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AN EMPIRICAL INVESTIGATION OF SYSTEMATIC RISK IN AGRIBUSINESS

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Abstract

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Historically agriculture has seen several bouts of financial prosperity and stress which have also affected agribusiness. This paper examines whether the variability surrounding agriculture and agribusiness has caused a significant risk premia associated with agricultural stocks above what would normally accrue.

keywords: risk premia, systematic risk, agribusiness stock prices

AN EMPIRICAL INVESTIGATION OF SYSTEMATIC RISK IN AGRIBUSINESS

The inherent variability of agriculture in the United States during this century has been the stuff of fiction and academic research. Steinbeck immortalized the plight of agricultural workers during the depression. The first seventy years of this variability and what it has meant to the development of agriculture is well documented by Cochrane and others. More recently, academic literature has traced the encounter with financial stress during the 1980s. Melichar and Jolly et al. document the incidence of financial stress at the farm level during the 1980s. However, producers are not the only entities that suffer during the periods of financial stress in agriculture. Agribusinesses that sell inputs or purchase outputs from the sector also may endure hardship as the sector suffers financial difficulties.

During the 1980s, several developments in the financial markets could point to such difficulties in the agribusiness sector. First, a series of mergers induced by increased financial difficulties emerged. Secondly, fairly strong agribusiness corporations have been the target of takeover and merger. The question then arises whether the stock returns on agribusiness are priced differently than other stock opportunities in the marketplace.

To agriculture's defense, all stock investments are subject to certain risk. Some stocks such as those of automotive manufacturers may be more sensitive to fluctuations in employment or income. The question then becomes whether agribusiness stock suffers an effect disproportionate with its relative risk. This study investigates whether a significant risk premium exists in the pricing of agribusiness stocks using the arbitrage pricing theorem.

Capital Asset Pricing Model

The pricing mechanism of stock investment in a well functioning capital market has long been of interest to financial economist. The Capital Asset Pricing Model (CAPM) developed by Sharpe and Lintner hypothesizes that individual stocks are priced according to their relative risk. Specifically, if individuals are risk averse and stock returns are normally distributed or the investor possesses a quadratic utility function, the expected return on each stock is a function of its common variation with the market return. Specifically, the CAPM equation states

$$(1)\ E(R_i) = R_f + \beta_i [E(R_m) - R_f]$$

where R_i is the return on stock i, R_f is the risk free return, β_i is the sensitivity of return i to changes in the market return, and R_m is the rate of return on the aggregate market portfolio. As typically developed the CAPM model requires a risk free asset** and a market portfolio. Roll and others have raised several questions concerning the CAPM. Most recent criticisms center on the market portfolio and assumptions about investor utility or normally distributed returns.

Arbitrage Pricing Theory

Ross developed an alternative equilibrium asset pricing model, the Arbitrage Pricing Theory (APT). APT is formulated under significantly different assumptions than CAPM. The major difference is that APT is not based on the equivalence between the security market line and the capital market line. As a result, the market portfolio does not play a central role in measuring the risk of assets. Instead, APT relies on arbitrage arguments to draw conclusions about pricing relationships between stocks.

The APT assumes that asset returns in the economy are generated by k linear common factors

$$(2)\quad \tilde{R}_i = E(R_i) + \beta_{i1}\tilde{f}_1 + \beta_{i2}\tilde{f}_2 + \ldots\ldots + \beta_{ik}\tilde{f}_k + \tilde{e}_i$$

where R_i are the returns on asset i in period t, $E(R_i)$ are the average returns on investment i. Similar to the CAPM the β_{ij}

**However, a zero beta portfolio can typically be constructed to replace the risk free asset.

are the sensitivity of investment i to the jth common factor, where f_k is the jth common factor. And e_i is the return on asset i not explained by common factors, or the unique (unsystematic) risk of asset i. It is assumed that the number of assets is much larger than the number of factor. Furthermore, $E(f_j)=0$, $E(e_i)=0$, $E(e_i,e_j)=0$ for $i \neq j$, $E(e_i)^2 = \sigma_e^2$, and $E(e_i f_k) = 0$. If there are no arbitrage opportunities there must be coefficients $\lambda_0, \lambda_1, \lambda_2, \ldots.\lambda_k$ such that

$$(3)\ E[R_i] = \lambda_0 + \beta_{i1}\lambda_1 + \beta_{i2}\lambda_2 + \ldots\ldots + \beta_{ik}\lambda_k.$$

