial and social characteristics of their household. During the 1990 survey, respondents were asked for their corn program payment yield on land they owned. A total of 175 farm households had information for all the variables used in this analysis. Average existing corn payment yield for these farms is 110.9 bushels per acre, close to the state of Ohio's average of 110.5 bushels per acre (USDA, 1991, p. 6). Payment yields range from 68 to 150 bushels per acre.

Consistent with *FACTA 1990*, an updated payment yield was calculated by using the 1986 payment yield (same as the 1990 payment yield since payment yields have been frozen) and the actual corn yields reported during the 1987, 1988, and 1990 surveys by the farm operators included in this analysis. The actual corn yields were reported as an average for all land operated, both owned and rented. Since farm operators tend to rent land in the same local in which they own land, a high correlation is likely to exist between yields on owned and rented land. Thus, the difference in observational unit for corn program yield and actual yield should have minimal effect on the results.

High and low yields among these four yields were eliminated before the average was calculated. The resulting updated payment yield ranged from 52.5 to 160 bushels per acre, with an average of 109.7 bushels per acre. Payment yield increased for 50 percent of the farm operators, declined for 44 percent, and remained the same for 6 percent.

These results may seem surprising given the expectation of increasing yields over time. Therefore, two sensitivity tests were conducted. One used expected yield for 1991, which was elicited from the operators surveyed. This yield was elicited only for owned acres. Therefore, it provides not only a different measure of updated yields, but also provides insight into the impact of the different observational units for payment yield and actual yield.

The second sensitivity test was selected in part to evaluate the potential impact of not having data for 1989. Ohio's average yield was 118 bushels per acre in 1989, compared with 120, 85, and 121 bushels per acre in 1987, 1988, and 1990, respectively (a major drought occurred in 1988). Given the relatively close state averages for 1987, 1989, and 1990, an alternative measure of updated payment yield was created by eliminating only the low yield from among the four yields.

Average yield for the four years after eliminating the low yield was 116.8 bushels per acre with a range of 71.3 to 173.3. Average expected yield was 120.4 bushels per acre with a range of 60 to 210. Existing payment yield was less than the average yield excluding the low yield (expected yield) for 66 (69) percent of the operators. In contrast, existing payment yield exceeded average yield excluding the low yield (expected yield) for 31 (22) percent of the operators. Although the proportions are different, all three measures suggest that updating corn payment yield to 1991 levels would result in a lower payment yield for a substantial number of farm operators (in excess of one-fifth).

The regression analysis which is described below for updated payment yield, measured as average yield excluding the high and low yields, also was conducted for the other two measures. Significance of the independent variables was not affected. This finding lends confidence in the robustness of the analysis.

Conceptual and Empirical Model

Updated payment yield is hypothesized to be a function of several factors. This relationship can be expressed as the following equation:

$$(1)\ Y_i = f(x_{1i}, X_{2i}, X_{3i}, X_{4i})$$

where: Y_i = Updated Corn Payment Yield for Farmer i
X_{1i} = Vector of Variable Inputs
X_{2i} = Vector of Characteristics Associated with the Adoption of New Technology
X_{3i} = Local Growing Conditions
X_{4i} = Existing Corn Payment Yield

Variable inputs are an important determinant of corn yields. In this study, variable inputs are divided into two categories: pesticides (herbicides plus insecticides) and fertilizer. Expenditures on these two input categories account for approximately 75 percent of the variable cost of producing an acre of corn in the corn belt (USDA, 1992, p. 12). Assuming that farmers use variable inputs rationally, fertilizer and pesticide expenses are hypothesized to be positively related with updated payment yield.

