The Relationship between Incomes, Farm Characteristics, Cost Efficiencies, and Rate of Return to Capital Managed

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Abstract

Farm-level, cross-section and panel data were used with econometric methods to examine relationships between variability in the rate of return to capital managed and explanatory variables including government payments per crop acre, gross crop income, gross livestock income, costs, efficiency measures, and other socioeconomic characteristics. Quantifying the impacts of socioeconomic factors on variability of the rate of return was difficult. Increasing the standard deviation of gross revenue and government payments increased the variability in rate of return to capital managed. An increase in the variability of labor, crop & equipment, livestock, and interest costs had the opposite effect. In addition, increase in labor and livestock costs to gross revenue increases variability in the rate of return. The smaller the amount of land rented and the larger the number of acres, the higher the variability in rate of return. The panel data results indicated that annual changes in rate of return had a positive relationship with increases in gross revenues, government payments, and decreased changes in costs. Decreases in the efficiency of interest cost resulted in a larger change in the annual rate of return, whereas crop & equipment and livestock costs caused the opposite effect. Age and diversification had positive effects. The above findings reaffirmed that reducing the variation in government payments and gross revenue, and increasing the variation in costs, will lower the variability in the rate of return to capital managed. Cost efficiency measures were also important, but with the previous model, the effects on the rate of return were uncertain.

keywords: rate of return, financial variability, diversification, farm planning, panel data, risk

Introduction

Several factors have contributed to the need for improved understanding of risk management at the farm level. In particular, the elimination of deficiency payments, the development of new risk management tools, and freer trade have brought about changes in the risk environment faced by producers. Farm-level risk is a major area of interest to agricultural economists as well as farm managers, particularly with the decoupling of commodity payments from production and prices under the 1996 farm bill.

Collins and Barry presented a brief overview of the extensive literature on risk analysis at the firm level. Although much has been written to guide decision making and analysis of risk management, particularly that from yield and price variabilities, studies of the socioeconomic characteristics of individual farms that affect overall profitability are scarce. This scarcity is due largely to the limited availability of detailed farm-level data.

The objective of this study was to use farm-level, cross-section and panel data to examine the relationships between the variability of the rate of return to capital managed; government program payments per crop acre; gross income variability from production and price variabilities; and farm characteristics, such as measures of production efficiency, diversification, operator age, leverage, land tenure position, and farm size as reflected in total acres. Specifically, the variations of the rate of return as they relate to these farm socioeconomic characteristics were studied.

Previous Work

Purdy, Langemeier, and Featherstone used a sample of Kansas farms to examine the effect of risk and specialization on mean financial performance. Risk, age of operator, financial efficiency, and

farm size had the largest impacts on mean financial performance. Additionally, farms with both crops and a livestock enterprise (beef, swine, or dairy) tended to have less variability in financial performance. Zenger and Schurle investigated net income variability related to size for a sample of 128 north-central Kansas farms from 1973-1979. Gross farm income, acres per operator, taxable non-farm income, and machinery investment per acre were related significantly to variability of net income. Schurle and Williams used second degree stochastic dominance to identify preferred farm organizations in Kansas. Their results suggested that larger farms usually generate net income distributions that have higher average incomes and higher variance, but they were preferred by risk-averse individuals. Pope and Prescott examined the relationship between farm size, other socioeconomic variables, and diversification for a cross section of California crop farms. They found that diversification was related positively to farm size. They also suggested that a trade-off occurred between the diversification benefits of reducing risk and the economies of size benefits from specialization. Sonka, Hornbaker, and Hudson used panel data from Illinois grain producers to examine how farm characteristics influenced the placement of farms into top and bottom quartiles based upon returns to management per acre. Their logit model results indicated that, although prices and yields were related positively to better returns, soil productivity and operating expenses were related negatively. The result for soil productivity indicated that higher quality land may have been overvalued relative to its income generating capacity. Their data also indicated that year-to-year variation in performance was substantial for both high- and low-quartile groups.

An alternative approach to using econometric methods for examining the effect of socioeconomic variables on farm risk is to apply portfolio theory. Farms can be considered a portfolio of enterprises, for which variability of net farm income can be described with the following equation.

$$\text{Net Income Variance} = \sum_{i=1}^{N} \sum_{j=1}^{N} X_i X_j r_{ij} s_i s_j \qquad [1]$$

where:

X_i = proportion of farm assets invested in enterprise i

X_j = proportion of farm assets invested in enterprise j

N = number of enterprises

D_{ij} = correlation coefficient between net return from enterprise i and j

F_i = standard deviation of net return for enterprise i

F_j = standard deviation of net return for enterprise j

Variability of net return as measured by variance or standard deviation is influenced by the proportion of total investment allocated to each enterprise and the correlation between the return on these investments and the standard deviation of these investments. Theoretically, this equation could be used to determine how the mix of investments on a farm could affect the standard deviation of net farm income. These results could be used to examine the optimal enterprise mix given a decision criterion for risk versus net return. The typical approach is to construct a representative case farm using farm enterprise budgets that reflect current costs. A distribution of net returns then is estimated by subtracting these costs from gross returns calculated with historical yields and prices. These distributions are used to obtain correlation coefficients between enterprises and standard deviations of

net return for each enterprise. Examples of studies using this method include Schurle and Erven and Held and Zink.

This approach potentially could be used to determine how changes in enterprise mix reduce risk on these farms. This result could be compared to the actual enterprise allocations. Although this approach is conceptually useful, few farm-level data are available that organize returns by enterprise or contain accurate estimates of the dollars invested in each enterprise on a typical diversified farm. Some investments, such as machinery, buildings, and equipment, are shared by several enterprises. Developing these shares is complex. This process is complicated further by the reality that many farms have both crops and livestock enterprises, so all returns cannot be measured on a per acre basis, which often is done with crop enterprise data to standardize the analysis.

Mafoua-Koukebene, Hornbaker, and Sherrick used a sample of 183 farms participating in the Illinois Farm Business Farm Management Association to analyze both farm and off-farm investment decisions, across risk-aversion levels, with risk-efficient optimal portfolios. With low levels of risk aversion, they found significant investments off the farm in common stocks and specialization in corn and soybean production. The results also showed the farm had higher certainty equivalent returns from subsidized than unsubsidized production, but there were important impacts from farm programs on acreage allocation and operation size. As the risk aversion level increased, the farm also had the tendency to diversify more rapidly toward livestock production and low-risk off-farm investments in the absence of government acreage reduction program payments.

