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The Role of Agribusiness Assets in Investment Portfolios

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Abstract

Investment in agribusiness assets has grown significantly in recent years. The question of interest is whether including agribusiness assets in investment portfolios provide benefits. The effects of diversification by including agribusiness assets in two investment portfolios, a mixed asset portfolio and a diversified share portfolio was investigated using Markowitz's (1952) Modern Portfolio Theory (MPT) of mean-variance optimization. To measure the performance of agribusiness assets, an index of agribusiness companies listed on the Australian Stock Exchange was used. The results of the study suggested that agribusiness assets provided some diversification benefits in both the mixed asset and diversified share portfolio. The benefits of including agribusiness assets in a mixed asset portfolio were shown to be more significant than in a diversified share portfolio. Allocations of agribusiness assets in the portfolios tended to increase with portfolio risk, up to a peak of 32.10% agribusiness assets in the mixed asset portfolio, with allocations tending to decrease with increasing risk in the diversified share portfolio, peaking at a 17.72% allocation in the minimum risk portfolio. For both the portfolios analysed, agribusiness assets entered efficient portfolios at the minimum risk portfolio.

1. Introduction

Agricultural-related business activity, called agribusiness, can be defined as the sum of all operations in the economy involved in the production, processing and wholesale marketing of agricultural products. Agribusiness defined in this way accounted for 4.8% of GDP in 2002-03 of the Australian economy (DAFF, 2004). It provides a broad range of investment opportunities for both institutional and private investors. A large increase in the number of agribusiness companies listed on the Australian Stock Exchange (ASX) combined with increasing numbers of tax-effective Managed Investment Schemes (MIS)

and widespread real increases in rural land prices in recent years has seen investment in agribusiness increase markedly. Despite this, there has been little research on the effects of including agribusiness assets in investment portfolios, in an Australian context. In this paper an attempt is made to determine the effects of including agribusiness assets in investment portfolios using Markowitz's (1952) Modern Portfolio Theory of mean-variance optimisation.

There is evidence of the rapid expansion of investment in agribusiness in recent years. First, the number of listed agribusiness companies has doubled to almost 60 over the last decade. Further, the value of MIS agricultural investment was $663 million in 2003-04, approximately double the 2002-03 level of $345 million (Kelly, pers. comm. 2004). Meanwhile, rural land prices in many agricultural regions increased in real terms over past decade in many regions.

A reason for growth in agribusiness investment that is widely propagated, within the agribusiness industry, particularly by the managers of MIS projects, and is sometimes believed, is; *'because agribusiness returns have a low correlation to other investments, they have the potential to improve returns and reduce risk in a diversified portfolio'* (The Age, 2004). This research investigates the validity of this argument by testing the hypothesis that agribusiness assets can provide diversification benefits in investment portfolios. The effect of including agribusiness assets in a mixed asset portfolio consisting of shares, bonds, property and agribusiness as well as a diversified share portfolio made up of eleven ASX industry sectors and agribusiness, is analysed.

In undertaking the research, answers to the following research questions were sought;

1. Can agribusiness assets provide diversification benefits in a mixed asset portfolio?
2. What is the optimal allocation of agribusiness assets in a mixed asset portfolio at different levels of risk?
3. Can agribusiness assets provide diversification benefits in a diversified share portfolio?
4. What is the optimal allocation of agribusiness assets in a diversified share portfolio at different levels of risk?

In this study the performance of the agribusiness sector over a four-year period between 30 June 2000 and 30 June 2004 was measured, using an index of ASX listed agribusiness companies. There are several reasons for using listed agribusiness over the performance of MIS projects or farmland. First, the almost sixty listed agribusiness companies on the ASX covered all parts of the agribusiness industry from primary production to wholesale marketing. These companies had a market capitalization of over $30 billion and were a readily accessible and liquid means for investors to invest in the agribusiness industry. Further, the performance of listed agribusiness companies is readily available based on daily share prices. Finally, the performance of agribusiness companies can be compared to other sectors of the stock market by constructing an agribusiness index of performance and comparing this to other market indices. This study used an index of 57 listed

agribusiness companies to measure agribusiness performance and determine the diversification benefits of agribusiness assets in investment portfolios.

The decision not to include farmland and/or MIS in the measurement of agribusiness asset performance was because of several problems with the amount and quality of data available for these parts of the agribusiness industry. Most MIS have an investment horizon of greater than ten years. Given the majority of agribusiness MIS have been established over the last five years, there is little information currently available on the financial performance of these investments. As such, it is difficult to include MIS' in this study.

The financial performance of farmland in terms of capital and income returns is available in Australia through ABARE's Farm Survey Reports. These measures are based on reported income from farming rather than cash rents. Most institutional and individual investors prefer to cash rent the farmland they own (Lins, Sherrick and Venigalla, 1992). Data on the performance of the rental market for farmland is not readily available in Australia as the level of institutional investment in farmland is minimal. It is also argued that the volatility evident in ABARE data is underestimated because the estimates are not transactions based; rather they are based on farmer estimates of land values. Farmland is also a considerably less accessible and less liquid asset than listed agribusiness. Furthermore, farmland and its performance represent only the production side of the agribusiness sector. For these reasons farmland, although a key component of the agribusiness sector, is not considered representative of the performance of the sector from the viewpoint of institutional and individual investors. As a result investment and returns to farmland have not been considered in this study.

In Section Two of the paper, Literature Review, the existing research into the diversification of agribusiness assets is looked at, and a justification for the research that has been undertaken is provided. In Section 3, Method, an explanation of the Modern Portfolio Theory of mean-variance optimisation used in the study is provided. The assumptions and method behind the construction of the agribusiness index as well as the data that have been used in the analysis are explained in Section 3. Section 4, Results, contains the results of the research for the both the mixed asset and diversified share portfolio with the performance of the agribusiness index also considered. The results are presented in such a way that the research questions are addressed. Section 5, Discussion, is a consideration of the implications of the results. As well, the limitations of the study and some suggestions for further research are canvassed. Finally, in Section 6, Conclusion, the findings are summarized.

2 Literature Review

This literature review provides an overview of the existing research into the diversification benefits of agribusiness assets in investment portfolios.

2.1 Listed Agribusiness

In a first attempt at tracking the performance of listed agribusiness companies, the Australian Agribusiness Group (AAG), an independent agribusiness research firm, recently published their "AAG Agri-Index". The index tracks 53 ASX listed agribusiness stocks categorized into five sub-sectors, Producer, Manufacturing, Service, Diversified, and Forestry (Jarrot 2004). The performance of the listed agribusiness companies since October 2000 is presented monthly as a Total Agribusiness Index along with individual sub-sector indices. The companies making up the index also provided a useful resource for selecting the agribusiness companies to be assessed in this research.

Accounting firm Ernst and Young's monthly Food and Agribusiness newsletter provides the only other source of information on agribusiness stock performance in Australia. As part of the newsletter, Ernst and Young monitor the performance of 37 listed rural and agribusiness stocks. This data is presented in table form with an accompanying commentary on the factors influencing their performance. Ernst and Young do not conduct any analyses of the long-term performance of the stocks or any comparative assessment. Despite this, the list was also a useful resource for identifying the agribusiness listed companies that should form the basis of this research.

2.2 Farmland

Much of the research into the performance of agribusiness assets in a mixed asset portfolio has focused on farmland and comes out of the United States. The focus on farmland reflects the relatively high level of institutional investment in farmland in that country. This type of research provides a useful insight into the performance of this important component of the agribusiness sector. Importantly, it also provides a guide to the types of research methods that can be applied in conducting this type of study.

There have been three studies into the role of farmland in investment portfolios in an Australian context. Eves (2003) investigated the role of rural land in mixed asset portfolios. This research was based upon the performance of New South Wales rural property and compared rural land to other property assets (office, retail and industrial) as well as Australian equities and bonds using portfolio optimization techniques. This analysis addressed both the capital returns as well as the total returns (capital returns and income) associated with each asset class. The study concluded that rural land can provide significant portfolio diversification benefits in both mixed asset and mixed property portfolios. While Eves' paper provides an indication of the role of an agribusiness asset – land - in diversified portfolios, the research uses a relatively narrow definition of rural land. As such it is unreasonable to imply that agribusiness assets in general provide similar diversification benefits. Despite this, the methods that are used provide a framework for the following analysis particularly with respect to the use of the 'solver' suite of functions in Excel for portfolio analysis as well as in presentation of the data and results.

A publication by the AAG (2004) also looked at the performance of Australian rural land as an agribusiness asset using ABARE data on farm performance between 1980 and 2003 against the All Ordinaries Index, and 10 year bonds. It suggested that that farmland returns are negatively correlated with the All Ordinaries Index and have a low correlation to 10 year government bonds. It also suggested that the addition of agribusiness assets provided diversification benefits through increased returns and decreased risk in a two-asset portfolio of the All Ordinaries Index and the 'top 25%' of agribusinesses. This analysis is limited as it uses a small sample of the 'best' performing farms and compares them only with the All Ordinaries Index and no other asset classes. It also only uses farmland as a representation of agribusiness assets, which, as previously outlined, is only one avenue of investment in agribusiness. The limited extent of this study underlines the need for a more detailed study into the performance of the agribusiness sector.

The studies that have been carried out in the United States provide far more comprehensive guides for this paper in terms of the research methods to be used. Early studies on the addition of farmland to an investor's portfolio focused on the reduction in risk available by diversifying across asset types. Papers by Kaplan (1985), Webb and Rubens (1988), Moss, Featherstone and Baker (1988), Lins, Sherrick and Venigalla (1992) and Hardin and Cheng (2002) all address the role of farmland as an agribusiness asset in mixed asset portfolios. The analysis in each of these papers uses the MPT of mean-variance portfolio optimization to construct efficient mixed asset portfolios. The studies vary in their treatment of income and capital appreciation, variance of returns, diversification between regions and industries, time horizons, taxation and inflation. Farmland is compared to a range of asset classes including common stocks, corporate bonds, government bonds, residential and commercial real estate and other stock market indices in order to determine its role and optimal allocation in mixed asset portfolios. These studies have shown that farmland as an aggregate asset class has the favorable characteristics of a positive correlation with inflation and low or even negative correlation with many other equity classes and corporate debt. In addition farmland tended to have stable returns for the level of expected total return.

