An Empirical Evaluation of Yield Performance and Cross-Crop Yield Correlation

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Abstract

This analysis considers two aspects of yield performance using a large sample of data collected from individual U.S. farms. In the first, observable farm and operator characteristics are related to relative yield performance. In general, larger, more diversified farms have higher relative yields. In addition, more intensive use of productive inputs tends to be associated with higher yields. In a second segment of the analysis, we focus on the extent to which yield performance for different crops on a single farm tend to be correlated. Our results suggest that farms in major growing regions tend to have greater correlation of crop yields. In addition, larger, more specialized farms tended to have more consistent yield performance across crops. Implications for whole-farm insurance contracts are discussed.

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1 Introduction

The profitability of an individual crop farm depends on a number of factors. Aggregate market conditions are of course important determinants of the profitability of a farm. These conditions are likely to influence producers of a given crop in similar ways. Likewise, aggregate financial conditions are likely to influence large numbers of producers, although those producers that are more highly leveraged may be more vulnerable to such conditions. Finally, yield performance is an important determinant of the overall financial performance of a farm operation. Yield performance is influenced both by observable and latent individual farm and operator characteristics as well as common shocks such as weather, climate, and pest damages.

Factors influencing yield performance may have important implications for policy. In particular, a wide range of highly subsidized (and ever-expanding) crop (and revenue) insurance programs are directed toward providing producers with a means for coping with yield and price shortfalls. To the extent that insurable yields and crop insurance premium rates can be conditioned on observable factors, the performance of insurance programs may be enhanced. Recent policy changes have also made the question of yield performance important as the new planting flexibility brought about by the 1996 FAIR Act led many producers to adopt new crops. This flexibility was maintained in the provisions of the recent 2002 Farm Bill legislation.

Crop insurance rates and guarantees are based on historical production for a given crop and do not consider yield performance relationships across crops. In particular, the amount of yield protection that can be purchased by an individual producer is determined by that producer's historical average yield for the crop in question. This average is known as the "actual production history" (APH) yield and is based upon the arithmetic average of the preceding 4-10 years of actual yields on the farm. Much has been written about the potential inaccuracies inherent in such an approach to insurance contract design (see, for example, Goodwin (1993)). However, regardless of the the validity of such criticisms, it is important to recognize that farm records are generally quite sparse and thus any insurance provider or underwriter is faced with the difficult task of assigning coverage on the basis of very limited information. A key question then pertains to the information that can be brought to bear on the problem of predicting yield performance. To the extent that observable farm factors may be used to condition expectations about yield performance, more accurate contract parameters and insurance rates may be possible. Such conditioning is very common in commercial lines of insurance—a fact that anyone who has applied for life or automobile insurance is well-aware of.

As noted, an important fact underlying the actuarial design of crop insurance rates is that correlation of yields across different crops is not considered. Intuition certainly would suggest that a producer that has had a strong history in producing one crop (say, for example, corn) would be expected to also have strong production if they began producing another crop, such as soybeans. However, the potential for using such information in assessing yield risk and expected yield performance has been ignored in designing and rating crop insurance contracts. The issue assumed much greater relevance after the 1996 FAIR Act, since the Act eliminated the acreage restrictions that had characterized U.S. agricultural policy over most of its history. This planting flexibility, along with highly favorable loan rates for certain crops, brought about a great deal of crop shifting by individual producers. For those producers wishing to participate in the ever-expanding crop insurance program, the result in many cases was a lack of APH yield histories. Producers frequently argued that the yields that they were assigned (essentially the county-average yield) was too low.[1] Of course, for those producers with expected yields beneath the county average, the level of protection assigned under provisions for new producers of a crop would be too high, potentially resulting in

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[1] Producers meeting certain provisions (essentially those that could prove they had not previously produced the crop) could claim 100% of the transition yield parameter, which essentially is the NASS county average. Producers lacking production records are assigned a proportion of this yield.

excessive losses to the insuring agency (i.e., the U.S. taxpayer).

The extent to which crop yields are correlated across crops has also taken on new importance in light of new revenue insurance products, which offer discounts for whole-farm coverage. These products insure whole-farm (i.e., multiple crop) revenues and, to the extent that crop yield realizations are not perfectly correlated, important insurance premium discounts may be implied. Indeed, such discounts are currently present in whole-farm revenue insurance contracts, although the specification of these discounts is largely ad-hoc. In this light, a better understanding of the correlation of yields across different crops is an important research and policy topic.

Yield performance is also of interest in the broader context of understanding factors relevant to the overall financial performance and well-being of U.S. farms. Of course, yields are subject to the randomness of weather, disease, and pest damages. However, such factors (especially weather) typically affect all producers in a geographic area (such as a county). Yet, there is a considerable degree of variability in yields among seemingly similar producers in a given area such as a county. An important fundamental question involves why some producers realize lower yields while their neighbors realize higher yields. Are there observable farm and operator factors relevant to this yield performance? These are the issues that we intend to address in this study.

