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Enhancing the competitiveness and risk-efficiency of farm assets through holding farm/financial asset and off-farm income portfolios

by

Carl J. Lagerkvist*, Mark Gregory and Kent D. Olson

Abstract

This study employs a dynamic continuous time model to calculate farm and total farm/financial/off-farm investment portfolios. Data are from the Southwestern Minnesota Farm Business Management Association records. Results are derived for classes of farms sorted by farm profitability. It is shown that this categorization of farm assets has a significant impact on the portfolio results as well as on the degree of competitiveness of the farm asset in relation to financial assets. The impact of off-farm income to portfolio selection is modest but found to differ across farm types.

Keywords: Portfolio selection, Agricultural Finance, Off-farm income

JEL Classification:

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Introduction

A problem facing many farmers today is the risk-return imbalance often associated with farm asset returns. When considered as independent, individual investments, the returns to farm assets often prove uncompetitive with the return performances of non-farm assets given the level of risk involved. The historic variability of returns to farm assets appears set to continue as competition in agriculture increasingly occurs on a global scale and traditional sources of risk remain. Encouraging farmers to use effective investment and portfolio planning methods should improve the risk-return efficiency of farm and total assets as well as force rationality upon current capital allocations in the face of competition from alternative investments.

Many developed countries consistently expend a tremendous amount of resources in assisting farmers with the reduction and management of risk to enhance of farm incomes. An underlying goal of such policies is to improve farm asset risk-return imbalances. However, using policy mechanisms to stabilize and enhance farm asset returns has met with mixed results and often times proved counter productive (Clark, Klein, and Tompson, 1993; Kalaitzandonakes, 1994; Featherstone, Moss, Baker, and Preckel, 1988). In fact, the existence of such policies often acts as an additional source of uncertainty and risk as farmers are not guaranteed the continuance or consistency of the existing policies (Lagerkvist, 2002). Encouraging alternative means of decreasing the volatility of farm cash flows and improving the performance of farmer's total assets could be beneficial to all concerned parties.

We investigate the possibilities of obtaining risk-return efficiency benefits and gains through holding more optimal combinations of farm and financial assets and off-farm income. To allow for a re-balancing of the portfolio mix motivated by structural changes, this study employs a dynamic model to calculate farm and total farm/financial/off-farm investment portfolios. The model developed follows the work by Svensson & Werner but provide a generalization since we

do not presuppose given preferences. Similar multiperiod studies have been conducted by Moss, Featherstone, and Baker (1987) for farm and financial assets and in theoretical work by Andersson, Ramamurtie, and Ramaswami (2003) for farm/financial and off-farm assets.

Methods

The model developed in this section follows the approach taken by Svensson & Werner. Farm operator income is generated by investing in traded assets; farm and financial, as well as by claims to non-traded assets. In this study off-farm income represents claims on non-traded assets. It is assumed that the off-farm income is not spanned by income from traded assets¹. Spanning exists if a linear combination of income from traded assets so that the value of the replicating portfolio perfectly correlates with the risk in the non-traded asset (Dixit & Pindyck, p. 117). To further simplify the problem we assume that there is no stochastic dependence on a state variable and no short sales constraints are imposed. The farm operator then maximizes the utility, for given levels of wealth W inclusive of the value of off-farm income F , of an uncertain infinite consumption path $\{C(s)\}_{s=t}^{\infty}$ and with continuous opportunities for trades in $n+1$ different assets. Asset 0 is characterized by the instantaneously risk-less rate of return r . A Brownian motion process governs the return on each risky asset so that $dq = \alpha_q dt + \sigma_q dz$ $\nabla q = 1 \dots n$ where each α and σ , respectively are constants. Let Ω and Ω^{-1} denote the $n \times n$ variance-covariance matrix and the inverse of this matrix of traded assets, respectively². Off-farm income is modeled as

¹ Bodie, Merton & Samuelson; Andersson, Ramamurtie & Ramaswami represent recent work that assumes spanning to hold. To our knowledge there are no empirical support for the existence of spanning. In addition, Duffie & Jackson showed that the value of a non-traded asset is independent on preferences when traded assets span a non-traded asset.