The surveyed farm operators reported fertilizer and pesticide expenses for the farm during the survey year. These expenses were allocated to corn using the following formula, expressed in terms of fertilizer:

(2) $Fert_i/A_{ic} = (Fert_i) \cdot [(A_{ic} \cdot K_c)/(\Sigma(A_{ij} \cdot K_j))]$

where: $Fert_i/A_{ic}$ = Fertilizer Expenses per Acre of Corn, Both Rented and Owned, Reported by Farm Operator i
A_{ic} = Acres of Corn Reported by Operator i
$Fert_i$ = Total Fertilizer Expenses for Farm Reported by Operator i
K_c = Fertilizer Expenses per Acre of Corn as Reported in the *Ohio Crop Enterprise Budgets*
A_{ij} = Acres of Crop j Reported by Operator i
K_j = Fertilizer Expenses per Acre of Crop j as Reported in the *Ohio Crop Enterprise Budgets*

This calculation assumes that a producer fertilizes each crop the same amount relative to standards established for the crops. Standards are taken from the *Ohio Crop Enterprise Budgets*, where standards are based on recommendations of university and private industry experts. The same calculation procedure was used for pesticide expenses.

Because the updated corn payment yield is calculated using actual yields for 1987, 1988, and 1990, fertilizer and pesticide expenses per acre of corn are calculated as an average of the values for 1987, 1988, and 1990. Fertilizer expenses ranged from \$7.45 to \$92.68 per acre of corn, while pesticide expenses ranged from \$0 to \$55.18 per acre of corn (Table 1). Average fertilizer and pesticide expenditures for all 175 operators were \$39.69 and \$22.45 per acre of corn, respectively.

Adoption of technology is often associated with lower costs and higher yield (e.g., Cochrane, Griliches). Thus, early adopters of technology for corn production may gain more from updating payment yield. After summarizing approximately 900 studies, Rogers noted that the following socioeconomic characteristics were associated with early adopters of technology in developed economies: larger sized farms, more specialized operations, more favorable attitude toward credit, and additional education (Rogers, pp. 251–259)[1].

Given the relationship between size and adoption of technology, farm size is hypothesized to be positively related to updated payment yield. Because this analysis is concerned with corn yields, farm size is measured as the average number of owned and rented acres of corn harvested during 1987, 1988, and 1990 as reported by the farm operator. Average number of owned plus rented corn acres for the analyzed farm operations is 213 acres, with a range of 10 to 1520 acres (Table 1).

As the share of the farming operation devoted to livestock increases, resources as well as managerial expertise become concentrated on livestock production instead of crop production (Nelson, p. 13). Given this argument and the relationship between specialization and adoption of technology, it is hypothesized that the relative importance of livestock production is negatively related to updated payment yield. Livestock specialization is measured as the average of the ratios for 1987, 1988, and 1990 of gross sales earned from livestock and livestock products (including milk sales) to total gross farm sales. Average share of gross farm sales obtained from livestock for individual farms ranged from 0 to 100 percent. The average share across all 175 farms was 40 percent (Table 1).

The farm operator's attitude toward credit was not collected in the longitudinal survey. However, the ratio of farm debt to farm assets is available

[1] Rogers also found that social status was positively related to adoption of technology (Rogers, p. 251). However, social status is often measured by income and/or wealth. Both of these variables are related to farm size. Thus, a separate measure of social status is not included in this study.

Table 1. Descriptive Statistics for Farm Production and Operator Characteristics Associated with Updating Corn Program Payment Yield, Ohio, 1991

	Descriptive Statistics[a]		
Independent Variable	Mean	Standard Deviation	Range
Fertilizer Expenses ($/acre)	39.69	14.79	7.45–92.68
Pesticide Expenses ($/acre)	22.45	10.86	0–55.18
Total Corn Acres Operated	213.32	258.59	10–1520
Livestock Sales Ratio	0.40	0.36	0–1.00
Farm Debt-to-Asset Ratio	0.20	0.23	0–1.23
Operator Education	12.70	1.95	6–20
Average County Yield	113.59	8.60	88–131
Existing Program Yield	110.94	12.99	68–150

[a]Based on 175 observations.
Source: Ohio Farm Longitudinal Surveys for 1987, 1988, and 1990; and Original Calculations.

from the 1987, 1988, and 1990 surveys. This ratio is a revealed measure of the attitude toward credit given the size of the farm as measured by assets. Operators whose attitude toward credit is unfavorable will use little to no credit while operators whose attitude toward credit is more favorable will tend to use relatively more credit. Given these arguments and Roger's summary, farm debt-to-asset ratio is hypothesized to be positively related to updated payment yield. Average farm debt-to-asset ratio for the 175 operators was 0.20 (Table 1). This ratio ranged from 0 to 1.23 for individual operators.

