International Food and Agribusiness Management Review
Volume 25, Issue 4, 2022; DOI: 10.22434/IFAMR2021.0051

Received: 26 April 2021 / Accepted: 11 February 2022

Risk and return of heterogenous farmland locations and qualities

RESEARCH ARTICLE

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Abstract

Using data on farmland values in Indiana and Iowa, this study examines the risk and return characteristics surrounding top, medium, and poor farmland qualities in different locations in these two states. We find that systematic risks of locations/qualities are very low (indistinguishable from 0). In terms of risk-adjusted return, our results show that Indiana farmland has more excess return and higher reward-to-risk ratios than Iowa. Also, adding the quality dimension to the geographic dimension in portfolio selection strategies improved the portfolio reward-to-risk ratio for Indiana but not for Iowa. Interestingly, we found that the average quality farmland has more weight in portfolios relative to top- and poor-quality farmland.

Keywords: farmland, farmland quality, minimum-variance (min-var) portfolio, reward-to-risk ratio, capital asset pricing model (CAPM)
JEL code: G11, G12, Q14, Q24

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1. Introduction

Farmland represents more than 80% of the aggregate U.S. farm balance sheet (Burns *et al.*, 2018). Being the dominant agricultural asset coupled with the recent surge in farmland prices has encouraged practitioners and researchers to conduct economic and investment analysis of farmland as an asset class like other traditional asset classes (i.e. stocks and bonds). Favorable investment features of farmland investment highlighted in the literature include, but are not limited to, higher return compared to other non-agricultural assets, low systematic risk (β): low correlation with other traditional asset classes, and a hedge against inflation (Baker *et al.*, 2014; Barry, 1980; Bjorson and Innes, 1992; Chen *et al*, 2015; Irwin *et al.*, 1988). In almost all of these studies, farmland data were either at the national or regional levels, and did not account for heterogenous land quality. Therefore, the main aim of this paper is to decompose the farmland performance into the performance of different farmland qualities in different geographical regions. Specifically, we revisit the asset pricing and portfolio selection models employed in the previous studies to explore the portfolio performance of farmland locations/qualities.

The typical criteria used to differentiate farmland quality is soil quality. Two Corn Belt states are considered: Indiana and Iowa. We investigate whether the above features of farmland investment still hold when we decompose farmland into three quality levels (poor, average, and top) for different regions in these states. We estimate the return, volatility, and the systematic risk (β) of each of the different locations/qualities of farmland in the two states. In this regard, we take advantage of two farmland surveys published in Indiana and Iowa that report cash rent and farmland values for each location/quality in Indiana and Iowa. Also, we use a portfolio approach to farmland investment with two dimensions, geographic location and quality. Using each farmland quality/location category as an asset class, we determine the optimal portfolios composed of different weights for these asset classes. The general approach is similar to Lins *et al.* 1992) who examined the geographic diversification of farmland across twenty-eight U.S. states. We extend their work by combining the farmland quality dimension with the location dimension and forming a portfolio of farmland based on these two dimensions. Also, the geographic location in Lins *et al.* 1992) is defined by state while our geographic location is defined by regions within states. Our motive for using a portfolio approach for farmland investment is to enable investors to garner better insights pertaining to farmland investment. In addition to our portfolio analysis, we use the capital asset pricing model (CAPM) to examine the performance of each land location/quality when added to a diversified portfolio of other assets.

In a nutshell, this study provides an answer to the following research question: what is the portfolio performance of heterogenous farmland locations/qualities? We provide a significant contribution to the farmland investment literature by paving the path for examining the portfolio performance of heterogeneous farmland (i.e. quality and location heterogeneity).

Our findings show that systematic risks of locations/qualities in Indiana and Iowa are indistinguishable from 0. This result is shared by the general literature on risk and return of farmland. In terms of risk-adjusted return, our results show that Indiana farmland has more excess return and higher reward-to-risk ratios than Iowa. Also, adding a quality dimension to the geographic dimension in portfolio selection strategies showed mixed results: it improved the portfolios' reward-to-risk ratio for Indiana, but not for Iowa. An interesting finding is that the average farmland quality in Indiana has the dominant weight in different portfolio strategies relative to poor- and top-quality farmland.

2. Literature review

This study is related to two main strands of literature. The first strand involves studies examining the relationship between soil quality and farmland prices and /or returns. Intuitively, the better the soil quality, the higher the farmland price and higher operating return per acre. However, we argue that this does not necessarily imply that the better the soil quality, the better the diversification potential. The second strand is the portfolio selection and asset pricing studies that investigate the investment performance of farmland relative to other assets, like stocks, bonds and real estate.

2.1 Land value and soil quality

Several studies have investigated the relationship between farmland characteristics and values. One of the key characteristics that is relatively common among previous studies is soil quality. Indeed, soil characteristics are expected to have an important role in farmland productivity and farmland value. Empirical evidence mostly substantiates this relationship. Miranowski and Hammes (1984) attempted to address whether soil characteristics are capitalized into farmland values. Using both transaction and survey data, they found that three measures of soil characteristics (top soil depth, RKLS, and pH[1]) have a statistically and economically significant effect on farmland value in Iowa. Similar results were found by Gardner and Barrows (1985).

Miranowski and Hammes (1984) and Gardner and Barrows (1985) motivated a line of literature examining the impact of improvements in farmland characteristics on its value. In this vein, the findings are mixed. For instance, Palquist and Danielson (1989) used a hedonic model to examine the impact of erosion control and drainage on land value in North Carolina. Their findings indicate that improving soil quality is an important determinant of farmland price, however, its effect is radically reduced in farmland that is subject to urban conversion. Ervin and Mill (1985) showed that erosion control has mixed effects on farmland prices. They concluded that farmland markets can succeed in transmitting the appropriate signals on the soil erosion effect given that this information is available.