Recent research by Goodwin, Featherstone, and Zeuli (2002) demonstrated that relative yield performance tends to be associated with a number of observable farm factors, such as diversification, livestock production, and the size of the farm operation. They also determined that a modest learning process was present, where relative yields tend to improve over time. Perhaps most important, they demonstrated that yield performance tends to be highly correlated across crops, though the extent of correlation is highly variable across different crop pairs. This finding has important implications for crop insurance and other farm policies in that yield performance is only considered for single crops in determining policy parameters.

The research of Goodwin, Featherstone, and Zeuli was, however, very limited in that it only considered a relatively small panel of commercial Kansas farms. The objective of this research is to broaden and extend this analysis to consider the extent to which cross-crop yield correlation and yield performance determinants may vary across farm types, crops, and regions of the country. We utilize data taken from the USDA-NASS Agricultural Resource Management Surveys (ARMS) for 1996-2000. We focus on this period in light of the substantial policy environment changes that came about as a result of the 1996 FAIR Act. "Relative" crop yields, defined as the ratio of each farm's yield to the NASS county average yield, are the focus of our analysis.

The objectives of our study are two-fold. First, we consider an analysis of the relationship between farm and operator characteristics and relative yield performance using a large sample of data. Second, we pursue an empirical analysis of how and why such performance may differ across multiple crops grown on an individual farm. This second aspect of our analysis is especially pertinent to crop insurance contract design issues in light of the above-mentioned fact that information regarding performance on one crop is ignored when assigning coverage to another. We also focus on how the correlation patterns may vary across geographic regions (i.e., states).

The outline of our paper is as follows. The next section discusses an empirical modeling framework and discusses our data. Particular econometric considerations involved in our analysis are also discussed. The third section presents the results of our empirical analysis of individual farm data. There are three segments to this analysis—a consideration of individual farm yield performance for specific crops; an evaluation of the relationship of yield performance across alternative crops grown on an individual farm; and a consideration of how yield correlations may vary across crop pairs and across different states.

2 Empirical Framework and Data

Our analysis utilizes data collected from a large sample of U.S. farms. The data were collected under the Agricultural Resource Management Survey (ARMS) project by the National

Agricultural Statistics Service of the USDA. We focus on data taken from four years of the NASS survey—1996-2000. These years were chosen as representative of the FAIR Act policy environment. The ARMS surveys collect detailed information regarding farm and operator characteristics. In addition to the micro farm level data, we also collected county data for crop yields from the NASS database. Our overall data set is comprised of 19,337 individual annual farm observations. Of course, every farm we consider did not produce every crop evaluated in our study.

Our analysis investigates three aspects of the relative yield performance for six different crops—corn, wheat, soybeans, grain sorghum, cotton, and barley. Our overall objectives are two-fold. We first evaluate observable farm and operator characteristics that are correlated with the relative yield performance for producers of these six crops. Inferences drawn from this analysis may be useful in refining crop insurance actuarial and contract design methods. In particular, to the extent that observable farm characteristics may be associated with higher or lower relative yields, refinements in actuarial methods may result in more accurate premium rates and insurance guarantees. A second component of our analysis focuses on factors related to differences in the relative performance across crop pairs for farms that produce multiple crops. This aspect of our analysis is relevant to the fact that current actuarial practices used in constructing crop insurance contracts and premium rates only consider yield performance for a single crop. Information about the history of one crop is completely ignored when considering another crop. In this segment of the analysis, we first consider a simple correlation matrix for normalized crop yields. We then consider the extent to which this correlation is constant across space. In particular, an informal graphical analysis of spatial differences in this correlation structure is considered. Finally, we evaluate the squared differences of relative yields across pairs of crops. Our goal is to identify factors that may be associated with the degree to which yields for different crops follow one another. Again, information regarding the extent to which yield performance for one crop is similar to that of another may be important in structuring multiple crop insurance contracts—the ultimate goal of this line of research.

Of course, yields cannot be compared over space and across time without normalization. The effects of localized weather events and deterministic time effects associated with yield trends are inherent in the yields realized by any farmer in a given year. To compensate for such effects, we normalize each individual farm's yield by dividing by the average yield for the county in which the farm is located. National Agricultural Statistics Service (NASS) county average yields are used in the normalization. Thus, our empirical analysis of yield performance utilizes normalized crop yields for individual producers:

$$\hat{y}_{itj} = y_{itj}/\bar{y}_{tj}, \tag{1}$$

where $\hat{y}_{itj}$ is the normalized yield for farmer i of crop j in year t, y_{itj} is the actual observed yield, and $\bar{y}_{jt}$ is the NASS county average yield for all producers of crop j in farmer i's county. Of course, by construction, our index of yield performance should have a mean close to one (to the extent that the farms in the ARMS sample are representative of the county they are located in).