Schurle and Tholstrup used econometric methods to examine income variability for farms in Kansas over a 13-year period from 1973 to 1985. However, the portfolio approach was used as a

conceptual guide for their work. Their basic model estimated the relationship between the ratio of variance to the square of capital managed and enterprise shares, as well as other variables such as government payments, age of operator, interest payments, and machinery investment.

Their conceptual approach followed the general form

$$\frac{V(Net)}{T^2} = \sum_i S_i^2 V(N_i) + \sum_i \sum_j S_1 S_j C(N_i, N_1) \quad for\ i \neq j \qquad [2]$$

which is the relative variance of

$$\text{Net} = \sum_i S_i TN_i \qquad [3]$$

where:

Net = net farm income

S_i = share of assets in enterprise i

T = total assets

N_i = net income per dollar of assets in enterprise i

V = variance

C = covariance

Their study has some limitations. Sales of crops were based upon production and average prices, because specific crop enterprise net returns were not available. Shares of assets devoted to each enterprise also had to be approximated using budgets because they were not available in the farm data.

Kansas Farm Management Data

The data for this study were obtained from the Kansas State University Farm Management Whole-Farm Data Bank (Langemeier). This data set contained whole farm records for individual farms enrolled in the Kansas Farm Management Association Farm Records program. Data were obtained from 276 farms that participated continuously in the records program each year between 1973 and 1996. A geographic distribution of the farms by county is provided in Figure 1. All financial variables were adjusted to 1996 dollars using the personal consumption expenditure (PCE) index, so that variability measures used would reflect constant dollars.

Gross farm income was calculated from the data as total commodity sales plus all forms of government payments, inventory changes, and miscellaneous farm income. The livestock, crop, and product inventory change, used for gross farm income calculations, are farm income items that are recorded in the data on accrual basis. However, milk product sales, egg sales, other product sales, government payments, and other income are recorded on a cash basis. Therefore, gross farm income is a combination of both accrual and cash accounting.

Gross crop income and gross livestock income were also calculated from the data records. Gross crop income included grain, hay/forage, and cash crop incomes, all on accrual basis. While gross livestock income consisted of income from beef, dairy, sheep, swine, poultry, and other livestock/futures, which were also on accrual basis. As we have calculated these gross incomes, gross farm does not equal gross crop plus gross livestock. There are additional product sales and inventory changes included in the gross farm income calculation.

Total costs were calculated from the farm records data bank as follows. There were 24 total expense items included in the cost estimation. The expense categories were: hired labor, machinery repairs, building repairs, interest paid, feed purchased, seed expense, fertilizer & lime, machine hire, organization fees/misc/etc., vet-medicine-drugs, crop storage-marketing, livestock marketing & breeding, gas-fuel-oil, real estate taxes, personal property taxes, general farm insurance, telephone & electricity, cash farm rent, herbicide & insecticide, conservation, auto expense, expense inventory change, motor vehicle depreciation, machinery-equipment depreciation, and building depreciation. Depreciation that was calculated for tax reporting purposes was available for 1973 to 1991. From 1992 to 1996, depreciation was the estimated change in market value. Total cost was used in net farm income calculations, but for regression purposes these costs were split into four subsets: labor, crop & equipment, livestock, and interest.

Net farm income was calculated by subtracting total costs and depreciation from gross farm income. The return to capital managed, or more precisely the return to capital managed, opportunity costs, unpaid labor, and management, was estimated by adding interest paid back to net farm income. Total capital managed was equal to total assets (current + intermediate + long-term) plus the value of rented land. The rate of return to capital managed, opportunity cost, unpaid labor, and management was calculated by dividing return to capital managed, etc., by total capital managed. To simplify matters, the "rate of return to capital managed" was used to represent the above expression.

The farm records data provided production values and acreages by enterprise. These figures were used to compute a Schurle diversification index, Equation [5]. The data also contains

socioeconomic variables, such as age of the principal operator; total acres owned, rented, and operated; and financial measures such as the debt to equity ratio.

Variability in net farm income was measured as the standard deviation of net farm income. To examine the effect of farm characteristics on the standard deviation of net farm income, the data were collapsed to means resulting in a cross-section data set of 276 observations for each variable.

Structure of Models

Model Using Cross-Section Data

The model estimated using cross-section data to examine effects of farm characteristics on standard deviation follows the general form

$$y_i = b_0 + b x_i + e_i \qquad [4].$$

A description of the model that was estimated using ordinary least squares (OLS) regression and cross-section data follows.

(1) SRORCAPM = F(SGOVCAP, SGCICAP, SGLICAP, SLBRCAP, SCNECAP, SLIVCAP, SINTCAP, LABOR, CR&EQ, LIVE, INT, AGE, DIV, D/E, RENT, ACRES, NW, WC, NC, C, SC, NE, EC, SE)

where:

SRORCAPM = standard deviation of the rate of return to capital managed, opportunity costs, unpaid labor, and management

SGOVCAP = standard deviation of government payments per crop acre divided by thousand dollars of total capital managed

SGCICAP = standard deviation of gross crop income divided by thousand dollars of total capital managed

SGLICAP = standard deviation of gross livestock income divided by thousand dollars of total capital managed

SLBRCAP	=	standard deviation of hired labor cost divided by thousand dollars of total capital managed
SCNECAP	=	standard deviation of crop and equipment costs divided by thousand dollars of total capital managed
SLIVCAP	=	standard deviation of livestock costs divided by thousand dollars of total capital managed
SINTCAP	=	standard deviation of interest cost divided by thousand dollars of total capital managed
LABOR	=	hired labor cost per dollar of gross farm income from crop and livestock sales
CR&EQ	=	crop production and equipment expense per dollar of gross farm income from crop and livestock sales (seed, fertilizer and lime, herbicide and insecticide, machinery repairs, gas-fuel-oil, and equipment depreciation)
LIVE	=	livestock production expense per dollar of gross farm income from crop and livestock sales (feed purchased, veterinary and drug costs, marketing and breeding expenses, building repairs, and building depreciation)
INT	=	total interest expense per dollar of gross income
AGE	=	age of principal operator
DIV	=	Schurle diversification index that accounts for both crop and livestock enterprises.
D/E	=	debt to equity ratio
RENT	=	percent of total acres farmed that are rented
ACRES	=	total crop acres plus total pasture acres
NW	=	northwestern Kansas Crop and Livestock Reporting Region
WC	=	west central Kansas Crop and Livestock Reporting Region

NC	=	north central Kansas Crop and Livestock Reporting Region
C	=	central Kansas Crop and Livestock Reporting Region
SC	=	south central Kansas Crop and Livestock Reporting Region
EC	=	east central Kansas Crop and Livestock Reporting Region
NE	=	northeast Kansas Crop and Livestock Reporting Region
SE	=	southeast Kansas Crop and Livestock Reporting Region

Model (1) was designed to determine the effects on variability in the rate of return on capital managed by the three major sources of revenue for a farm; cost efficiency measures; and other farm characteristics such as diversification, operators age, leverage, tenure position, size, and region.