² Ω^{-1} exists if Ω is non-singular (Merton).

exogenous³ at each instant and is generated by the arithmetic process $dy = \alpha_y dt + \sigma_y dz_y$, where α_y represents the expected rate of change and σ_y is the instantaneous standard deviation. We let Ω_{qy} represent the $n \times 1$ covariance matrix for risky assets and off-farm income. The optimality condition is obtained by following the approach by Svensson & Werner (to which is referred to for details of the derivation) in solving for the $n \times 1$ vector of optimal portfolio weights $X^*(W)$ with the exception that our result (1) is derived without specifying the utility preferences properties of the decision maker. The system of optimal weights is then:

$$X^* = (-J_w/J_{ww})\Omega^{-1}v_q - \Omega^{-1}\Omega_{qy} \quad (1)$$

where $(-J_w/J_{ww})$ represents partials of the indirect utility function w.r.t the comprehensive wealth argument. This term is interpreted as the reciprocal of risk aversion. $v_q = \alpha_q - r\mathbf{1}$ is $n \times 1$ and represents the excess rate of returns for risky assets and $\mathbf{1}$ is a vector of ones.

The terms on the r.h.s of (1) has a clear and known economic interpretation. The first term represents the tangency portfolio (i. e. the tangency between the efficient frontier in the mean-variance dimension and the security market line) (Merton; Bodie *et al*; Constantinides & Malliaris). The second term on the r.h.s of (1) is the income hedge portfolio (Svensson & Werner; Andersson *et al*.). The optimal weights of the risky farm and financial assets are decreasing in the correlation between off-farm income and individual risky assets. In case of no correlation

³ Endogenous off-farm income is desirable to include in the model but was excluded due to lack of annual data on hours worked off-farm. Empirical work considering endogenous off-farm found that capital investments in Israeli agriculture prevented farmers from seeking off-farm employment (Ahituv & Kimhi). Andersson, Ramamurtie & Ramaswami shows (eq. 20) that higher off-farm income increases investments in risky traded assets if off-farm income is exogenous and spanned.

between off-farm income and risky asset returns, off-farm income would still affect the portfolio weights through the comprehensive wealth argument in the indirect utility function.

The portfolio selection is independent of comprehensive wealth if preferences are characterized by constant absolute risk aversion (Svensson & Werner).

It is also straightforward to observe that eq. (1), in case of logarithmic utility and no correlation between the risky asset returns and the off-farm income, collapses to the dynamic log-optimal growth portfolio (Luenberger, 1998, 1993) and, in a static formulation to the portfolio selection model by Sharpe. In the dynamic formulation it is also of interest to note the close correspondence between the log-optimal growth portfolio and other selection measures such as value preserving portfolios, numerarie portfolios, and martingale measures as shown by Korn & Schäl.

Data

Farm data are from the Southwestern Minnesota Farm Business Management Association records. The time series initially collected covers the period 1984 through 2001 only sole proprietors are included. Farms in approximately 12-15 Minnesota counties annually submit firm information with which the data has been developed. The farms from which data is derived are primarily involved in soybean, corn, hogs, cattle, milk, and combinations of these and other activities of lesser importance. All data is in nominal terms unadjusted for inflation. Data for all potential portfolio entrants must be kept in like-terms, either nominal or real returns for all farm and financial assets in this case. Which terms (nominal or real) used has no effect on resultant portfolio calculations, consistency is important, however.