Perhaps of greater importance is our measure of yield performance differences for multiple crops grown on a single farm. Many different measures of the variability in yield performance across crops are conceivable. We choose to represent this difference (across pairs of crops) by using the squared difference in normalized crop yields:

$$\hat{d}_{itjk} = (\hat{y}_{itj} - \hat{y}_{itk})^2. \tag{2}$$

Before proceeding to our empirical analysis, it is essential that we acknowledge one important limitation of our analysis of the ARMS data. Crop yield data are collected without regard to crop practice types. Of course, observable farm characteristics (such as equipment expenses) are important indicators of crop practices. We are, however, limited in our ability to directly measure such factors and must rely upon our observable characteristics to capture yield differences related to crop practices. This may be less of a concern in considerations of yield relationships across different crops since such unobserved factors may be expected to affect different crops on a farm in similar ways, though this is by no means guaranteed.

A number of important econometric issues underlie our empirical analysis. An important characteristic of the ARMS data relates to the stratified nature of the sampling used to collect the data. Various estimation approaches have been suggested for problems such as this involving stratification. In our case, we utilize weighted regression techniques that account for the stratified sampling used in collecting the ARMS data. The ARMS database contains a population weighting factor, representing the number of farms in the population (i.e., all U.S. farms) represented by each individual observation. This can be used in a probability-weighted sampling scheme whereby the likelihood of being selected in any given replication is proportional to the number of observations in the population represented by each individual ARMS observation.[2] It should be acknowledged that our approach may result in less efficient estimates than would be the case were sampling from individual strata possible. This could occur in cases where inferences are being made about variables used in designing the stratification scheme in that such information is being ignored by not drawing from individual strata. To the extent that this is relevant to our analysis, the t-ratios reported below represent conservative estimates.

Summary statistics for variables of interest are presented in Table 1. Individual producer yields appear to be relatively similar to what was experienced for the county as a whole in that the averages of the normalized yields are typically quite close to one. Of course, not every producer grows every crop. Corn is by-far the dominant crop in our sample, followed closely by soybeans. A large number (10,204) of producers grew both corn and soybeans. The typical farm is fairly well diversified, as is represented by a Herfindahl index of crop acreage diversification. Likewise, the typical proportion of the overall farm accounted for by each particular crop ranges from a high of about 44% for cotton to a low of 11% for grain sorghum. The summary statistics indicate that the typical farm consists of about 50% rented acreage and 50% owned acreage. In that we only consider farms with at least 50 acres of crop land, the relative proportion of overall sales accounted for by livestock products is low, averaging about 22%. The largest share of total production expenditures is accounted

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[2] An extended version of this paper uses a probability-weighted bootstrapping estimation and inferential procedure.

for by fertilizer, with labor and equipment expenditures accounting for considerably smaller shares of production costs.

Table 2 presents Pearson correlation statistics for the normalized crop yields. As would be expected, a high degree of correlation is apparent across the different crop pairs. However, this degree of correlation varies considerably across the alternative crop pairs. Corn and soybean yields are highly correlated, with a coefficient of 0.42. Likewise, wheat and barley yields appear to be highly correlated with one another, having a correlation coefficient of 0.46. A high degree of correlation between barley and soybean yields is revealed, although the number of producers growing both commodities (276) is quite small. Lesser degrees of correlation are revealed for corn and wheat, corn and cotton, wheat and soybeans, and soybeans and grain sorghum, though in each case the correlations coefficients are highly significant. In all, this simple consideration of yield correlation does confirm that crop yields for various crops grown on the same farm tend to be highly correlated, though the degree of correlation varies considerably across crops.

2.1 Yield Performance

Table 3 presents the results of a simple regression analysis of relative yield performance. Although the yields are normalized to account for annual yield shocks common across all farms in the county, we have also included a set of dummy annual effects variables. F-tests of these fixed annual effects (Table 3) confirm their statistical significance in every case. Although the R^2 terms are low, they are certainly reasonable given the very large number of observations and the cross-sectional nature of our data. Overall regression F-statistics are highly significant in every case, confirming that the conditioning factors represented by the regressors are statistically significant as a group.

Our regression models include two factors that represent the scale of production. The first is the total number of acres of the crop in question. The second is a measure of overall farm scale–the total number of crop acres. The measures are undoubtedly correlated, though the large samples will hopefully allow us to identify each effect. An extensive literature has considered the relationship between farm size and productivity. A so-called "inverse productivity puzzle" has frequently been noted, especially in developing countries, where yields are frequently observed to decrease as farm size rises. This inverse productivity relationship has been confirmed by many authors, including Benjamin (1995) (rice farmers in Java) and Barrett (1996) (Madagascar rice farmers).[3] Recent research by Lamb (2002) suggests that measurement error may play an important role in the implied relationships for size and productivity.

Our empirical results do not provide especially strong support for any such inverse productivity relationship for U.S. farmers. Of course, this is not surprising since the factors generally assumed to explain the puzzle (e.g., labor market failures) are not generally applicable to U.S. agriculture. In general, the results suggest that greater specialization (as represented by the proportion of total acres involved in producing the crop in question) does tend to be associated with higher yields, at least for corn, wheat, and grain sorghum. Only in the case of barley is a significant negative result suggested. In terms of total farm size, larger farms tend to have stronger relative yields, though the effect is statistically significant only in the case of corn and wheat. Greater production of the specific crop, holding other factors constant, tends to be associated with lower yields for corn and wheat.