Other recent studies confirmed the role of soil quality on farmland value. For example, Nickerson *et al.* 2012) found a strong positive correlation between farmland values and soil quality in Corn Belt, Lake States, and North Dakota and a negative relationship between farmland and soil quality in the Appalachian region. Sklenicka *et al.* (2013) show that the one of the key factors affecting farmland prices in the Czech Republic is soil quality. Ma and Swinton (2012) applied the hedonic method to value farmland in Southwestern Michigan using both appraisal and transaction data. Their results suggest that there is significant emphasis on the soil quality in the appraisal of farmland values. Our study will contribute to this line of literature by looking at the portfolio performance, as opposed to the individual performance, of different farmland qualities.

2.2 Portfolio of farmland and other assets

Over the last three decades, farmland has been regarded as an attractive asset class to non-agricultural investors, particularly institutional investors. Thus, a lot of academic interest has been directed toward assessing the risk and return of farmland. This is primarily done by applying asset pricing and portfolio theory to farmland investment. The farmland portfolio selection literature involves two lines of thought.

The first one involves ‘independent’ farmland diversification. By independent we mean forming a portfolio of only one asset class which in our case is farmland, irrespective of other asset classes. This involves studies that looked at geographic diversification of farmland. For example, Lins *et al.* (1992) formed a farmland portfolio based on farmland in 28 states. Hardin and Cheng (2002) conducted a formal test of whether there was a significant difference between portfolio performance of a farmland portfolio formed based on the mean-variance rule compared to the naïve equal weighted geographic allocation rule. Their results suggested that there is no significant difference between the two allocation methods.

The second line of thought examines the portfolio performance of the traditional asset classes when farmland is added to the portfolio (e.g. Hardin and Cheng, 2002; Lins *et al.*, 1992; Wan *et al.*, 2015). The common finding of these studies is the existence of diversification benefits when farmland is added to a portfolio containing traditional assets, such as stocks and bonds.

[1] RKLS is a measure of the potential soil erosion and pH is a measure soil acidity.

3. Methods

Our primary goal is to investigate whether the previously mentioned favorable investment features of farmland still hold when we use different land qualities. The minimum-variance (min-var) portfolio selection model is applied to a portfolio of farmland locations/qualities. A typical M-V model is as follows:

$$\min_{X} \boldsymbol{X}^{`}\,\Omega\,\boldsymbol{X} \tag{1}$$

$$S.T\ \ \boldsymbol{X}^{`}\mathbf{1} = 1. \tag{2}$$

where X is the vector of asset weights, Ω is the covariance matrix of the returns of the assets considered. In this problem we minimize the portfolio risk X`ΩX. The only constraint (Equation 2) implies that all asset weights should sum to one. We also consider the naïve equal weight portfolio, and the maximum reward-to-risk portfolio. In an equal weight portfolio, each constituent has the same weight in the portfolio. The maximum reward-to-risk portfolio has the following model:

$$\max_{X} \frac{\boldsymbol{X}^{`}\mathrm{C}}{(\boldsymbol{X}^{`}\,\Omega\,\boldsymbol{X})^{1/2}} \tag{3}$$

$$S.T\ \ \boldsymbol{X}^{`}\mathbf{1} = 1. \tag{4}$$

The numerator of the objective function is the portfolio return while the denominator is the standard deviation (volatility) of the portfolio return.

In addition, we estimate the beta of each farmland location/quality. We use the CAPM developed by Sharpe and Lintner to estimate the systematic risk for each farmland location/quality. According to the CAPM model:

$$E\left(R_{ij}\right) = R_f + \beta_{ij}\left[\left(E(R_m) - R_f\right)\right] \tag{5}$$

Where $E(R_{ij})$ is the expected return on of farmland in location i with quality j, R_f is the rate of return on the risk-free asset, β_{ij} is the systematic risk associated with farmland in location i with quality j, and $E(R_m)$ is the expected market return. Based on this CAPM formula, the only risk that affects asset price is market risk. Previous literature provides several extensions of the CAPM by including other risk factors. With respect to the farmland market, Irwin *et al.* (1988) added uncertain inflation and Bjornson (1994) added changes in expected inflation, bond yield curve, and term structure of interest rates. The beta (β_{ij}) is estimated by regression asset's excess return on market excess return where the slope of the regression corresponds to the beta of the asset (i.e. farmland location/quality).

4. Data

Data for farmland values and cash rents of different farmland location/quality is obtained for two corn-belt states, namely Indiana and Iowa. In Indiana, we rely on the Purdue Agricultural Economics Report (PAER) published by Purdue University. PAER has been published on annual basis since 1974, and involves data about land values and cash rents in the state of Indiana. These data are typically survey data where the respondents to the survey are appraisers, commercial banks, loans officers, FSA personnel, farmers, and farm managers. PAER shows the average estimated Indiana farmland value and the annual percentage change by location and land quality. Data covers six Indiana regions (North, Northeast, West Central, Central, Southwest, and Southeast) and three land qualities (top, average, and poor).