The use of stock market and other indices as well as bond prices to represent the asset classes and/or industry sectors within a portfolio has been a common feature of almost all of the previous studies into the diversification benefits of agribusiness assets in investment portfolios in Australia and the United States. While it is unlikely that in reality investors are able to make investment decisions in this way, this type of 'style' investing is seen to be more common in the current investment climate. The rising prevalence of index linked products, such as mutual funds, options and futures point to investors using an 'index' category to make allocation decisions is evidence of this (Barbaris and Shleifer, 2003). As such, the use of such performance measures has been deemed to be appropriate in this study.

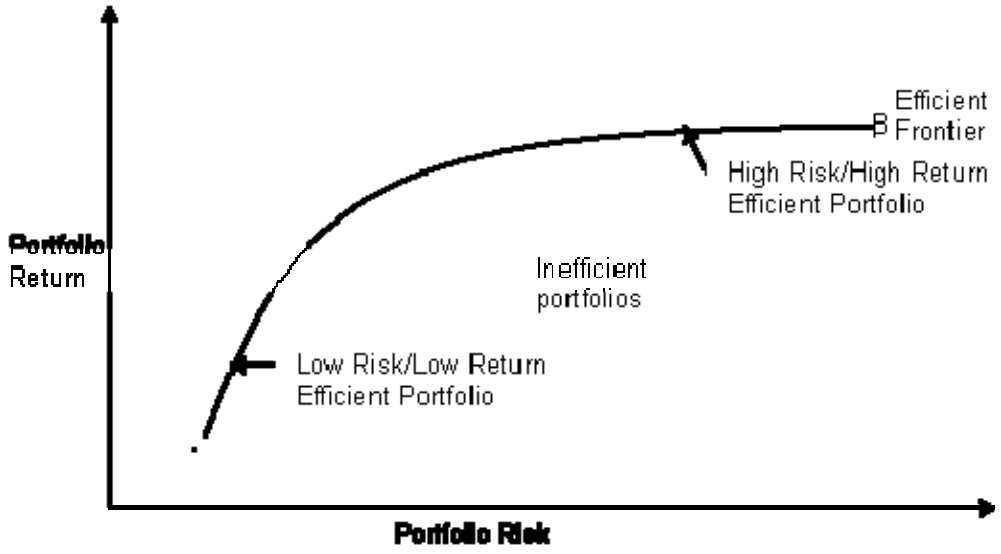
3. Method

This section is presented in five parts in order to present clearly the methods by which the study has been conducted. Firstly, an explanation of the Modern Portfolio Theory (MPT) that underpins the analysis is presented. Following this, the reasons behind and methods involved in the selection of the data used in the study and the make up of the mixed asset and diversified share portfolio are outlined. Third, the construction of the agribusiness index is explained in detail. In the final three parts of section three the performance of each asset in the portfolios is presented, the techniques involved in constructing the efficient frontiers for the portfolios are explained and the way the results of the study are tested empirically is explained.

3.1 Modern Portfolio Theory – Mean-Variance Optimization

To determine the role of agribusiness assets in a mixed asset portfolio, the Modern Portfolio Theory (MPT) of mean-variance optimization is used. Using the assumption that investors want higher rather than lower returns, and prefer lower risk to higher risk, Markowitz (1952) showed that different assets can be combined to produce an 'efficient' portfolio that will give the highest level of portfolio return for any given level of portfolio risk, with risk measured by the standard deviation of returns. Alternatively, an efficient portfolio gives the lowest level of portfolio risk for a given level of portfolio return. These portfolios can be connected to generate what is known as an 'efficient frontier'.

Figure 1: An Efficient Frontier



An example of an efficient frontier, which represents the boundary of the risk/return set of asset combinations. The frontier is a plot of all the efficient portfolios along the range of risk levels (standard deviation) and return levels between the minimum risk portfolio (A) and the maximum return portfolio (B). Inefficient portfolios are those below the

efficient frontier that could improve their return without increasing risk, or decrease risk for the same level of return.

On the efficient frontier represented in Figure 1, by letting w_i be the weight of the portfolio in any asset i, n the number of assets, R_i the expected annual continuously compounded rate of return, P the daily stock price and t the time period, the expected rate of return on the portfolio is given by:

$$E(R_p) = \sum_{i=1}^{n} w_i R_i \qquad \text{where:} \quad R_i = \ln \frac{P_t}{P_{t-1}} \qquad (3.1)$$

That is, the expected return of the portfolio is equal to the weighted average of the return on each asset making up the portfolio.

Similarly, the variance of the return of a portfolio is the weighted average of the variances of each asset making up the portfolio and can be calculated using:

$$Var(R_p) = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j (R_i - E(R_i))(R_j - E(R_j)) \qquad (3.2)$$

where $(Ri – E(Ri))(Rj – E(Rj))$ is the covariance between assets i and j, denoted by $Cov_{i,j}$.

The covariance is an important part of the analysis as it takes account of the amount of co-movement between the returns for each pair of assets. This can also be represented by the correlation coefficient ($\rho_{i,j}$), which is a standardised measure of covariance where the correlation is scaled to a value between -1 and +1, given by;

$$\rho_{i,j} = \frac{Cov_{i,j}}{SD_i SD_j} \qquad (3.3)$$

The standard deviation of the portfolio ($SD(R_p)$) is used in the calculations in this paper and is given by the square root of the portfolio variance:

$$SD(R_p) = \sqrt{Var(R_p)} \qquad (3.4)$$

One important assumption of MPT is that rational investors will prefer portfolios that are on the efficient frontier; that is, portfolios that have the minimum level of risk for each given rate of return. Choices from the portfolios on this frontier are made on the basis of risk preferences and the availability of a risk-free asset. This method of describing investment choices has been criticized because some of the assumptions about risk preferences are thought to be implausible or violated empirically. However, several studies including Levy and Markowitz (1979) and Kroll, Levy and Markowitz (1984) have found that the mean-variance approach is quite robust in the face of violations of

these assumptions. This being the case, MPT is accepted as a tool for portfolio selection guidance and so is used in this study. By using mean-variance portfolio optimization, this analysis will determine the diversification benefits and optimal allocation of agribusiness assets at different risk levels in a diversified share portfolio and mixed asset portfolio.

3.2 Data

The analysis will span a four-year time horizon from 30 June 2000 to 30 June 2004 for both portfolios. The four-year time frame is being used primarily because the Standard and Poor's/ASX (S & P/ASX) sector indices used in the diversified share portfolio were only first published in early 2000, making it difficult to carry out similar analysis over a longer period. The source of all the data used in the study is the IRESS online database.

3.2.1 Daily Capital Lognormal Returns

This study uses daily lognormal capital returns (change in market price) of the assets making up the mixed asset and diversified share portfolios in order to measure the asset performance. Daily data is used in order to fully capture the volatility of asset returns. A lognormal distribution of daily asset returns is assumed in the analysis of all assets and portfolios, including the agribusiness index. The lognormal distribution of returns is preferred in this type of analysis over a normal distribution for two reasons. Firstly, whereas a normal distribution admits any value including negative values, actual stock prices cannot be negative. Secondly, the normal distribution does not account for compounding. Both of these issues are addressed by using lognormal returns in the analysis. It should also be noted at this point that lognormal returns were also used in determining the returns of each of the other assets making up the mixed asset and diversified share portfolio respectively.

The capital return on an asset is the change in the market price of the assets over time (Bodie, Kane and Marcus, 2002). It could be argued that capital returns do not necessarily provide an accurate or appropriate reflection of investment performance as they do not take into account the income earned on an asset. In this study, the assets that make up the portfolios can earn income in the form of dividends paid on shares or coupon payments on bonds. While there is merit in including the income earned by the assets when measuring their performance in the study, the decision to use change in market price of assets, or capital returns, has been made for several reasons. First, capital returns still provide an adequate indication of asset performance over the four -year study duration. All assets in this study are being measured by their capital return, thus there is consistency of measurement across all assets. Further, an important aspect of this study given the lack of research that exists in this area is the application of MPT in studying the diversification of agribusiness assets in an Australian context using an agribusiness index. In terms of applying these methods, whether capital or total returns are used is somewhat irrelevant. Finally, using capital returns enables the analysis to be simplified to a level that is more manageable for this type of study.

3.2.2 The Mixed Asset Portfolio

The mixed asset portfolio consists of agribusiness and three major asset classes; shares, property and bonds. As previously outlined, agribusiness asset performance was measured using an agribusiness index (to be referred to as agribusiness). The performance of the share, property and bond markets over the study were measured using the S & P/ASX 200 Index (shares), S & P/ASX 200 Property Trust index (property) and 5-Year Government Bonds (bonds) respectively.

The S & P/ASX 200 index was chosen over the All Ordinaries Index and S &P/ASX 300 index as its construction methodology (section 3.3.2) reflects that of the other market indices used in this study, particularly in the way market capitalization of companies is calculated and the quarterly re-weighting process. This method is also the basis on which the agribusiness index is constructed. Although the S & P/ASX 200 index is not as broad in its scope as the S & P/ASX 300 Index or the All Ordinaries Index, it still provides an appropriate reflection of stock market performance for this type of study. Furthermore, in using this index, consistency across indices used in the study in terms of the way they are constructed is maintained. This is important in this type of research.

5-Year Government Bonds were an obvious choice to represent bond market performance given that their holding period is the closest to the length of the data sample period. In order to determine the capital return on the 5-year government bonds the daily bond prices for the study period were calculated using daily yield data (refer to Appendix II). The S & P/ASX 200 Property Trust index is being used in the study to represent the performance of the property sector. Most property indices, such as those produced by the Property Council of Australia, are published on a monthly or quarterly basis. As the data that was used to measure the performance of the assets making up the mixed asset and diversified share portfolios is daily data, this index provided an appropriate measure of the performance of the property sector on a daily basis.