An interesting finding is that farms that produce relatively more livestock commodities tend to have lower relative crop yields. However, this effect is statistically significant only in the cases of corn and cotton. A similar result was obtained by Goodwin, Featherstone, and Zeuli (2002) for Kansas crop farms. This may suggest that farmers producing more livestock tend to allocate a lower effort to crop production, though it is important to also note that our models condition yields on input usage. It is also possible that patterns of production, vis-a-vis livestock versus crops, reflect comparative advantages, such that land with lower yield capacity is more likely to be used for livestock production.

Diversification, as measured by a Herfindahl index of diversification, tends to be associated with stronger relative yield performance. In five of the six cases, more diversified farms

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[3] A somewhat dated review of the literature is presented by Berry and Kline (1979).

tend to realize higher yields. The operator's age tends to have a negative association with relative crop yields. The age effect is statistically significant for corn, wheat, soybeans, grain sorghum, cotton, and barley. An obvious explanation for this robust result is unclear, though it may be associated with different production patterns that are inherent in different generations of farmers. Goodwin and Schroeder (1995) demonstrated that younger farmers are more likely to participate in educational programs and to adopt new marketing procedures. The lower typical yields for older farmers may reflect a similar relationship.

The empirical estimates imply mixed results for the relationship between tenure and yield performance. In the case of corn and wheat, farms with a greater proportion of owned acreage tend to have lower relative yields. The opposite effect is implied for cotton and grain sorghum. A priori, the expected effect of tenure on yield performance is unclear.

The intensity of input usage (fertilizer and agricultural chemicals, labor, and equipment) generally exhibits the expected effects on yield performance. In four of the six cases, more fertilizer usage (as a percentage of overall farm production costs) tends to result in higher yields. This effect is statistically significant in every case except for soybeans and grain sorghum. The effect for soybeans may not be too surprising given the relatively modest fertilizer needs associated with soybean production.

A similar effect is confirmed for labor, where higher labor expenditures (as a proportion of overall farm costs) tend to be associated with higher yields. In the case of equipment, significant positive effects of higher relative expenditures on equipment are implied for corn and soybeans while a negative relationship is suggested for wheat. Of course, it is important to again note that the input usage indicators are all expressed in relative terms (i.e., relative to total farm expenditures). Higher applications of fertilizer, for example, may not be fully captured in this measure if fertilizer accounts for a very large share of total production costs.

2.2 Yield Correlation

Table 4 presents parameter estimates and summary statistics for our evaluation of the squared differences in relative (normalized) yields across pairs of crops. Sufficient observations were available to consider farms that grew corn and soybeans, wheat and soybeans, soybeans and barley, and cotton and soybeans. As might be expected, greater specialization in one or the other crop tends to lower the degree of difference between normalized yields. Greater specialization in these crops tends to suggest less production of other alternative crops and thus may correspond to a concentration of effort that leads to similar yield performance.

However, diversification, as measured by the Herfindahl index, tends to lower relative yield differences. The diversification effect is significant in the cases of corn-soybeans, wheat-soybeans, and soybeans-barley. The scale of production tends to have varying effects on yield performance relationships across different crops. In the case of farmers producing both corn and soybeans, more corn production increases the difference in corn and soybean yields while more acreage of soybeans has the opposite effect. In the case of wheat and soybeans, more acreage of each crop tends to lower yield differences, though total farm acreage has the opposite effect. This is as expected since larger farms likely realize a greater degree of spatial separation between crop fields.

No statistically significant effect on normalized yield differences is revealed for livestock production, tenure, and equipment expenditures. Operator age has a positive effect on yield differences for corn/soybean and cotton/soybean producers. In contrast, a negative effect is revealed for wheat and soybeans. Greater fertilizer and agricultural chemical intensity is correlated greater corn and soybean yield differences, but has no significant effect on other crop combinations. More intensive use of labor, as is represented by a larger labor cost share, is correlated with greater yield differences for corn-soybean and wheat-soybean growers. However, the opposite relationship is implied for cotton-soybean growers.

In all, the results suggest that the effects of observable farm and operator characteristics on relative yield performance differences vary considerably, depending on the particular crop combinations being considered. In terms of the potential for adjusting corrections for correlation of yields in multi-crop insurance products, such as whole-farm revenue coverage, these results may hold some promise. However, further refinements in the models are needed in light of the fact that, in most cases, the models do a relatively poor job in explaining crop yield correlations.

It is also of interest to consider the extent to which the correlation of normalized crop yields may vary across different regions and growing areas. To this end, we considered state averages of Pearson correlation coefficients for pairs of normalized crop yields. Figure 1 illustrates the degree of correlation between normalized corn and soybean yields. Distinctive spatial patterns are obvious. In major growing regions (i.e., the Corn Belt), correlation is very high. As one moves into minor growing regions, this correlation decreases. A similar illustration is presented for wheat and soybeans in Figure 2. In this case, spatial patterns of correlation are not as obvious. However, wheat and soybeans are not crops that are prominently grown in pairs as is the case for corn and soybeans. Figure 3 presents state average correlations for wheat and barley, crops that are often grown together. A high degree of correlation is apparent for yields, especially in the major growing regions in the Northwest and in California.

