FARMLAND RISK-RETURN CHARACTERISTICS AND FAMA-FRENCH 5 FACTOR MODEL

A Thesis

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ABSTRACT

With an increasing number of professional entities directing their focus towards farmland investments, there has been a burgeoning interest in the distinctive risk-return profile of farmland, especially when contrasted with conventional financial assets like stocks. Building on the foundational work of scholars such as Barry (1980), who utilized the CAPM model to ascertain the marginal risk farmland contributes to a diversified portfolio, this study aims to examine if latest methodologies, such as the Fama-French five-factor model, can offer a more nuanced explanation of farmland returns or affirm the unique risk-return dynamics of farmland identified in earlier research. Additionally, this paper delves into the particular risk attributes associated with farmland, including aspects of illiquidity. It further explores the risk-return traits within the farmland investment spectrum, disaggregating the data by regional classifications.

BIOGRAPHICAL SKETCH

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CHAPTER 1
INTRODUCTION & LITERATURE REVIEW

The exploration of factors influencing asset returns has been a central theme in financial economics research. The seminal Capital Asset Pricing Model (CAPM) developed by Sharpe (1964) and Lintner (1965) posits that an asset's expected return is solely determined by its systematic risk, measured by its beta with respect to the market portfolio. However, subsequent empirical studies have identified several other factors that appear to explain the cross-section of asset returns, challenging the adequacy of the single-factor CAPM.

Fama and French (1993) proposed a three-factor model that augments the CAPM with factors capturing the size and value effects. The size factor (SMB) reflects the outperformance of small-cap stocks over large-cap stocks, while the value factor (HML) captures the higher returns of value stocks (high book-to-market ratio) compared to growth stocks. Carhart (1997) extended the Fama-French model by adding a momentum factor (UMD), based on the finding that stocks with high past returns tend to outperform those with low past returns in the short run (Jegadeesh and Titman, 1993). More recently, Fama and French (2015) introduced a five-factor model that extends their earlier three-factor model by incorporating two additional factors: profitability (RMW) and investment (CMA). The profitability factor captures the difference in returns between stocks with robust and weak profitability, while the investment factor reflects the difference in returns between stocks of low and high investing firms. Empirical tests have generally supported the efficacy of the five-factor model in explaining the cross-section of stock returns across various markets and time periods (Fama and French, 2015; Chiah et al., 2016; Guo et al., 2017; Foye, 2018).

Despite the success of the five-factor model and other multifactor asset pricing models in capturing the risk and return characteristics of traditional financial assets such as stocks and bonds, relatively little attention has been paid to the role of alternative asset classes in these models. One alternative asset class that has gained increasing interest among investors in recent years is farmland. Farmland exhibits several unique

features that set it apart from conventional financial assets, which may have important implications for its risk and return dynamics.

The literature on farmland investment has largely focused on its diversification potential and attractive risk-return characteristics. Kaplan (1985), Moss et al. (1987), Lins et al. (1992), and Hardin and Cheng (2005) have provided evidence on the favorable risk-return profile and diversification benefits of farmland investments. However, these studies have primarily analyzed farmland in isolation, without considering its interactions with other financial assets in a broader asset pricing context. Liang et al. (2011) is an exception, finding that farmland returns are related to macroeconomic variables differently than traditional financial assets.

The present study aims to provide a comprehensive assessment of the potential role of farmland investments in diversified investment portfolios.

Our objectives include:

(1) systematically analyzing the risk and return characteristics of U.S. farmland investments from 1991 to 2022;

(2) examining the relationship between farmland returns and returns on traditional financial assets;

(3) quantifying the impact of farmland allocation on the efficient frontier;

(4) investigating the performance of different types of farmland and regions;

(5) decomposing the sources of farmland returns and evaluating the unique risks and factors influencing farmland investments.

Through these analyses, this paper seeks to provide new empirical evidence and insights into the role of farmland as an alternative asset class in asset allocation, contributing to a deeper understanding of its risk and return characteristics and offering valuable information for investors. Beyond examining the risk and return dynamics, this study explores the evolving landscape of farmland investment opportunities. The traditional view of farmland as solely a direct ownership opportunity has expanded significantly, with the emergence of innovative investment vehicles like Farmland REITs and ETFs. As highlighted by Peterson and Kuethe (2015), these publicly traded entities offer investors a liquid and accessible entry point to the farmland market,

providing diversified exposure and professional management. Additionally, the private equity market plays a critical role in farmland investment, with specialized funds targeting institutional investors and high-net-worth individuals seeking potentially higher returns and active management strategies (Baral & Mei, 2023).

The growing interest in farmland as an investment is fueled by several compelling factors. Firstly, farmland offers attractive diversification benefits due to its low correlation with traditional asset classes, as demonstrated by Barry (1980) and subsequent research. This characteristic allows investors to reduce portfolio volatility and enhance risk-adjusted returns. Secondly, farmland acts as a hedge against inflation, with land values and agricultural commodity prices tending to rise in inflationary environments. Thirdly, farmland provides a stable income stream through rental income from agricultural production or land leases, offering investors a predictable source of cash flow. Furthermore, farmland has historically demonstrated the potential for long-term capital appreciation driven by factors such as population growth, increasing food demand, and limited land availability.

Finally, the rising focus on sustainability and impact investing has drawn investors to farmland as a means of supporting food security, environmental stewardship, and rural economic development. Farmland investments can contribute to sustainable agricultural practices, promote responsible land management, and create economic opportunities in rural communities. This alignment with environmental and social goals adds another dimension to the appeal of farmland as an investment option. By examining both the traditional and emerging investment avenues, this study aims to provide a comprehensive understanding of the opportunities and challenges associated with farmland as a dynamic and evolving asset class.

CHAPTER 2
METHODOLOGY

2.1 Data Sources

Our analysis is anchored on a robust dataset that integrates returns from farmland investments with the comprehensive Fama-French five-factor model, spanning an extensive period from the first quarter of 1991 to the fourth quarter of 2022. The cornerstone of our farmland data is derived from the NCREIF Farmland Property Level Database, a repository renowned for its detailed quarterly performance insights into a diverse array of U.S. farmland properties. The National Council of Real Estate Investment Fiduciaries (NCREIF) stands at the forefront, providing pivotal investment performance data for institutional real estate assets, with farmland being a notable focus. This dataset's significance is well-acknowledged in academic and research circles, contributing valuable insights into farmland investment dynamics.

The NCREIF database meticulously documents a variety of metrics, including but not limited to total returns, income returns, capital appreciation, net operating income, and capital expenditures. The study primarily focuses on the total return metrics, capturing the holistic quarterly financial performance of farmland investments, which comprises income derived from agricultural operations and land leasing, alongside capital appreciation. By the end of 2022, the NCREIF Farmland Index covered a portfolio of 1,347 properties with a combined value of over $15 billion. This index vividly portrays the varied tapestry of U.S. farmland investments, covering different geographical terrains, types of crops, and strategic investment methodologies, thus providing a well-rounded perspective of the national farmland investment landscape.

To delve deeper into the risk and return characteristics associated with farmland investments, we harness data pertaining to the Fama-French five factors from the Kenneth R. French Data Library. This repository provides a continuous historical sequence of data points for several risk factors, including market risk premium (Mkt-RF), size (SMB), value (HML), profitability (RMW), and investment (CMA). These factors are calculated based on the differences in value-weighted returns of stocks across

the NYSE, AMEX, and NASDAQ, in comparison to the 3-month U.S. Treasury bill rates, which are used as the risk-free rate. Moreover, the inclusion of size, value, profitability, and investment dimensions enables a thorough analysis of risk factors, encompassing data from both ends of the market capitalization spectrum, variations in book-to-market ratios, operational profitability, and asset investment rates.

In addition to these variables, our study incorporates the 3-month U.S. Treasury bill rates (DTB3) as the proxy for the risk-free rate, sourced from the French Data Library. The choice of the 3-month Treasury bill rate as the risk-free rate proxy is based on its maturity alignment with the quarterly nature of our farmland investment data. Using a shorter-term rate, such as the 1-month Treasury bill rate, could introduce short-term fluctuations that may not be representative of the risk-free rate over the quarterly investment horizon.

This amalgamation of farmland performance data with the multifaceted Fama-French five-factor framework facilitates an exhaustive examination of farmland investments' risk-adjusted returns. Leveraging these datasets, recognized for their accuracy and reliability, we ensure the robustness and replicability of our empirical findings. The granular, quarterly nature of the data empowers our analysis, enabling a detailed exploration of the temporal dynamics that influence farmland returns in correlation with broader macroeconomic trends.

