Does Modern Portfolio Theory Apply to Agricultural Land Ownership? Concepts for Farmers and Farm Managers

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Abstract

Farmers often have cash flow problems, although many build substantial wealth with the appreciation on their most valuable asset, land. Many agricultural products often consider diversification differently than the typical financial investor may. Agricultural producers usually only consider diversification approaches only within the farm itself, although there may be considerable benefits from truly financially diversifying beyond the farm enterprise. This article provides a theoretical link between financial market concepts and the desire of farmers, farm owners, and farm managers to maximize total income and minimize aggregate income risk.

Diversification of agricultural production units has been widely suggested as a risk management tool to reduce the impact of fluctuating farm incomes. Risk management literature is filled with causes for fluctuating farm incomes, but perhaps no more direct and succinct a list has ever been written than Kay and Edwards' which includes five major sources of farm income risk: production and technical, marketing and price, financial, legal, and personal (Kay and Edwards, 1999).

The inability to forecast or control either of the two critical components of total revenue – output (whether due to insects, weeds, temperature, wind, or precipitation) and price (due primarily to supply fluctuations and a competitive market structure) – introduces a major source of risk into agricultural production. Secondly however, having key people unavailable when needed (due either to health or resignation), having any buyers or market at all, or changes in government programs (including taxes) all introduce risk that must be considered by an agricultural producer.

Agricultural economists have developed a multitude of risk management methods to help in the decision-making process, but the methods are cumbersome to apply, extremely difficult to understand theoretically (which leads to user skepticism about their efficacy), or costly. The search for a simple but powerful tool seems to us to lie with the Capital Asset Pricing Model, commonly used in the world of financial markets.

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Although risk management discussions have been broad and thoughtful over the last 30 years, evidence of on-farm adoption of risk management tools, from diversification of crop enterprises to commodity price hedging to use of multiperil crop insurance, has been relatively small. If anything, a general observation seems to find agricultural producers specializing even more rather than diversifying as time goes forward: specializing in fewer commodities (note especially hog and dairy producers), calving at just one time of the year, using on-farm storage for both inputs and outputs, and buying in quantity. These strategies are aimed at minimizing transportation, purchasing, and other transactions costs and/or maximizing output prices. They are, however, opposite to the goals of diversification. Are agricultural producers unaware of how to manage risk or are they outright rejecting the risk management tools offered to them?

Agricultural producers are not alone in the quest to control income fluctuation and yet to capture economies of size and scale. Investors, both in farm-related and in non-farm markets, wish to avoid income fluctuation and to maximize income at the same time.

Diversification may be defined as spreading risk among many assets or activities to offset changes in markets that will not likely react similarly to economic or financial news and phenomena. Because farms can be thought of as assets within an overall portfolio, agricultural producers should also give attention to the concept of diversification in their operations, and consider diversification approaches beyond the farming enterprise itself.

Historically, agricultural producers and farm managers may not have considered diversification in the same manner that the typical financial investor may; they often look at diversification as changing their crop mix, rotational system, livestock breeds, or even purchasing another operation several miles away for geographic diversification. None of these actions would consistently fit the definition of diversification from a purely financial perspective, and may even increase risk. Commodity yields and prices have a tendency to trend together, and producers are still subject to the same uncontrollable market forces and weather conditions if they expand within the same set of crops or within the same general geographic area. Given this, crop mixes and rotations may not result in an effective diversification strategy to lessen the actual underlying risk, and in fact if the covariances work the way they might be expected to, whole-farm risk may actually increase. Moreover, expanding geographically may spread fixed costs over more acres and generate larger gross returns; however, this may lead to inefficiencies in labor and managerial resources as well as increase mileage on equipment given the scale of the operation and ultimately increase fixed costs and may increase rather than reduce risk. So, how should a landowner or farm manager truly diversify?

Don't assume that an agricultural landowner should sell the farm and invest the proceeds entirely in the domestic stock market or any other investment market, but rather consider the opportunities to increase the overall portfolio value by investing a portion of operating profit in financial assets and diversifying across asset classes. Diversifying in this manner may provide investors with greater returns on their investment opposed to production agriculture alone, while allowing the producer to continue with the chosen lifestyle in the agricultural environment.