3 Concluding Remarks

The objective of our analysis was to consider two aspects of relative yield performance. In the first segment of the analysis, we focused on the extent to which the yield performance on individual farms is related to observable farm and operator characteristics. In general, we found that larger farms have higher relative yields. Diversification of a farm tends to correspond to higher relative yields. This may reflect benefits associated with crop rotations or other farming practices related to diversification. As expected, more intensive use of productive inputs tends to be associated with higher yields.

In the second segment of our analysis, we considered the more difficult issue of differences in yield performance across different crops on a single farm. Our results, though preliminary, were somewhat disappointing. In general, our analysis suggests that the relationship between yields for a pair of crops varies substantially, depending on the particular crops being considered. Larger, more specialized farms tended to have more consistent yield performance across crops. Beyond scale and diversification effects, substantial differences in the degree of similarity in crop yields existed across different crop pairs. We also considered the extent to which correlation of crop yields tended to vary across different growing regions. As might be expected, yield correlation is strongest in the major growing regions of the country. For example, corn and soybean yields are highly correlated in the Corn Belt, though this correlation tends to diminish as one moves outside of the major Midwest growing region.

Though this work is preliminary, the results may have important implications for the design and construction of multi-crop insurance contracts. In particular, an understanding of correlation and the overall determinants of yield performance may contribute toward more accurate premium rates and more effective insurance contracts.

Table 1. Variable Definitions and Summary Statistics

Variable	Definition	n	Mean	Std. Dev.
μ_{it} corn	Normalized yield for corn	13,046	0.9874	0.2590
μ_{it} wheat	Normalized yield for wheat	10,970	1.0120	0.3406
μ_{it} soybeans	Normalized yield for soybeans	12,372	1.0187	0.2627
μ_{it} sorghum	Normalized yield for sorghum	1,679	0.9321	0.4984
μ_{it} cotton	Normalized yield for cotton	1,149	0.9224	0.4266
μ_{it} barley	Normalized yield for barley	1,186	1.0148	0.3437
Corn Proportion	Acreage share for corn	13,046	0.3788	0.1911
Wheat Proportion	Acreage share for wheat	10,970	0.3553	0.2885
Soybeans Proportion	Acreage share for soybeans	12,372	0.3990	0.1877
Sorghum Proportion	Acreage share for sorghum	1,679	0.1093	0.1656
Cotton Proportion	Acreage share for cotton	1,149	0.4307	0.2269
Barley Proportion	Acreage share for barley	1,186	0.1813	0.1363
Corn Acres	Corn acres (thousands)	19,337	0.2438	0.4766
Wheat Acres	Wheat acres (thousands)	19,337	0.2669	1.0213
Soybean Acres	Soybean acres (thousands)	19,337	0.2624	0.4427
Sorghum Acres	Sorghum acres (thousands)	19,337	0.0334	0.2309
Cotton Acres	Cotton acres (thousands)	19,337	0.0604	0.2821
Barley Acres	Barley acres (thousands)	19,337	0.0203	0.1161
Diversification	Herfindahl index of diversification	19,337	0.5260	0.1816
Total Acres	Total harvested acres	19,337	1.0732	1.4594
Livestock Ratio	Livestock sales / total sales	19,337	0.2195	0.8701
Age	Operator age	19,337	51.2971	11.8919
Fertilizer	Fertilizer expenditures / total expenditures	19,337	0.3134	0.1636
Labor	Labor expenditures / total expenditures	19,337	0.0833	0.1034
Tenure	Owned acres / total acres	19,337	0.4757	0.3266
Equipment	Equipment expenditures / total expenditures	19,337	0.0631	0.1643

Table 2. Pearson Correlation Coefficients for Normalized Yields[a]

	Corn	Wheat	Soybeans	Sorghum	Cotton	Barley
Corn	1.0000	0.2469	0.4177	0.2637	0.2176	0.1679
	—	[0.0001]*	[0.0001]*	[0.0001]*	[0.0001]*	[0.0026]*
	13,046	5,784	10,204	757	707	319
Wheat		1.0000	0.2598	0.1703	0.1346	0.4578
		—	[0.0001]*	[0.0001]*	[0.0018]*	[0.0001]*
		10,970	5,647	1,282	534	1080
Soybeans			1.0000	0.2234	0.0180	0.4745
			—	[0.0001]*	[0.5954]	[0.0001]*
			12,372	774	873	276
Sorghum				1.0000	0.2821	—
				—	[0.0188]*	—
				1,679	69	0
Cotton					1.0000	—
					—	—
					1,149	1
Barley						1.0000
						—
						1,186

[a] Numbers in brackets are p-values for test that $\rho = 0$ An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level. Numbers beneath the p-values are the number of farms that produced the pairs of crops.