Table 1: Data Source Overview

Data Component	**Description**	**Source**
Farmland Investment Returns	Quarterly returns including income and capital appreciation	NCREIF Farmland Property Level Database
Market Risk Premium (Mkt-RF)	Excess return of the market over the risk-free rate	Kenneth R. French Data Library
Size Premium (SMB)	Excess return of small-cap stocks over large-cap stocks	Kenneth R. French Data Library
Value Premium (HML)	Excess return of high book-to-market stocks over low book-to-market stocks	Kenneth R. French Data Library

Profitability (RMW)	Excess return of stocks with high operating profitability over those with low	Kenneth R. French Data Library
Investment (CMA)	Excess return of stocks with conservative investment over aggressive investment	Kenneth R. French Data Library
Risk-Free Rate (RF)	3-month U.S. Treasury bill rates	Kenneth R. French Data Library

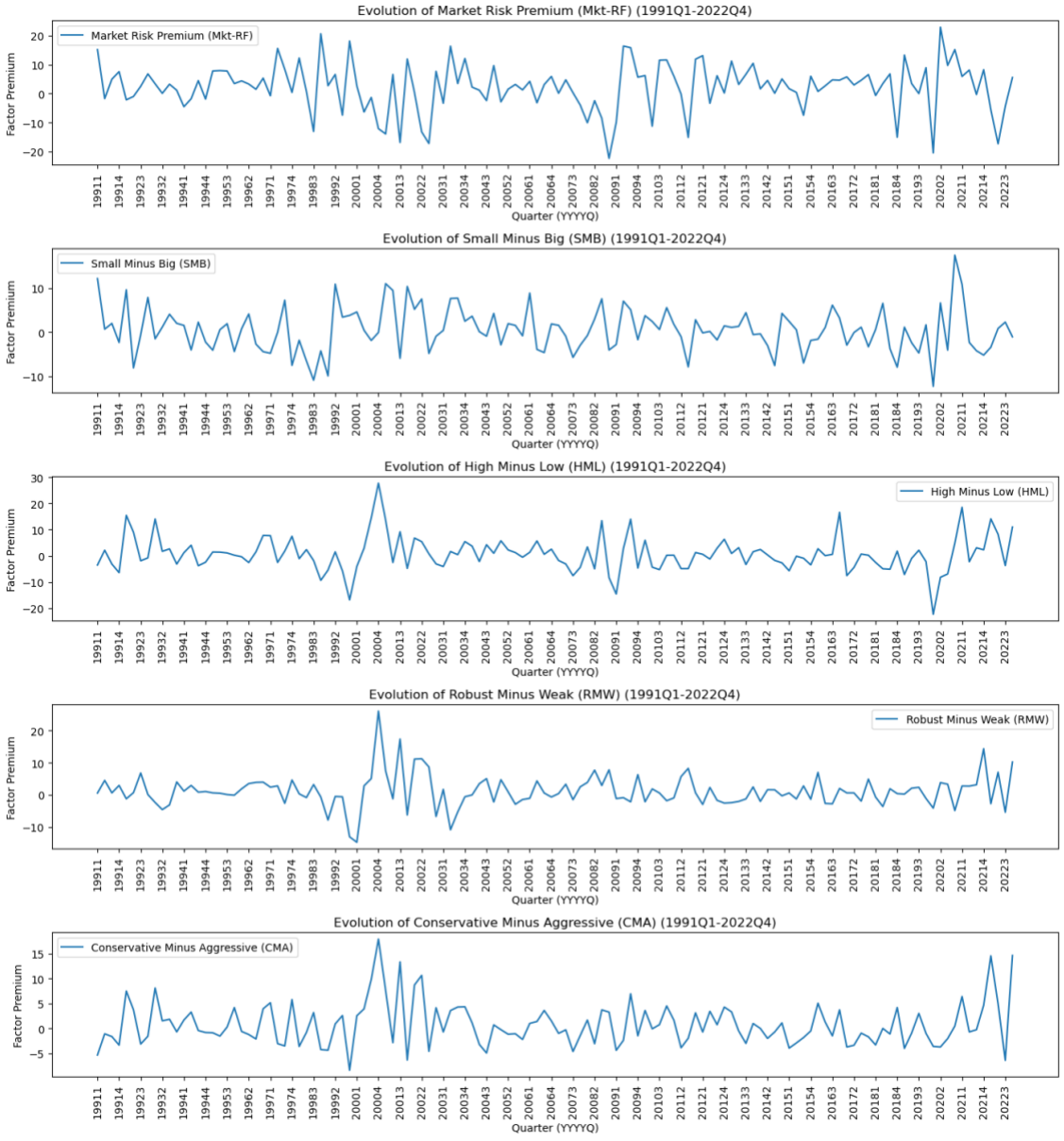

Figure 1: Evolution of Fama-French Five Factors (1991Q1-2022Q4)

Illustrates the historical trends in each of the five factors, providing insights into their potential impact on farmland investment returns.

These additional tables and figures serve not only as visual aids but also as a quantitative foundation that enriches our understanding of the interplay between farmland investments and the broader financial market dynamics, underpinning the meticulous analysis conducted in this study.

2.2 Analytical Methods and Rationale

This study employs a range of analytical methods to comprehensively assess the risk and return characteristics of U.S. farmland investments and their potential role in diversified portfolios. These methods are chosen to provide a multifaceted understanding of farmland as an alternative asset class and its implications for investment decisions.

(1) Risk-Adjusted Performance Measures: To evaluate the attractiveness of farmland investments relative to their risk, this study utilizes risk-adjusted performance measures. The Sharpe ratio, calculated as the excess return of the investment over the risk-free rate divided by the standard deviation of those excess returns, is employed to assess the return per unit of total risk taken. A higher Sharpe ratio indicates a more favorable risk-return trade-off. Additionally, the information ratio is used to evaluate the consistency and stability of excess returns relative to a benchmark, such as the S&P 500.

(2) Portfolio Efficiency Analysis: To explore the impact of incorporating farmland into a diversified investment portfolio, this study conducts efficient frontier analysis. By considering a range of potential portfolio allocations between farmland and a benchmark asset (e.g., the S&P 500), the efficient frontier visually represents the set of optimal portfolios that offer the highest expected return for a given level of risk. This analysis allows for assessing the potential benefits of farmland in terms of improving portfolio diversification and risk-adjusted returns.

(3) Correlation and Diversification Potential: To investigate the diversification benefits of farmland investments, the study examines the correlation between farmland returns and the returns of traditional financial assets like the S&P 500 index. Correlation

analysis provides insights into the extent to which asset returns move together. A low correlation suggests that farmland returns are not closely tied to the performance of the stock market, indicating its potential as a diversification tool to reduce portfolio risk and enhance overall portfolio stability.

(4) Liquidity Assessment: The liquidity characteristics of farmland investments are crucial for understanding the potential challenges and limitations associated with buying and selling farmland. This study analyzes the liquidity of farmland investments by examining the turnover rate, which measures the frequency with which assets within a portfolio are traded. Comparing the turnover rate of farmland with traditional financial assets helps inform investors about potential holding periods and the impact of transaction costs on investment decisions.

2.3 Variable Definitions and Descriptive Statistics

This segment delineates the pivotal variables incorporated in our analysis alongside their statistical summaries. A systematic summary of the variable definitions and their data origins is delineated in Table 2 below.

Table 2: Variable Definitions and Data Sources

Variable	**Definition**	**Source**
$R_{f,t}$	Quarterly total return on farmland investments	NCREIF Farmland Property Level Database
$ER_{f,t}$	Excess return on farmland (total return minus RF)	Calculated using data from NCREIF & French Data Library
Mkt-RF	Market risk premium	Kenneth R. French Data Library
SMB	Size premium	Kenneth R. French Data Library
HML	Value premium	Kenneth R. French Data Library
RMW	Profitability factor	Kenneth R. French Data Library
CMA	Investment factor	Kenneth R. French Data Library
RF	Risk-free rate (3-month U.S. Treasury bill rates)	Kenneth R. French Data Library

The focal point of our analysis is the quarterly total return on farmland investments ($R_{f,t}$), procured from the NCREIF database. We calculate the excess return on farmland ($ER_{f,t}$) as the difference between the total return and the risk-free rate (RF), with RF representing the 3-month U.S. Treasury bill rate as obtained from the Kenneth R. French Data Library.

The Fama-French five factors, also derived from the French Data Library, include the market risk premium (Mkt-RF), size (SMB), value (HML), profitability (RMW), and investment (CMA) factors. These are integral for adjusting farmland investment returns for market-wide risk factors.