The results generated by adoption studies suggest that the relationship between education of the farm operator and updated payment yield should be positive. Education of the operator is measured as the number of years of schooling. It ranged from 6 to 20 years, with an average of 12.7 years (Table 1).

Local weather conditions in combination with the inherent productivity of the soil also may affect which farm operators gain from updating payment yields. In other words, the farm operator may gain or lose because of relatively good or poor weather in his/her area relative to the rest of the corn production area. In addition, more productive soils may have a greater response to yield enhancing technologies than less productive soils.

One variable which proxies the interaction between these two effects is county average yield. County average yield was measured as the average of county corn yields for 1986 through 1990 (*Ohio Agricultural Statistics Service*). This five year average covers the period being investigated in this study, thus providing a measure of the average growing conditions in the farm's geographical area over the period investigated, as well as the county's inherent soil productivity. County yields range from 88 to 131 bushels per acre (Table 1), and are hypothesized to be positively related to updated yield.

Given the preceding discussion, the following empirical model is estimated using ordinary least squares regression:

$$(3)\quad Y_i = \alpha + \beta_1 FE_i + \beta_2 PE_i + \beta_3 CA_i + \beta_4 LS_i + \beta_5 DA_i + \beta_6 ED_i + \beta_7 CY_i + \beta_8 AY_i + \epsilon_i$$

where:
- Y_i = Updated Corn Program Payment Yield for Farmer i
- FE_i = Fertilizer Expenses per Acre of Corn
- PE_i = Pesticide Expenses per Acre of Corn
- CA_i = Total Corn Acres Operated
- LS_i = Livestock Sales Ratio
- DA_i = Farm Debt-to-Asset Ratio
- ED_i = Operator Education
- CY_i = Average County Yield
- AY_i = Existing Corn Program Payment Yield
- α, β_j = Regression Parameters
- ϵ_i = Random Error Term

Because specific directional relationships are hypothesized, a one-tailed t-test is used for all variables.

Results

The objective of this analysis is to determine whether differential impacts exist among farm operators if program payment yields are updated. One potential dependent variable is updated program payment yield minus current program payment yield. However, this specification forces the relationship between updated and current program payment yield to be expressed as a coefficient of one between the two variables. A chi-squared test of alternative dependent variables (difference between updated and current program yield vs. updated program yield) revealed that restricting the coefficient to 1 is not statistically valid at the one percent significance level. Therefore, to use the difference between updated and current program yield as the dependent variable to is to introduce model misspecification into the analysis.

Given this finding, updated program payment yield is used as the dependent variable, with current program payment yield used as an independent variable. This model specification still provides insights into the differential effects on farm operators of updating program payment yields because regression coefficients are interpreted as the change in the dependent variable given all other independent variables. Consequently, when the regression coefficient of independent variables other than current program payment yield is interpreted, current program payment yield is assumed to be given.

The independent variables were evaluated for multicollinearity. No evidence of multicollinearity was found as the highest correlation coefficient between any pair of independent variables was 0.33 between pesticide expenses and livestock sales ratio. In addition, cross sectional data is often subject to the problem of heteroskedasticity. Thus, the Breush Pagan test was conducted (Pindyck and Rubinfeld, p. 134). Heteroskedasticity was found for existing payment yield, fertilizer expenses, pesticide expenses, corn acres, and livestock sales ratio. Heteroskedasticity was corrected on these variables by using weighted least squares.

Before correcting for heteroskedasticity, R^2 of the regression equation was 0.42. Because of the nature of the correction for heteroskedasticity, R^2 is not a valid measure after the correction is made.