This article attempts to provide a theoretical link between what financial market investors have come to understand about their markets and the concerns of farm investors for long-run profit maximization with appropriate risk management. Specifically, we hope to bridge gaps between agricultural property managers or investors, agricultural producers, and financial markets by bringing the Capital Asset Pricing Model literature to bear on agricultural land ownership and farm income fluctuation. Farm managers, rural appraisers, and agricultural consultants can all play major roles in helping investors make decisions with greater ease and greater likelihood of meeting investor goals. A companion article in this Journal (Kohler, Libbin, and Hawkes, 2004) applies this theory to a realistic example of farm income fluctuation and stock market performance over time to maximize the wealth for owners of ten representative New Mexico farms.[1]

Modern Portfolio Theory (MPT)

The nature of each investor and the objectives of investors may differ, although Markowitz (1959) identifies two objectives common to all investors:

1. They want return to be high. The appropriate definition of return may vary from investor to investor. But, in whatever sense is appropriate, they prefer more to less.

2. They want this return to be dependable, stable, not subject to uncertainty; i.e., they prefer certainty to uncertainty.

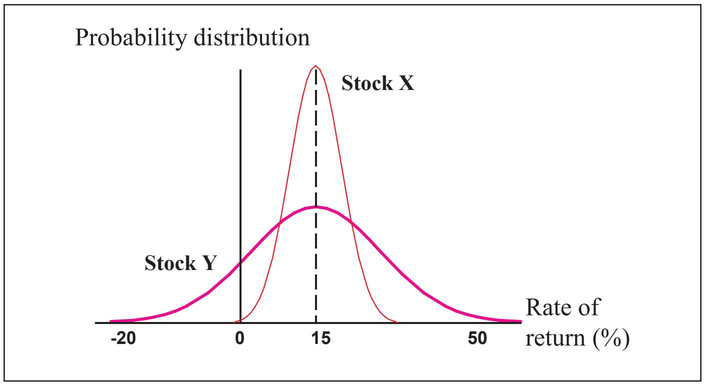
A good portfolio is more than a large combination of securities. It is balanced as a whole with the intent of providing the investor with protections and opportunities under a wide range of possibilities. Investors should build portfolios that are tailored to their individual needs. Developing portfolios begins with information on individual assets and ends as a mixed whole.

Portfolio Risk

Risk can be a difficult concept to recognize; there has not been a universal agreement on how to define and measure it in a portfolio context. Risk can be separated into both market (non-diversifiable or systematic) risk and stand-alone (diversifiable or non-systematic) risk; therefore an asset's risk is equal to its systematic risk plus its non-systematic risk. Diversifiable risk is affected by factors associated with a particular asset and can be nearly eliminated by diversification. Market risk stems from factors such as inflation, recession, business cycles, or interest rates and cannot be eliminated by diversification. A common definition for non-systematic risk is stated in terms of normal probability distributions as seen in Figure 1.[2] The tighter the probability distribution of expected returns, the less risky is the investment. The smaller the standard deviation, the tighter the distribution and the lower the risk of the investment.

Two key components of portfolio analysis are covariance and the correlation coefficient. Covariance is a measure of the tendency of investment returns to move together and describes whether the returns of two stocks tend to rise and fall together and how large those movements are.[3] The correlation coefficient standardizes the covariance by dividing by a product term to create a relative and comparable scale of measurement. The correlation coefficient[4] is confined to values between -1.0 and +1.0.[5]

Figure 1. Probability Distributions of Returns



Efficient Portfolios

Efficient portfolios are defined as those portfolios that provide the highest expected return for any degree of risk, or the lowest degree of risk for any expected return. Unreachable (or unattainable) portfolios must be eliminated quickly to leave the attainable (or feasible) sets; the efficient set is found within the attainable sets. If a group of assets were to be combined to construct a portfolio, which portfolio would actually be the best? The answer involves determining the efficient set of portfolios and choosing from the efficient set the single best portfolio for the investor.

In Figure 2, the boundary line BCDE defines the efficient set of portfolios, which is also called the efficient frontier.[6] Portfolios to the left of the efficient set are not possible because they lie outside of the attainable set. Portfolios to the right of the boundary line are inefficient because some other portfolio would provide either a higher return for the same degree of risk or a lower risk for the same rate of return. For example, portfolio X is dominated by Portfolios C and D (Brigham and Ehrhardt, 2002).