Table 3. Parameter Estimates and Summary Statistics:

Determinants of Relative Yield Performance[a]

Variable	Corn	Wheat	Soybeans	Sorghum	Cotton	Barley
Crop Proportion	0.2395	0.0909	−0.0407	0.1371	−0.0221	−0.2060
	(0.0132)*	(0.0165)*	(0.0165)*	(0.0725)*	(0.0613)	(0.1143)*
Specific Crop Acres	−0.0186	−0.0381	0.0668	0.0172	−0.0225	−0.0145
	(0.0067)*	(0.0084)*	(0.0126)*	(0.0320)	(0.0305)	(0.0693)
Diversification	0.2114	0.1077	0.0263	0.2529	0.1953	0.1323
	(0.0175)*	(0.0218)*	(0.0201)	(0.0864)*	(0.0640)*	(0.0719)*
Total Acres	0.0260	0.0428	0.0058	0.0004	0.0147	0.0121
	(0.0037)*	(0.0057)*	(0.0043)	(0.0053)	(0.0167)	(0.0169)
Livestock Ratio	−0.0038	−0.0013	0.0020	0.1035	−0.1004	0.0234
	(0.0019)*	(0.0081)	(0.0030)	(0.1418)	(0.0429)*	(0.0099)*
Age	−0.0008	−0.0011	−0.0007	−0.0029	−0.0024	−0.0017
	(0.0002)*	(0.0003)*	(0.0002)*	(0.0012)*	(0.0008)*	(0.0008)*
Fertilizer	0.0791	0.2223	0.0149	−0.1500	0.2744	0.3686
	(0.0139)*	(0.0213)*	(0.0157)	(0.1073)	(0.0748)*	(0.0661)*
Labor	0.1790	0.2649	−0.0064	0.1410	0.1312	0.6810
	(0.0281)*	(0.0365)*	(0.0323)	(0.1529)	(0.1162)	(0.1194)*
Tenure	−0.0138	−0.0209	0.0051	0.2771	0.0584	−0.0229
	(0.0066)*	(0.0103)*	(0.0073)	(0.0428)*	(0.0315)*	(0.0316)
Equipment	0.0251	−0.0534	0.0740	0.0112	−0.0026	−0.0262
	(0.0132)*	(0.0112)*	(0.0130)*	(0.0370)	(0.0442)	(0.0466)
R^2	0.0441	0.0419	0.0150	0.0955	0.2505	0.0791
F-Statistic	42.94*	34.21*	13.44*	13.53*	29.18*	7.75*
F-test of Fixed Year Effects	7.57*	10.19*	2.52*	29.97*	103.76*	8.73*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 4. Parameter Estimates and Summary Statistics:

Determinants of Relative Yield Performance Differences[a]

Variable	Corn/ Soybeans	Wheat/ Soybeans	Soybeans/ Barley	Cotton/ Soybeans
Crop 1 Proportion	−0.2452	0.0219	−0.1863	−3.2899
	(0.0356)*	(0.0222)	(0.0498)*	(0.8865)*
Crop 2 Proportion	−0.1272	−0.0446	−0.1452	−1.0673
	(0.0377)*	(0.0257)*	(0.0785)*	(0.7953)
Crop 1 Acres	0.0530	−0.0218	−0.0041	0.3536
	(0.0217)*	(0.0096)*	(0.0299)	(0.2561)
Crop 2 Acres	−0.0931	−0.0665	0.0565	−0.7659
	(0.0265)*	(0.0183)*	(0.0490)	(0.2848)*
Diversification	−0.1148	−0.1134	−0.2885	−1.5616
	(0.0556)*	(0.0350)*	(0.0664)*	(0.9710)
Total Acres	0.0023	0.0190	−0.0128	−0.0088
	(0.0086)	(0.0084)*	(0.0188)	(0.0345)
Livestock Ratio	0.0036	0.0027	−0.0023	−0.9590
	(0.0052)	(0.0112)	(0.0067)	(1.4892)
Age	0.0007	−0.0007	−0.0007	0.0216
	(0.0004)*	(0.0003)*	(0.0006)	(0.0091)*
Fertilizer	0.0803	−0.0275	−0.0049	−1.3774
	(0.0303)*	(0.0236)	(0.0468)	(0.8568)
Labor	0.2206	0.0739	0.0270	−2.5770
	(0.0651)*	(0.0401)*	(0.0756)	(1.1841)*
Tenure	−0.0175	0.0274	0.0189	−1.0383
	(0.0141)	(0.0105)	(0.0218)	(0.3268)
Equipment	−0.0117	−0.0073	−0.0078	−0.1953
	(0.0261)	(0.0175)	(0.0332)	(0.2321)
R^2	0.0101	0.0127	0.0555	0.0730
F-Statistic	6.51*	4.52*	4.17*	4.50*
F-test of Fixed Year Effects	2.07*	2.21*	9.35*	6.41*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