Sales or gross returns on these farms fit into three major categories. Those included government payments, income from crop sales, and income from livestock sales. Therefore, three variables were used to examine the impact each of these income sources had on the standard deviation of the rate of return to capital managed. Government payments were converted to per crop acre basis to eliminate the variability caused by fluctuations in total acreage. Gross crop income and gross livestock income remained in total dollars. Since the dependent variable was expressed as a rate of return (i.e. dollar of return per dollar of total capital), the income variables in the regression were divided by thousand dollars of total capital managed. Thus, they were converted to dollar of income per thousand dollar of total capital managed. Because variability in rate of return was being examined, the standard deviations of the three gross revenue variables were used as the independent variables. We hypothesized that increasing the standard deviation of any of these three variables would increase

the standard deviation of the rate of return to capital managed. The goal was to determine which variable had the greatest influence on the standard deviation of the rate of return.

Government payments were common sources of revenue on most of these farms. Farms in this data set received an average of 52% of their net farm income from government payments. We hypothesized that more variability in government payments per crop acre would increase the standard deviation of the rate of return to capital managed.

Because individual enterprise income was not available nor were prices received for each crop and livestock commodity by farm, variables to capture separate crop yield, livestock production, and price variability were not included. The standard deviations of gross crop income and gross livestock income were included in an attempt to capture the aggregate value of yield and production variabilities.

Variation in costs also affects variability of rate of return to capital managed. To evaluate the effect of production, costs were separated into four specific categories: labor expense, cropping & equipment expense, livestock expense, and interest expense. Labor included hired labor cost. Cropping and equipment expenses contained seed, fertilizer-lime, herbicide-insecticide, machinery repairs, machine hire, gas-fuel-oil, and equipment depreciation. The livestock expenses consisted of feed purchased, veterinary and drug costs, marketing and breeding expenses, building repairs, and building depreciation. Interest was total interest expense. The cost categories were divided by thousand dollars of total capital managed to convert them into dollar cost per thousand dollar of capital managed basis, then the standard deviations of the terms were used as independent variables in Model (1). We hypothesized that increased variation in costs would lead to increased variation in rate of return to capital managed. The cost variable that had the greatest influence on the standard deviation of

rate of return was of interest. Alternatively, increased variation in cost may lead to less variation in the rate of return if costs were adjusted by the manager due to economic conditions.

Four variables were used to measure how input efficiency influences the standard deviation of the rate of return to capital managed. Labor costs, crop & equipment expenses, livestock expenses, and interest costs, all were divided by the total of gross crop and livestock income. The total of gross crop and livestock income was used because many of these farms market grain produced through livestock enterprises in the form of feed. These variables are percentages. The lower the percentage, the more efficient the farm at producing gross income relative to input costs. Decreasing efficiencies, measured by an increase in these variables, generally would decrease the rate of return to capital managed. We hypothesized that less input efficiency would lead to a higher standard deviation of the rate of return.

The effect that the age of the principal operator had also was considered. We hypothesized that as an operator ages, the standard deviation of the rate of return to capital managed would decline because of increasing management experience and better ability to manage risk. However, an alternative hypothesis is that older operators take on additional risk because of improved financial positions.

We used an enterprise diversification variable, Schurle index (equation [5]), which was based on percentages of produced value in 17 potential enterprises that exist in the production information of the farm database (Schurle and Williams). Diversification based upon production value was used, because livestock enterprises exist on all but a few farms, so creating a diversification index based upon acres alone was not logical. The value of livestock sales from each livestock enterprise was used. For

crop enterprises, the values were the products of annual farm yields and statewide average annual commodity prices.

$$DIV = N - \frac{N}{2}\left(\sum_{i=1}^{N} \left| P_i - \frac{1}{N} \right| \right) \quad [5]$$

The variable N is the total number of enterprises that exist in the data (17), and P_i is the percentage that the enterprise contributes to gross value of production. For this diversification index, a 1 indicates complete specialization and N indicates complete diversification. The reader should note that this is the reverse interpretation of a Herfindahl index, where a value closer to 0 indicates more diversification, and a value of 1 indicates complete specialization. As suggested by portfolio theory, we hypothesized that farms with more diversification would have lower standard deviations of the rate of return to capital managed. An alternative hypothesis is that farms that are more specialized have lower standard deviations of the rate of return because of economies of scale.

The effect of financial strength was measured with the debt to equity ratio. We hypothesized that a higher debt to equity ratio would increase the standard deviation of the rate of return to capital managed. Farm tenure characteristics were measured by using the percentage of acres farmed that are rented. Increasing the percent rented may increase the standard deviation of the rate of return by increasing management complexity.

Preliminary calculations showed a high correlation between crop acres and the standard deviation of government payments. However, after further analysis the correlation between total acreage and the standard deviations of government payments was found acceptable. The farm size issue was addressed by including total acres as an independent variable. The variable in the model, *ACRES*, combined "total crop acres" and "total pasture acres" from the farm database. We

hypothesized that increased acreage, or farm size, would lead to increased variation in rate of return to capital managed.

The nine Crop and Livestock Reporting Regions in Kansas were used to capture the effect of varying weather conditions and other geographical effects (Figure 1). We hypothesized that regional variables such, as rainfall and temperature conditions, would cause differences in the standard deviations of the rate of return to capital managed. The base region was southwestern Kansas. Rainfall and humidity generally increase from west to east in the state.

Model Using Panel Data

Panel data sets provide a rich source of information and enable regressions to capture variations across groups and time. Because panel data were available, they were used in the analysis of variability in the rate of return to capital managed. The fundamental advantage of a panel data set over a cross section is that it allows the researcher greater flexibility in modeling the differences in behavior across groups (Greene, 1997).