Fertilizer expenses and pesticide expenses per acre are positively significant at the one and ten percent significance levels, respectively (Table 2). The coefficient for fertilizer implies that, for each dollar increase in fertilizer expenses per acre, updated corn payment yield increases by 0.23 bushel per acre, given the other independent variables including current program payment yield. For each dollar increase in pesticide expenses per acre, updated corn payment yield increases by 0.12 bushel per acre given the other independent variables including current program payment yield.

Total corn acres and county average yield are positively significant at the one percent level. These results imply that payment yield will increase more for larger farms and farms located in counties with higher average yields during the late 1980s. In contrast, livestock sales ratio, farm debt-to-asset ratio, and operator education are statistically insignificant in explaining updated payment yield.

Table 2. Regression Analysis of Farm Production and Operator Characteristics Associated With Updating Corn Program Payment Yield, Ohio, 1991

	Regression Analysis[a,b]	
Independent Variable	Estimated Coefficient	T-ratio
Constant	−2.3400	−0.18
Fertilizer Expenses ($/acre)	0.2295	4.76***
Pesticide Expenses ($/acre)	0.1189	1.59*
Total Corn Acres Operated	0.0051	2.11***
Livestock Sales Ratio	0.1937	0.08
Farm Debt-to-Asset Ratio	0.0530	0.02
Operator Education	0.2171	0.55
Average County Yield	0.2584	2.50***
Existing Program Yield	0.6054	9.63***

*,**,***indicates a significant coefficient at the 10%, 5% and 1% level, respectively.

[a]Based on 175 observations.

[b]R^2 for the regression before the correction for heteroskedasticity is 0.42.

Source: Ohio Farm Longitudinal Surveys for 1987, 1988, and 1990; and Original Calculations.

Existing payment yield is positively significant at the one percent significance level (Table 2). Consistent with the earlier discussion, the coefficient on existing payment yield is significantly smaller than one at the one percent significance level (standard error of the regression coefficient is 0.0629). This coefficient, therefore, suggests that, relative to updated payment yield, low existing payment yields are understated while high existing payment yields are overstated. To further illustrate the important of this finding, the following text table presents for given ranges of current program payment yields the difference between the calculated updated program payment yield and the current program payment yield:

Current Corn Payment Yield	Average of Updated Minus Current Payment Yields
----------bushels/acre----------	
68–89	6.45
90–99	0.99
100–109	−0.02
110–119	−0.45
120–129	−2.74
130–150	−16.36

Overall, this data set suggests that updating corn program payment yields to 1991 levels would have little impact on total government payments, given that the deficiency payment program remains constant. This conclusion is drawn from the small difference that exists between the average current program payment yield (110.9 bushels/acre) and updated program payment yield (109.7 bushels/acre). In contrast, the distribution of deficiency payments would be altered. Farm operators whose updated program yield would increase had an average seven percent increase in program payment yield. In contrast, farm operators whose program payment yield would decrease had an average 11 percent decrease in their payment yield.

Summary, Conclusions, and Implications

This study investigated the distributional effects among farm operators from updating corn program payment yields. The empirical results imply that updating payment yields to 1991 levels generates greater benefits for farm operators with larger farms and farm operators located in counties with higher average yields during the late 1980s. Thus, updating payment yields will have structural impacts as well as differentially affect farms based on geographic location.

The empirical results imply that updating payment yield will benefit operators who use higher rates of fertilizer and pesticides per acre. Thus, updating corn program payment yields may be viewed as a public policy decision which rewards the greater use of fertilizer and pesticides per acre.

The results also suggest that low existing payment yields are understated relative to updated yields while high existing payment yields are overstated relative to updated yields. This observation raises an equity issue which is different from the frequently debated issue concerning the level of payment yields. Specifically, this observation suggests that a policy option is to maintain the average payment yield across all operators at the current level, but recalculate payment yields to more accurately reflect the distribution of updated yields among farm operators.

In assessing these conclusions, it is important to remember that the missing year (1989) may have biased the results to some extent. In addition, some of the explanatory variables are measured using data for 1987, 1988, and 1990. Thus, the variable may not reflect the situation of the farm in 1991, the year for which the updated yield was calculated.

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