Descriptive Statistics

The analysis encompasses data spanning from Q1 1991 to Q4 2022. The annualized average return for farmland investments stands at 9.35%, with a standard deviation of 7.19%, highlighting a notable performance with moderate volatility. The Sharpe Ratio, calculated at 0.97, signifies an attractive risk-adjusted return profile for farmland investments compared to the broader market.

(1) RESULTS: Overview/Summary of Farmland Investment Performance

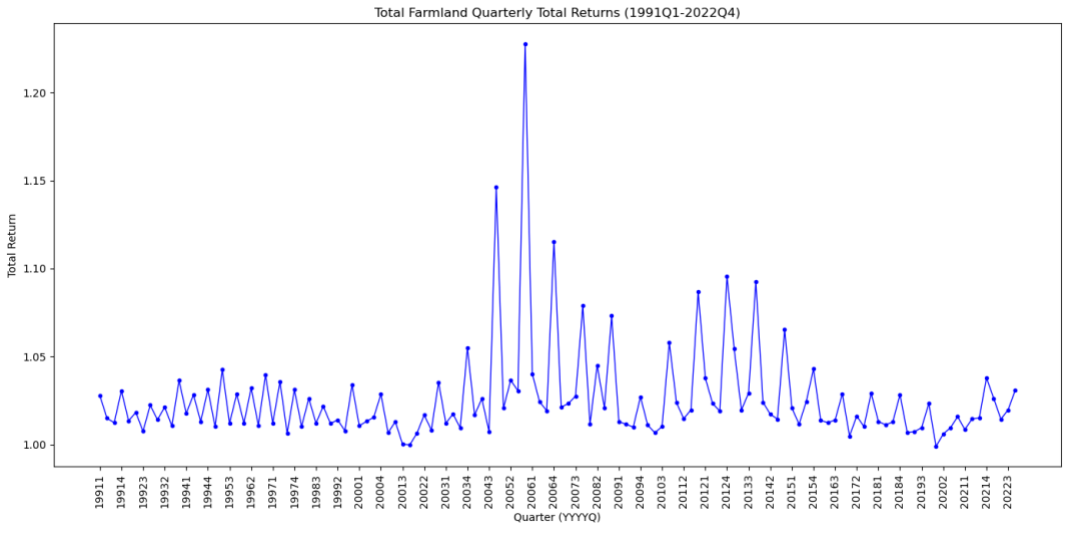

Figure 2: Farmland Investments Quarterly Total Returns (1991Q1-2022Q4)

Depicts the fluctuating returns of farmland investments over the study period.

Farmland investments, categorized under various indices based on crop type and geographic location, demonstrate a range of growth and volatility. For instance, the 'Total Farmland' category exhibits an average total return factor of 1.025981, which translates to an average quarterly return of approximately 2.6%. This, along with a standard deviation of 0.028548, showcases the generally positive and relatively stable performance of farmland investments across diverse categories.

(2) Market and Risk-free Rate Analysis

The 3-month U.S. Treasury bill rate, serving as our risk-free rate, averaged at 2.378273% with a standard deviation of 2.064691%, indicating fluctuations in the economic and interest rate environment over the period. Meanwhile, the S&P 500 index, a proxy for market performance, showed an average value-weighted return (including dividends) of 0.009139, with variability reflecting market cycles and economic changes.

The following table presents a comprehensive statistical analysis of various farmland investment indices over the studied period. These indices represent different types of farmlands, including cropland categories and geographic regions, offering insights into their respective performance metrics such as total returns, mean, standard deviation, and range values.

Table 3: Descriptive Statistics for Farmland Indices

Index Name	Count	Mean	Standard Deviation	Minimum	25th Percentile	Median	75th Percentile	Maximum
Annual - All Others	128	1.02	0.02	0.98	1.01	1.02	1.03	1.13
Annual - Commodity	128	1.02	0.02	1.00	1.01	1.02	1.03	1.09
Annual - Fresh Produce	116	1.03	0.03	0.99	1.01	1.02	1.02	1.28
Annual Cropland	128	1.02	0.02	1.01	1.01	1.02	1.03	1.12
Appalachian	22	1.01	0.01	0.98	1.01	1.01	1.01	1.04
Corn Belt	128	1.03	0.03	0.97	1.01	1.02	1.03	1.14
Delta States	128	1.02	0.02	1.00	1.01	1.02	1.03	1.10

Lake States	113	1.02	0.04	0.96	1.00	1.01	1.02	1.20
Pacific Northwest	127	1.02	0.03	0.95	1.00	1.01	1.03	1.16
Pacific West	128	1.03	0.05	0.98	1.01	1.02	1.03	1.41
Permanent - Almonds	124	1.03	0.08	0.96	1.00	1.01	1.04	1.68
Permanent - Pistachios	81	1.06	0.09	0.99	1.00	1.02	1.05	1.59
Permanent Cropland	128	1.03	0.04	0.98	1.01	1.01	1.03	1.33
Southeast	128	1.02	0.03	0.91	1.01	1.02	1.03	1.22
Total Farmland	128	1.03	0.03	1.00	1.01	1.02	1.03	1.23

Note: The 'Count' column indicates the number of data points available for each index over the study period. The 'Mean' represents the average total return factor, which reflects the growth multiple of the initial investment over a given period (typically a quarter). To calculate the percentage return from the total return factor, subtract 1 and multiply by 100. 'Standard Deviation' measures the variability of these returns. The 'Minimum', '25th Percentile', 'Median', '75th Percentile', and 'Maximum' values illustrate the range and distribution of total return factors for each index.

This table elucidates the performance landscape of farmland investments, illustrating the diversity in returns across different types of farmland and geographic regions. The data reveals several noteworthy observations:

Permanent cropland, particularly in the "Permanent - Pistachios" and "Permanent - Almonds" categories, exhibits the highest mean returns at 1.056348 and 1.033292, respectively. This suggests that investing in permanent crops, such as pistachios and almonds, has yielded higher average returns compared to other farmland categories.

However, the "Permanent - Pistachios" and "Permanent - Almonds" categories also display the highest standard deviations at 0.092969 and 0.079623, respectively, indicating a greater degree of volatility and risk associated with these investments.

The "Pacific West" region demonstrates the highest mean return among the geographic regions at 1.030578, suggesting strong performance of farmland investments in this area. Nonetheless, it also shows a relatively high standard deviation of 0.049334, implying elevated risk levels.

Conversely, the "Appalachian" region exhibits the lowest standard deviation at 0.010795, indicating a lower level of volatility and risk. However, its mean return is

also comparatively lower at 1.009802, suggesting a potential trade-off between risk and return.

The "Total Farmland" category, which represents an aggregated view of all farmland investments, shows a mean return of 1.025981 and a standard deviation of 0.028548. This provides a benchmark for comparing the performance of specific farmland categories and regions against the overall farmland investment landscape.

Comparing FARMLAND INVESTMENT AND THE MARKET PORTFOLIO (S&P500)

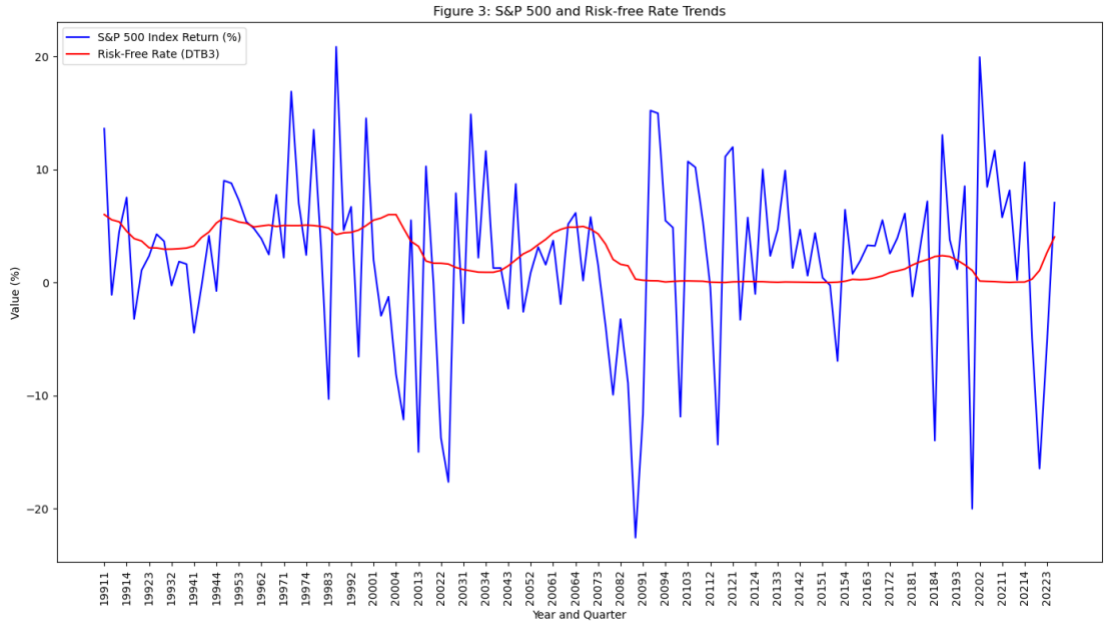

Figure 3: S&P 500 and Risk-free Rate Trends

This figure displays the historical trends of the S&P 500 index returns and the risk-free rate, providing context for understanding the performance of farmland investments within the broader economic landscape. While a direct causal relationship between these variables and farmland returns is not established in this study, exploring their concurrent fluctuations offers valuable insights for investors. Further research is needed to investigate and quantify the specific mechanisms through which broader economic conditions impact farmland investment returns.