The empirical analysis of the competitiveness between farm and financial assets including off-farm income is novel. Our preliminary static results (Gregory, 2002) reported size of farm

operation as well as type of farming to reveal major differences with respect to optimal portfolio selection. It was not possible to identify the same farm classes when off-farm income were considered since data on net farm wages, salaries and business income could not be sorted out from a broader total non-farm income measure for the period of consideration. Instead, we hypothesize that the profitability of farm operations can be used to illustrate the portfolio impacts of off-farm income. We assume that incentives for off-farm work are decreasing in farm profits and variability (the latter shown by Mishra & Goodwin; Mishra & Holthausen). Three classes of farms were therefore identified in our analysis, the low 20 %, the average, and the high 20 % of average farm profits. Table 1 provides the characteristics of these firm classes. Figure 1 then reveals that the share of non-farm wages, salaries and business income (NFWSBI) to the total of net cash farm income and NFWSBI constitutes a large an increasing pattern for low profitability farm, while only marginally affects the income for the more profitable farm operations. Andersson *et al.* (Proposition 2) shows that an increase in off-farm income increases the weight of the farm asset in the portfolio of traded assets if the coefficient of variation of farm asset returns times the correlation between the farm asset and off-farm income is less than the corresponding product between the financial assets.

Table 1. Firm characteristics of classes of farm operations

	Low 20 %	Average	High 20 %
Average no. of farms	39.9	200	40
Average Return on farm assets (ROA) *	0.004	0.0699	0.1108
Standard deviation (ROA)	0.0202	0.0314	0.0373
Average total farm assets	581085	657086	1032216
Average farm liabilities	282589	257850	331853
Average non-farm assets	92890	99077	132683
Average net farm income	40099	62035	109744
Average non-farm wages, salaries and business income (NFWSBI)	14020	7944	4565
Standard deviation NFWSBI	6592	3306	2171
Average operator age	45.5	45	46.2
Average years in farming of senior operator	22.2	22.3	23.7

Note: * ROA is in continuous time and is based on fair market values of farm assets, obtained by an AR(1) process (autocorrelation checked for but absent).

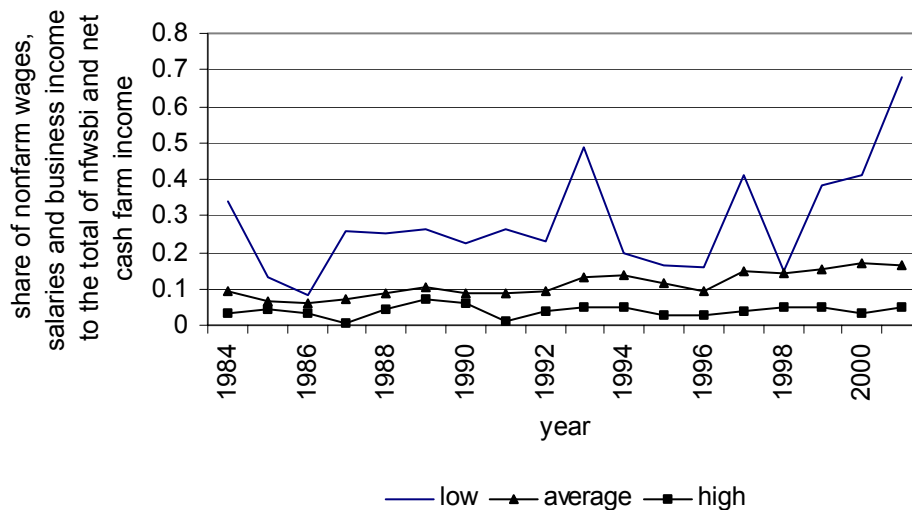


Figure 1. Shares of non-farm wages, salaries and business income to gross household income for various classes of farms by farm profitability, Southwestern Minnesota Farm records 1984-2001.

The financial asset data used in this study was obtained on-line from *Economagic* (www.economagic.com). Two financial assets, representing different return-risk characteristics were represented in the study: the Standard & Poor's 500 Total return index and Treasury bonds with a 10-year constant time to maturity (a total return index). The Standard & Poor's stock index represents the 500 largest U.S. corporations in each of the data years. Most sectors are represented in this diverse index. The S&P 500 can be considered low to medium risk for stock market investing. Total return indexes were sought to obtain a correspondence to the farm ROA. Both of the financial indexes were transformed from monthly measures to continuous annual return series by the methodology presented in Ibbotson Associates. The S&P total return index reveals an annual expected value of 13.35 percent with a standard deviation of 13.45 percent. The expected annual total return on the Treasury bonds is 10.67 percent with a standard deviation of 8.63 percent.