Given a set of efficient portfolios, a specific portfolio remains to be chosen. To determine the optimal portfolio for a particular investor, the investor's attitude toward risk must be considered. This is revealed by a risk/return trade-off function, also known as an indifference curve.[7] Each investor has a map

Figure 2. Feasible and Efficient Portfolios

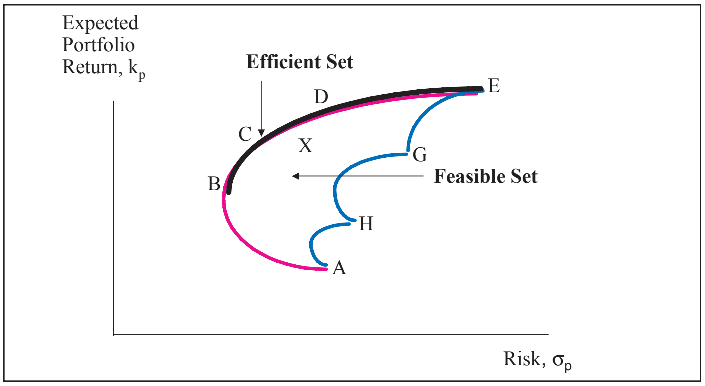
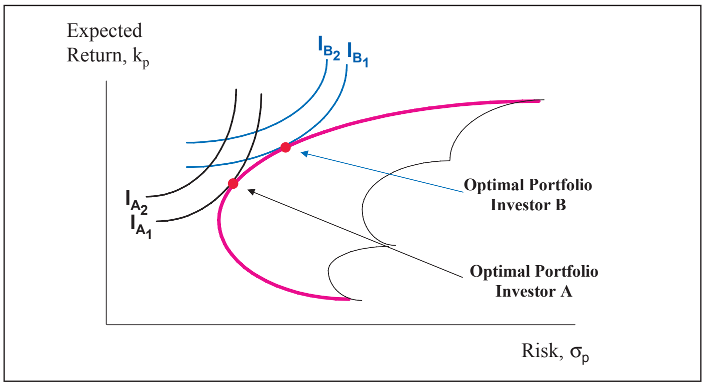


Figure 3. Optimal Portfolios



of indifference curves and the higher indifference curves represent a higher measure of utility. The curves in Figure 3 represent indifference curves for individuals A and B. Notice that individual A requires a higher expected rate of return at a given amount of risk than does individual B; thus individual A is said to be more risk averse than individual B. Generally, the steeper the slope of the indifference curve, the more risk averse the investor. I_{B2} is better than I_{B1} because for any level of risk, IB2 has a higher level of return. Each investor has a unique and infinite map of indifference curves.

Figure 3 also shows the optimal portfolios for each individual. The optimal portfolio for each investor occurs at the tangency point between the efficient set of portfolios and the investor's indifference curves. This tangency point represents the highest level of utility an investor can achieve within the feasible set of portfolio opportunities. Investor A, who is more risk averse, picks a portfolio with a lower expected return but less risk than does investor B, who chooses a portfolio with a higher expected rate of return and more risk.

Capital Asset Pricing Model (CAPM)

Investments have both non-systematic and systematic risk. Since a large part of non-systematic risk can be eliminated by diversification, the rational investor will only be concerned with market risk. Therefore, the relevant risk on an investment is its contribution of risk to a well-diversified portfolio. The Capital Asset Pricing Model demonstrates the relationship between risk and required rates of return on assets when they are held in a well-diversified portfolio, and is an important tool used to analyze this relationship.[8]

The Capital Market Line (CML

We have shown a set of portfolio opportunities and illustrated how indifference curves can be used in order to select the optimal portfolio from the feasible set. We now show a similar illustration for an optimal portfolio that also includes a risk-free asset with a return of k_{RF}. The riskless asset by definition has zero risk, therefore it's $\sigma = 0$. When a risk-free asset is added to the feasible set, portfolios can be created that combine this asset with a portfolio of risky assets to achieve any combination of risk and return on the straight line k_{RF} MZ, called the Capital Market Line (CML). Some portfolios on the CML will be preferred to most risky portfolios on the efficient frontier, so the points on this line now represent the best attainable combinations of risk and return.

Investors should hold portfolios that combine both riskless and risky securities lying on the CML under the conditions assumed in the CAPM. The addition of the risk-free asset changes the efficient set. It now lies on the CML rather than on the curve AMB, and all investors should hold portfolios at which their indifference curve is tangent to the CML.