(1) The S&P 500 index return reached its lowest point of -22.56% in Q4 2008, which can be attributed to the 2008 financial crisis. The financial tsunami triggered by the subprime mortgage crisis led to a sharp decline in the stock market during this period.

(2) Conversely, the S&P 500 index return peaked at 20.87% in Q4 1998, potentially linked to the technology stock bubble of the late 1990s. The year 1998 marked the height of the internet bubble, resulting in a significant surge in the stock market.

(3) Over the entire period, the average return of the S&P 500 index stands at 2.26%, indicating a moderate long-term upward trend in the U.S. stock market. Despite short-term fluctuations, the annualized return of the S&P 500 index hovers around 10% when viewed from a long-term perspective.

(4) The standard deviation of the S&P 500 index returns is 7.96%, highlighting the high volatility of the U.S. stock market. The standard deviation measures the dispersion of returns and reflects the risk level associated with stocks. Short-term volatility is a typical characteristic of the U.S. stock market.

Understanding the dynamics of farmland investment returns requires considering broader market conditions. This study analyzes the S&P 500 index and the risk-free rate as representative indicators of the overall economic landscape and investor sentiment. While a direct causal relationship between these factors and farmland returns is not established in this study, observing their concurrent fluctuations offers valuable context for interpreting the relative attractiveness and risk profile of farmland investments within a diversified portfolio. For example, during periods of high market volatility, investors may seek the stability of farmland as a way to diversify and mitigate risk, potentially impacting its demand and returns.

2.4 The Five-Factor Model and Farmland Investment

To assess the risk-adjusted performance of farmland investments, we estimate the Fama-French five-factor model using the ordinary least squares (OLS) regression method. The model is specified as follows:

$$ER_{f,t} = \alpha_f + \beta_{f,M}\left(R_{M,t} - RF_t\right) + \beta_{f,S}SMB_t + \beta_{f,H}HML_t + \beta_{f,R}RMW_t + \beta_{f,C}CMA_t + \varepsilon_{f,t}$$

where $ER_{f,t}$ is the excess return on the farmland portfolio in quarter t, α_f is the intercept term representing the abnormal return not captured by the five factors, $\beta_{f,M}$, $\beta_{f,S}$, $\beta_{f,H}$, $\beta_{f,R}$, and $\beta_{f,C}$ are the factor loadings on the market (Mkt-RF), size (SMB), value (HML), profitability (RMW), and investment (CMA) factors, respectively, and $\varepsilon_{f,t}$ is the error term.

This approach aimed to determine how well the model's factors—market risk (Mkt-RF), size (SMB), value (HML), profitability (RMW), and investment (CMA)—could explain the returns on farmland investments.

The regression analysis focused on the total return of farmland investments as the dependent variable. The summary of the analysis is presented in the table below:

Table 4: OLS Regression Analysis Summary

Variable	Coefficient	Std. Error	t-Statistic	P-Value	95% Confidence Interval
const	1.0249	0.003	361.225	0.000	[1.019, 1.030]
Mkt-RF	0.0013	0.001	1.197	0.233	[-0.001, 0.003]
SMB	-0.0010	0.002	-0.560	0.577	[-0.004, 0.002]
HML	-0.0004	0.002	-0.207	0.836	[-0.004, 0.003]
RMW	-0.0008	0.002	-0.456	0.649	[-0.005, 0.003]
CMA	0.0022	0.003	0.782	0.436	[-0.003, 0.008]

Analysis Summary:

R-squared: 0.019, indicating that the model explains 1.9% of the variance in farmland total returns.

Adjusted R-squared: -0.021, suggesting adjustments for the number of predictors in the model reduces the explanatory power.

F-statistic: 0.4689 with a Prob (F-statistic) of 0.799, indicating the model's factors collectively do not significantly explain the variance in farmland returns.

The constant term (const) is significantly different from zero, suggesting a base level of return that is not explained by the five factors. However, none of the coefficients for the Fama-French factors (Mkt-RF, SMB, HML, RMW, CMA) were statistically significant, as indicated by their P-values. This outcome suggests that these factors, as

they relate to the broader market, do not significantly influence the total returns of farmland investments within the observed data set.

The low R-squared value underscores the limited capacity of the Fama-French five-factor model to account for the variance in farmland returns. This suggests that other, perhaps non-market or sector-specific factors, might play a more critical role in influencing farmland investment returns.

Moreover, the high Durbin-Watson statistic (1.887) indicates a low level of autocorrelation in the residuals of the regression, while the Omnibus and Jarque-Bera tests signal non-normality in the distribution of residuals, pointing to the potential for other explanatory variables or models to better capture the dynamics of farmland returns. The analysis indicates that while the Fama-French five-factor model provides a framework for evaluating investment returns, it may not fully capture the unique aspects influencing farmland investments. This suggests the necessity for further research, potentially incorporating additional or alternative factors, to model the risk and return characteristics of farmland investments more accurately.

2.5 Performance Evaluation Measures for Farmland Portfolio

To understand the risk-adjusted returns of the farmland investment portfolio, we utilize well-established performance metrics in financial analysis. These metrics help quantify the portfolio's returns in excess of a risk-free rate, adjusted for the risk undertaken. Among them, the Sharpe ratio is a key indicator that we can directly calculate based on the provided data.

Sharpe Ratio

The Sharpe ratio measures the performance of an investment compared to a risk-free asset, after adjusting for its risk. It is calculated as follows:

$$\text{Sharpe Ratio} = \frac{R_p - R_f}{\sigma_p}$$

Where:

R_p = portfolio return

R_f = risk-free rate

σ_p = standard deviation of the portfolio's excess returns

Given the average annualized return of the farmland portfolio is 9.35% and the standard deviation of these returns is 7.19%, assuming the risk-free rate as the 3-month U.S. Treasury bill rate (DTB3) with an average of 2.378273%, we calculate the Sharpe ratio as:

$$\text{Sharpe Ratio} = \frac{0.0935 - 0.0238}{0.0719} \approx 0.97$$

This Sharpe ratio of 0.97 signifies that the farmland portfolio has provided a high level of return per unit of risk, substantially outperforming the risk-free rate.

Interpretation

A Sharpe ratio of 0.97 demonstrates that the farmland portfolio has achieved considerable excess returns relative to the risk taken. This high ratio indicates an attractive risk-adjusted performance, suggesting that investors were compensated well for the risk incurred in these farmland investments.

CHAPTER 3
EMPIRICAL RESULTS

In this section, we provide a comprehensive analysis of the risk and return characteristics of farmland investments. We examine the performance of farmland portfolios over time and across different property types and regions. We also compare the risk-return profile of farmland to those of traditional asset classes, such as stocks and bonds.

3.1 Excess Returns, Volatility, and Sharpe Ratios

To assess the performance of farmland investments, we analyzed their excess returns, representing the returns exceeding the risk-free rate, and volatility, measuring the dispersion of those returns. Various farmland portfolios were examined over the period from 1991 to 2022, with the aim of understanding their risk-return dynamics and comparing performance across different sub-portfolios.