Conditional variances and covariances were obtained from the residuals of a vector autoregressive system (VAR). The covariance matrix (Ω) for each class of farm operation was obtained from the residuals of the financial assets and each of the farm asset returns, respectively.

Table 2-4 depicts the correlations between risky assets (S&P 500 TR, Treasury Bonds, and farm returns) for each farm class, respectively.

Table 2. Correlations between S&P 500 TR, Treasury Bonds, ROA for low 20%

	S&P 500 TR	Treasury Bonds TR	ROA low 20%
S&P 500 TR	1		
Treasury Bonds	-0.17	1	
ROA low 20%	-0.28	-0.23	1

Table 3. Correlations between S&P 500 TR, Treasury Bonds, ROA for average

	S&P 500 TR	Treasury Bonds TR	ROA low 20%
S&P 500 TR	1		
Treasury Bonds	-0.111	1	
ROA low 20%	-0.254	-0.032	1

Table 4. Correlations between S&P 500 TR, Treasury Bonds, ROA for high 20%

	S&P 500 TR	Treasury Bonds TR	ROA low 20%
S&P 500 TR	1		
Treasury Bonds	-0.093	1	
ROA low 20%	-0.409	-0.017	1

The covariance matrix (Ω_{gt}) representing the covariance between the risky traded assets and the growth rate in off-farm income (NFWSBI) was obtained from the residuals of a VAR system with the growth rate in NFWSBI included. Table 5 reports the correlations per class of farms.

Table 5. Correlations between risky assets and growth rate in off-farm income per farm class.

	Low 20 %	Average	High 20 %
S&P TR and NFWSBI	-0.231	-0.0149	-0.0343
Treasury Bonds and NFWSBI	0.1359	-0.343	0.14902
ROA and NFWSBI	0.3061	0.185	-0.0758

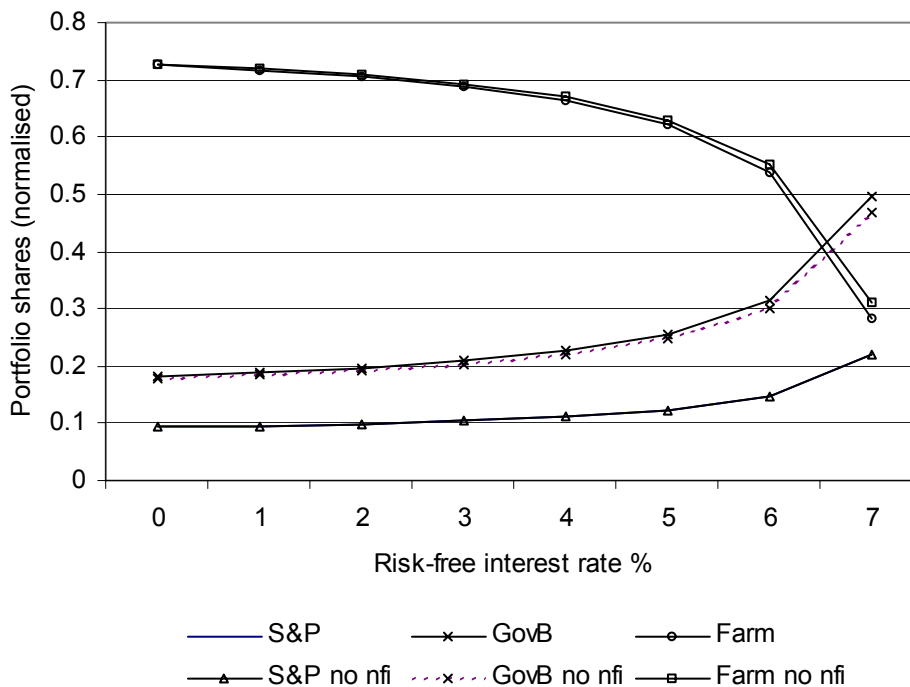
Results

For the classes of firms considered, we use (1) along with the estimated covariances to calculate the optimal portfolio weights of financial and farm assets. Risk aversion was not included in the portfolio selection, but is a research topic to which we allocate our current efforts.