For Iowa farmland values and cash rents, we relied on the Farmland Value Survey sponsored by Iowa State University. The Iowa Farmland Value Survey is sent to farm managers, licensed real estate brokers, appraisers, agricultural lenders, county assessors, and other individuals who are familiar with farmland markets. It has been published each year since 1941. Like PAER, the Iowa Farmland Value Survey provides information about the average farmland value for three land classes (top, average, and poor) and for nine Iowa regions. The period of the study is 1974-2018. This is the period that we have data for both Indiana and Iowa. In addition to farmland data, we obtained data for the S&P 500 and 3-month T-bills. Farmland is a long-lived asset. That is why some studies used long-run government loan rates as a proxy for the risk-free rate. This is useful to account for reinvestment risk. This choice, however, ignores inflation risk. Choosing short-term interest rate accounts for this inflation risk. In addition, demand for farmland is heavily dependent on access to credit which is strongly related to short-term interest rate. This is the main motivation for us to rely on three-month T-bills rate as proxy for the risk-free rate. Return data on S&P 500 is obtained from the Center for Research in Security Prices (CRSP).

5. Empirical results

5.1 Descriptive statistics

In this section, we begin by showing descriptive statistics and correlations results for Indiana and Iowa. Farmland data are decomposed by location and quality. Tables 1 and 2 illustrate the descriptive statistics for the annual returns on farmland locations/qualities of Indiana and Iowa, respectively. As can be seen from Table 1, the average returns for Indiana farmland ranged from 10 to 12%. The standard deviation ranged from 9 to 15%. This indicates that the dispersion of risk (9-15%) is larger than the dispersion of mean return (10-12%). This implies larger room for risk minimization than for return maximization when forming portfolios. The reward-to-risk ratio, as a measure of reward per unit of risk, ranged from 0.75 for the top farmland quality in the central region (C.top) of Indiana to 1.18 for average farmland quality in the southeast region (SE. AVG) of Indiana. The difference between lowest and highest reward-to-risk ratio (0.435) suggests that return and risk vary across regions in Indiana. It is worth noting that the southeast region has the greatest reward-to-risk ratio across all the Indiana six regions and that the average quality farmland in southeast Indiana has the highest reward-to-risk ratio.

Table 1. Descriptive statistics of annual returns for Indiana 1975-2018.[1]

	Mean	St.Dev.	Variance	Min	Max	Reward-to-risk ratio
NE.top	0.107	0.123	0.015	-0.203	0.415	0.864
NE.avg	0.110	0.119	0.014	-0.174	0.381	0.924
NE.poor	0.116	0.129	0.017	-0.154	0.437	0.903
WC.top	0.111	0.134	0.018	-0.140	0.550	0.830
WC.avg	0.113	0.128	0.016	-0.150	0.497	0.887
WC.poor	0.117	0.130	0.017	-0.213	0.437	0.902
C.top	0.099	0.132	0.017	-0.138	0.540	0.745
C.avg	0.112	0.126	0.016	-0.146	0.601	0.891
C.poor	0.111	0.132	0.018	-0.179	0.618	0.839
SE.top	0.108	0.099	0.010	-0.108	0.383	1.096
SE.avg	0.108	0.092	0.008	-0.092	0.352	1.181
SE.poor	0.108	0.106	0.011	-0.092	0.389	1.019
SW.top	0.114	0.147	0.022	-0.209	0.491	0.778
SW.avg	0.111	0.134	0.018	-0.198	0.437	0.830
SW.poor	0.116	0.143	0.020	-0.209	0.575	0.810
N.top	0.111	0.133	0.018	-0.138	0.581	0.833
N.avg	0.115	0.131	0.017	-0.140	0.530	0.878
N.poor	0.115	0.138	0.019	-0.169	0.487	0.835

[1] This table presents the descriptive statistics for the three levels of farmland quality (top, average, poor) for the six Indiana regions (northeast NE, north N, central C, west central WC, southwest SW, and southeast SE). St.Dev. = standard deviation.

Table 2. Descriptive statistics of annual returns for Iowa 1975-2018.[1]

	Mean	St.Dev.	Variance	Min	Max	Reward-to-risk ratio
Top.NW	0.062	0.143	0.020	-0.293	0.336	0.435
Avg.NW	0.064	0.147	0.022	-0.297	0.429	0.434
Poor.NW	0.064	0.145	0.021	-0.332	0.378	0.444
Top.NC	0.054	0.142	0.020	-0.329	0.378	0.385
Avg.NC	0.058	0.139	0.019	-0.354	0.387	0.413
Poor.NC	0.060	0.141	0.020	-0.338	0.309	0.423
Top.NE	0.062	0.139	0.019	-0.297	0.372	0.449
Avg.NE	0.065	0.137	0.019	-0.315	0.349	0.475
Poor.NE	0.067	0.132	0.017	-0.328	0.310	0.509
Top.WC	0.060	0.137	0.019	-0.282	0.350	0.442
Avg.WC	0.063	0.138	0.019	-0.289	0.366	0.458
Poor.WC	0.065	0.142	0.020	-0.299	0.346	0.457
Top.C	0.054	0.133	0.018	-0.324	0.328	0.407
Avg.C	0.058	0.135	0.018	-0.336	0.340	0.427
Poor.C	0.057	0.130	0.017	-0.286	0.302	0.441
Top.EC	0.057	0.123	0.015	-0.281	0.410	0.462
Avg.EC	0.059	0.118	0.014	-0.309	0.307	0.501
Poor.EC	0.061	0.120	0.014	-0.326	0.274	0.506
Top.SW	0.061	0.125	0.016	-0.288	0.390	0.487
Avg.SW	0.062	0.127	0.016	-0.264	0.341	0.488
Poor.SW	0.063	0.137	0.019	-0.279	0.333	0.462
Top.SC	0.058	0.124	0.015	-0.245	0.313	0.468
Avg.SC	0.060	0.125	0.016	-0.248	0.292	0.478
Poor.SC	0.065	0.132	0.018	-0.311	0.291	0.488
Top.SE	0.053	0.114	0.013	-0.277	0.341	0.462
Avg.SE	0.057	0.117	0.014	-0.275	0.349	0.487

[1] This table presents the descriptive statistics for the three levels of farmland quality (top, average, poor) for the nine Iowa regions (northeast NE, northwest NW, north central NC, central C, west central WC, east central EC, southwest SW, south central, and southeast SE). St.Dev. = standard deviation.