Table 5: Risk and Return Metrics for Farmland Portfolios

Index Name	Volatility	Average Excess Return	Sharpe Ratio
Annual - All Others	0.0267	0.0012	0.0462
Annual - Commodity	0.0278	0.0009	0.0341
Annual - Fresh Produce	0.0369	0.0032	0.0862
Annual Cropland	0.0263	0.0009	0.0369
Appalachian	0.0155	-0.0028	-0.1782
Corn Belt	0.0351	0.0024	0.0695
Corn Belt Annual Cropland	0.0351	0.0024	0.0695
Delta States	0.0264	-0.0001	-0.0052
Delta States Annual Cropland	0.0264	-0.0001	-0.0052
Lake States	0.0400	-0.0001	-0.0035
Lake States Annual Cropland	0.0294	0.0002	0.0051
Lake States Permanent Cropland	0.0658	0.0160	0.2437
Leased Annual Cropland	0.0261	0.0009	0.0355
Leased Permanent Cropland	0.0377	0.0006	0.0152
Leased Permanent and Annual Cropland	0.0254	0.0004	0.0148
Mountain	0.0298	-0.0007	-0.0227
Mountain Annual Cropland	0.0299	-0.0004	-0.0132
Northeast	0.0149	-0.0063	-0.4216
Northern Plains	0.0241	0.0044	0.1830
Pacific Northwest	0.0394	-0.0060	-0.1525

Pacific Northwest Annual Cropland	0.0348	-0.0009	-0.0268
Pacific Northwest Permanent Cropland	0.0537	-0.0064	-0.1188
Pacific West	0.0525	0.0071	0.1346
Pacific West Annual Cropland	0.0348	0.0028	0.0803
Pacific West Permanent Cropland	0.0595	0.0088	0.1484
Permanent - All Others	0.0554	0.0042	0.0757
Permanent - Almonds	0.0810	0.0107	0.1323
Permanent - Apples	0.0694	-0.0075	-0.1074
Permanent - Citrus	0.0397	0.0016	0.0411
Permanent - Pistachios	0.0913	0.0438	0.4796
Permanent - Wine Grapes	0.0458	0.0059	0.1308
Permanent Cropland	0.0490	0.0039	0.0801
Permanent Cropland Operated	0.0575	0.0047	0.0819
Southeast	0.0375	-0.0023	-0.0615
Southeast Annual Cropland	0.0157	0.0123	0.7807
Southern Plains	0.0168	0.0143	0.8461
Southern Plains Annual Cropland	0.0168	0.0143	0.8461
Total Farmland	0.0345	0.0026	0.0741

Analysis Summary

Volatility: This metric indicates the risk associated with each farmland investment sub-portfolio. "Permanent - Pistachios" exhibits the highest volatility (0.0913), signifying higher risk, while "Northeast" shows the lowest volatility (0.0149), indicating lower risk.

Average Excess Return: This measure reflects the return of the portfolio above the risk-free rate. "Permanent - Pistachios" offers the highest average excess return (0.0438), showcasing its potential for high returns. Conversely, "Northeast" experiences the lowest excess return (-0.0063), highlighting its underperformance.

Sharpe Ratio: The Sharpe ratio evaluates the risk-adjusted return, providing insight into the excess return per unit of risk. The "Permanent - Pistachios" sub-portfolio has the highest Sharpe ratio (0.4796), indicating superior risk-adjusted performance. In contrast, the "Northeast" sub-portfolio has the lowest Sharpe ratio (-0.4216), suggesting poor performance when accounting for risk.

These findings elucidate the diverse risk-return profiles across different farmland investment sub-portfolios, highlighting the particular appeal of investments like "Permanent - Pistachios" for their high risk-adjusted returns. This analysis underscores the importance of due diligence and strategic selection when considering farmland investments to optimize for both risk and return.

3.2 Analysis of Farmland Investment Portfolios Versus S&P 500

In examining the risk and return characteristics of farmland investments compared to traditional asset classes, we focus on the S&P 500 as a benchmark for equities. This comparison helps to contextualize the performance of farmland investments within the broader investment landscape.

(1) Volatility Comparison

The volatility, or the degree of variation in investment returns, is a key metric for assessing the risk associated with different asset classes.

Farmland volatility: Volatility across farmland investment indexes varies significantly, with Permanent Cropland showing the highest volatility (0.0573) and Southern Plains showing the lowest (0.0183). This diversity indicates the varying risk profiles within farmland investments themselves.

S&P 500: Exhibits a volatility of 0.0265, positioning it in the moderate range when compared to the farmland investment indexes.

(2) Average Quarterly Return Comparison

Average quarterly returns provide insight into the performance of investments over the analyzed period.

Farmland return: Returns also vary widely, from a high of 0.0053 in Permanent Pistachios to a slight negative return in Southern Plains Annual Cropland (-0.0001). This variance underscores the importance of selectivity within farmland investments.

S&P 500: Demonstrates a higher average quarterly return of 0.0091, outperforming all individual farmland investment indexes in the dataset.

Table 6: Volatility and Average Quarterly EXCESS Return

Property	Volatility	Average Quarterly Return
Total Farmland	0.0374	0.0007
Annual Cropland	0.0233	0.0003
Permanent Cropland	0.0573	0.0016
Pacific West	0.0634	0.0019
Pacific Northwest	0.0389	0.0010
Corn Belt	0.0356	0.0006
Delta States	0.0218	0.0004
Southeast	0.0395	0.0008
Mountain	0.0271	0.0005
Southern Plains	0.0183	-0.0001

Lake States	0.0468	0.0013
Northeast	0.0140	0.0003
Appalachian	0.0159	0.0002
Northern Plains	0.0219	0.0025
Pacific West Annual Cropland	0.0422	0.0009
Pacific Northwest Annual Cropland	0.0356	0.0008
Corn Belt Annual Cropland	0.0356	0.0006
Delta States Annual Cropland	0.0218	0.0004
Southeast Annual Cropland	0.0182	0.0001
Mountain Annual Cropland	0.0273	0.0005
Southern Plains Annual Cropland	0.0183	-0.0001
Lake States Annual Cropland	0.0310	0.0005
Pacific West Permanent Cropland	0.0726	0.0025
Pacific Northwest Permanent Cropland	0.0569	0.0019
Lake States Permanent Cropland	0.0869	0.0059
Permanent Cropland Operated	0.0698	0.0024
Leased Permanent and Annual Cropland	0.0209	0.0003
Leased Annual Cropland	0.0229	0.0003
Leased Permanent Cropland	0.0447	0.0011
Annual - Commodity	0.0240	0.0003
Annual - Fresh Produce	0.0439	0.0008
Annual - All Others	0.0252	0.0004
Permanent - Almonds	0.0929	0.0037
Permanent - Apples	0.0778	0.0039
Permanent - Pistachios	0.1196	0.0053
Permanent - Wine Grapes	0.0665	0.0019
Permanent - Citrus	0.0458	0.0004
Permanent - All Others	0.0699	0.0025
S&P 500	0.0265	0.0091