Optimal portfolio weights are derived by successively alter the risk-free interest rate. We derive the weights for the case when off-farm income is correlated to risky asset return as reported in Table 5, as well as for the case of no correlation. This is done to illustrate the magnitude of off-farm income in affecting risk and portfolio choice.

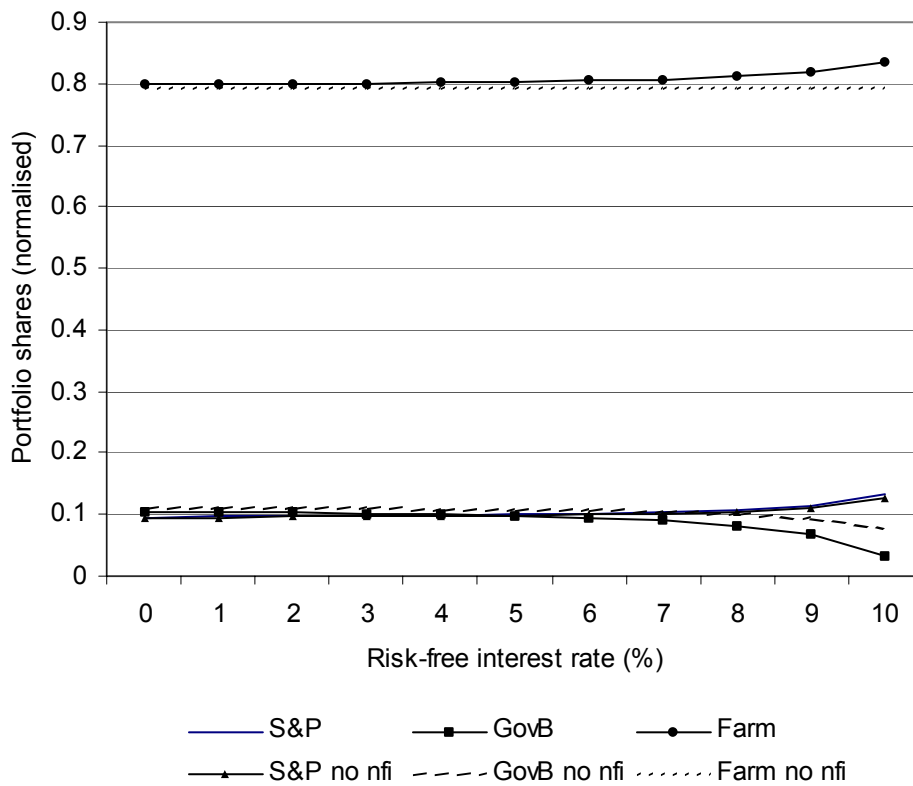
We find that the 20 % low of farms is highly uncompetitive for any choice of the risk-free interest rate. Instead, this asset is short-sold for reasonable levels of the risk-free interest rate (positive).

The farm asset is, however, competitive for the two other classes when considered together with the chosen financial assets. Figure 2 and 3 reports the normalized optimal portfolio weights.



Note: “nfi” is off-farm income (NFWsBI).

Figure 2. Optimal portfolio shares of S&P 500 TR Index, Treasury Bonds TR Index and farm assets for the class of firms with average profitability.



Note: “nfi” is off-farm income (NFWSBI).

Figure 3. Optimal portfolio shares of S&P 500 TR Index, Treasury Bonds TR Index and farm assets for the class of firms with 20% high profitability.

The magnitude of impact of off-farm income to the portfolio selection is modest for both farm classes. It is, however, noteworthy to observe that the impacts of off-farm income is largely opposite for the two farm classes considered. To the average class, off-farm income decreases the weight of the farm asset at an increasing rate as the excess rate of return is diminishing (higher risk-free rate of return), while to opposite is found for the high 20% class. These impacts are reported in Figure 4.