As evident in Table 2, for Iowa, the mean returns for different farmland locations/qualities ranged from 5 to 6%. The standard deviation ranges from 11 to 15%. At first glance, it appears that Indiana farmland has, on average, a better risk-return relationship than Iowa farmland. This is obvious when we compare the ranges of reward-to-risk ratio (0.4 to 0.5) for Iowa and Indiana farmland for which the reward-to-risk ratios ranges from 0.75 to 1.18. The highest reward-to-risk ratio for Iowa farmland is 0.509 for the poor-quality farmland in northeast Iowa. The lowest reward-to-risk ratio in Iowa farmland is 0.385 for the top-quality farmland in north central Iowa.

Overall, the key message from Table 1 and 2 is that Indiana farmland has, on average, a higher reward-to-risk ratio than Iowa farmland. The primary driver for this difference in reward-to-risk ratio between Indiana and Iowa is the difference in return rather than difference in risk. For instance, our data shows that the average return for different locations and qualities of Indiana farmland is 0.11 compared to 0.06 for different locations and qualities in Iowa (0.05 difference). However, the average standard deviation for different locations and qualities of Indiana farmland is 0.126 compared to 0.132 for Iowa (0.006 difference).

5.2 Correlation results

Table 3 reports the correlation coefficients between farmland qualities in Indiana. Although the correlation among qualities within districts are strongly positive, it is noticeable that the lowest correlation is between the top and poor qualities. The average correlation between top and poor qualities are 0.86 compared to the correlation coefficients of 0.94 and 0.92 between the top and average qualities, and the average and poor qualities, respectively. The high correlation values suggest that the potential for diversifying across quality alone is low. For instance, Figure 1 shows the time series of farmland value per acre in Indiana for each farmland quality (top, average, and poor. The time series are nearly parallel indicating that all the values of farmland qualities move up and down together. In other words, there is little diversification benefits within the space of farmland qualities alone. That is why our focus in this paper is on the two dimensions of farmland, quality and location.

Table 3. Correlation between farmland qualities in each of the six regions in Indiana.[1]

	North				**Northeast**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.985	1		Avg	0.974	1	
Poor	0.933	0.964	1	Poor	0.880	0.925	1
	West Central				**Central**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.982	1		Avg	0.935	1	
Poor	0.938	0.970	1	Poor	0.918	0.964	1
	Southeast				**Southwest**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.917	1		Avg	0.854	1	
Poor	0.706	0.825	1	Poor	0.770	0.859	1

[1] This table presents the correlation between the three farmland qualities (top, average, poor) in each of the six regions in Indiana.

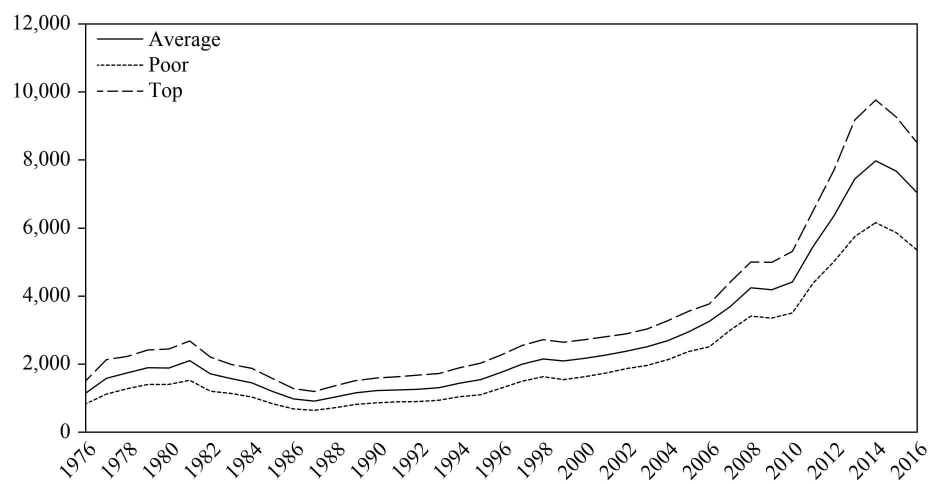

Figure 1. Average value per acre of the three farmland qualities (poor, average, top) in Indiana over the period 1976-2016.

We also examined the correlation between locations and qualities within Indiana. The table is not included in the paper to save space and is available upon request. Correlation coefficients between different locations/qualities within Indiana are all positive yet widely dispersed with an average correlation of 0.78. The lowest correlation coefficients are also between the top and poor quality farmland. The minimum correlation (i.e. 0.39) is between southeast top-quality farmland and northeast poor-quality farmland. Looking at these results and Table 3, it appears that there is potential for diversifying across locations and qualities in Indiana.