3.2.3 The Diversified Share Portfolio

The diversified share portfolio constructed in the analysis comprised the Agribusiness Index and the eleven major Global Industry Classification Standard (GICS) S & P/ASX sector indices. These are Energy, Materials, Industrials, Consumer Discretionary (Discretionary), Consumer Staples (Staples), Healthcare (Health), Financials excluding Property Trusts (Financials), Property Trusts (Property), Information Technology, Telecommunication Services and Utilities. These indices can be thought of as a natural asset class or category for investors. The rising prevalence of index linked products, such as mutual funds, options and futures points to investors using an 'index' category - as per Barbaris and Shleifer (2003) - to make allocation decisions. Using these indices to represent the performance of each sector in comparison to the agribusiness sector is appropriate given the classification standards that apply to the companies these indices encompass.

3.3 Constructing the Agribusiness Index

The construction of the agribusiness index involved several steps. Each of these is outlined in the following paragraphs.

3.3.1 Agribusiness Company Selection and Price Data

Agribusiness companies listed on the ASX were selected using the basic definition that agribusinesses are the sum of all operations involved in the production, storage, processing and wholesale marketing of agricultural products. Another important criterion that was considered when narrowing the field of companies was to include only those companies that had greater than half of their revenues being generated from agribusiness industries.

To assist in the selection process, the companies that comprised AAG's Agri-Index and those listed in Ernst and Young's Agribusiness Newsletter provided the primary source for company selection. These sources were used in conjunction with a search of the ASX company database and consultation with agribusiness research firm Adviser Edge. The revenue criterion was used as a last resort in the inclusion decision. Following the selection process, a total of fifty-seven agribusiness companies were selected to make up the agribusiness index to be used in the study. Refer to Appendix I for a complete listing of the companies that make up the agribusiness index.

The price data that were used for each of the agribusiness companies has been adjusted for company actions. Company actions include rights issues and stock splits and are taken into account in order given a proper reflection of historical share price performance (IRESS 2005). The IRESS database automatically makes the adjustments in its time-series data. This adjustment is an important consideration in ensuring the data used in the study accurately reflects the performance of each company over the time period and that of the agribusiness sector.

3.3.2 Index Method

In order to ensure that the agribusiness index is easily comparable to the other S & P/ASX Indices used in the study, the construction of the index was based on the S & P index methodology (Standard and Poor's, 2005). S & P determine the market capitalisation of the companies comprising their respective indexes based on the Investable Weight Factor (IWF) of each company, rather than the total number of shares on issue. The IWF is based on its 'free float', or, the percentage of each company's shares that are freely available for trading in the market. For S & P/ASX index purposes, free float is defined as excluding the following holdings:

- Government and government agencies;
- Controlling and strategic shareholders/partners;

- Any other entities or individuals which hold more that 5% of the stock (excluding insurance companies, securities companies, finance companies and investments funds such as pension funds); and

- Other restricted portions, such as treasury stocks or strategic holdings.

IWF's are reviewed quarterly by the Standard and Poor's Australia Index Committee who govern the S & P/ASX indices. This study also uses IWF's in determining the market capitalisation of an individual company for index weighting purposes with market capitalisation (MC_i) being calculated using the formula:

$$MC_i = IWF_i \times P_{i,t} \qquad (3.5)$$

The All Ordinaries Index weights companies based on the total number of shares on issue. The IWF can in some cases be significantly smaller than the total number of shares on issues. This is one of the main reasons why the All Ordinaries Index has not been used in the study.

Standard and Poor also have a range of other criteria for a company or stock to be included in a specific index with only stocks listed on the ASX being included in indices. Companies are assessed for their size according to market capitalisation with smaller companies not included in the indices. Liquidity is a key consideration for stock inclusion. Only stocks that are actively and regularly traded are considered for inclusion in any S & P/ASX index. Relative Liquidity ($RL\ i$) is the main indicator that is used to make a judgment on a company and is calculated using the Stock Mean Liquidity ($L\ i$) and Market Liquidity ($L\ m$) and is given by:

Stock Median Liquidity is the median daily liquidity for each stock over six months, where the daily liquidity is the daily value of stock traded divided by the day-end market capitalisation adjusted for free float. Market Liquidity is determined using the weighted average of the stock median liquidities of the largest 500 domestic stocks, based on six month average market capitalisation. Companies included in S & P/ASX indices must satisfy a free float threshold level of 30%, equivalent to an IWF of 30.

The S & P/ASX indices are rebalanced quarterly to ensure that market capitalization is reflected. At this rebalancing, both market capitalisation and liquidity are assessed using data from the previous six-months. Quarterly rebalance changes take place on the third Friday of December, March, June and September. Intra quarter deletions of stocks from

the index may also occur if a company is acquired by another company, a company goes into voluntary administration or if it is restructured.

In constructing the agribusiness index, all of the above methods have been used where possible. Market capitalisation for each company was determined using IWF values with quarterly adjustments being made on the respective third Friday of each quarter over the five-year period. The adjusted IWF and market capitalisation data that were used for companies that made up the agribusiness index were obtained from the IRESS online database. The S & P 30% free float requirement was also met for all companies. Companies included in the index were only those which were trading on the final day of the study's time frame, 30 June 2004. Thus, no stocks needed to be deleted during the study. Only companies listed on the ASX were considered for the index.

In constructing the agribusiness index, the liquidity and size requirements for companies included were not fully considered. The main reason for this is that the exact size and liquidity criteria that S & P set for stocks to include in the S & P/ASX indices are not clearly stated in any of the literature or by the company in quantitative terms. Up to ten of the agribusiness stocks that are included in the study could be considered small (market capitalisation of less than $5 million) and relatively illiquid, compared to the larger companies. Despite this, there are no clear inclusion or exclusion criteria and as these companies still represent the agribusiness sector in which they were included. Further, given their small size, the index weighting that applies to each of these companies is relatively small. As such, they do not influence the index in significantly to warrant exclusion on liquidity or size grounds. The final consideration in constructing the index was how to treat agribusiness companies that had listed on the ASX throughout the five year study period. The S & P index criteria do not discuss how new listing are treated in indices. As 13 out of the 57 companies that were listed on 30 June 2004 were listed during the previous five years, it was concluded that is was appropriate to include these stocks. To keep true to the S & P method, newly listed companies were added to the agribusiness index at the first quarterly rebalance that took place following their listing.

Based on the S & P index methodology outlined above, the agribusiness index was constructed using Microsoft Excel in the following way:

1. Daily lognormal return ($R_{i,t}$) calculated for each agribusiness company (equation 3.1).
2. Daily Market Capitalisation ($MC_{i,t}$) calculated for each agribusiness company based on MF (equation 3.5).
3. Daily weight ($w_{i,t}$) for each agribusiness company stock:
$$w_{i,t} = \frac{MC_{i,t}}{\Sigma MC_{i,t}} \qquad (3.7)$$
4. Daily Weighted Return ($R_{p,t}$) for all agribusiness stocks:
$$R_{p,t} = \Sigma w_{i,t} R_{i,t} \qquad (3.8)$$
5. Converted the daily return information to an index (I_t) with a base value of 100 using:
$$I_t = I_{t-1} . (1 + R_{p,t}) \qquad (3.9)$$

Having undertaken the above process, the agribusiness index was constructed and was able to be used in determining the diversification benefits of agribusiness assets in the mixed asset and diversified share portfolio.

3.4 Presenting Portfolio Asset Performance

In order to make a comparative analysis of the performance of assets in the portfolios, each of the stock market indices and the 5-Year Government bonds were also set to a base of 100 on 30 June 2000. This calculation was done in the same way that the agribusiness index was constructed (equation 3.9), using the daily lognormal capital return for each index and the bonds. Following this, the performance of the assets comprising the mixed asset portfolio and diversified share portfolio respectively over the four-year study was graphed. This was done to give an indication of the relative performance of each index over the four-year period and may be used to make a comparison to other indicators of agribusiness asset performance, such as the Australian Agribusiness Group's Agri-Index.

Following this, the compound annual return and annualized standard deviation for each index was calculated. The compound annual return for each index was calculated by solving for R_c in the equation:

$$I_{end} = I_{start} . (1 + R_c) \qquad (3.10)$$

Compound annual returns have been used in the study instead of annual average returns or any other return calculations as they give the best reflection of asset performance over the life of the study. That is, they reflect the annualized capital return an investor would have received if they invested in each of the assets in the study on June 30, 2000 and sold those assets on June 30, 2004. The standard deviation of the indices was determined based on the daily lognormal returns of each asset. This was done using the 'STDEV' function from Microsoft Excel. To calculate the annualized standard deviation, the five-

year time horizon of the data as well as the fact that there are only 261 trading days each year had to be taken into account. As such, the standard deviation for the whole series will be modified by multiplying it by the square root of the number of trading days in each year of the study (261). This gives an annualized standard deviation of returns that can be used in the efficient portfolio construction process. The compound annual growth rate and annualized standard deviation for each index is presented in table format in order of compound annual return.

The correlation between each of the indices was also determined at this stage. The correlation coefficients are an important factor in determining the relative weight of individual assets in each portfolio as they provide an indication of the degree to which the assets making up each portfolio move in tandem with each other. The correlation matrix between the assets making up the two portfolios the in the study is presented in tables with particular consideration given to the correlation between the agribusiness index and the other assets making up each portfolio in the analysis.

3.5 Efficient Frontier Construction

The next stage in determining the role of agribusiness assets in investment portfolios is to construct the set of efficient portfolios for both the mixed asset portfolio and the diversified share portfolio. In determining the efficient frontier, an efficient frontier for both portfolios with and without the Agribusiness Index was constructed. This was done to better indicate the role of agribusiness assets in the investment portfolios.

The method for constructing the efficient frontier in both the mixed asset and diversified share portfolio is identical except for the assets that are included in each. The procedure was carried out in Microsoft *Excel* using the Solver add-in.

The first step in the analysis was to record the compound annual return and the standard deviation for each asset in the portfolio into an excel spreadsheet. Following this, the correlation matrix was also calculated and inserted into the sheet. Using the relationship:

$$Cov(r_i, r_j) = A_{ij}\sigma_i\sigma_j \qquad (3.11)$$

a covariance matrix was calculated for all the assets in the portfolio. For ease of calculation, one correlation matrix and covariance matrix containing all assets was calculated rather than two separate matrices for each portfolio.