Panel regressions take two general forms, a fixed effects model and a random effects model. These two systems also can reflect one-way or two-way effects, which are for group (farm) and/or time effects. The fixed effects (FE) model, also called the least squares dummy variable (LSDV) model, uses binary variables (dummies) to capture variance unique to cross-section and/or time periods. These dummy variables are treated as parameter shifts presented in the following two equations,

$$y_{it} = \alpha_i + x_{it}\beta + \varepsilon_{it} \qquad \text{(one-way effects)} \qquad [6]$$

$$y_{it} = \alpha_i + \gamma_t + x_{it}\beta + \varepsilon_{it} \qquad \text{(two-way effects)} \qquad [7]$$

where μ_i represents group effects, and λ_t denotes time period effects. A common formulation of the model assumes that differences across groups can be captured in differences in the constant term. The usual t ratio for μ_i and/or λ_t implies a test of the hypothesis that μ_i and/or λ_t equals zero, but the hypothesis that the constant terms are all equal to zero also can be tested with an F-test. This test determines if the group and time effects were jointly significant at a given level and also establishes whether or not the FE model was preferred to the OLS regression.

The FE model assumes that differences between cross section and/or time can be viewed as parametric shifts in the regression. The random effects (RE) model, however, uses random error in time, space, or both to derive efficient and unbiased estimates. The error structure is captured in the covariance matrix. The RE model also has one-way (OW) and two-way (TW) systems. The following equations represent the RE models,

$$y_{it} = \alpha + x_{it}\beta + u_i + \varepsilon_{it} \qquad \text{(one-way effects)} \qquad [8]$$

$$y_{it} = \alpha + x_{it}\beta + \varepsilon_{it} + u_i + v_t \qquad \text{(two-way effects)} \qquad [9]$$

The component u_i is the random distribution characterizing the i^{th} observation and is consistent through time. In equation [9], the v_t variable designates the random distribution contained in the t^{th} period. The OWRE model is estimated using generalized least squares (GLS), whereas the TWRE model is

estimated with feasible generalized least squares (FGLS). The significance of the random effects model then can be determined using a Lagrange multiplier test.

An area of some concern when conducting panel data analysis is the selection of the fixed or random effects model as the appropriate formulation. The FE model is costly in terms of degrees of freedom, but the RE model may be inconsistent because of omitted variable bias. The FE model allows estimation and interpretation of each specific group or time effect; however, the RE model may be more appropriate for longitudinal data. The Hausman test can be used to determine which model is suitable. It tests the hypothesis that although both OLS and GLS are consistent, OLS is inefficient. The following equation represents the test statistic and the hypothesis.

$$H = \left[b - \hat{b}\right]' \hat{\Sigma}^{-1}\left[b - \hat{b}\right] \sim c_k^2 \qquad [10]$$

H_0: random effects (OLS is inefficient)

H_1: fixed effects (OLS is not inefficient relative to GLS)

where *k* is the number of continuous independent variables, *b* are from OLS, and $-hat are from GLS. If the null hypothesis is rejected, then the FE model is preferred to the RE model.

The preceding concepts were applied to this study of the variability in the rate of return to capital managed in an attempt to better explain the interactions of changes in rate of return with gross revenue attributes and farm characteristics. The panel data models were estimated using LIMDEP version 7.0 because of its panel data capabilities. The two models used in the analysis are as follows:

(2) A)RORCAPM = F(A)GOVCAP, A)GCICAP, A)GLICAP, A)LBRCAP, A)CNECAP, A)LIVCAP, A)INTCAP, LABOR, CR&EQ, LIVE, INT, AGE, DIV, D/E, RENT, ACRES)

where:

Δ RORCAPM	=	annual change in the rate of return to capital managed, opportunity costs, unpaid labor, and management
Δ GOVCAP	=	annual change in government payments per crop acre divided by thousand dollars of total capital managed
Δ GCICAP	=	annual change in gross crop income divided by thousand dollars of total capital managed
Δ GLICAP	=	annual change in gross livestock income divided by thousand dollars of total capital managed
Δ LBRCAP	=	annual change in hired labor cost divided by thousand dollars of total capital managed
Δ CNECAP	=	annual change in crop and equipment costs divided by thousand dollars of total capital managed
Δ LIVCAP	=	annual change in livestock costs divided by thousand dollars of total capital managed
Δ INTCAP	=	annual change in interest cost divided by thousand dollars of total capital managed
LABOR	=	hired labor cost per dollar of gross farm income from crop and livestock sales
CR&EQ	=	crop production and equipment expense per dollar of gross farm income from crop and livestock sales (seed, fertilizer and lime, herbicide and insecticide, machinery repairs, gas-fuel-oil, and equipment depreciation)
LIVE	=	livestock production expense per dollar of gross farm income from crop and livestock sales (feed purchased, veterinary and drug costs, marketing and breeding expenses, building repairs, and building depreciation)
INT	=	total interest expense per dollar of gross income
AGE	=	age of principal operator

DIV	=	Schurle diversification index that accounts for both crop and livestock enterprises.
D/E	=	debt to equity ratio
RENT	=	percent of total acres farmed that are rented
ACRES	=	total crop acres plus total pasture acres

Model (2) examined the annual change in the rate of return to capital managed based on the annual change in gross revenues and expenses per thousand dollars of capital managed. Cost efficiency measures and farm characteristics also were included. The change in rate of return from year to year was used as the dependent variable, instead of standard deviation as in Model (1). The annual changes in government payments per crop acre, gross crop income, gross livestock income, labor expense, crop & equipment expense, livestock expense, and interest expense, per thousand dollar of capital managed, were seven of the independent variables. We hypothesized that increases in the annual changes in government payments, gross crop, and gross livestock would have positive effects on the annual change in the rate of return to capital

managed. However, we expect that an increase in the annual production cost (labor, crop & equipment, livestock, and interest) would have a negative effect on the annual change in rate of return.

The cost efficiency measures (labor, crop & equipment, livestock, and interest), and the farm characteristics (operators age, diversification, leverage, tenure position, and total farm acreage) used in the previous model were also in Model (2), although the variables were now in panel data structure instead of a cross-sectional framework. We believe that as cost efficiency (percentage increase in

costs relative to gross) declined the annual change in rate of return to capital managed also would decrease.

The data set had 6600 observations from 275 farms. One additional farm was dropped from the previous model due to significant lack of observations for operators age variable in all years.

Results and Analysis

Cross-Section Model

The cross-section model was estimated using OLS with STATA Statistical Software. The Breush-Pagan test for heteroskedasticity was used and was determined to be insignificant. The results of Model (1) are reported in Table 1. The standard deviation of labor cost per thousand dollar of capital managed (*SLBRCAP*), the standard deviation of interest cost per thousand dollar of capital managed (*SINTCAP*), crop and equipment expenses per dollar of gross income (*CR&EQ*), age of the operator (*AGE*), debt to equity (*D/E*), and the region variables were not statistically significant. All other hypothesized explanatory variables were significant at an " of .10 or less.