The Capital Market Line has an intercept of the risk-free rate and a slope that is equal to the risk premium, which is called the market risk premium, multiplied by the portfolio's standard deviation. Thus, the CML specifies a linear relationship between expected return and risk. The CML is expressed as follows:

$$\text{CML: } \hat{k}_p = k_{RF} + \left(\frac{\hat{k}_M - k_{RF}}{\sigma_M} \right) \sigma_p$$

Where:

$\hat{k}_p$ = expected rate of return on the portfolio,

k_{RF} = risk free rate of return,

$\hat{k}_M$ = expected return on the market portfolio of securities,

σ_M = standard deviation of returns on the market portfolio,

σ_p = standard deviation of the portfolio

Slope of the CML = $(\hat{k}_M - k_{RF}) / \sigma_M$

Beta

The primary conclusion of the CAPM is that the relevant risk of an individual investment is its contribution of risk to a well-diversified portfolio. The benchmark for a well-diversified portfolio is the market portfolio, which would contain all securities. Therefore, the relevant risk of an individual investment is the amount of risk that it contributes to the market portfolio. We refer to this relevant risk as the beta coefficient. The beta coefficient, denoted by bi, is defined as:

$$b_i = \left(\frac{\sigma_i}{\sigma_M} \right) r_{iM}$$

Where:

b_i = beta coefficient of the *i*th security,

σ_i = standard deviation of expected returns of the *i*th security,

σ_M = standard deviation of expected returns of the market,

r_{iM} = correlation between the *i*th security's expected return and the expected return on the market

This suggests that a stock with a high standard deviation will tend to have a high beta. This is logical since a stock with high stand-alone risk will contribute more risk to a portfolio. Also, a stock with high correlation to the market will have a large beta coefficient. This is also fitting since high correlation means that diversification does little to help, and the stock contributes a lot of risk to the portfolio. Accordingly, the tendency of a security to move up and down with the market is measured by its beta coefficient. An average security is defined as one that tends to move along with the market as defined by an index or some other market proxy. So, an average stock will, by definition, have a beta coefficient of 1.0, which means that the security moves concurrently with the market. Securities with betas larger than 1.0 are said to be more risky, while securities with betas less than 1.0 are said to contribute less risk to the portfolio. Thus, since beta is a measure of a security's contribution of risk to a portfolio, it is theoretically the correct measure of risk (Brigham and Ehrhardt, 2002).

Security Market Line (SML)

The CML illustrates the relationship between risk and return of an efficient portfolio, but what if we are concerned about the risk and return of individual assets? For a given level of risk, measured by beta, what should investors require as a rate of return for bearing that risk? The market risk premium, which is the difference between the market return and the risk-free return, is the premium that investors require for bearing the risk of a security. The required rate of return for an investment can be generally expressed as a risk-free return plus a premium for risk. With this, the relationship between the risk and required rate of return for an individual security is called the Security Market Line (SML). The following is the SML equation:

$$\text{SML} = k_i = k_{RF} + (k_M - k_{RF}) b_i$$

Where:

k_i = required rate of return on the individual investment,

k_{RF} = risk-free rate of return,

$(k_M - k_{RF})$ or RP_M = market risk premium,

b_i = beta coefficient of individual security

The SML indicates that the required rate of return is equal to the risk-free rate plus a premium for bearing risk. That premium is equal to the market risk premium multiplied by the beta coefficient of the individual security. Remember that the beta coefficient is a measure of the amount of risk that the individual security contributes to the market portfolio. The beta reflects the measure of risk after taking diversification benefits into account. Thus, beta is the correct measure of risk for a security when held in a well-diversified portfolio. This is a major distinction between the CML and the SML (Brigham and Ehrhardt, 2002).

Single Index Model (SIM)

The Single Index Model, developed by Sharpe in 1963, embodies a method of risk analyses, which considerably decreases the amount of probability information required for making decisions about a single period portfolio. It allowed Markowitz's work to be applied to real world portfolios with actual equity securities and actual investors. "The differences between the CAPM and the SIM are as basic as the differences between positive and normative economics," according to Collins (1988). Sharpe developed the SIM to overcome two practical limitations of Markowitz's work. The first noted limitation of Markowitz's theory is that the number of covariance terms required by the model increases twice as fast as the number of portfolio assets. Secondly, the number of sample observations in the time series of asset returns must be greater than the total number of assets in the portfolio. Input parameters required by the SIM increase linearly with the total number of assets in the portfolio. A major strength of the SIM is that it involves fewer terms and is easier to implement than CAPM.