To establish a benchmark against which to evaluate the efficient portfolios, an equally weighted portfolio, that is, a portfolio with equal proportions of each asset, was derived. For the mixed asset portfolio this meant a 1/3 weighting for each asset without agribusiness and 1/4 weighting with agribusiness. For the diversified share portfolio it meant a 1/11 weighting without agribusiness and 1/12 weight with the inclusion of agribusiness. Using these weights, the equally weighted portfolio return (R_p) and variance (Var_p) was determined using equations 3.1 and 3.2 respectively and the respective values

in the spreadsheet. The standard deviation *(SD)* was then also calculated from the portfolio variance using equation 3.4.

With these calculations complete and the spreadsheet set up, the efficient frontier can be constructed. This was done using the Solver add-in in Microsoft Excel to solve for the maximum level of portfolio return for a given level of risk as measured by portfolio standard deviation. The portfolio was also restricted such that there could be no negative weights. Negative weights imply that short selling is possible. This is not considered in this study as short-selling is restricted by law in Australian financial markets.

To plot the efficient frontier, efficient portfolios were determined at 1.0% standard deviation intervals for both the mixed asset portfolio and diversified share portfolio between the minimum risk portfolio standard deviation and the maximum return portfolio standard deviation. To determine the allocation of assets in each portfolio the weighting of each asset at twenty intervals between the minimum risk portfolio standard deviation and the maximum return portfolio standard was also calculated. Having completed this process the efficient frontier was plotted. The efficient frontier for the mixed asset and diversified share portfolio was plotted for portfolios both with and without the agribusiness included to clearly illustrate the role of agribusiness assets in the portfolios. Using the weighting of each asset in the efficient portfolios at the twenty standard deviation intervals, the proportion of each asset making up the efficient portfolios including agribusiness was also plotted to illustrate the relative allocation (and optimal allocation) of agribusiness assets in the mixed asset and diversified share portfolio at different risk levels.

3.6 Testing of Results

This study used non-parametric linear programming methods (outlined above) to determine the efficient portfolios along the efficient frontier. As a result of the non-parametric nature of the study, the statistical significance of the efficient portfolios including agribusiness cannot be analysed. Hardin and Cheng (2002) show that by including a risk free asset in the portfolio and using Sharpe ratio's, the Gibbons, Ross, Shanken F-test can be used to determine the significance of the new efficient frontier. The portfolios used in this study do not contain a risk free asset and so this method cannot be applied. To overcome this problem, Hardin and Cheng (2002) used a more complex bootstrap method in assessing the significance of new efficient portfolios containing farmland. While it would have been be possible to apply this method in this study, the depth of analysis required to answer the research questions and achieve the research objectives did not warrant undertaking this complex procedure.

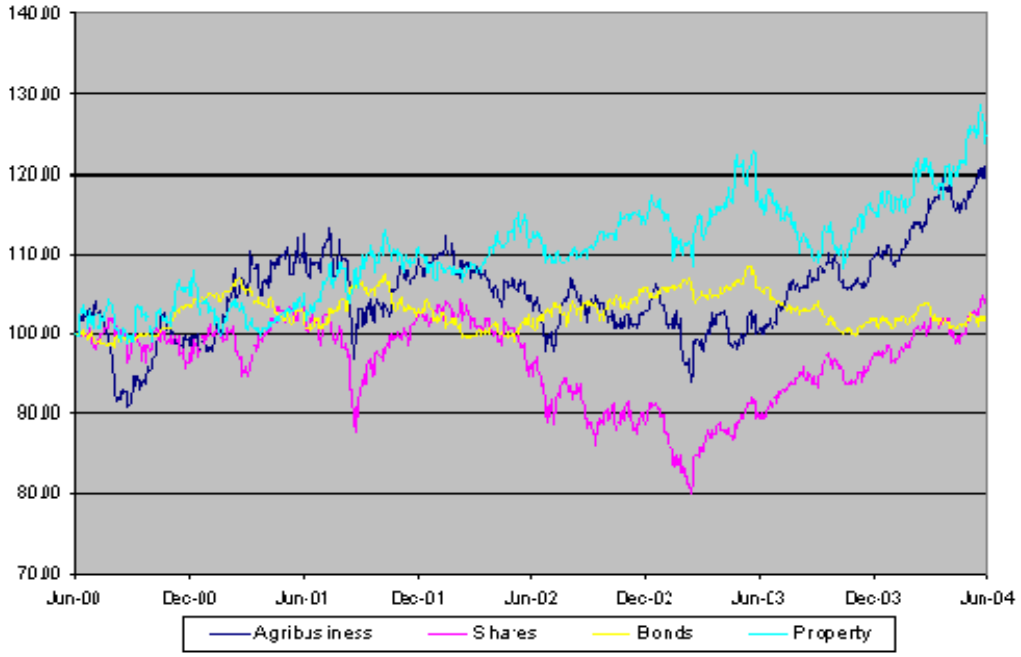
Although no statistical tests were undertaken when assessing the results of the study, the effect of altering the standard deviation of returns for agribusiness index on efficient portfolio allocations and the efficient frontier was considered. Furthermore, in the construction of the agribusiness index, the effect of different construction methods, particularly with respect to index weighting and re-weighting periods, were determined for comparative purposes.

4. Results

In this section the results of the study are presented. The results are separated into two parts with the mixed asset portfolio results presented first and the diversified share portfolio results presented second. The structure of the results for both portfolios is the same in order to achieve consistency of analysis.

4.1 Mixed Asset Portfolio

Figure 2. Mixed Asset Portfolio - Indexed Asset Performance



The performance of each asset making up the mixed asset portfolio between June 30 2000 and June 30 2004. Asset performance is based on daily lognormal returns and has been indexed to a base value of 100 as at 30 June 2000 using equation 3.9.

Looking at Figure 2 it is apparent that property has been the best performed asset class over the study period with agribusiness performing marginally below property. The performance of bonds and shares, which exhibited minor increases over the study-period, was well below that of agribusiness and property. In Figure 2 is shown the relative performance of each of the asset classes in the study. The relative volatilities of each asset class can be interpreted from Figure 2. Bonds appear to be the least volatile asset class, while agribusiness, property and shares appear to exhibit significantly higher levels volatility. Significantly for this study, this information suggests that the returns on agribusiness during the study period were comparable to the other assets.

Table 1. Mixed Asset Portfolio Compound Annual Return and Standard Deviation

	Compound Annual Return (*R*)	Standard Deviation (σ)
Property	5.75%	10.15%
Agribusiness	3.97%	11.33%
Shares	1.02%	10.96%
Bonds	0.35%	5.44%

The compound annual return and annualised standard deviation for each asset making up the mixed asset portfolio is represented in Table 1. Compound annual return calculated using the 30 June, 2000 index value and the 30 June, 2004 index value for each asset. Standard deviations were based on daily lognormal returns converted to an annualised rate. Assets are ranked in order of return performance.

In Table 1 is numerical evidence of the features that were apparent in Figure 2 with regard to the relative performance and volatility of each asset class. In terms of their compound annual return, property was the best performing asset class with a return of 5.75%, significantly above agribusiness at 3.97%, with shares (R = 1.02%) and bonds (R = 0.35%) significantly lower. The standard deviation of bond returns of 5.44% was almost half that of the other asset classes. This level of volatility was to be expected given the nature of bonds as a traditionally low-risk asset class. Agribusiness had the highest standard deviation of 11.33%, followed by shares (σ = 10.96%) and property (σ = 10.15%). The risk-return trade-off is evident for property and bonds in particular, with a higher return corresponding to a higher risk level or standard deviation. This relationship was evident to a lesser extent in agribusiness and shares. Agribusiness appears to have been the most risky (highest standard deviation) class of investment out of property, shares, bonds and agribusiness, despite not having the highest return. It is also important to note that the return on shares was relatively low given a standard deviation that is comparable to property and agribusiness.

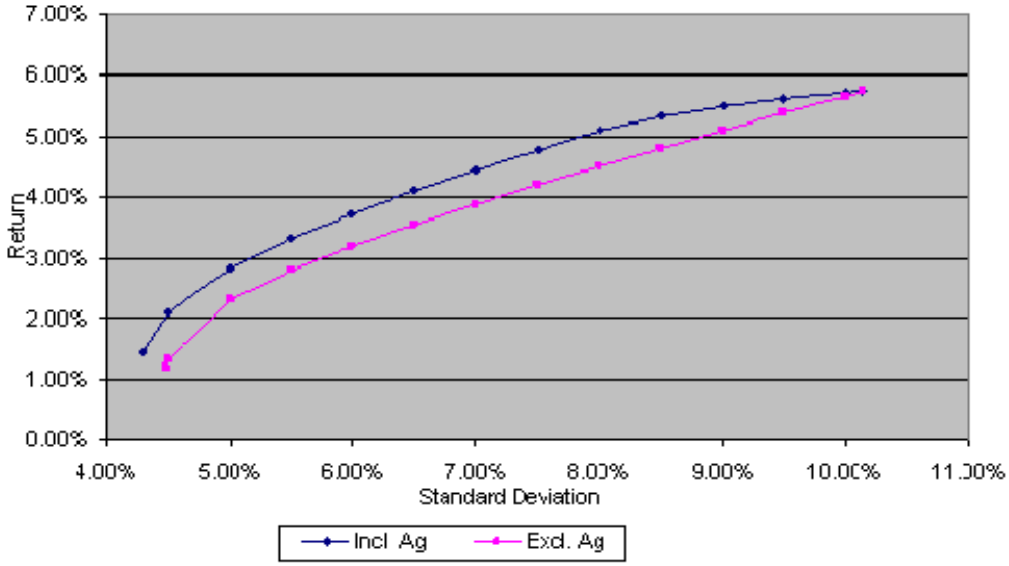
Table 2. Mixed Asset Portfolio Correlation Matrix

	Agribusiness	Shares	Bonds	Property
Agribusiness	1.00			
Shares	0.48	1.00		
Bonds	-0.06	-0.18	1.00	
Property	0.23	0.35	0.15	1.00

Table 2 shows the correlation coefficients for each of the assets making up the mixed asset portfolio. Coefficients are based on daily lognormal returns for each asset between 30 June 2000 and 30 June 2004.