Increases in the standard deviation of government payments per crop acre for each thousand dollars of capital managed (*SGOVCAP*) had positive effects on the standard deviation of the rate of return to capital managed. For example, a $0.01 increase in *SGOVCAP* would result in a 0.25% growth in variability of the rate of return. The parameter appears quite large in comparison with the other gross revenue variables; however, government payments were on per crop acre basis instead of total dollars. Thus, the $0.01 increase in the standard deviation of the ratio of government payments per crop acre to thousand dollars of total capital managed would only be caused by a large change in total government payments. This would greatly impact the standard deviation of the rate of return to capital managed, hence the large parameter estimate.

The standard deviation of gross crop income (*SGCICAP*) and gross livestock income (*SGLICAP*) per thousand dollar of capital managed also had positive effects on the standard deviation of the rate of return to capital managed. An increase in *SGCICAP* had the largest effect on the variability in rate of return. An increase of $1.00 in the standard deviation of the ratio of gross crop income to thousand dollars of total capital managed increased the standard deviation of the rate of return by 0.06%, whereas a similar increase in the gross livestock income ratio increased it by 0.05%. This result is consistent with that reported by Harwood et al. They reported that during the years 1987-1996, price variability was generally higher for crops than livestock. Livestock production per unit generally was more stable than yield per acre.

Only crop & equipment and livestock cost categories were significant. Increasing the standard deviation of crop & equipment costs (*SCNECAP*) and livestock costs (*SLIVCAP*) per thousand dollars of total capital managed decreased the standard deviation of the rate of return to capital managed. This was not the result that was hypothesized, but all four cost categories had a negative coefficient estimate. This might be plausible if those managers who have a higher standard deviation for production costs adjust inputs more to changing economic conditions and, therefore, were better at reducing rate of return variability. In addition, those farms that have greater variability in production costs might have enterprises that are less variable in rate of return to capital managed because the level of gross income is correlated with the production cost.

Two of the four efficiency measures, labor (*LABOR*) and livestock (*LIVE*) per dollar of gross crop and livestock income, had the hypothesized sign and were statistically significant. As labor

efficiency decreased and livestock costs per dollar of gross crop and livestock increased, the standard deviation of the rate of return to capital managed increased. This suggests that as hired labor and livestock costs relative to gross income increase, the variability of the rate of return increases. The sign for crop & equipment costs (*CR&EQ*) for per dollar of gross was as expected, but the coefficient was not statistically significant. However, the sign for interest costs (*INT*) per dollar of gross crop and livestock revenue was negative and significant. This implies that as interest cost efficiency increases, so does the standard deviation of the rate of return to capital managed.

The average age variable (*AGE*) was not significant. Other research has indicated that as farmers aged the standard deviation of the rate of return to capital managed increased. Schurle and Tholstrup presented several possible reasons for this. "It is possible that the operator's experience was overshadowed by inability or unwillingness to extend their labor efforts. Second, the older operator may be less flexible in adjusting to unusual circumstances. Third, older operators may not keep pace with technological advances. Finally, as the operator gets older, his wealth position may increase, so he may not be as risk averse. Thus, he may not be so willing to sacrifice to reduce income variability."

The diversification variable (*DIV*) had a positive sign and was statistically significant. As the amount of diversification increased, the standard deviation of the rate of return to capital managed also increased. This result was not consistent with the prior hypotheses or with portfolio theory. Portfolio theory indicates that the standard deviation can be reduced if diversification takes place with enterprises that are not correlated perfectly. Portfolio theory was developed and tested with liquid investments that are homogeneous across units and have similar attributes like common stocks. Increasing the investment in a crop or livestock enterprise by $10,000 is not the same as increasing the investment in a

stock by $10,000. With stocks, the variance of income per unit is constant as more units are added to the portfolio. This relationship generally does not hold in agricultural enterprises because of size factors. Each unit of common stock behaves the same, but, as has been shown with field segment data from precision agriculture research, each acre of a crop enterprise does not. In addition, different production skills, as well as different equipment and marketing knowledge, are required for different enterprises. Changing the allocation of investments in a portfolio is a simple procedure compared to managing several farm enterprises and adjusting the investment allocated to each. Diversification of farm enterprises may spread the managerial capacity of the producer too much. Interestingly, Coble et al., using a Herfindahl index, found that the degree of crop specialization did not impact a manager's decision to purchase crop insurance. Goodwin also found that a Herfindahl index calculated on sales shares showed no statistically significant relationships to the coefficient of variation for crop yields, with the exception of irrigated sorghum. In that one case, the CV decreased as specialization increased. This model examined the variability in percent returns (rate of return to capital managed), and found similar results to previous work conducted with this data set.

The debt to equity ratio variable (*D/E*) had a negative sign and was not significant. The tenure variable (*RENT*), measured by percent of total acres rented, also had a negative coefficient and was significant at the 5% level. As the percent of total acres rented grew, the standard deviation of the rate of return to capital managed decreased. Tenure was probably significant because rented land value was included in the total capital managed calculations, and, therefore, it was reflected in the rate of return.

The size variable (*ACRES*) was included to address the farm size issue. *ACRES* was significant and positive, although the estimated coefficient was quite small. This indicated that it would take a large change in total acreage for the variability of the rate of return to capital managed to be affected to any great degree.

None of the crop reporting region intercept shifters were significant. The southwest region was used as the default. Therefore, no region had a statistically different intercept from the default.

This cross-sectional model (Model 1) was similar to previous work using net farm income as a measure of farm profitability. Dunn and Williams regressed the standard deviation of net farm income on the standard deviation of gross revenues and production costs, cost efficiencies, and farm characteristics to explain the relative impacts on the variability of net revenue (Table 2). In comparison, both models took a standard deviation approach to evaluate the variability in profits at the farm-level. However, two major differences did exist between the models, in addition to different dependent variables. The gross revenues and costs were scaled by thousand dollars of capital managed under the rate of return to capital managed (RORCAPM) model, and government payments were expressed in dollars per crop acre instead of total dollars, as in the standard deviation of net farm income (STDNFI) model.

The STDNFI model displayed in Table 2 had fewer significant variables but a higher adjusted r-squared value than the RORCAPM model shown in Table 1. Government payments, crop & equipment and livestock costs, livestock and interest expense efficiencies, diversification, and tenure were not significant under the STDNFI, like their counterparts in the RORCAPM. None of the

regional dummy variables were significant in the RORCAPM, but three regional variables were significant in STDNFI.