The expected return on asset i is a function of the $\lambda's$ and $\beta's$. The $\lambda's$ are interpreted as the economy wide risk premiums on the risky factors, and the $\beta_{ik}'s$ (formally called factor loadings) are the sensitivities of the returns of asset i to changes in factor k (Ross, Huberman). The coefficient λ_0 has a natural interpretation as the return on a risk-free asset, R_f***; since an asset with zero sensitivities to all factors $(\beta_{i1} = \beta_{i2} = \ldots = \beta_{ik} = 0)$ is risk-free in equilibrium.

Since introduced by Ross this model has been extended by Huberman, Connor, and numerous others. In addition work has

***This risk free rate of return is the zero beta rate of return that results from buying and selling a combination of stocks such that there is no risk. The concept is identical to the zero beta portfolio approaches in CAPM.

focus on the relationship of CAPM to APT. Wei develops a model that integrates the two models and addresses the relationship of the market portfolio to the factors in the APT. This work supports the theory that the APT model collapses to the CAPM.

Since introduced APT has been subject to empirical testing and applied to problems concerned with risk return estimation (Roll and Ross). The empirical testing of APT examines the hypothesis that $\lambda_1=\lambda_2=....\lambda_k=0$. The APT can not be rejected if this hypothesis is rejected. Intuitively, if the set of $\lambda's$ are not simultaneously zero, then the observed variation in expected returns is explained by systematic risk.

The empirical testing and subsequent applications typically proceeds using a two step procedure. First maximum likelihood factor analysis of the covariance matrix Σ for the asset returns is used to derive the number of factors (k) and estimates of the factor loadings, β_{ik}. The resulting estimated factor loadings, β_{ik} , are then used to explain the variation in estimated expected returns. The is done using the general least squares regression

$$(4)\ \hat{\lambda}_t = (\beta\Sigma^{-1}\beta')^{-1}\beta\Sigma^{-1}R_t$$

where $\hat{\lambda}_t$ is the estimates of the risk premium and R_t is the vector of returns on the stocks at t. The APT can then be tested by determining whether the estimated $\hat{\lambda}$'s are significantly different from zero. The average lambda, $\bar{\lambda}$ is

$$(5)\quad \bar{\lambda} = \frac{1}{T}\Sigma\hat{\lambda}_t$$

where T is the number of periods. The variance matrix for the risk premia can then be computed as

$$(6)\quad W = \frac{1}{T}\sum_{t=1}^{T}(\lambda_t-\bar{\lambda})(\lambda_t-\bar{\lambda})'.$$

Drhymes et al. provide a test of the basic arbitrage hypothesis given these sets of parameters

$$(7)\quad \tau = T\bar{\lambda}W^{-1}\bar{\lambda} \sim \chi^2_{(k)}$$

where K is the number of common factors.

In addition to the standard test of arbitrage, we are concerned with the significance of an individual risk premia. Specifically, this study is concerned with whether agricultural stocks are systematically discounted beyond their systematic risk. Following Glutekin and Glutekin we insert a column of dummy factor loadings. This dummy loading is one if the stock is an agricultural stock and zero if it is a nonagricultural stock. The $\bar{\lambda}$ associated with this dummy factor then gives the risk premium accruing to agricultural stock independent of their systematic risk. To determine whether this is statistically significant we can test whether $\bar{\lambda}_i$ for the dummy factor is equal to zero using the $\bar{\lambda}$ as an estimate of the mean and the corresponding element of the variance matrix **W** to estimate its standard deviation. This procedure is similar to an "event study" using traditional CAPM.

Data and Procedure

The data used in this study are stock returns for individual securities traded on the New York and American stock exchanges and maintained by the Center for Research in Security Prices. First the returns data for the agribusiness stocks were separated using the CUSID code. Then a random sample of two hundred stocks and their returns data were drawn. Each group was then evaluated for return data completeness with all stocks discarded that had missing data. A total sample of 40 stocks remained with 9 agribusiness firms and 31 random stocks (see the appendix for listing of stocks).