Table 2 provides an insight into the correlation of returns for each of the assets in the mixed asset portfolio and provides the first indication of diversification benefits of agribusiness in the portfolio. Agribusiness had a negative correlation with bonds: returns for these two assets tended to move in opposite directions during the study period. Agribusiness return also had a relatively low correlation with returns from shares and property. The low correlations of bonds with each of the other asset classes, negative for agribusiness (ρ = -0.06) and shares (ρ = -.18), and marginally positive for property (ρ = 0.15) is typical of that asset class and was expected. The remaining correlation coefficients reflect a low positive correlation (ρ<0.50) between assets. These correlation values suggest that returns from these assets were imperfectly correlated. This is an important finding given the role that correlation between assets plays in determining the standard deviation of a portfolio (equations 3.3 and 3.4).

Figure 3. Mixed Asset Portfolio Efficient Frontier - Including and Excluding Agribusiness



The efficient frontiers for the mixed asset portfolio including and excluding agribusiness. Both frontiers were calculated by determining the compound annual return of the efficient portfolios at 1.0% risk (standard deviation) intervals between the minimum risk portfolios and maximum return portfolios.

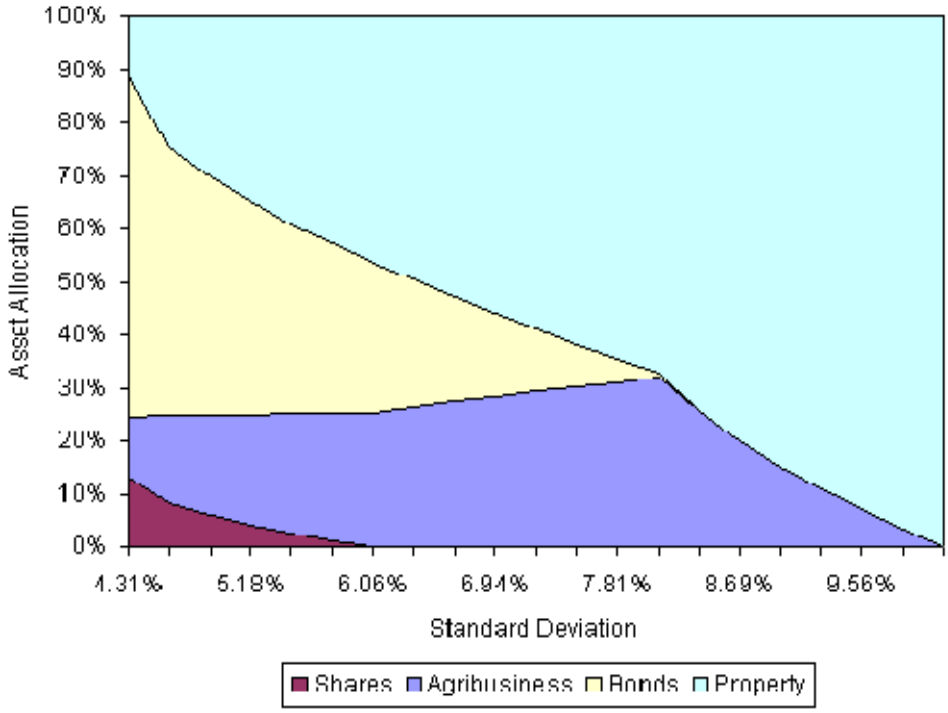
The evidence presented in Figure 3 suggests that including agribusiness in the mixed asset portfolio provided significant diversification benefits over the study period. The shape of the frontier is typical of an efficient frontier (refer to Figure 1) and illustrates that there is a risk-return trade off for the efficient mixed asset portfolios with a positive relationship existing between portfolio risk and return.

The minimum risk portfolio excluding agribusiness was found to have a standard deviation of 4.49% and return of 1.19%, and the maximum return portfolio had a

standard deviation of 10.15% and return of 5.75%. Including agribusiness assets in the efficient portfolios caused the efficient frontier to shift upwards. This shift implies that at each risk level, the efficient portfolios containing agribusiness provided a higher level of return than those efficient portfolios that did not contain agribusiness.

The minimum risk portfolio including agribusiness was shown to have a return of 1.45% and standard deviation of 4.31%. These are both improvements on the performance of the minimum variance portfolio excluding agribusiness, outlined above. The maximum return portfolio exhibited the same risk-return profile as the efficient portfolio that excluded agribusiness, suggesting that agribusiness is not contained in the higher risk/return portfolios. The maximum return portfolio was the only efficient portfolio that was not improved by the inclusion of agribusiness. These results show that agribusiness assets did provide diversification benefits in the mixed asset portfolio.

Figure 4. Mixed Asset Portfolio Asset Allocation Including Agribusiness



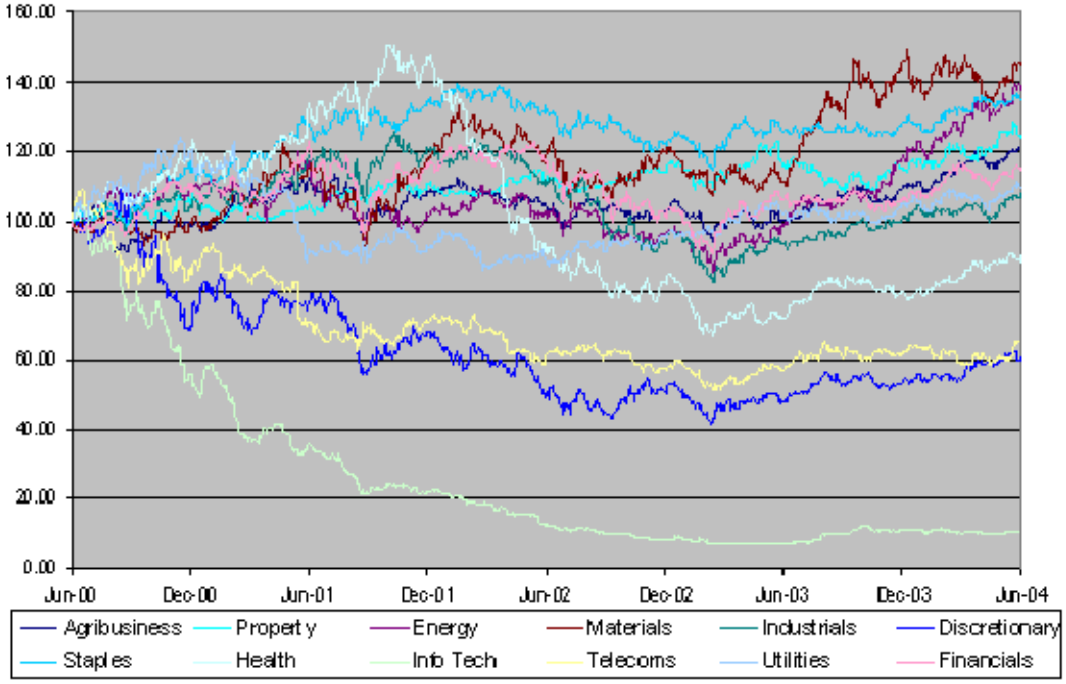
Represents the allocation to each of the four assets making up the efficient mixed asset portfolios along the efficient frontier including agribusiness presented in Figure 3. The allocation has been determined at 20 intervals between the minimum risk portfolio's standard deviation and maximum return portfolio's standard deviation that had been determined previously.

In Figure 4, agribusiness is shown to enter the efficient portfolio at low risk levels and then having a significant allocation as risk levels are increased before declining rapidly at higher risk levels. The minimum risk portfolio with agribusiness is made up of 11.10% agribusiness, 64.26% bonds, 13.37% shares and 11.27% property.

As risk levels increase the allocation of agribusiness to the efficient portfolio increases to a peak allocation of 32.01% at a portfolio standard deviation of 8.10% and a portfolio return of 4.80%. As portfolio risk increases above 8.10%, the agribusiness allocation decreases and is replaced by property until the maximum portfolio return is reached at full property allocation. As the maximum return portfolio is fully allocated to property, this explains why inclusion of agribusiness did not provide diversification benefits at this level of risk. The evidence presented in Figure 4 suggests that the optimal allocation to agribusiness varied with risk. Agribusiness allocations tended to increase with increasing risk levels, before declining at higher levels of portfolio risk.

4.2 Diversified Share Portfolio

Figure 5. Diversified Share Portfolio - Indexed Asset Performance



The performance of each asset making up the diversified share portfolio between June 30 2000 and June 30 2004. Asset performance is based on daily lognormal data indexed to a base value of 100 as at 30 June 2000 using equation 3.9.

The large number of sectors making up this portfolio resulted in the data being more difficult to interpret. However, Figure 5 provides an indication of those sectors that have performed relatively well over the four-year study and those that have performed relatively poorly. The materials sector was the best performing over the study with staples, energy and property the next best. The agribusiness sector was positioned marginally below the property sector, which was to be expected as these two indices were also in the mixed asset portfolio. After agribusiness, the only assets that showed growth in their index value over the study were the financials excluding property, utilities and industrials sectors. There is no clear evidence in the figure that enables us to distinguish the relative volatilities of each sector. This information contained in the Figure 5 provides an initial indication of those sectors that are likely to make up the diversified investment portfolio. For example, it could be concluded that the information technology, discretionary, telecommunication services and healthcare sectors, which decreased over the study are unlikely to be components of portfolios on the efficient frontier.

Table 3. Diversified Share Portfolio Asset Compound Annual Return and Annualised Standard Deviation

	Compound Annual Return (R)	Standard Deviation (σ)
Materials	9.88%	17.24%
Energy	8.21%	15.46%
Staples	7.62%	11.03%
Property	5.75%	10.15%
Agribusiness	3.97%	11.33%
Financials	3.54%	13.38%
Utilities	2.42%	13.77%
Industrials	1.98%	13.43%
Healthcare	-2.46%	17.46%
Telecoms	-10.17%	18.65%
Discretionary	-11.81%	27.02%
Info Tech	-43.33%	28.18%

The compound annual return and annualised standard deviation for each asset making up the diversified share portfolio is represented in Table 3. Compound annual return calculated using the 30 June 2000 index value and the 30 June 2004 index value for each asset. Standard deviations were based on daily lognormal returns converted to an annualised rate. Assets are ranked in order of return performance.