The SIM requires relatively simple arithmetic to measure and compare portfolio risk (Collins and Barry, 1986). There are two primary advantages of the SIM model over traditional risk analysis methods. The SIM is a more general measure of risk for individual activities of a multiproduct firm since the beta risk measures estimate the full variance-covariance matrix. The second advantage is that a better representation of future risk measures may be provided with use of the SIM model than by the full variance-covariance matrix.

The SIM has four basic assumptions, the first is that COV(,i,,j) = 0; i.e., abnormal returns are independent for different securities. Secondly, E(,j,t) = 0; the expected (abnormal) return at time t, is zero. The third assumption is COV(,j,rm) = 0; the abnormal returns are uncorrelated to the returns of a well-diversified market portfolio. The final assumption in the SIM is that various asset revenues are related by covariance with some basic index. This assumption implies that the only reason individual securities vary together systematically is because of a common co-movement with the market. There are no effects beyond the market that account for co-movement between securities. Turvey (1990) adds that "the measure of enterprise risk is relative to the risk associated with the index."

The equation most often used in determining the SIM is:

$$R_i = \alpha_i + \beta_i R_M + \varepsilon_i$$

Where:

R_i = return to enterprise or security,

α = a constant,

β = the return risk measure,

R_M = return to the market,

ε_i = an error term

Enterprise i's return is linearly related to the market's return. This equation looks exactly like that of the CAPM; however with the CAPM "market forces will cause the expected rate of return to equal the required rate of return through adjustments in the price of the security" (Collins, 1988).

Modern Portfolio Theory Research and Real Estate

Portfolio management of agricultural production units could be thought of as simply a special case of investment portfolio management in general or of real estate portfolio management in particular. One of our underlying (although unstated) hypotheses is that farmers wish to maximize returns from their aggregate portfolio. However, we believe that the farm would not be a candidate for sale in order to invest in a more profitable investment alternative. Even with that caveat, diversification and portfolio management of agricultural production units should theoretically be no more than a special case of real estate portfolio management. Consequently, the real estate portfolio management literature should be a fruitful area for theoretical guidance.

Real estate returns have traditionally been evaluated by their net income and appreciation components. Pagliari and Webb (1993) explored other components of real estate return, and they suggest that, alternatively, returns from real estate investments can be attributed to other factors. These factors include initial current yield, growth in operating income, and pricing movements. They suggest that separating returns into these three factors provides more insightful information on real estate returns. This allows investors to better materialize their perception on real estate returns and portfolio management.

Firstenberg, Ross, and Zisler (1988) studied how investors have traditionally thought of equity real estate as an inefficient market and that investment success relies upon selection and negotiation. The authors suggest that most investors seem to buy properties only because they are a good deal and give little consideration of how it fits into a portfolio context, and the impact that it might have on risk and return objectives. It is important to set risk and return objectives for a real estate portfolio, which are consistent with the goals of the investor's entire portfolio. The skill with which individual assets are managed will be a major determinant of return, although the composition of the portfolio as a whole impacts both the level and variability of returns.

Investors search for assets which provide reasonable returns and that are negatively correlated with common portfolios of stocks and bonds. Froot (1995) describes how real assets may be used to hedge portfolios. These broad groups of assets are at least partially hedged against inflation since they tend to increase in price in response to an inflation shock. Real assets may be valuable for portfolio diversification since stock and bond portfolios are often negatively correlated with inflation. These real assets may provide a kind of inflation insurance. Even though this may be a common understanding, it is not well understood how different real assets should be chosen by investors and how different real assets might protect portfolios. There has been relatively low allocation of real estate in overall investment among most non-farm investors; this seems to conflict with the suggestion of most academic studies. Brown and Schuck (1996) attempted to derive estimates of risk and correlations between common stocks and real estate for use in a mean-variance analysis to determine the effects on optimal two-asset portfolio allocations. This study found that there is strong evidence that allocation of real estate declines as the portfolio size declines, and there is evidence of skewness in the optimal real estate allocation. It was shown that over a wide range of portfolio sizes justifiable real estate allocations vary anywhere between 5 percent and 75 percent, but investors should not be discouraged from holding real estate as an asset class.

Yet another question that has been presented, although never fully answered, is how much of each property type should be held within the real estate allocation. Mueller and Laposa (1995) reviewed past property type diversification information and present suggestions for answering the property type diversification question. The total size of the real estate basket and the value of the properties, as well as historical and projected returns for weightings should be considered. Mueller and Laposa recognize that property type should not be the only diversification strategy; rather they find that property type allocation may enhance investor returns over real estate market and/or economic cycles.