Correlation coefficients between farmland qualities in Iowa are presented in Table 4. The correlation coefficients between Iowa farmland qualities are quite a bit higher than those in Indiana. The average correlation between Iowa top and average quality is 0.97. Correlation between Iowa average and poor farmland qualities is 0.94, while the lowest average correlation is between the top and poor farmland qualities (0.91). Like Indiana, the correlation between the top and poor qualities is the lowest. We also conducted the correlation analysis for each location/quality in Iowa. However, to save space, we have not included a table containing these results. The table is available upon request. The minimum correlation is 0.68, which was between poor quality, southeast Iowa farmland and average quality, northwest Iowa farmland. This also indicates the possibility for diversification benefits in Iowa across location/qualities.

5.3 Capital asset pricing model results

In this subsection, we estimate α and systematic risks β for location/qualities in Indiana and Iowa. Table 5 shows these estimates for Indiana by location and quality. Generally speaking, the CAPM results in Table 5 are consistent with prior literature. The parameter used to measure excess farmland returns (α_s) range from

Table 4. Correlation between farmland qualities in each of the nine regions in Iowa.[1]

	Northwest				**North Central**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.984	1		Avg	0.987	1	
Poor	0.960	0.974	1	Poor	0.962	0.981	1
	Northeast				**West Central**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.980	1		Avg	0.992	1	
Poor	0.941	0.962	1	Poor	0.951	0.965	1
	Central				**East Central**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.992	1		Avg	0.924	1	
Poor	0.953	0.968	1	Poor	0.890	0.940	1
	Southwest				**South Central**		
	Top	Avg	Poor		Top	Avg	Poor
Top	1			Top	1		
Avg	0.979	1		Avg	0.970	1	
Poor	0.929	0.964	1	Poor	0.857	0.892	1
	Southeast						
	Top	Avg	Poor				
Top	1						
Avg	0.959	1					
Poor	0.846	0.903	1				

[1] This table presents the correlation between the three farmland qualities (top, average, poor) in each of the nine regions in Iowa.

Table 5. Capital asset pricing model results for Indiana.[1]

Farmland location and quality	α	*P*-value	β	*P*-value
NE.top	0.059	0.007	0.066	0.607
NE.average	0.062	0.004	0.087	0.491
NE.poor	0.068	0.000	0.093	0.496
WC.top	0.066	0.007	0.027	0.850
WC.average	0.069	0.003	0.015	0.912
WC.poor	0.070	0.003	0.054	0.695
C.top	0.055	0.017	-0.011	0.937
C.average	0.064	0.000	-0.051	0.609
C.poor	0.064	0.007	0.063	0.651
SE.top	0.064	0.001	-0.056	0.598
SE.average	0.064	0.000	-0.051	0.421
SE.poor	0.057	0.002	0.088	0.420
SW.top	0.075	0.004	-0.103	0.504
SW.average	0.070	0.003	-0.073	0.598
SW.poor	0.072	0.005	0.001	0.996
N.top	0.068	0.005	-0.028	0.839
N.average	0.072	0.003	-0.020	0.886
N.poor	0.070	0.004	0.021	0.882

[1] This table presents the α and β of each farmland quality at each region in Indiana. Results are based on annual data for 1974-2018. α and β are estimated by regressing the excess return of different farmland qualities/locations on the excess market return which is proxied by the difference between the return on S&P 500 and the 3-month Treasury bills.

0.06 to 0.08, and are economically and statistically significant. Nonzero alphas for farmland locations/qualities in Indiana indicate that incorporating Indiana farmland locations/qualities into a well-diversified benchmark portfolio improve the Sharpe ratio and/or reward-to-risk ratio of the new portfolio. β estimates are statistically indistinguishable from zero indicating that farmland has weak correlation (or covariance) with the overall market index. This weak correlation with the S&P 500 makes farmland a good diversifier of risk and encourages its inclusion in mixed asset portfolios. The low beta of farmland is consistent with previous studies such as Baker *et al.* 2014).

In Table 6 we show the α and β of different farmland location/qualities in Iowa. Unlike the results for Indiana, excess return for Iowa locations/qualities are not significant, either economically or statistically. The β estimates were also insignificant.

5.4 Portfolio analysis

In this section, we perform a portfolio analysis of Indiana and Iowa farmland location/qualities. Diversification benefits are apparent when we compare the reward-to-risk ratios in Table 1 to the reward-to-risk ratios of three portfolio selection rules (equal weight, minimum-variance, and maximum reward-to-risk ratio portfolios). As shown in Table 7, the reward-to-risk ratio of minimum-variance and maximum reward-to-risk ratio portfolios are greater than the reward-to-risk ratio of individual location/quality farmland in the state of Indiana. It is also evident that the farmland that has the highest reward-to-risk ratio (SE.Avg which has reward-to-risk ratio of 1.18 from Table 1) has the dominant weight in minimum-variance and maximum reward-to-risk ratio portfolios. The portfolio weight of SE.Avg farmland in minimum-variance and maximum reward-to-risk ratio portfolios are 71 and 67%, respectively. This indicates that, from a portfolio perspective, the average quality farmland in Indiana is more attractive relative to top-and poor-quality farmland.