The relative ranking of the returns for each asset class in Table 3 reflects the evidence presented in Figure 5. The materials sector was the best performing asset class with a return of 9.88%, followed by energy, (R = 8.21%), staples (R = 7.62%) and property (R = 5.75%). Agribusiness asset returns were the same as for the mixed asset portfolio (R = 3.97%) and ranked fifth over the study. The only other sectors with positive returns were financials (R = 3.54%), utilities (R = 2.42%) and industrials (R = 1.98%). The significant variations in the performance of the different assets, or sectors of the share market, over

the study period, illustrates the extent to which different sectors can perform variably over a period of time. For example, the information technology sector return of –43.33% was the poorest performance and reflected the downturn in the sector during the period of the study while the strength in materials reflected the strong commodity prices that materials companies benefited from. The negative returns on the information technology sector along with discretionary (R = -11.81%) telecommunication services (R = -10.17%) and health (R = -2.46%) confirms that they are unlikely to contribute to the efficient portfolios.

The standard deviation of each sector in the diversified share portfolio showed evidence of a risk-return trade-off. This was particularly evident in the better performing assets, with the materials (R = 7.83%, σ = 17.24%) energy (R = 6.51%, σ = 15.46) staples (R = 6.05%, σ = 11.03%) and property (R = 4.57%, σ = 10.15%) sectors exhibiting increasing asset returns in line with for increased risk.

Agribusiness, as in the mixed asset portfolio, exhibited an increased risk level despite its lower return compared to property. Interestingly, the other sectors that recorded positive returns, financials, utilities and industrials also exhibited increased standard deviations despite having a lower return than the above asset classes. The remaining sectors that recorded negative returns exhibited increasing standard deviation in line with decreasing returns, which is not necessarily reflective of a risk-return trade-off. As the negative performing assets are unlikely to be included in the efficient portfolios this outcome has no effect on the study.

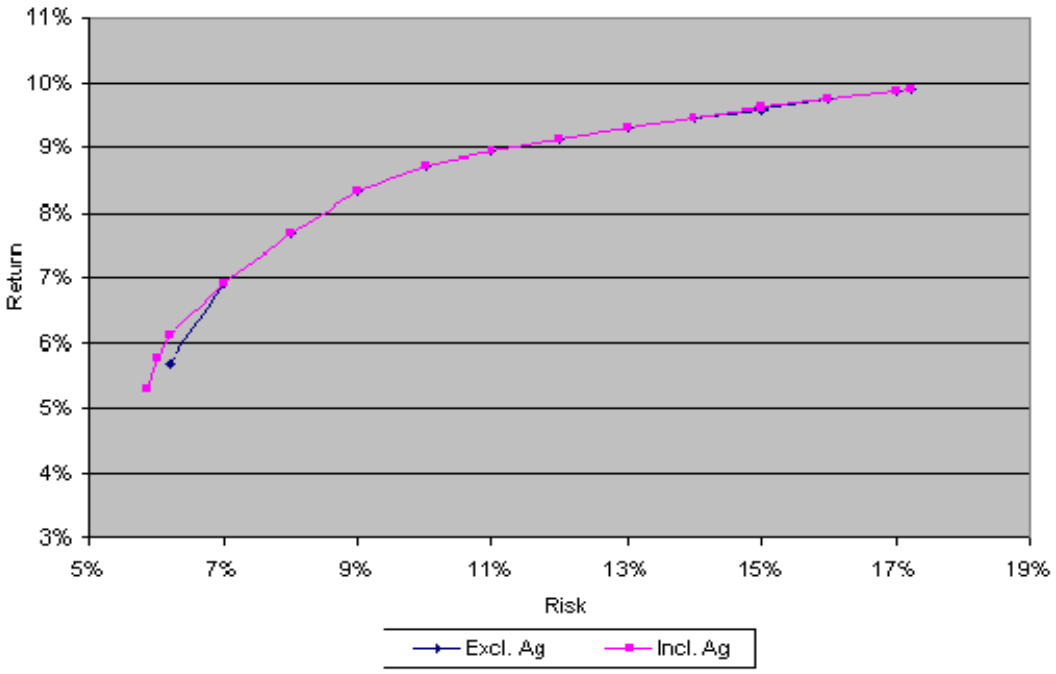
Table 4. Diversified Share Portfolio Correlation Matrix

	Ag.	Prop.	En.	Mat.	Ind.	Disc.	Stap.	Health	I.T	Tele.	Util.	Fin.
Agribusiness	1.00											
Property	0.23	1.00										
Energy	0.22	0.25	1.00									
Materials	0.29	0.12	0.33	1.00								
Industrials	0.41	0.25	0.26	0.38	1.00							
Discretionary	0.27	0.10	0.15	0.44	0.41	1.00						
Staples	0.67	0.28	0.23	0.28	0.41	0.31	1.00					
HealthCare	0.34	0.24	0.26	0.30	0.41	0.32	0.35	1.00				
Info Tech	0.30	0.19	0.17	0.34	0.40	0.33	0.29	0.36	1.00			
Telecoms	0.21	0.14	0.15	0.26	0.29	0.31	0.25	0.25	0.29	1.00		
Utilities	0.28	0.27	0.20	0.10	0.27	0.12	0.31	0.25	0.26	0.18	1.00	
Financials	0.38	0.31	0.31	0.40	0.48	0.37	0.43	0.41	0.36	0.24	0.29	1.00

Table 4 shows the correlation coefficients for each of the assets making up the mixed asset portfolio. Coefficients are based on daily lognormal returns for each asset between 30 June 2000 and 30 June 2004.

The information in Table 4 suggests that most of the sectors in the diversified share portfolio had a low positive correlation ($\rho<0.5$) with each other. This imperfect correlation, like that of the mixed asset portfolio, suggests that there were diversification benefits associated with constructing a portfolio from these assets. The correlation coefficients for the agribusiness sector reflect the low positive correlation in all sectors except staples ($\rho = 0.67$). This value is the highest correlation coefficient found and the only one greater than 0.5 found in the study. This may reflect the fact the staples sector is comprised of many of the same companies (food, drinks and agriculture) as the agribusiness sector. Unlike the mixed asset portfolio, there are no negative correlations in the diversified share portfolio. This was expected given that all the sectors are from the same asset class (shares).

Figure 6. Diversified Share Portfolio Efficient Frontiers Including and Excluding Agribusiness



The efficient frontiers for the diversified share portfolio including and excluding agribusiness. Both frontiers were calculated by determining the compound annual return of the efficient portfolios at 1.0% risk (standard deviation) intervals between the minimum variance portfolios and maximum return portfolios.

The evidence presented in Figure 6 suggests that the inclusion of agribusiness assets in the portfolio provided diversification benefits. The shape of frontier, like that of the mixed asset portfolio frontier, is typical of an efficient frontier and illustrates the risk-return trade off for the efficient diversified share portfolios.

The minimum risk portfolio excluding agribusiness was found to have a standard deviation of 6.20% and return of 5.76% while the maximum return portfolio exhibited a standard deviation of 17.24% and return of 9.88%. The inclusion of agribusiness assets into the efficient portfolios caused the efficient frontier to be shifted left and up at the lower levels of risk only. This shift implied that the inclusion of agribusiness provided a higher level of return than those efficient portfolios that did not contain agribusiness and the lower risk levels.

The minimum risk portfolio including agribusiness was shown to have a return of 5.87% and standard deviation of 5.27%. These outcomes are both improvements on the performance of the minimum variance portfolio excluding agribusiness outlined above. The maximum return portfolio exhibited the same risk-return profile as the efficient portfolio that excluded agribusiness, suggesting that agribusiness is not contained in the higher risk/return portfolios. The efficient frontier including agribusiness only exhibited an outward shift at the first three risk intervals. This suggests that, although clear diversification benefits are evident, they are not as significant as those seen in the mixed asset portfolio.

Figure 7. Diversified Share Portfolio Asset Allocation Including Agribusiness

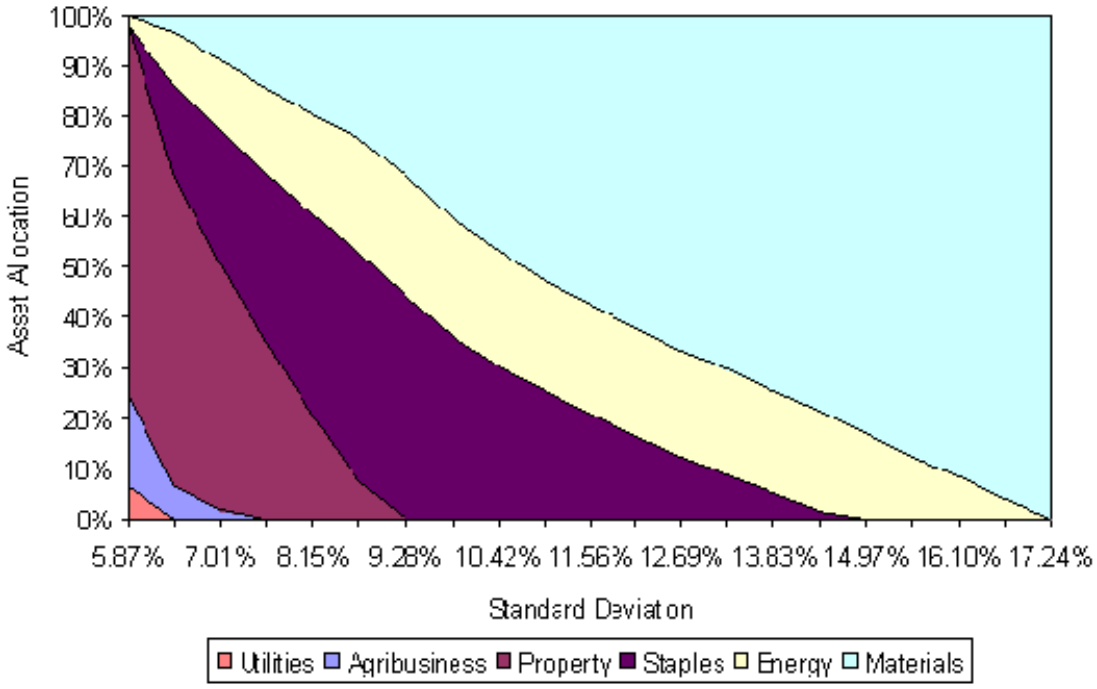


Figure 7 represents the allocation to each of the six assets that made up the efficient mixed asset portfolios along the efficient frontier including agribusiness presented in Figure 6. The allocation has been determined at 20 intervals between the minimum risk portfolio's standard deviation and maximum return portfolio's standard deviation that had been determined previously.