Over time, real estate investors have come to favor different property types as industries and property types have gone through cycles. With little guidance on property types, many investors have specialized in one or two property types, while others have dealt with all types of properties. Property-type diversification including retail, office, warehouse, hotel, and multifamily rental units can be analyzed using an allocation based upon the relative size of investments, however, Mueller and Laposa are convinced that real estate size can be quantified from both a volume and value standpoint, and they propose that total return should be the most important consideration to real estate investors in the long run.

Mueller and Laposa conclude that property type diversification is a very important strategy for a portfolio investment. Depending on the criteria used, there has been a wide range of the appropriate amount of real estate to use. Using returns during different real estate and economic cycles, the efficient frontier analysis implies that property type returns move differently during different time periods. Thus, having a mix of property types within a portfolio should reduce an investor's risk through the cycles. Finally, the findings suggest the correct mix can easily be determined from past information, although it is much more difficult to determine the correct mix for the future.

Giliberto (1992) examines the role of real estate in institutional portfolios. The role of real estate in an investment portfolio has received a great deal of attention, and studies have typically been concerned with how much real estate should be allocated to a mixed-asset portfolio. The common method has been to determine mean-variance efficient portfolios and evaluate the risk and return with the inclusion of real estate. This study analyzes real estate as a portfolio asset in a different way. Rather than evaluating how much of a portfolio should be allocated to real estate, it investigates how large real estate returns should be in order to be included in a mixed-asset portfolio.

Real estate markets are cyclical and investment results vary along with these market cycles. Most researchers believe that real estate volatility is actually higher than observed because of the use of appraisal values rather than transaction prices. Again, correlations among assets are very important to an investment strategy, and Giliberto confirmed that real estate has a low correlation with most other financial assets. He recommends that investors must pay attention to correlations over time, as they do change.

This study concluded that real estate returns need to be in the range of 10 to12 percent in order to justify its inclusion as 5 to 15 percent of a mixed-asset portfolio. This was determined using mean-variance optimization, although it is pointed out that there are some drawbacks. Precise estimates of real estate returns may not be possible. There may also be problems with the uncertainty of the holding period of real estate investments, and the high transaction cost of real estate versus financial assets have not been thoroughly considered.

A major structural distinction between the financial and real estate markets is agency (transaction) costs. Graff and Webb (1997) investigated agency costs as a possible source of pricing inefficiency in the real estate market. Market efficiency is key in nearly all modern investments. It has influenced models of market economics, and has led to the expansion of performance benchmarks for asset classes in the institutional investment industry. Influence has also come from the beliefs that asset performance is solely due to economic events.

Real estate has long been considered an illiquid asset, and the belief in market efficiency has been more of an act of faith rather than a conclusion supported by empirical evidence. This is incorporated into the thought about appraisal-based valuation for real estate and the inadequacies accounted for with this methodology. This assumption is implied across all property types to evaluate the efficiency or inefficiency in the real estate market.

Graff and Webb conclude that real estate markets face different challenges than those experienced by the purely financial markets. The transactions for real estate are typically private events that are not observable by most researchers. Also, these transactions are not openly available to statistical examination. With these limitations, researchers have been constrained to adapting portfolio theory to the real estate context. A number of possibilities are available for implementation into assessing institutional controls providing adequate comfort levels for both investors and portfolio managers as real estate becomes better understood and more applicable to the modern portfolio.

The benefits of including real estate as a component of a portfolio and its diversification are not complete when real estate is treated as simply a generic asset. For this reason, Hudson-Wilson and Elbaum (1995) encourage diversification across the various components of real estate. They propose that an investor can benefit by holding a managed portfolio of real estate assets and consider the real estate market as broadly consisting of four quadrants representing the interaction of public and private markets with debt and equity. The four quadrants include publicly traded mortgage securities, privately originated mortgages, privately held real estate equity, and publicly traded equity real estate investment trusts (REITs). Real estate clearly brings diversification benefits to a mixed-asset portfolio, though effective management will best serve the investor. Also, the asset mix of the portfolio is not only a function of the risk and return preference, but also the relative position of each market over time.

Webb (1990) makes two main arguments as to why real estate should be included in any market portfolio proxy. The first is the remarkable magnitude of real estate. Real estate makes up more than half of all U.S. aggregate investable wealth; double that of all corporate securities combined. Secondly, real estate is favorable because of its correlation among other asset classes and inflation.