The procedure used to evaluate the systematic risk in agribusiness follows from the previous discussion on tests and empirical applications of APT. A three step process based on the steps used to test the APT process is used to estimate and test the significance of the risk premium in agribusiness stocks.

First the covariance matrix for the 40 stocks, Σ, is used to estimate the factor loadings, β_{ij}. This step also allows for testing for the number of factors that explain the variation in returns. Second the factor loadings are combined with the returns data to estimate the factor premiums, $\hat{\lambda}_{kt}$, for all t using the generalized least squares in equation 4. The $\overline{\lambda}_k$ in equation 5 are estimated along with their variance matrix W. The APT test of the risk premiums allow then for acceptance or rejection of the model for prediction of systematic and nonsystematic risk for the entire sample of stocks. The third stage of the analysis examines specifically the question of whether the stock returns on agribusiness are priced differently than other stock opportunities in the marketplace.

Results

The initial factor analysis of the stock returns indicated that the number of factors in addition to λ_0 necessary to explain the variation in returns was four (k=4). This result is consistent with other empirical results, such as Roll and Ross.

Table 1 presents the estimates of $\overline{\lambda}$ for the typical arbitrage pricing model using the matrix of factor loadings identified by maximum likelihood and a vector of ones to estimate the risk free rate of return. The test statistic τ

for this representation is 26.35 which is distributed $\chi^2_{(5)}$. Thus, we reject the hypothesis that the risk premium are jointly zero. Hence, the results are consistent with arbitrage efficiency.

Next we estimate $\hat{\lambda}$ using the matrix of estimated factor loadings, the vector of ones for the risk free rate of return, and the dummy factor for agribusiness. The results of this estimation are also presented in Table 1. Again testing for arbitrage equilibrium using τ , we obtain a test statistic of 26.65 which is now distributed χ^2 with 6 degrees of freedom. Like the first scenario we reject the hypothesis that the risk premia are simultaneously zero. However, we are now particularly interested in the last factor. The estimated risk premium accruing to agribusiness is .000106 yielding a test statistic of .2883 which is compared with t with one degree of freedom. Therefore, we reject the hypothesis that agribusinesses accrue a significant premium apart from their systematic risk.

Conclusions

The results of the Arbitrage Pricing Model indicate that the prices and returns for agribusiness stocks are in equilibrium with the risk associated with these firms. Therefore the systematic risk measures of the model can be used from an investment perspective to evaluate the riskiness of the firm in this industries cost of capital. These empirical estimates also should prove useful from a policy point of view in evaluating the international competitiveness of the entire industry.

Table 1. Estimates of Risk Premium

$\bar{\lambda}$	Without Dummy Factors	With Dummy Factors
λ_0 (zero beta)	.000100	.000580
λ_1	.000654	.000521
λ_2	.000279	.000332
λ_3	-.000149	-.000100
λ_4	.000090	.000103
λ_5 (Agribusiness dummy)	--	.000106

Appendix

Non-agribusiness

BALLY MFG CORP
BOWNE & CO INC
CHICAGO RIVET & MACH CO
CONSOLIDATED EDISON CO NY INC
DATARAM CORP
EPA CORP
FIRST FIDELITY BANC CORPORATION
LONG ISLAND LTG CO
MONTANA PWR CO
NL INDS INC
NORTH EUROPEAN OIL RTY TR
PACIFICORP
PUBLIC SVC CO COLO
REALTY REFUND TR
SYSCO CORP
TELEPHONE & DATA SYS INC
TOOTSIE ROLL INDS INC
UNIVERSAL CORPORATION
WEBB DELAWARE CORP
WITTAKER CORP
WILSHIRE OIL CO TEX
ACTION INC INC
AMERICAN BLDG MAINTENANCE AIDS
APACHE CORP
CENTRAL ME PWR CO
COLGATE PALMOLIVE CO
ETZ LAVUD LTD
GRUBB & ELLIS CO
GULF RES & CHEM CORP
INTER REGIONAL FINL GROUP
INTERSTATE PWR CO

Agribusiness

ARCHER DANIALS MIDLAND
CONAGRA
DEERE & CO
GENERAL FOODS
INT MULTFOODS CORP
KELLOG CO.
NAVISTAR INTL CORP
QUAKER OATS CO
RALSTON PURINA CO