In Figure 7 it is shown that agribusiness was allocated only to the efficient portfolios with the lower levels of risk. This was expected given the results presented in Figure 6. Agribusiness entered the portfolio at the minimum variance portfolio with an allocation of 17.72%. As the risk level is increased the portfolio allocation to agribusiness declined rapidly. At portfolio risk levels above and including 7.58% there was no allocation to agribusiness. This reflected the higher returns on offer in the other sectors that were included in those efficient portfolios.

Of the eleven other assets (or sectors) that could have made up the efficient diversified share portfolios only five of the eleven sectors were included; Materials, Staples, Energy, Property and Utilities. This outcome reflected the higher rates of return on these sectors in shown in Table 3 and was in line with expectations. Interestingly, the financials sector, while having a higher return (R = 3.54%) and lower standard deviation (σ = 13.38%) than the utilities sector (R = 2.42%, σ = 13.77%) was not included in the efficient portfolio. This may be explained by the significantly lower correlation coefficient for the utilities sector with the other sectors making up the efficient portfolio in comparison to the financials sector.

In terms of the optimal allocation to agribusiness assets in a diversified share portfolio, these results suggest that, like in the mixed asset portfolio, allocations to agribusiness vary with risk. Clearly apparent, however, is that allocations should decrease as portfolio risk increases above the minimum risk portfolio. The allocation to agribusiness in the minimum risk portfolio suggests a significant agribusiness allocation was appropriate at such risk levels.

5. Discussion

In this section the significant results of the study and the implications of these results are discussed in relation to the objectives of the study and the existing literature in the subject area.

5.1 Agribusiness Index Performance

The Agribusiness Index was constructed in order to determine the performance of agribusiness assets for the four-year time frame of the study. The performance of the agribusiness index provided some insights into the performance of the agribusiness sector over the study period and underlined the importance of the index method used in the development of such an index.

Overall, the agribusiness index provided an adequate representation of agribusiness performance in this study. The inclusion of agribusiness assets provided significant diversification benefits in both the mixed asset and diversified share portfolios. The agribusiness index had a compound annual return (capital return) of 3.87% over 2000-2004, which was comparable to many of the better performing assets in the portfolios assessed and provided a reasonable rate of return. It is notable that both the compound annual return on agribusiness calculated in this study and the correlation coefficient between agribusiness and the S & P/ASX 200 were significantly lower than shown by the AAG Agri-Index (2004), the only other measure of listed agribusiness asset performance that has been published.

5.2 Mixed Asset Portfolio

The results of the mixed asset portfolio showed that agribusiness assets provided significant diversification benefits when included in the portfolio. For all portfolios, except the maximum return portfolio that contained only property, the efficient portfolios containing agribusiness were positioned above (had superior returns) the efficient portfolios that did not contain agribusiness. This demonstrates the valuable role that agribusiness assets played in improving portfolio returns at a given level of risk, or alternatively, decreasing portfolio risk at a given level of portfolio return.

The implications of the results in terms of the diversification benefits of agribusiness assets are significant for investors as they showed that the inclusion of agribusiness assets in a mixed asset portfolio such as the one constructed in this study improved the investor's portfolio risk-return profile. This result reflects the relatively low correlation between agribusiness and the other three assets that made up the mixed asset portfolio, shares, bonds and property and suggest that the argument put forward in favour of including agribusiness assets to achieve benefits from diversification cannot be rebutted based on the results of the mixed asset portfolio. That is, because agribusiness assets have a low correlation to other investments, they have the potential to improve returns and reduce risk in a diversified portfolio (in this case a mixed asset portfolio).

The results also show that as the risk profile of a portfolio increased the allocation of agribusiness assets in the portfolio tended to increase before deceasing at higher risk levels. The optimal allocation to agribusiness at each risk level provides investors with some guidance as what the appropriate allocation to agribusiness assets (and the three other asset classes) would have been, and possibly with some relevance to future investment, depending on their risk and return preferences.

The diversification benefits of agribusiness assets that were evident in the mixed asset portfolio reflected those shown in Eves' (2003) study of rural land in a similar mixed asset portfolio as well as the work by AAG on the subject. The increasing allocation to agribusiness as the risk level increases from the minimum variance portfolio that was evident in this study was also a feature of Eves' (2003) paper. Eves' (2003) results, however, showed that allocation to rural land did not decline at higher risk levels. The results of this study are also in line with the evidence from the United States on the role

of agribusiness assets (as farmland) in mixed asset portfolios. In using listed agribusiness to represent agribusiness asset performance, the results of this study have provided some insights into the benefits of diversification using agribusiness assets in a mixed asset portfolio.

5.3 Diversified Share Portfolio

The results of the analysis of the diversified share portfolio showed that agribusiness assets provided only moderate diversification benefits. Agribusiness assets only provided diversification benefits at lower levels of risk with agribusiness having no allocation in the efficient portfolios as risk increased to medium and higher levels. These results were much less significant than those for the mixed asset portfolio and reflected the relative positioning of agribusiness in terms of returns and volatility compared to the other assets included in the diversified share portfolio.

The implications of the results in terms of the diversification benefits of agribusiness assets are still significant for investors as they show that the inclusion of agribusiness assets in a diversified share portfolio improved the portfolio's risk-return profile, if only at lower risk levels. This result, as in the mixed asset portfolio, reflected the moderate to low correlation between agribusiness and the eleven other sectors making up the diversified share portfolio. This finding further supports the hypothesis that because agribusiness assets have a low correlation to other investments, they have the potential to improve returns and reduce risk in diversified portfolio (in this case a diversified share portfolio).

In terms of the optimal allocation of agribusiness assets in the diversified share portfolio, the results demonstrated that the allocation to agribusiness declined as the risk level increased. Despite the fact that agribusiness allocations decline rapidly with increasing risk, there is still a significant allocation to agribusiness in the minimum variance portfolio, underlining the role that agribusiness can play in providing diversification benefits in the portfolio at lower risk levels. The declining allocation as risk increased was in direct contrast to the mixed asset portfolio which showed an increasing agribusiness allocation up to relatively high risk levels before falling away. As risk increased the five other sectors making up the efficient diversified share portfolios provided a superior risk-return outcome over agribusiness. The allocation to agribusiness at only the lower risk level provides investors with guidance as to the benefits that could have been achieved by including agribusiness in such a share portfolio, particularly with respect to reducing the risk profile of the portfolio and maximizing portfolio returns.

The diversification benefits of agribusiness assets evident in the diversified share portfolio that are demonstrated in this study cannot be compared to any previous studies on the subject due to the lack of research that has been published on listed agribusiness. The findings do, however, further support the evidence that has been presented in the mixed asset portfolio and previous studies on rural land in mixed asset portfolios as to the diversification benefits of agribusiness assets.

5.4 Limitations of the Results and Suggestions for further Research

In interpreting and discussing the results of the study, the limitations of the methods used to determine and interpret the diversification benefits of agribusiness assets in investment portfolios need to be considered. This is particularly the case with respect to drawing conclusions about future investment decision and allocations to agribusiness in portfolios based on these findings. In discussing these limitations some areas for further research following on from this paper will become apparent. As such, recommendations for future research into the topic that follow logically from this paper accompany the discussion on the limitations of this research. By undertaking further research in the areas outlined, the applicability of the research has the potential to be significantly improved.

The primary limitation of the study is the use of capital returns to measure asset performance in the study. The decision not to include dividend payments and income earned on the assets was taken in order to simplify the analysis given that there has been no other research in this area using listed agribusiness to date. The exclusion of income payments on the assets making up the portfolios affects the relative performance of each asset, its allocation within the portfolio as well as portfolio performance. This being the case, basing investment decisions on the findings of this study would be difficult to justify as income is not taken into account. The addition of income to the capital returns on the assets used in this study provides a significant opportunity for further research that stems directly from this paper as data on income and dividends is readily available for all assets used in the study.

Another limitation of this type of portfolio optimisation study is that the portfolios constructed are done so on an ex-post basis. That is, the efficient portfolios were formed using historical data. The historical performance of each asset class in the mixed asset portfolio and sector in the diversified share portfolio, including agribusiness, will not necessarily be reflective of the future performance of these assets in similarly constructed portfolios. For an investor, this means that although there is strong evidence to suggest that agribusiness assets can provide diversification benefits in investment portfolios based on the data they do not guarantee such a result into the future. Using returns forecasts in a similar model is one way of addressing this problem, while expanding the time period of the study could provide a better estimate of historical asset performance. This study was limited in its ability to expand the time horizon due to the lack of data available for the indices making up the diversified share portfolio.

The unrestricted nature of the portfolios that were constructed should also be taken into account when considering the results of the study from an investor's point of view. By using unrestricted portfolios, the allocation to each asset in the efficient portfolios is unlimited and can range from 0% to 100%. Constructing unrestricted, ex-post portfolios tend to result in portfolio returns being biased upwards and risk downwards (Lins, Sherrick and Venigalla, 1992). This is because in reality it is unlikely that an investor would elect to invest in one asset class or sector only (despite the higher return) due to the risks associated with such an investment decision. Although the mixed asset portfolio included all asset classes that were considered when constructing that portfolio, the

diversified share portfolios along the efficient frontier that were constructed only included six of the twelve sectors that were considered in the study. This is an example of how using unrestricted portfolios can result in a bias towards increased return and decreased risk.

One way to take this into account is to restrict the portfolio such that a maximum allocation to each asset class in the efficient portfolios is permitted (Lins, Sherrick and Venigalla 1992). This approach has become more common in recent studies in the United States into rural land performance in portfolio as the volume of work on the subject has increased. For example, Lins, Sherrick and Venigalla (1992) restrict allocations to 10% of the portfolio. There is an obvious benefit associated with using restricted portfolios in providing a more realistic view of the optimal allocations to agribusiness assets in the investment portfolios constructed. This is an area where there is considerable scope to improve and further refine the methods used in this study to improve its applicability through further research. Despite this, such a process is unlikely to affect the overall outcomes of this study with respect to its major objectives in determining whether agribusiness assets provide diversification benefits in investment portfolios.