Agricultural Adaptations and Applications

Mishra and Morehart (2001) indicate that risk in agriculture is widespread due to unexpected climate, biological, economic, and political events, all of which present possible threats to the farm business. They suggest that farmers are generally faced with three types of risk: production and marketing risk, financial risk, and price risk. Farmers challenge the threats with several methods and strategies attempting to lessen the adverse affects. One strategy, which has not received much of attention, is investing in non-farm financial assets. By holding a portfolio of farm and non-farm assets, farm households can diversify and perhaps reduce risk. Mishra and Morehart investigated and considered factors affecting off-farm investment of farm households.

A national farm-level survey was used with the objectives of identifying factors that affect off-farm investments by farm households, and to quantify their relative importance in off-farm investment decisions by farm households. The authors point out that the farm household is no different than any other investor, i.e., maximize expected utility by allocating initial wealth among competing investment alternatives. Farm households can invest in on-farm assets and off-farm assets such as stocks, bonds, IRAs, CDs, and mutual funds. Many studies have analyzed farm and non-farm investment and the overall conclusion is that off-farm financial diversification reduces risk exposure.

This study found that the operator's level of education and age had a positive influence and were significant in explaining off-farm investment decisions. Net worth and off-farm employment had positive effects on off-farm investment and large farms are more likely to be financially diversified than small farms. Conversely, increased farm diversification and debt reduces the likelihood of off-farm investment.
Barry (1980) first applied CAPM methods to agricultural investments by analyzing agricultural real estate as an alternative investment to be held in a portfolio. He evaluated how well the CAPM assumptions correspond to characteristics of farm real estate markets and computed risk premiums required to hold farm real estate in a well-diversified market portfolio by estimating the beta coefficient of the market model. Ten regional annual rates of returns on farm real estate and a weighted market index containing annual returns were statistically regressed on stocks, bonds, and farm real estate. He reported low beta values, which implies that investment in farm real estate has low risk relative to other assets and is a promising candidate for risk reduction in a well-diversified investment portfolio. He determined that CAPM methodically treats risk pricing in an equilibrium framework that yields important insights about the effects of an investor's behavior and market characteristics. He found, however, that CAPM fails to reflect the expectations of inflation, which causes CAPM risk measures to be overestimated.

Irwin, Forster, and Sherrick (1988) extended Barry's farm real estate study by explicitly accounting for effects of uncertain inflation. They included inflation by using a broader market proxy and lengthening the sample period. Their results modified Barry's results. They found that farm real estate returns contribute little risk to a well-diversified portfolio, and farm real estate returns are not strongly related to the performance of the market portfolio but are systematically related to uncertain inflation. It was determined that inflation causes returns to vary but to an extent that will not affect the economy.

Agricultural SIM – A New Mexico Example

Kohler, Libbin and Hawkes (2004) applied the Single Index Model directly to a series of 10 representative New Mexico farms. Each of the 10 farms was unique (one was a dryland grain farm, one a diversified row crop-vegetable-forage irrigated farm, several used pump irrigation and several surface water irrigation systems, some were part time and some were large, some emphasized row crops while others included alfalfa). Each example farm was assumed to have been purchased in 1989 (at various debt load assumptions) and was modeled through 2001. Net cash flows after cash operating expenses, after debt service, and after family living expenditures were considered to be not investable or cash. Excess cash was used in a variety of strategies including early debt retirement, retain excess cash as cash, invest excess cash in money market or mutual funds, and invest in stocks using a CAPM/SIM approach applied using stocks from farm input manufactures and supplies as well as farm product processors and retailers.

Efficient portfolios were defined as those portfolios that provide the highest return for any degree of risk, or the lowest degree of risk for any return. With that in mind, an efficient set of stocks was chosen from an available set of fifty stocks. The efficient frontier, or efficient set, included a set of five stocks that dominated all other stocks. These five stocks (McCormick & Co., Wrigley Co., Winn-Dixie Stores, Merck & Co., and Pfizer Inc.) dominated all other stocks since they offered a higher return for any degree of risk or a lower degree of risk for any return.

Portfolio betas were calculated at the maximum debt load for each model. The market beta included land appreciation as part of annual return. Cash basis portfolio betas excluded non-cash appreciation of land. All of the computed betas were virtually zero or very close to zero.