The actual effects of the estimated coefficients can not be compared directly, but the relative impacts of the parameters on their dependent variable may be contrasted to recognize any unusual differences between the models. Gross crop and gross livestock incomes showed similar effects, both being positive with STDNFI and RORCAPM. This result implied that an increase in the variability of gross crop and gross livestock revenue would increase the variation in profitability. Another interesting comparison was the production costs. With the STDNFI model, two of the four cost categories had positive signs on their coefficients even though only one cost variable was significant, while all four were negative under the RORCAPM model. These inconsistent results left questions remaining about the true effects of cost variability on the variation in profitability. Only labor expense efficiency was significant in both models, but the parameter estimates were positive implying an increase in efficiency would decrease variability of profits. Livestock and interest expense efficiencies, diversification, and tenure had the same signs for both models, although they were not significant for the STDNFI. The farm size variable was positive and significant in both situations, indicating a growth in size would increase the dependent variable.

Panel Data Model

Model (2) was estimated using the *panel* command in the LIMDEP software package, which automatically examined the one-way and two-way, fixed and random effects models for panel data sets. According to the F-test, the one-way (group) fixed effects model did not have a significant impact on the ordinary least squares (OLS) regression; thus, OLS was preferred to the fixed effects model.

However, with the Lagrange Multiplier test the group fixed effects model was favored over the OLS method. Similar conflicting results were discovered when the two-way effects were analyzed. Although the Hausman tests managed to discern that fixed effects were preferred to the random effects, the selection of OLS over fixed effects was unclear. Since the insignificance of the dummy variables was questionable, the coefficient estimates and p-values for the OLS model, group (one-way) fixed effects model, and the two-way (group and time) fixed effects model were displayed in Table 3 for comparison purposes.

Results in Table 3 show that only small changes occurred between the models in most of the coefficient estimates. Nevertheless, with the inclusion of the group (and time) dummy variables, the significance of certain parameters did change. For example, the debt to equity ratio (*D/E*) was only significant ($p \# .10$) under OLS but not with the fixed effects models. The *CR&EQ*, *LIVE*, and *ACRES* variables displayed similar changes in significance. Only the three gross revenue variables, the four production costs, and the interest cost efficiency measure were significant under all three model situations (Table 3).

The first seven independent variables were the annual changes in government payments per crop acre ($A) GOVCAP$), gross crop income ($A) GCICAP$), gross livestock income ($A) GLICAP$), and production costs ($A) LBRCAP$, $A) CNECAP$, $A) LIVCAP$, and $A) INTCAP$), all on a per thousand dollar of capital managed basis. All seven coefficients were highly significant. The revenue variables showed positive effects (i.e., a larger annual change of the revenue sources increased the annual change of the rate of return to capital managed). For instance, under OLS if the annual change in the ratio of government payments per crop acre to thousand dollars of capital managed was

increased by $0.01, then the annual change in the rate of return to capital managed would increase by 0.34%. This result appears quite large, but a $0.01 increase in $\Delta GOVCAP$ would only be caused by a substantial change in total government payments. As well, this parameter could not be compared to gross crop income and gross livestock income because government payments were on a per crop acre basis. Gross crop and gross livestock revenues were in total dollars and may be compared to one another. However, the differences in their estimated coefficients were quite small. Gross livestock was slightly greater under OLS and group fixed effect, while gross crop was barely larger under group and time fixed effects. The parameters for gross crop and livestock implied a $1.00 increase in the annual change of the ratio of gross crop (or livestock) to thousand dollars of capital managed would result in an increase of approximately 0.09% in the annual change of the rate of return to capital managed.

The labor, crop & equipment, livestock, and interest costs per thousand dollar of capital managed had the opposite effect, a negative impact on the dependent variable. This implies that a larger annual change of production expenses results in a decrease in the annual change of net farm income. For example, if $\Delta LBRCAP$ was to increase by $1.00, then the annual change in the rate of return to capital managed would decrease by 0.092%. Crop & equipment and labor had the largest effects under OLS and the fixed effects models, with the magnitude of livestock and interest third and fourth, respectively.

Only one of the four cost efficiency measures, interest expense (*INT*) per dollar of the gross crop and livestock income, was statistically significant under all three model situations (OLS, group fixed effects, and group & time fixed effects). The interest efficiency coefficient decreased slightly as the fixed effects were added to the OLS model, but remained positive throughout. The positive

parameter implied that as the efficiency measure declined, or as the cost per dollar of gross income increased, the annual change in the rate of return to capital managed increased. This was opposite of the expected negative direction. Two of the remaining measures, *CR&EQ* and *LIV*, had varying significance levels for the different model situations. Livestock efficiency was significant under OLS, while crop & equipment was significant with the fixed effects models. Yet, the estimated coefficients were always negative, suggesting that a growth in cost efficiency would increase the annual change of the rate of return. Labor cost efficiency was not significant at the 10% level for any of the model situations.

The coefficient for age (*AGE*) and the diversification coefficient (*DIV*) were only significant under the group fixed effects model. Both significant parameters were also positive, implying that as the operator aged or diversification increased the annual change in the rate of return to capital managed would increase. The debt to equity ratio variable (*D/E*) was significant and positive under OLS, while the tenure variable (*RENT*) was not significant for each model situation. The size variable (*ACRES*) was positive and significant under both OLS and the group effects model. It indicates that an increase of 1,000 in total acres would increase the annual change in the rate of return by 0.15%

The panel data model (Model 2) was comparable to a prior study using net farm income. Dunn and Williams regressed the annual change in net farm income on the annual change in gross revenues and production costs, cost efficiencies, and farm characteristics to explain the relative impacts on the variability of net revenue (Table 4). Both models used panel data to evaluate the variability in profits at the farm-level. However, it was found with the net farm income (ΔNFI) model that random effects models were preferred to fixed effects models, while results from the rate of return to capital managed

(A) RORCAPM) model favored fixed effects over random effects. Other differences between the models include the gross revenues and costs being scaled by thousand dollars of capital managed under the (A) RORCAPM) model, and government payments being expressed in dollars per crop acre instead of total dollars as in the (A) NFI) model.

The A) NFI model displayed in Table 4 had a similar number of significant variables and only slightly higher r-squared values than the A) RORCAPM model shown in Table 3. All of the gross revenue and cost variables were significant in both models, while the cost efficiencies and socioeconomic characteristics varied to some degree between the models. The actual effects of the estimated coefficients can not be compared directly, but the relative impacts of the parameters on their dependent variable may be contrasted to recognize any unusual differences between the models.