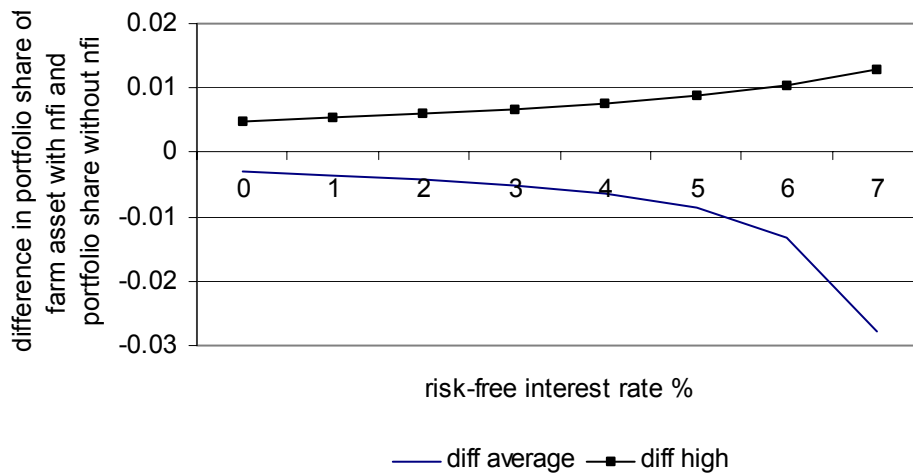


Figure 4. Impact of non-farm wages, salaries and business income on the optimal weight of the farm asset for the average class and the high 20% class.

Concluding comments

No other studies have been found that have looked at the optimal farm asset, financial asset, and off-farm income portfolio for different classes of farms in a dynamic setting. We find, under risk-neutrality, that off-farm income has a modest effect on the portfolio selection process. Similar results have been reported for Sweden when farms were categorized by geographical location (Andersson, Ramamurtie, Ramaswami, 1994). The low ratio of off-farm income to total wealth contributes to this result besides the weak correlation between the risky asset returns and the change in off-farm income. This necessarily does not impose off-farm income to be of no further interest for agricultural investment analysis for at least three reasons. First, off-farm income may affect the capital accumulation of farm assets. Secondly, aversion to wealth and consumption risk may likely affect the portfolio composition. And thirdly, the measure of off-farm income (growth in net farm wages, salaries and business income) used in our analysis, as well as in Andersson, Ramamurtie, Ramaswami, 1994, explicitly assumes off-farm labor efforts

of the farm household to be exogenous while the endogenous nature of off-farm income seems more reasonable. This simplification in our model, although motivated, may well underscore the dynamic nature and impact of off-farm income as an appropriate risk management instrument. To accommodate the analysis to these three caveats is addressed in our current research.

Our additional preliminary analysis showed that the classification of farms according to size (by value of farm income) and type (production) has a significant impact on static portfolio results as well as on the degree of competitiveness of the farm asset in relation to financial assets. Off-farm income was not included in those results. We continue to address the question if size and type of production in a dynamic environment including off-farm income.

Classes of farms that exhibited strength in the portfolio setting were found to perform well as independent investments. Therefore, the results in this respect may serve to underscore the benefits of holding certain sizes and types of farm operations or assets, namely profitable farms. There would, therefore, seem to be incentives for farmers to expand the farm operation in order to achieve the scale economies and accompanying return performances that farm assets must yield to effectively compete with alternative assets.

For many farms, improving and maintaining farm asset return performances at competitive levels may consume the majority of the farmer's capital budget. This leaves limited capital for acquiring the non-farm assets that optimal portfolio solutions suggest are in order. However, this does not dismiss the fact that risk-reduction benefits may be realized for all classes of farms by incorporating other assets into the farmers' total portfolios.

Many farmers will continue to appear to engage in irrational investments as by the analysis in this study. These farmers may gain from securing even limited diversification measures, where adjusting the model, model inputs develops such optimal strategies, and constraint set to fit the individual farm and decision maker.

Further distinguishing the classification of farms based upon financial leverage levels for example may provide interesting results. Highly leveraged farms should display more variable return cash flows and therefore prove less competitive in the portfolio environment. Classifying farms in this way will allow us to analyze the impact of capital structure on farm asset risk-return efficiency.

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