Investing in the efficient set of stocks dominated all other strategies for all five farm models at every debt load. This strategy resulted in the highest ending value of liquid investments, hence, the highest ending portfolio value and growth rate. Retaining all cash resulted in the smallest ending portfolio value for most models at nearly all debt loads. The mutual fund strategy had the worst effect on portfolio value for some scenarios. All other financial strategies were ranked differently depending upon the individual farm model and the initial debt load.

Summary

This article provides a summary of relevant research directed at diversification of financial portfolios and potential adaptations and applications of the Capital Asset Pricing Model approach to agriculture. A companion article (Kohler, Libbin, and Hawkes, 2004) illustrates the approach using 10 representative New Mexico farms. While the results of that article do not seem to reach a broadly applicable conclusion that will meet all farm owner-investor-manager goals, the CAPM approach attacks the issue of diversification at the most important level - that of total farm income rather than at any of its many parts.

Endnotes

[1] This article requires some mathematics, but we have included only the bare minimum necessary to accurately portray the theoretical development. The reader should skip over the math the first time through the article; the math should illuminate and simplify rather than complicate.

[2] The most useful measure of this risk is the standard deviation, denoted by .The following equation is used to calculate the standard deviation (SD) of a portfolio:

$$\text{Portfolio SD} = \sigma_p = \sqrt{\sum_{i=1}^{n} (k_{pi} - \hat{k}_p)^2 P_i}$$

Where: σ_p = standard deviation of the portfolio, k_{pi} = return on the portfolio under the *i*th state of the economy,
$\hat{k}_p$ = expected return on the portfolio, P_i = probability of occurrence of the *i*th state of the economy

[3] The following equation is used to calculate the covariance between to stocks:

$$\text{Covariance} = \text{Cov(A,B)} = \sum_{i=1}^{n} (k_{Ai} - \hat{k}_A)(k_{Bi} - \hat{k}_B)P_i$$

Where: $(k_{Ai} - \hat{k}_A)$ = deviation of Stock A's return from its expected value, $(k_{Bi} - \hat{k}_B)$ = deviation of Stock B's return from its expected value, P_i = probability of the *i*th state occurring

[4] The correlation coefficient, denoted as r, is calculated as:

$$\text{Covariance} = \text{Cov(A,B)} = \sum_{i=1}^{n} (k_{Ai} - \hat{k}_A)(k_{Bi} - \hat{k}_B)P_i$$

Where: $(k_{Ai} - \hat{k}_A)$ = deviation of Stock A's return from its expected value, $(k_{Bi} - \hat{k}_B)$ = deviation of Stock B's return from its expected value, P_i = probability of the *i*th state occurring

[5] Stock X is less risky than stock Y because it has a tighter distribution of returns, and therefore, a smaller standard deviation. To calculate the risk of a two-asset portfolio, the following equation would be used:

$$\text{Portfolio SD} = \sigma_p = \sqrt{w_A^2\sigma_A^2 + (1-w_A)^2\sigma_B^2 + 2w_A(1-w_A)r_{AB}\sigma_A\sigma_B}$$

Where: w_A = fraction of portfolio invested in security A, $(1-w_A)$ = fraction of portfolio invested in security B, σ_A = standard deviation of security A, σ_B = standard deviation of security B, r_{AB} = correlation coefficient of securities A and B

[6] A procedure for determining efficient portfolios was developed by Harry Markowitz and first reported in his article "Portfolio Selection," Journal of Finance, March 1952. This article developed the basic concepts of portfolio theory, and further work developed the Capital Asset Pricing Model. These efforts let to the Nobel Prize in economics awarded to Markowitz and William Sharpe in 1990.

[7] An investor's risk/return trade-off is based on the standard economic concepts of utility theory.

[8] A number of assumptions were made in the development of the CAPM. They can be summarized as: 1. All investors focus on a single holding period, and they seek to maximize the expected utility of their terminal wealth by choosing among alternative portfolios on the basis of each portfolio's expected return and standard deviation. 2. All investors can borrow or lend an unlimited amount at a given risk-free rate on interest, , and there are no restrictions on short sales of any asset. 3. All investors have identical estimates of the expected returns, variances, and covariances among all assets (i.e., investors have homogenous expectations). 4. All assets are perfectly divisible and perfectly liquid (i.e., marketable at the going price). 5. There are no transaction costs. 6. There

are no taxes. 7. All investors are price takers (i.e., all investors assume that their own buying and selling activity will not effect security prices). 8. The quantities of all assets are given and fixed (Brigham and Ehrhardt, 2002).

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