Table 6. Capital asset pricing model results for Iowa.[1]

Farmland location and quality	α	*P*-value	β	*P*-value
Top.NW	0.015	0.556	0.046	0.766
Avg.NW	0.018	0.482	0.035	0.823
Poor.NW	0.018	0.483	0.048	0.756
Top.NC	0.010	0.699	0.014	0.924
Avg.NC	0.013	0.592	0.008	0.960
Poor.NC	0.014	0.564	0.026	0.865
Top.NE	0.018	0.465	0.007	0.961
Avg.NE	0.019	0.416	0.028	0.847
Poor.NE	0.021	0.376	0.052	0.716
Top.WC	0.015	0.546	0.035	0.813
Avg.WC	0.017	0.496	0.054	0.720
Poor.WC	0.020	0.421	0.012	0.938
Top.C	0.008	0.730	0.037	0.799
Avg.C	0.011	0.635	0.046	0.750
Poor.C	0.011	0.620	0.039	0.785
Top.EC	0.012	0.582	0.014	0.918
Avg.EC	0.017	0.419	-0.038	0.770
Poor.EC	0.019	0.366	-0.053	0.683
Top.SW	0.015	0.494	0.032	0.813
Avg.SW	0.016	0.468	0.030	0.829
Poor.SW	0.017	0.475	0.035	0.813
Top.SC	0.017	0.437	-0.068	0.617
Avg.SC	0.016	0.460	-0.020	0.880
Poor.SC	0.024	0.301	-0.081	0.574
Top.SE	0.007	0.746	0.040	0.757
Avg.SE	0.008	0.716	0.109	0.400
Poor.SE	0.011	0.618	0.062	0.634

[1] This table presents the α and β of each farmland quality at each region in Indiana. Results are based on annual data for 1974-2018. α and β are estimated by regressing the excess return of different farmland qualities/locations on the excess market return which is proxied by the difference between the return on S&P 500 and the 3-month Treasury bills.

It is also interesting to note that the relatively low correlation between the southeast and northeast Indiana farmland is reflected in the portfolio weights in the minimum-variance portfolio and maximum reward-to-risk ratio portfolio. As evident in Table 7, most of the portfolio weights in the aforementioned portfolios are concentrated in these two regions.

Table 8 shows the portfolio performance for location/qualities of Iowa farmland. Unlike Indiana location/qualities, Iowa farmland shows very little (or even negligible) improvement in diversification benefits. The difference between the highest reward-to-risk ratio of individual location/quality Iowa farmland (0.508) and the maximum reward-to-risk ratio of Iowa farmland (0.540) is only 0.032, a negligible difference.

5.5 Robustness check

In this sub-section, we conduct a robustness check for the diversification potential of locations/qualities of Indiana farmland. In the previous section, we observed that farmland in southeast Indiana had a dominant weight in the minimum-variance and maximum reward-to-risk ratio portfolios. In fact, there are several characteristics of southeast Indiana farmland that make it unique. First, as previously shown, southeast Indiana farmland has generally low correlation with other farmlands in Indiana. Second, southeast Indiana

Table 7. Portfolio analysis of Indiana farmland.[1]

	Equal Wt	Min Var	Max reward-to-risk ratio
NE.top	5.56%	11.98%	0.00%
NE.avg	5.56%	0.00%	24.08%
NE.poor	5.56%	11.67%	4.54%
WC.top	5.56%	0.00%	0.00%
WC.avg	5.56%	0.00%	0.00%
WC.poor	5.56%	0.00%	0.00%
C.top	5.56%	0.00%	0.00%
C.avg	5.56%	0.00%	0.00%
C.poor	5.56%	0.00%	0.00%
SE.top	5.56%	1.97%	0.00%
SE.avg	5.56%	70.90%	66.74%
SE.poor	5.56%	0.00%	0.00%
SW.top	5.56%	3.48%	4.64%
SW.avg	5.56%	0.00%	0.00%
SW.poor	5.56%	0.00%	0.00%
N.top	5.56%	0.00%	0.00%
N.avg	5.56%	0.00%	0.00%
N.poor	5.56%	0.00%	0.00%
Sum	100%	100%	100%
μ	0.112	0.110	0.111
σ	0.110	0.085	0.086
μ/σ	1.018	1.292	1.299

[1] In this table, we apply three portfolio strategies (equal weight, minimum-variance, and maximum reward-to-risk ratio portfolios) to different farmland location/qualities in Indiana. μ and σ are the portfolio return and standard deviation, respectively.

farmland has the lowest average farmland quality in Indiana and, therefore, has the cheapest prices. Third, as found by Carson and Langemeier (2019): the relationship between cash rent and net return to land is weaker in southeast Indiana than it is for other parts of Indiana. In some sense, cash rent and land values are decoupled from crop net returns for this region of Indiana.

As a robustness check we omit southeast Indiana from the assets considered in the portfolio. Our aim is to see whether there is a significant improvement of the reward-to-risk ratio without including southeast Indiana farmland. As shown in Supplementary Table S1, there is a significant improvement in reward-to-risk ratio of the portfolios even without including farmland in the southeast region. The reward-to-risk ratios of the minimum-variance and maximum reward-to-risk ratios portfolios are significantly greater than the reward-to-risk ratios of individual location/quality in Indiana.

5.6 Diversifying across quality

In this section, we examine whether geographic diversification benefits are enhanced by adding a second diversification dimension, farmland quality. In order to answer this question, we need to compare the reward-to-risk ratios of different portfolio selection strategies before and after introducing the quality dimension to the geographic dimension of portfolio analysis. In doing so, we formulated portfolios with the same quality in different geographic regions in Indiana. There is no need to perform the same analysis for Iowa because, as shown in the previous section, there is no significant diversification benefits for diversifying across location/quality in Iowa.