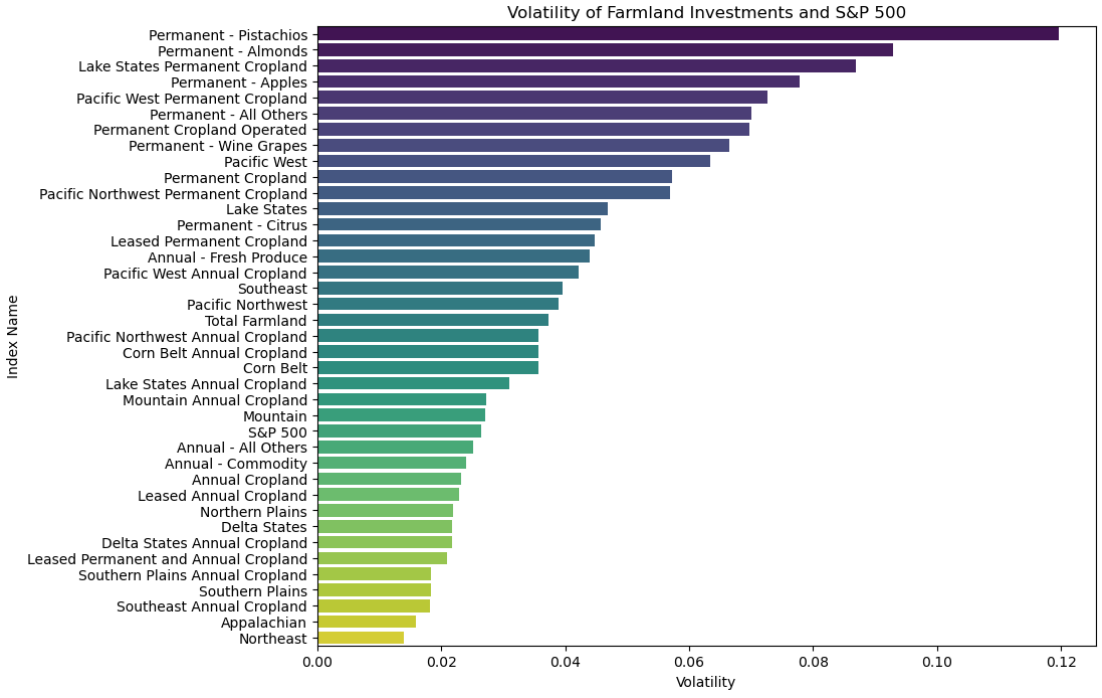

Figure 4: Volatility of Farmland Investments and S&P 500

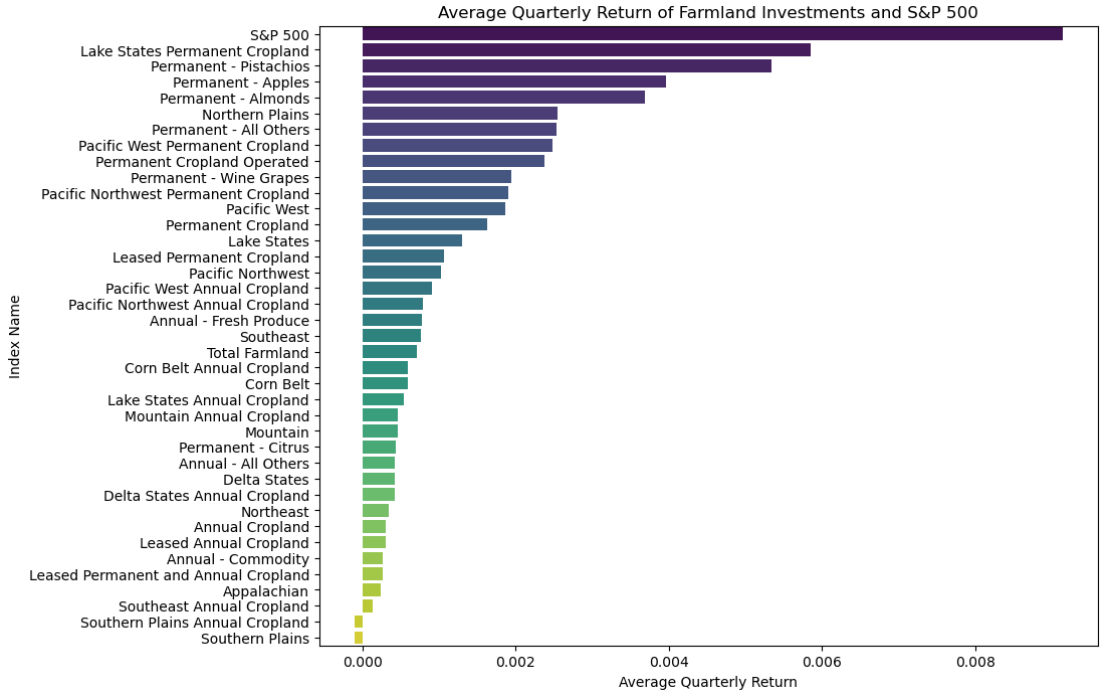

Figure 5: Average Quarterly Return of Farmland Investments and S&P 500

Volatility of Farmland Investments and S&P 500 shows the distribution of volatility across farmland indexes versus the S&P 500. This visualization highlights the broader range of risk profiles within farmland investments compared to the more uniform risk of the S&P 500.

Average Quarterly Return of Farmland Investments and S&P 500 compares the performance of farmland indexes against the S&P 500 over the same period. It illustrates that while some farmland investments have managed to outperform others significantly, none have matched the average quarterly return of the S&P 500.

The comparison between farmland investments and the S&P 500 underscores a critical diversification lesson for investors. Farmland investments exhibit a wide range of volatility and returns, suggesting that they can offer both conservative and aggressive investment opportunities within a single asset class. However, the overall performance of farmland investments, as measured by average quarterly returns, falls short of the

S&P 500, indicating that equities may offer superior growth potential over the analyzed period.

Nonetheless, the inclusion of farmland in an investment portfolio could serve as a diversification strategy, potentially mitigating risk through exposure to assets that do not correlate directly with the stock market's movements. This analysis highlights the importance of thorough research and strategic selection when incorporating alternative investments like farmland into a broader investment portfolio.

3.3 Impact of Portfolio Size on Farmland Investment

To examine the effect of portfolio size on the risk and return characteristics of farmland investments, we divide the farmland properties into quartiles based on the size of the properties, from the smallest (Q1) to the largest (Q4). We then analyze the volatility, average excess returns, and Sharpe ratios across these quartiles.

Table 7: Volatility, Excess Returns, and Sharpe Ratios by Quartile

Quartile	Volatility	Average Excess Return	Sharpe Ratio
Q1	0.0121	0.0114	0.9465
Q2	0.0448	0.0211	0.4708
Q3	0.0293	0.0331	1.1285
Q4	0.0100	0.0145	1.4499

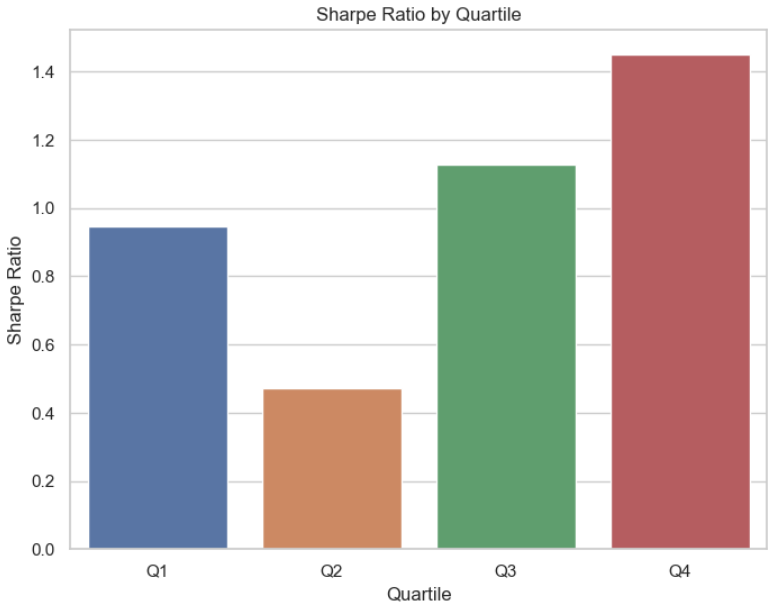

Figure 6: Sharpe Ratio by Quartile

The data presented in Table 7 and Figure 6 of the paper indicates a varied relationship between portfolio size and risk-return characteristics. The farmland properties are divided into quartiles based on their size, from the smallest (Q1) to the largest (Q4), and the volatility, average excess returns, and Sharpe ratios are analyzed across these quartiles.

Notably, the largest quartile (Q4) demonstrates the lowest volatility among all quartiles, at 0.0100. This suggests that larger farmland portfolios tend to have more stable returns and are less susceptible to market fluctuations. Additionally, Q4 exhibits a higher average excess return of 0.0145 compared to the smallest quartile (Q1), which has an average excess return of 0.0114. The combination of low volatility and higher excess returns results in Q4 having the highest Sharpe ratio of 1.4499 among all quartiles.

These findings imply that larger farmland portfolios offer better risk-adjusted returns compared to smaller portfolios. The lower volatility and higher Sharpe ratio of Q4 indicate that investors can potentially benefit from economies of scale and diversification effects when investing in larger farmland properties. Larger portfolios may have more resources to mitigate risks, access advanced technology, and diversify across different geographical regions and crop types, leading to more stable and profitable returns.

Interestingly, the second quartile (Q2) shows significantly higher volatility of 0.0448 compared to the other quartiles. This higher volatility, coupled with a lower average excess return of 0.0211, results in a lower Sharpe ratio of 0.4708 for Q2. This observation suggests that mid-sized farmland portfolios may face unique challenges or market dynamics that contribute to a less favorable risk-return trade-off. It is possible that mid-sized portfolios lack the benefits of diversification and economies of scale associated with larger portfolios while also facing more competition or resource constraints compared to smaller portfolios.

The analysis of portfolio size and risk-return characteristics in farmland investments highlights the potential advantages of investing in larger farmland portfolios. However, it is important to note that these findings are based on the specific

dataset and time period analyzed in the paper. Investors should consider various factors, such as market conditions, geographical differences, and individual farmland characteristics, when making investment decisions. Additionally, further research may be necessary to understand the specific factors contributing to the higher volatility and lower Sharpe ratio observed in mid-sized farmland portfolios.

3.4 Liquidity of Farmland Investments

Liquidity, measured by the turnover rate, provides insight into how frequently assets within a portfolio are traded. For the total farmland portfolio, we calculate the average turnover rate.

Average Turnover Rate: 0.0093

The low average turnover rate of approximately 0.93% indicates that farmland investments are relatively illiquid, with a small proportion of the portfolio's value being traded each quarter. This highlights the importance of considering liquidity and transaction costs in the investment decision-making process, as well as the potential benefits of a long-term investment horizon for farmland assets.