In assessing the results, the non-parametric nature of the study should also be taken into account. As a result of this, the efficient portfolios containing agribusiness were not tested for their statistical significance against the original portfolios excluding agribusiness. As discussed earlier it has been well documented in the literature that in an uncertain world, efficient frontiers and portfolio compositions are fuzzy, and asset allocations solely based on point estimates often produce counterintuitive results, particularly with respect to farmland (Hardin and Cheng 2002). For investors, this means that they may have little confidence in the weights prescribed by the mean-variance analysis (Hardin and Cheng 2002).

Hardin and Cheng (2002) showed that it is possible to test for the significance of efficient portfolios in the absence of a risk-free asset using a bootstrap simulation method. This complex process was not deemed to be appropriate in this type of study given the lack of basic research that currently exists in the subject area in Australia and the primary objectives of the study. It does, however, provide an opportunity to further expand the research conducted in this paper in order to improve its applicability for investors. Despite the lack of significance testing, the relatively large improvement in the efficient mixed asset portfolio performance with the inclusion of agribusiness assets suggests that the diversification benefits of agribusiness assets in the mixed asset portfolio are likely to be significant. For the diversified share portfolio, there may be a more compelling case for testing the significance of the efficient portfolios including agribusiness given the relatively minor improvement in the efficient frontier with the inclusion of agribusiness. Despite this, the results of the study are not counterintuitive; and provide answers to the research questions that are reasonable given the overall objectives of the research. Another alternative method for testing for the significance of the efficient portfolios is to include a risk-free asset and use Sharpe ratios and statistical tests such as the Gibbons, Ross, Shanken test of portfolio efficiency. Hardin and Cheng (2002) use this method in their research about farmland investment in the United States.

The use of indices to measure asset performance in the study is also an issue with respect to applying the findings. In the Australian market, investor's ability to invest in the indices used in the study are limited. Although there are index-linked products on the Australian stock exchange for the S & P/ASX 200 and 5-year government bonds are readily tradeable, the property index and agribusiness index are more difficult to invest in without purchasing shares in each company comprising the indices. As a result, the applicability of the findings in terms of investor decisions and action is limited. This is also the case for the diversified share portfolio, with no products that are linked to the performances of the sector indices readily available to investors in Australian markets. While it is unlikely that in reality investors are able to make investment decisions in this way, Barberis and Shleifer (2003) have shown that this type of 'style' investing is becoming more common in the current investment climate through the rising prevalence of index linked products, such as mutual funds, options and futures. This suggests that there may be an increasing applicability of this type of research into the future.

Finally, it was stated in the introduction to this paper that using listed agribusiness provides a limited view of the performance of the agribusiness sector as whole. While the index of listed agribusiness proved to be a useful tool to assess the performance of agribusiness assets, the exclusion of rural land and MIS performance from the study also limits the applicability of the findings. The findings of the study are compatible with the only previous study in Australia on agribusiness assets (as rural land) in mixed asset portfolios (Eves 2003), as well as with findings from work in the United States. This provides support for the conclusions about the diversification benefits of agribusiness assets in investment portfolios. Including rural land and/or MIS in the assessment of agribusiness asset performance provides significant opportunities to expand on the findings of this study. Importantly, these limitations did not significantly affect the ability of the study to achieve its research objective in determining the diversification benefits of agribusiness assets in investment portfolios.

6. Conclusion

The analysis of agribusiness asset performance in this study has provided a useful insight into the diversification benefits of agribusiness assets in investment portfolios. Using Markowitz's (1952) MPT mean-variance portfolio optimization techniques, the study showed that agribusiness assets provided diversification benefits in both the mixed asset and diversified share portfolios. The study also showed that agribusiness assets enter the efficient portfolios at lower levels of risk, with allocations declining at higher risk levels.

Agribusiness asset performance was measured by constructing an index of agribusiness companies listed on the Australian stock exchange. The index was constructed in accordance with the Standard and Poor's index methodology (Standard and Poor's, 2005). The index provided an adequate representation of agribusiness performance over the study and also demonstrated the importance of using an appropriate construction method.

The mixed asset portfolio comprised agribusiness, shares, bonds and property. The inclusion of agribusiness in the mixed asset portfolio resulted in a significant improvement in the positioning of the efficient frontier and the performance of the efficient portfolios along the frontier. This demonstrated the significant diversification benefits of agribusiness through improved portfolio returns and/or decreased portfolio risk compared to the original portfolio. The allocation to agribusiness within the efficient mixed asset portfolios was shown to increase with portfolio risk up to the higher the risk levels before declining. These results indicated that agribusiness assets provide diversification benefits in a mixed asset portfolio while also giving an indication of the optimal allocation to agribusiness at a range of portfolio risk levels.

The diversified share portfolio comprised the agribusiness index and the eleven major GICS sector indices on the ASX. The inclusion of agribusiness in the diversified share portfolio resulted in an improvement in the performance of the efficient portfolios and lower levels of risk only. This outcome proved to be less significant than that for mixed asset portfolio. Despite this, the diversification benefits of agribusiness assets within the diversified share portfolio were again apparent. The allocation to agribusiness within the efficient diversified share portfolios was maximized at the minimum-variance portfolio and decreased rapidly as portfolio risk increased. This was in contrast to the mixed asset portfolio and was attributed to the larger number of assets in this portfolio and relative performance of agribusiness to the assets making up the efficient portfolios. These results give a clear indication that agribusiness assets provide diversification benefits in a diversified share portfolio and also gave an indication of the optimal allocation to agribusiness at a range of portfolio risk levels.

For investors, these findings suggest that including agribusiness assets in their portfolios may provide significant diversification benefits by increasing portfolio return or decreasing portfolio risk. This said, there are some limitations of the research in terms of its practical application. In particular, the four years that were studied are unique; the analysis is based on capital returns and excludes dividend payments; and agricultural land is excluded from the analysis.

Given the lack of previous and current research into the subject and the rapid growth in agribusiness investment in Australia, there is potential for extensive further research in this area following on from this paper. It was also noted that the findings of the research are supported by the limited amount of existing literature on the subject both from within Australia and in the United States that use rural land as a representation of agribusiness.

In conclusion, this research has showed that agribusiness assets provide diversification benefits in investment portfolios. It also gave an indication of the optimal allocations of agribusiness assets at different portfolio risk levels. In doing so, the significant opportunities for further research in this emerging subject area in an Australian context were made apparent.

7. References

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8. Appendices

Appendix I - Agribusiness Index Companies

COMPANY	CODE	DATE LISTED
ABB	ABB	July 22, 2002
Atlantic	ATI	June 11, 1987
Auspine	ANE	September 20, 1984
Ausron Limited	AUX	February 23, 2000
Australian Agricultural Company Limited	AAC	August 10, 2001
Australian Food and Fibre	AFF	August 18, 1997
Australian Plantations Limited	APL	April 7, 2000
Australian Pure Fruits Limited	AFL	June 13, 2000
Australian Wine Holdings	AWL	December 20, 2000
Authorised Investment Fund	AIY	April 22, 1999
AWB Limited (B Class)	AWB	August 22, 2001
Buderim Ginger	BUG	December 14, 1989
Carter Holt Harvey	CHY	December 5, 1991
Challenger Beston Wine Trust	CWT	July 2, 1999
Chemeq	CMQ	August 25, 1999
Chiquita Brands	CHQ	January 4, 1996
CO2 Group Limited	COZ	June 14, 1990
Cockatoo Ridge Wines Limited	CKR	December 18, 1986
Constellation Brands	CBR	April 7, 2003
Coonawarra Australia Property Trust	CNR	May 9, 2003
Deep Sea Fisheries	DSF	December 10, 1986
East African Coffee Plantations	EAC	January 1, 1974
Farm Pride Foods	FRM	December 19, 1997
First Wine Fund Limited	FWF	June 10, 1999
Forest Enterprises	FEA	June 6, 2000
Futuris Corporation	FCL	April 8, 1983
Global Seafood Australia Limited	GSF	September 15, 1999
GrainCorp	GNC	March 30, 1998
Great Southern Plantations	GTP	July 5, 1999
Gunns	GNS	February 29, 1976
Integrated Tree Cropping	ITF	May 12, 2004
International Wine Investment Fund	IWI	November 22, 1996
Invitec-Pivot	IPL	July 28, 2003
John Shearer Holdings	SHR	June 30, 1972
Lowan	LAL	December 14, 1993
Maryborough Sugar	MSF	August 24, 1971

McGuigan Simeon	MGW	March 23, 1992
Namoi Cotton	NAM	April 6, 1998
National Foods	NFD	August 22, 1991
Nufarm	NUF	November 10, 1988
Piquant Blue Limited	PQB	January 7, 2004
Queensland Cotton	QCH	July 2, 1992
Ridley Corporation	RIC	August 1, 1987
Roberts	RBS	June 17, 1949
Rural Press	RUP	March 16, 1989
Ruralco Holdings	RHL	March 30, 1988
Select Harvests	SHV	December 22, 1983
Simon Gilbert Wines Limited	SGV	January 1, 1974
Southcorp	SRP	October 12, 1971
SPC Ardmona	SPC	September 1, 1993
Tandou Limited	TAN	November 26, 1987
Tassal Group Limited	TGR	November 12, 2003
Timbercorp Limited	TIM	May 30, 1996
Warnambool Cheese and Butter Factory Company	WCB	May 25, 2004
Webster Limited	WBA	January 1, 1974
Wilmott Forests	WFL	December 20, 2000
Xanadu Wines Limited	XAN	April 4, 2001

Appendix II - Bond Pricing Formula

$$P = v^{f/d}\left(g(1+a_{\overline{n}|}) + 100v^{n}\right)$$

where: $v = 1/(1+i)$

P = $100 Face Value

f = number of days to next interest payment

d = number of days in half year ending next interest payment date

g = half yearly coupon payment per $100 Face value

n = number of half years from next interest payment date until maturity.

a = $(1-v^n)/I$