Table 8. Portfolio analysis of Iowa farmland.[1]

	Equal Wt	Min Var	Max reward-to-risk ratio
Top.NW	0.037	0.000	0.000
Avg.NW	0.037	0.000	0.000
Poor.NW	0.037	0.000	0.000
Top.NC	0.037	0.000	0.000
Avg.NC	0.037	0.000	0.000
Poor.NC	0.037	0.000	0.000
Top.NE	0.037	0.000	0.000
Avg.NE	0.037	0.000	0.000
Poor.NE	0.037	0.000	0.136
Top.WC	0.037	0.000	0.000
Avg.WC	0.037	0.000	0.000
Poor.WC	0.037	0.000	0.000
Top.C	0.037	0.000	0.000
Avg.C	0.037	0.000	0.000
Poor.C	0.037	0.000	0.000
Top.EC	0.037	0.000	0.000
Avg.EC	0.037	0.221	0.027
Poor.EC	0.037	0.000	0.242
Top.SW	0.037	0.000	0.000
Avg.SW	0.037	0.000	0.042
Poor.SW	0.037	0.000	0.000
Top.SC	0.037	0.059	0.000
Avg.SC	0.037	0.000	0.000
Poor.SC	0.037	0.033	0.304
Top.SE	0.037	0.408	0.000
Avg.SE	0.037	0.000	0.170
Poor.SE	0.037	0.280	0.079
Sum	1.000	1.000	1.000
μ	0.060	0.056	0.062
σ	0.124	0.109	0.115
μ/σ	0.488	0.515	0.540

[1] In this table, we apply three portfolio strategies (equal weight, minimum-variance, and maximum reward-to-risk ratio portfolios) to different farmland location/qualities in Iowa. μ and σ are the portfolio return and standard deviation, respectively.

Table 9 shows the performance of portfolios based solely on geographic diversification holding farmland quality constant. The reward-to-risk ratios of the three portfolio allocation strategies are less than the reward-to-risk ratios when quality is added to the geographic allocation (shown in Table 7). In addition, what is evident in Table 9 is the relative attractiveness of southeast farmland with its three farmland qualities in terms of risk and return compared to other regions in Indiana. Other than the equal weighted portfolio, Indiana southeast farmland has the dominant weight regardless of the farmland quality. For example, as shown in Table 9, top-quality southeast Indiana farmland had a weight of the of 0.68 in the minimum-variance portfolio and 0.65 of maximum reward-to-risk ratio portfolio. Average and poor southeast Indiana farmland also had the dominant weight in the minimum-variance and maximum reward-to-risk ratio portfolio.

Table 9. Geographic diversification for Indiana holding quality constant.[1]

Panel A: Top farmland			
	Equal Wt	**Min Var**	**Max reward-to-risk ratio**
NE.top	0.167	0.202	0.154
WC.top	0.167	0	0.028
C.top	0.167	0	0
SE.top	0.167	0.675	0.652
SW.top	0.167	0.079	0.152
N.top	0.167	0.0433	0.015
Sum	1	1	1
μ	0.110	0.109	0.110
σ	0.109	0.090	0.091
μ/σ	1.002	1.209	1.214
Panel B: Average farmland			
	Equal Wt	**Min Var**	**Max reward-to-risk ratio**
NE.avg	0.167	0.223	0.256
WC.avg	0.167	0	0
C.avg	0.167	0	0
SE.avg	0.167	0.777	0.745
SW.avg	0.167	0	0
N.avg	0.167	0	0
Sum	1	1	1
μ	0.112	0.110	0.110
σ	0.109	0.087	0.087
μ/σ	1.030	1.266	1.267
Panel C: Poor farmland			
	Equal Wt	**Min Var**	**Max reward-to-risk ratio**
NE.poor	0.167	0.339	0.353
WC.poor	0.167	0	0
C.poor	0.167	0	0
SE.poor	0.167	0.661	0.647
SW.poor	0.167	0	0
N.poor	0.167	0	0
Sum	1	1	1
μ	0.113	0.112	0.112
σ	0.116	0.100	0.100
μ/σ	0.977	1.118	1.118

[1] This table shows the return (μ), standard deviation (σ), and reward-to-risk ratios of three portfolio strategies (equal weight, minimum-variance, and maximum reward-to-risk ratios) holding the quality level unchanged. Panel A represents analysis for top-quality farmland in Indiana. Panels B and C represent analysis for average and low-quality Indiana farmland.

5.7 Portfolios of farmlands in Indiana and Iowa

In this section, we look at the potential of geographic diversification of Indiana and Iowa farmland. Results are not in favor of Iowa farmland. This is also indicated by the correlation between farmland returns in Indiana and Iowa. For example, the minimum correlation for the location/quality combination in Indiana is 0.39, while the minimum correlation in Iowa is 0.68. When we merge Indiana and Iowa into one correlation matrix, this location/quality matrix has a dimension of 45×45, we found that the minimum correlation is still 0.39 which is between the southeast top-quality farmland and the northeast poor-quality farmland in Indiana. This indicates that there are very little diversification benefits for combining Indiana and Iowa farmland into a single portfolio.

In addition, Tables 1 and 2 show a big difference between reward-to-risk ratios in Indiana and Iowa. The average reward-to-risk ratio in Indiana is 0.90 while it is 0.46 in Iowa. This explains why the maximum reward-to-risk ratio portfolio illustrated in Table 10 has zero weights for Iowa locations/qualities combinations. In other words, the maximum reward-to-risk ratio portfolio is the same as a portfolio without adding Iowa farmland to the asset space. The minimum-variance portfolio, however, does include average quality farmland in southeast Iowa. It is important to note the large improvement in the reward-to-risk ratio moving from the equal weight portfolio strategy to the minimum-variance and maximum reward-to-risk ratio portfolios. The equal weight portfolio is clearly not optimal.