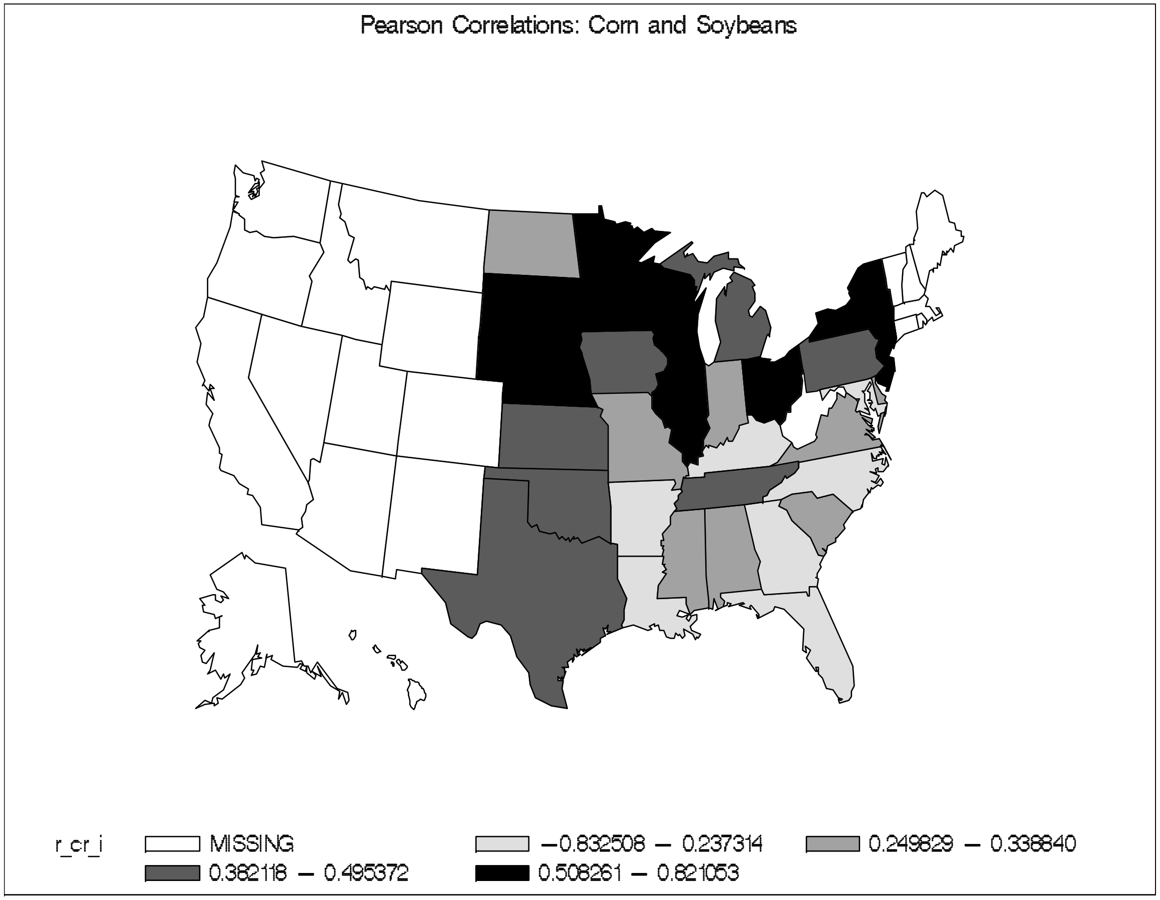

Figure 1: Geographic Differences in Correlation: Corn and Soybeans

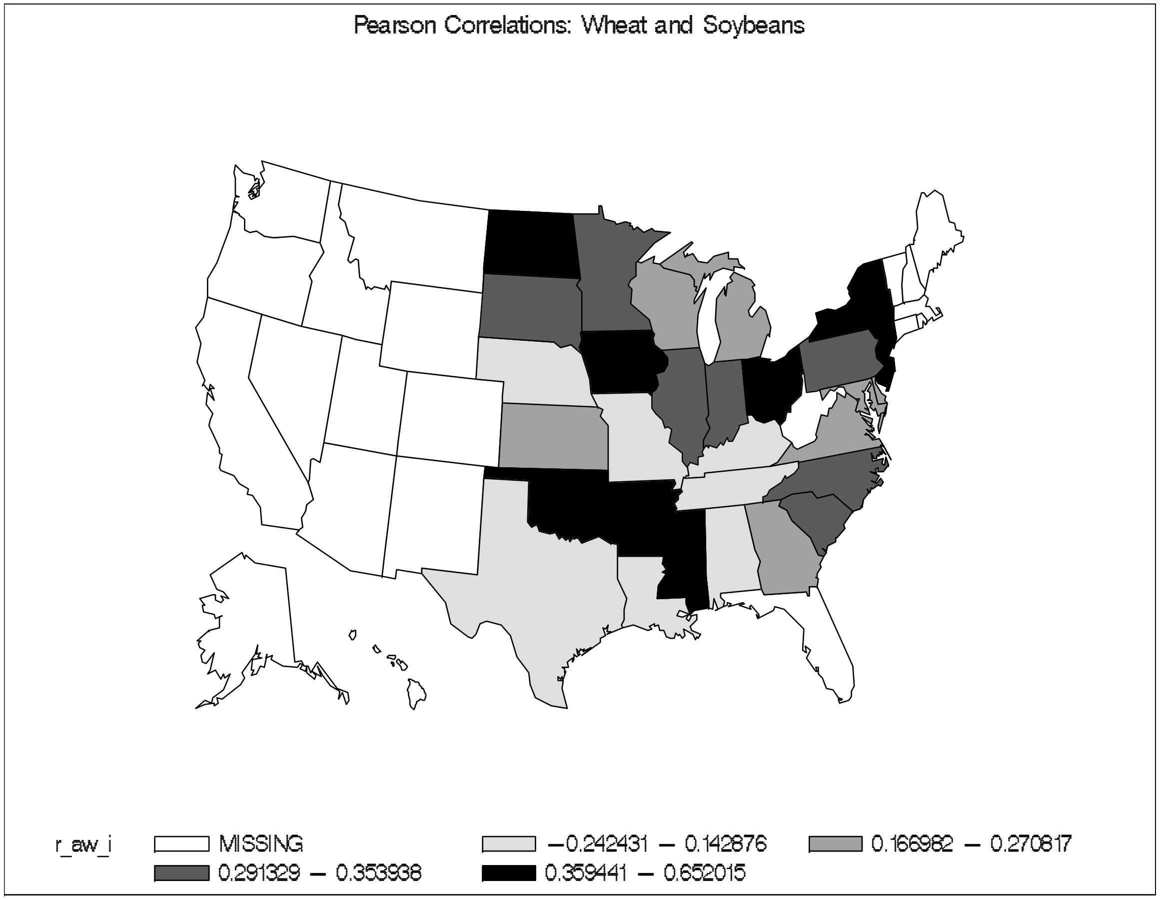

Figure 2: Geographic Differences in