The annual changes in the three gross income variables showed similar effects, all being positive with the A) NFI and the A) RORCAPM models. This result implied that an increase in the annual variability of gross revenue would increase the variation in profitability. Another interesting comparison was the production costs. Under both models, all four of the cost categories had negative signs on their coefficients, indicating that an increase in cost variability would decrease the variation in profitability. Only interest expense efficiency was significant in both models, but the parameter estimates were positive, implying an increase in efficiency would decrease variability of profits. Labor efficiency was the only expense measure that was not significant throughout both models. The remaining efficiency measures were significant under the A) NFI model, while significance varied in the A) RORCAPM model. Age also differed in significance between the models, but was always positive. The debt to equity ratio was only significant under OLS for each model, and was positive for both. Diversification

results varied between the models, while tenure was not significant for both. The farm size variable was positive for the A) NFI and A) RORCAPM models, but was only significant in the latter model indicating a growth in size would increase the dependent variable.

Summary and Conclusions

Two models were used in the examination of different factors that might have significant effects on rate of return variability at the farm level. The first model used cross-sectional data and the second employed a panel data approach.

Model (1) showed that increasing the standard deviation of government payments and the gross revenues per thousand dollars of capital managed also increased the standard deviation of the rate of return to capital managed. However, the standard deviation of labor, crop & equipment, and livestock costs per thousand dollars of capital managed had the opposite effect. This may indicate that managerial adjustment in input use reduced risk. Labor and livestock cost efficiencies had positive effects on the dependent variable, meaning a growth in the cost to gross revenue ratio (reduction in efficiency) would increase the standard deviation of the rate of return. Interest cost efficiency had an unexpected negative impact. Diversification had a positive effect, implying more diversification would increase the variability in the rate of return. The tenure variable was negative, while the farm size variable had a positive effect. All of the above effects were significant at " of .10 or less.

Model (1) showed that deviations in gross revenues caused deviations in the rate of return to capital managed, which was expected. Yet, cost deviations appeared to lower the standard deviation of the rate of return. Cost efficiency measures proved important, especially regarding labor and livestock, but interest efficiency had an unusual effect. These results also indicated that diversification

does not always have the anticipated result, and specialization may hold some advantages in reducing rate of return variability. Inferences about the size of a farming operation can be drawn from the results for *ACRES* variable, which implied that size positively effects the standard deviation of the rate of return.

Model (2) was a panel data analysis that focused on the annual changes in the rate of return to capital managed, which was the dependent variable, with annual changes in government payments, gross revenues, and costs as independent variables. Cost efficiency measures and the farm characteristics variables were the same independent variables used in the previous model. As found in the previous models, increased changes in the gross revenues and government payments and decreased changes in cost increased the change in the rate of return to capital managed. The interest expense efficiency measure was positive and significant under OLS and fixed effects models. Although livestock expense efficiency was negative and significant under just OLS, and crop & equipment efficiency was negative and significant for the fixed effects models. Decreases in the efficiency of interest resulted in a larger change in the rate of return, whereas livestock and crop & equipment cost efficiency caused the opposite effect. Age, diversification, and debt to equity ratio all had positive effects; but age and diversification were significant under the groups fixed effects model while debt to equity ratio was only significant with OLS. Farm size also had a positive impact on the annual change in the rate of return, yet was only significant with OLS and group fixed effects. The above findings reaffirmed that reducing the variation in gross revenue and increasing the variation in cost will lower the variability in the rate of return to capital managed. Cost efficiency measures were also important, but, as with the previous model, the effects on the rate of return were uncertain.

Overall, results suggest that rate of return to capital managed variability was related significantly to gross income changes, government payments, and farm size. Of course, gross income changes are largely affected by production variability and price changes. The variability in costs had unexpected negative effects and were significant in the various models. The cost efficiency measures had differing effects and significance with both models. Diversification varied in significance, but implied that more diversification increased the variability in the rate of return. In conclusion, obtaining consistent results and rankings for the socioeconomic variables (cost efficiency measures, age, diversification, debt to equity, and tenure) was difficult. The panel data model suggested that group and time fixed effects were important, and most farm characteristics beyond gross income, government payments, and costs were not as important.

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Figure 1: Farms per county and Kansas crop reporting districts

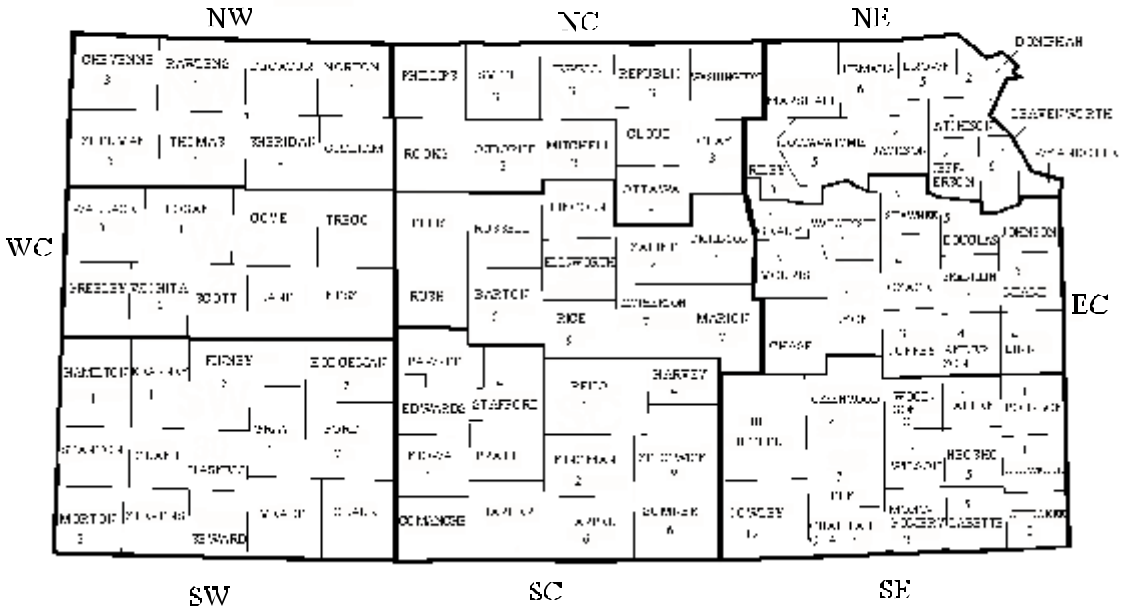

Table 1: Regression coefficients and test statistics with the standard deviations of the rate of return to capital managed as the dependent variable and deviations of gross returns and other farm characteristics as the independent variables.