The analysis of farmland investments across different portfolio sizes reveals that larger portfolios tend to have better risk-adjusted returns as evidenced by their Sharpe ratios. Additionally, the low liquidity of farmland investments underscores the need for careful consideration of holding periods and transaction costs. These findings contribute to a deeper understanding of the risk and return dynamics and liquidity characteristics of farmland investments, informing investors about the potential benefits and considerations of including farmland in their investment portfolios.

Farmland investments have gained increasing attention from investors seeking to diversify their portfolios and enhance risk-adjusted returns. In this chapter, we explore the diversification benefits of farmland investments and their implications for portfolio construction and management. By examining the correlation between farmland returns and traditional financial assets, we shed light on the potential of farmland to improve portfolio efficiency and risk-adjusted performance. Furthermore, we investigate the impact of farmland allocation on the efficient frontier and assess the

liquidity characteristics of farmland investments, providing valuable insights for investors considering the inclusion of this alternative asset class in their portfolios.

3.5 Correlation Analysis between Farmland Investments and Traditional Financial Assets

In evaluating the potential for diversification within an investment portfolio, we conducted a correlation analysis between farmland investments and traditional financial assets, specifically the S&P 500 index, over the period from 1991 to 2022. This analysis is pivotal to understanding the relationship between the returns on farmland investments and the broader equity market as represented by the S&P 500.

Table 8: Correlation Matrix Findings

Asset Class	S&P 500 Index Returns	Farmland Quarterly Returns
S&P 500 Index Returns	1.0000	0.1030
Farmland Quarterly Returns	0.1030	1.0000

The correlation coefficient between the S&P 500 index returns (inclusive of dividends) and the quarterly returns on farmland investments stands at approximately 0.1030. This coefficient indicates a minimal positive correlation between the two asset classes over the specified timeframe.

Diversification Potential: The low correlation suggests that farmland investments and the S&P 500 index returns tend to move somewhat independently. These characteristic underscores the diversification potential of including farmland in a portfolio predominantly composed of traditional equity investments. The benefit here is the potential for risk reduction without a proportional decrease in expected returns.

Strategic Portfolio Enhancement: For portfolio managers and individual investors, the insights from this correlation analysis advocate for the strategic inclusion of farmland as a means to achieve a diversified investment portfolio. The aim is to leverage the low correlation to mitigate overall portfolio volatility, enhancing the stability of returns across various market conditions.

Risk-Return Consideration: While the correlation provides a dimension of how asset returns co-move, a thorough evaluation should also encompass the risk and return profiles of the assets in question. Investors should weigh the expected returns against the associated risks.

Market Dynamics: It's important to note that historical correlation may not perfectly forecast future interactions between these asset classes. Market dynamics, economic shifts, and external factors can influence future correlation patterns.

Holistic Approach: This correlation analysis forms part of a broader analytical framework. A comprehensive investment strategy should consider additional factors, including asset volatility, economic indicators, and geopolitical impacts, to inform decision-making.

The analysis of the correlation between farmland investments and the S&P 500 index reveals a low positive correlation, suggesting that farmland can play a beneficial role in diversifying investment portfolios. This inclusion can aid in risk management and enhance portfolio efficiency. Investors are encouraged to consider this strategy within the context of their overall investment objectives, taking into account risk tolerance and financial goals.

3.6 Analysis of Risk-Adjusted Return Measures for the Farmland Investment Portfolio

This section delves into the performance and risk characteristics of a farmland investment portfolio through the lens of risk-adjusted return measures, focusing on the Sharpe Ratio and Information Ratio, alongside an exploration of annualized log returns as a method for evaluating performance.

(1)Sharpe Ratio and Information Ratio

Initially, the analysis computes the Sharpe Ratio and Information Ratio of the farmland investment portfolio relative to the risk-free rate and the S&P 500 index, respectively.

Calculation Steps

1. Sharpe Ratio: Calculated using simple returns with the formula:

$$\text{Sharpe Ratio} = \frac{E\left(R_{farmland} - R_f\right)}{\sigma\left(R_{farmland} - R_f\right)}$$

Where E represents the mean, σ the standard deviation, $R_{farmland}$ the return on farmland investments, and R_f the risk-free rate.

2. Information Ratio: Measures the stability of excess returns relative to the S&P 500 index, calculated as:

$$\text{Information Ratio} = \frac{E\left(R_{farmland} - R_{benchmark}\right)}{\sigma\left(R_{farmland} - R_{benchmark}\right)}$$

Here, $R_{benchmark}$ represents the return on the S&P 500 index.

(2)Annualized Log Returns Method

Additionally, the report examines the application of annualized log returns for calculating the Sharpe Ratio, an approach that offers advantages in assessing long-term investment performance.

Calculation Steps:

1. Compute log returns
2. Annualize log returns: Multiply quarterly log returns by 4.
3. Annualize the risk-free rate: Average the quarterly risk-free rate and annualize.
4. Compute the annualized Sharpe Ratio.

(3)Calculation Outcomes

Sharpe Ratio: 0.0621

Information Ratio: 0.4566

Average Annualized Return Rate: 9.35%

Standard Deviation of Annualized Returns: 7.19%

Annualized Sharpe Ratio: 0.97

The juxtaposition of Sharpe Ratios derived from simple and log return calculations reveals:

The annualized Sharpe Ratio, based on log returns, is more apt for the analysis of long-term investments, reflecting the compounding effect of returns and the additivity over time.

Sharpe Ratios and Information Ratios calculated with simple returns provide an intuitive assessment of the short-term performance of the farmland investment portfolio, especially in comparisons with the risk-free rate and market benchmark.

Overall, the annualized log return methodology offers a deeper analysis of long-term risk-adjusted returns, while simple return calculations facilitate an evaluation of short-term performance. Depending on the investment strategy and analysis requirements, both methodologies have their applicable contexts.

3.7 Portfolio Efficiency with the Inclusion of Farmland Investments

This section explores the risk-return trade-off in portfolios that include farmland investments compared to portfolios comprised solely of the S&P 500 index, based on historical quarterly returns analysis.

Table 9: Average Quarterly Returns

Asset	Average Quarterly Return
S&P 500 Returns	0.0091
Farmland Returns	2.4227

The analysis highlights that the S&P 500's average quarterly return stands at 0.91%, while farmland investments significantly outperform this benchmark with an average quarterly return of 2.42%. This disparity suggests that historically, farmland investments have offered higher returns than standard stock market investments.

Risk Analysis (Covariance Matrix)

Table 10: Covariance Matrix

	S&P 500 Returns	Farmland Returns
S&P 500 Returns	0.0007	0.0081
Farmland Returns	0.0081	5.9259

The covariance matrix reveals a variance of 0.0007 for S&P 500 returns and a significantly higher variance of 5.925887 for farmland investments, indicating that farmland investments exhibit markedly higher volatility and risk compared to the S&P

500. The covariance between the two stands at 0.008127, indicating a certain degree of positive correlation, although not particularly strong.

Analysis of the Efficient Frontier

Table 11: Efficient Frontier Analysis

Statistic	Portfolio Variance	Expected Return
count	50	50
mean	1.9983	1.2159
std	1.8225	0.7180
min	0.0007	0.0091
25%	0.3743	0.6125
50%	1.4863	1.2159
75%	3.3369	1.8193
max	5.9259	2.4227

The analysis of the efficient frontier shows that as the expected return increases, the portfolio's variance (risk) correspondingly rises. Across 50 different levels of expected returns, the portfolio's average variance is 1.9983 with a standard deviation of 1.822492, demonstrating a nonlinear increase in portfolio risk with higher expected returns.

Table 12: Minimum Variance and Maximum Expected Return Portfolios

Portfolio	Portfolio Variance	Expected Return
Minimum Variance	0.0007	0.0091
Maximum Expected Return	5.9259	2.4227

The minimum variance portfolio has an expected return of 0.91%, aligning with the S&P 500's average return (see Table 9), while exhibiting the lowest risk level. On the other hand, the portfolio with the maximum expected return corresponds to the average return of farmland investments (see Table 9), with a variance of 5.925887, indicating the highest risk is associated with pursuing the highest expected returns.