Correlation: Wheat and Soybeans

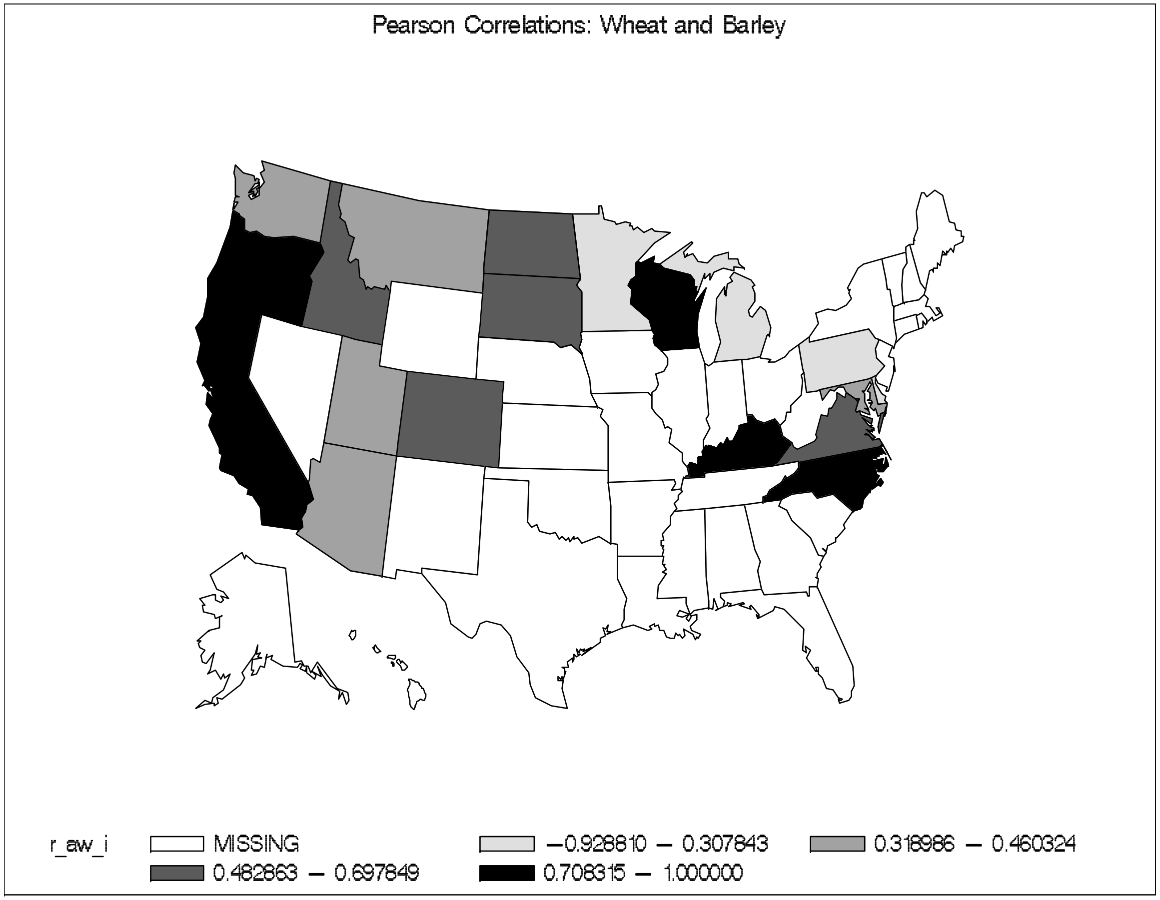

Figure 3: Geographic Differences in Correlation: Wheat and Barley

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