Independent Variable	Coefficient	t Value	p Value
SGOVCAP((	25.12755	2.336	0.020
SGCICAP((	0.0615875	13.233	0.000
SGLICAP((	0.0464478	12.133	0.000
SLBRCAP	-0.020365	-1.003	0.317
SCNECAP((	-0.0258899	-2.110	0.036
SLIVCAP((	-0.0202076	-3.405	0.001
SINTCAP	-0.0161513	-0.676	0.500
LABOR((	0.0983871	4.278	0.000
CR&EQ	0.0037982	0.671	0.503
LIVE((	0.0078379	2.619	0.009
INT(	-0.016112	-1.681	0.094
AGE	0.0019545	0.079	0.937
DIV((	0.3944141	2.284	0.023
D/E	-0.0341268	-0.613	0.540
RENT((	-2.211133	-2.804	0.005
ACRES(	0.0004204	1.937	0.054
NW	-0.7635341	-0.821	0.413
WC	-1.108736	-0.739	0.460
NC	1.19753	1.264	0.207
C	1.01461	1.277	0.203
SC	0.8070408	1.024	0.307
NE	0.2668134	0.317	0.752
EC	-0.1513777	-0.195	0.846
SE	1.001977	1.369	0.172
intercept	0.3446252	0.165	0.869

N = 276
Adj R^2 = .60

(Variable significant at .10 level, ((variable significant at .05 level.

Table 2: Regression coefficients and test statistics with the standard deviation of net farm income as the dependent variable and standard deviations of gross return, other farm characteristics, and acreage as the independent variables from Dunn and Williams.

Independent Variable	Coefficient	t Value	p Value
SDGOVP	-0.0452406	-0.241	0.809
SDGCI((	0.6159385	11.218	0.000
SDGLI((	0.2704362	5.856	0.000
SDLBR((	0.4764257	2.582	0.010
SDCNE	-0.120736	-1.050	0.295
SDLIV	-0.1075029	-1.647	0.101
SDINT	0.0701833	0.468	0.640
LABOR((	314.5947	2.525	0.012
CR&EQ	-37.69218	-1.134	0.258
LIVE	21.70866	1.305	0.193
INT	-22.65806	-0.387	0.699
AGE	123.1935	0.836	0.404
DIV	1274.507	1.273	0.204
D/E	-416.5711	-1.274	0.204
RENT	-5518.891	-1.191	0.235
ACRES((	8.758487	6.146	0.000
NW((	-13564.12	-2.496	0.013
WC	11927.79	1.346	0.179
NC((	11609.62	2.046	0.042
C	7087.8	1.502	0.134
SC	495.6238	0.109	0.913
NE((	10627.16	2.136	0.034
EC	4068.461	0.848	0.397
SE	5456.598	1.202	0.231
intercept	-9038.781	-0.798	0.426

N = 276
Adj R^2 = .82

(Variable significant at .10 level, ((variable significant at .05 level.

Table 3: Coefficients and test statistics from the panel regression analysis with the annual change in the rate of return to capital managed as the dependent variable and annual changes of gross returns and other farm characteristics as the independent variables.

	No Effects (OLS)		Group Fixed Effects		Groups and Time Fixed Effects	
Variable	Coefficient	p Value	Coefficient	p Value	Coefficient	p Value
A) GOVCAP	33.76519	0.000**	34.08987	0.000**	24.37759	0.000**
A) GCICAP	0.093038	0.000**	0.092991	0.000**	0.091403	0.000**
A) GLICAP	0.094606	0.000**	0.094762	0.000**	0.091316	0.000**
A) LBRCAP	-0.091675	0.000**	-0.093076	0.000**	-0.096694	0.000**
A) CNECAP	-0.094660	0.000**	-0.094911	0.000**	-0.090545	0.000**
A) LIVCAP	-0.078387	0.000**	-0.078726	0.000**	-0.075326	0.000**
A) INTCAP	-0.009954	0.007**	-0.009506	0.012**	-0.008225	0.029**
LABOR	-0.229858	0.299	0.310875	0.202	0.366160	0.128
CR&EQ	-0.032037	0.441	-0.078799	0.075*	-0.099302	0.023**
LIVE	-0.055418	0.048**	-0.010871	0.720	-0.001623	0.957
INT	0.162270	0.020**	0.143146	0.053*	0.136262	0.061*
AGE	0.004033	0.466	0.015549	0.065*	0.004850	0.698
DIV	-0.046682	0.239	0.142044	0.047**	0.107244	0.131
D/E	0.007459	0.073*	0.006134	0.157	0.005227	0.222
RENT	0.194296	0.318	0.082256	0.814	0.040827	0.906
ACRES	0.000158	0.001**	0.000263	0.026**	0.000183	0.125
Intercept	-0.481590	0.227	-	-	-1.178238	0.130
R^2	0.9019		0.9046		0.9077	

(Variable significant at .10 level, ((variable significant at .05 level.

Table 4: Coefficients and test statistics from the panel regression analysis with the annual change in net farm income as the dependent variable and annual changes of gross returns and other farm characteristics as the independent variables from Dunn and Williams.

	No Effects (OLS)		Group Random Effects		Groups and Time Random Effects	
Variable	Coefficient	p Value	Coefficient	p Value	Coefficient	p Value
A) GOVP	0.821665	0.000**	0.821698	0.000**	0.800653	0.000**
A) GCI	0.951815	0.000**	0.951851	0.000**	0.951431	0.000**
A) GLI	0.942908	0.000**	0.943078	0.000**	0.936623	0.000**
A) LBR	-0.922874	0.000**	-0.923001	0.000**	-0.923983	0.000**
A) CNE	-0.891529	0.000**	-0.891477	0.000**	-0.878918	0.000**
A) LIV	-0.860187	0.000**	-0.860065	0.000**	-0.855435	0.000**
A) INT	-0.987056	0.000**	-0.986665	0.000**	-0.959803	0.000**
LABOR	1250.817	0.382	1423.209	0.335	1602.300	0.274
CR&EQ	-664.2633	0.014**	-684.1597	0.013**	-729.0587	0.008**
LIVE	360.2432	0.047**	374.4470	0.045**	394.4003	0.034**
INT	778.5550	0.085*	771.0839	0.096*	768.8463	0.094*
AGE	74.12475	0.037**	78.87431	0.039**	52.21898	0.231
DIV	75.03304	0.769	98.28763	0.723	20.78864	0.940
D/E	44.71583	0.095*	43.37807	0.114	35.91194	0.187
RENT	912.9681	0.467	1014.101	0.458	771.2898	0.570
ACRES	0.309759	0.317	0.326353	0.341	0.250861	0.462
Intercept	-5644.099	0.027**	-6075.691	0.026**	-4088.081	0.195
R^2	0.9106		0.9106		0.9106	

(Variable significant at .10 level, ((variable significant at .05 level.