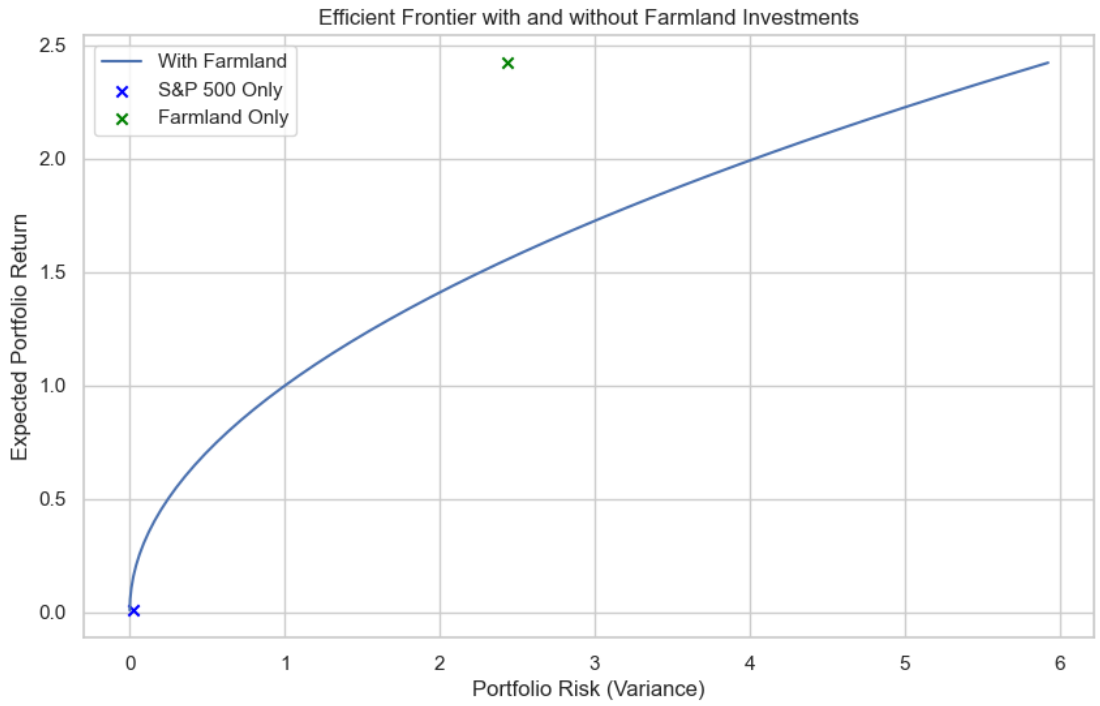

Figure7: Efficient Frontier with and without Farmland Investments

In conclusion, the inclusion of farmland investments into a diversified investment portfolio enhances the potential for higher returns but also introduces a dynamic risk profile. The efficient frontier analysis underscores the benefits of diversification, suggesting that an optimal mix of farmland investments can improve portfolio efficiency by offering a more favorable risk-return trade-off compared to a portfolio comprised solely of traditional financial assets like the S&P 500 index.

CHAPTER 4

CONCLUSION AND DISCUSSION

This study provides a comprehensive analysis of the risk and return characteristics of U.S. farmland investments from 1991 to 2022, examining their potential role in diversified investment portfolios. By employing the Fama-French five-factor model and various performance evaluation measures, we shed light on the unique features of farmland as an alternative asset class and its implications for asset allocation decisions.

Our findings suggest that farmland investments exhibit distinct risk and return dynamics compared to traditional financial assets. The Fama-French five-factor model, while effective in explaining the cross-section of stock returns, has limited explanatory power for farmland returns. This indicates that the factors driving farmland performance may differ from those captured by the model, such as market, size, value, profitability, and investment factors. The low R-squared value and insignificant factor coefficients underscore the need for alternative models or factors to better capture the unique risks and return drivers of farmland investments.

The analysis of risk-adjusted performance measures reveals that farmland investments have generated competitive returns with attractive Sharpe ratios over the studied period. The favorable risk-return profile of farmland, coupled with its low correlation with traditional asset classes like stocks and bonds, highlights its potential diversification benefits within investment portfolios. The inclusion of farmland in a mixed-asset portfolio can enhance risk-adjusted returns and provide a hedge against inflation, as evidenced by previous studies (Hardin and Cheng, 2005; Liang et al., 2011). Furthermore, our examination of different types of farmland and regions uncovers significant heterogeneity in their investment characteristics. Permanent cropland, particularly in the Pacific West and "Permanent - Pistachios" category, demonstrates high risk-adjusted returns and Sharpe ratios compared to other farmland segments. This suggests that investors should consider the specific attributes of farmland properties, such as crop type and geographic location, when making allocation decisions. The

varying risk-return profiles across farmland segments also highlight the importance of diversification within the farmland asset class itself.

The portfolio-level analysis reinforces the diversification potential of farmland investments. The efficient frontier analysis illustrates that the inclusion of farmland in a portfolio can improve its risk-return trade-off, offering higher expected returns for a given level of risk compared to a portfolio comprised solely of stocks. The low correlation between farmland and the S&P 500 index supports the notion that farmland can act as a diversifier, reducing overall portfolio risk.

However, our study also reveals some challenges and considerations associated with farmland investments. The liquidity analysis indicates that farmland is a relatively illiquid asset class, with low turnover rates compared to traditional financial assets. This illiquidity may limit the ability of investors to quickly rebalance their portfolios or exit positions, necessitating a long-term investment horizon. Moreover, the impact of portfolio size on farmland investment performance suggests that larger portfolios may benefit from economies of scale and better risk-adjusted returns, which could pose barriers for smaller investors.

The findings of this study have several implications for investors and portfolio managers. First, the unique risk and return characteristics of farmland investments warrant their consideration as a distinct asset class within a diversified portfolio. The low correlation with traditional assets and attractive risk-adjusted returns make farmland a valuable diversification tool. Second, the heterogeneity across farmland segments emphasizes the importance of due diligence and strategic selection when investing in farmland, taking into account factors such as crop type, geographic location, and portfolio size. Third, the illiquidity of farmland investments necessitates a long-term perspective and careful consideration of liquidity needs and investment horizons.

From a theoretical standpoint, our findings contribute to the growing body of literature on alternative investments and their role in modern portfolio theory. The limited explanatory power of the Fama-French five-factor model for farmland returns suggests that traditional asset pricing models may not fully capture the unique risks and return drivers of alternative assets. This calls for the development of specialized models or the

incorporation of additional factors that better reflect the underlying dynamics of farmland investments. Future research could explore the identification and quantification of such farmland-specific risk factors, as well as their integration into asset pricing frameworks.

Furthermore, our study highlights the need for more granular and comprehensive data on farmland investments. While the NCREIF database provides valuable insights, the availability of more detailed information on property characteristics, operational metrics, and local market conditions could enhance the understanding of farmland performance drivers and facilitate more precise risk assessment and valuation.

The NCREIF database could be expanded to include a wider array of property characteristics, such as soil quality, water availability, crop types, and climate conditions. These factors play a crucial role in determining the productivity and profitability of farmland investments. By incorporating these property-level details, investors and researchers could better understand the specific drivers of farmland performance and make more informed decisions based on the unique attributes of each property.

Additionally, the inclusion of operational metrics, such as crop yields, input costs, and revenue per acre, would provide a clearer picture of the financial performance of farmland investments. These metrics could help investors assess the efficiency and profitability of different farming practices and management strategies. By comparing operational metrics across properties and regions, investors could identify best practices and benchmark the performance of their investments against industry standards.

Local market conditions, such as land prices, rental rates, and supply and demand dynamics, also play a significant role in the performance of farmland investments. The NCREIF database could be enhanced by including data on these local market factors, allowing investors to assess the relative value and potential returns of farmland properties in different geographic locations. This information could also help investors identify emerging trends and opportunities in specific markets.

Furthermore, the integration of data from multiple sources, such as satellite imagery, weather data, and government agricultural reports, could provide a more

comprehensive and reliable picture of farmland investment performance. These additional data sources could help validate and supplement the information provided by the NCREIF database, increasing the overall credibility and usefulness of the data.

By expanding the NCREIF database to include more granular property characteristics, operational metrics, and local market conditions, investors and researchers would have access to a richer and more reliable dataset for analyzing farmland investment performance. This enhanced data would enable more precise risk assessment, valuation, and benchmarking, ultimately leading to better-informed investment decisions and improved transparency in the farmland investment market.

In conclusion, this paper presents a comprehensive analysis of the risk and return characteristics of U.S. farmland investments and their potential role in diversified portfolios. The findings underscore the distinct nature of farmland as an alternative asset class, its diversification benefits, and the heterogeneity within the farmland market. By considering farmland investments within a broader asset allocation framework, investors can make more informed decisions and potentially improve the risk-adjusted performance of their portfolios. However, the unique challenges associated with farmland investments, such as illiquidity and the need for specialized knowledge, should be carefully evaluated. As the demand for alternative investments grows and the focus on portfolio diversification intensifies, understanding the dynamics of farmland investments becomes increasingly relevant for both practitioners and researchers in the field of finance and investment management.

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