Previous discussion contributes to the fact that, even though they are both Corn Belt states, there are major differences in farmland investments in Indiana and Iowa. Over the period of this study, the average price of farmland was higher in Indiana than in Iowa. Figure 2 shows the difference between the average price of average quality farmland in Indiana and the average price of average quality farmland in Iowa. In almost 90% of the years, prices in Indiana were higher than prices in Iowa.

In the same vein, Langemeier *et al.* (2016) examined the trends in farmland values and cash rents in the states on Indiana, Illinois, and Iowa. They compared the price/rent ratios of farmland in the three states for the period 1973 to 2015. In almost all of this period, the price/rent ratio was higher in Indiana than in Iowa.

Table 10. Portfolio analysis of Indiana and Iowa farmland.[1]

	Equal Wt	Min Var	Max reward-to-risk ratio
	–	0.146 (NE.Top.IN)	0.240 (NE.Avg.IN)
	–	0.006 (NE.Poor.IN)	0.048 (NE.Poor.IN)
	–	0.665 (SE.Avg.IN)	0.668 (SE.Avg.IN)
	–	0.010 (SW.Poor.IN)	0.044 (SW.Top.IN)
	–	0.172 (Avg.Se.IO)	
Sum	1.000	1.000	1.000
μ	0.081	0.100	0.111
σ	0.112	0.084	0.086
μ/σ	0.723	1.192	1.299

[1] In this table, we apply three portfolio strategies (equal weight, minimum-variance, and maximum reward-to-risk ratio portfolios) to different farmland location/qualities in Indiana (IN) and Iowa (IO). μ and σ are the portfolio return and standard deviation respectively.

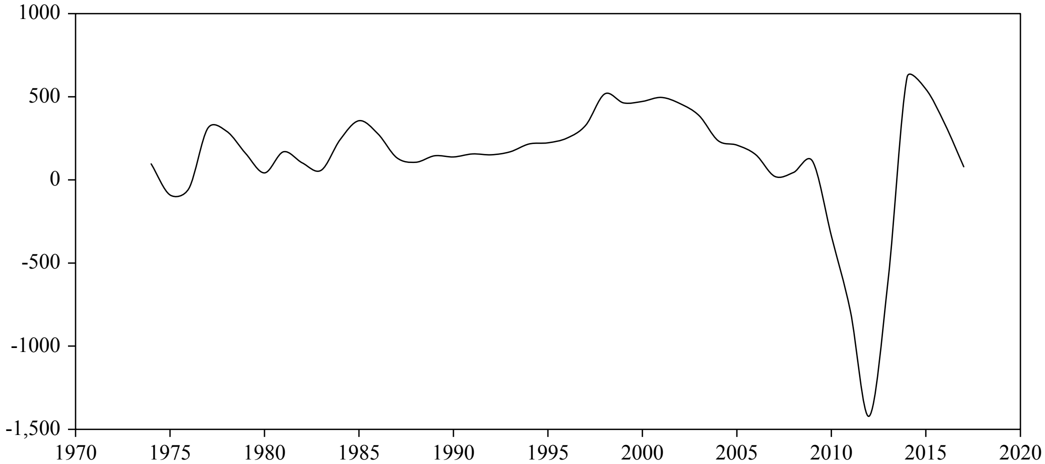

Figure 2. Difference between price per acre of Indiana medium quality farmland and Iowa medium quality farmland (Indiana price – Iowa price) over the period 1976-2016.

6. Conclusions

This paper examines the investment performance of different farmland qualities for different geographic regions in Indiana and Iowa. Essentially, this paper discusses the risk and return of different farmland location/qualities in these two states. Indiana and Iowa were chosen for two reasons. First, farmland value and cash rent data were available for each farmland quality and each geographic region in these two states. Second, both states are corn belt states. Thus, similar crops are produced in these two states.

Our findings confirm the role of farmland highlighted in prior literature as an attractive asset class relative to other capital assets. Farmland still outperforms other capital assets in terms of risk and return. We went a step further by considering the heterogeneity of farmland. Even though there are different farmland soil qualities, their systematic risks are not systematically different from each other. The betas of different farmland qualities for different regions in Indiana and Iowa are all around zero. Excess returns range 0.06 to 0.08 in Indiana but they are not statistically different from zero in Iowa.

The average correlation between farmland qualities in each region in Indiana and Iowa are 0.78 and 0.90, respectively, indicating that there are more diversification benefits in Indiana farmland. The portfolio analysis also underscored the attractiveness of southeast Indiana farmland relative to other farmland in Indiana. Its relative portfolio weight in the minimum-variance and the maximum reward-to-risk ratio portfolio significantly dominated farmland in other regions.

Our analysis of whether quality diversification improve the performance of geographically diversified portfolio reveals mixed results. We approached this goal by holding the quality level constant and diversifying geographically and then we compared the reward-to-risk ratio of the geographically diversified portfolio to the location/quality portfolio. We found that the reward-to-risk ratio of the latter portfolio is larger than that of the former one. Adding a quality dimension to the geographic dimension provided significant improvement in the reward-to-risk ratio in Indiana farmland, but not for Iowa. In addition, in contrast to the excess returns for Iowa farmland, the excess returns for Indiana farmland were significantly different from zero.

This study paves the path for considering diversification across quality. The mixed results in our study should motivate future researchers to dig deeper into examining the risk and return of farmland quality either using similar datasets or looking at transaction data on farmland sales. Based on data on farmland in Indiana and Iowa, the quality dimension alone does not have as large of diversification benefits as combining both the quality and location dimensions.

Supplementary material

Supplementary material can be found online at https://doi.org/10.22434/IFAMR2021.0051

Table S1. Portfolio analysis of Indiana farmland without southeast region.

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