# MODULE NO II

DENIS H CAMILLERI
VALUER DHI PERITI - dhc@dhiperiti.com
KAMRA TAL-PERITI

OCTOBER 2013

# LANDED PROPERTY

Readings: 2-1 Dairy Farm 2013    2-2 Farm Land
2-3 Site Depth Rules    2-4 Land Apportionment

## e AGRICULTURAL PROPERTY - 1

Land is a very scarce diminishing quantity for the Maltese Islands & thus is sold at a premium. Considering bare agricultural land, farmers in Malta are prepared to pay €120,000/ha as compared to the UK at €15,000/ha & at €5,000/ha in the US.

This fact is dependent not solely on the scarcity factor but is also influenced by the restrictive Land Agricultural Leases Ordinance Act. Further fields, are also purchased for their recreational value where prices attracting a price tag of €700,000/ha have also been undertaken making it impossible for farmers to enter into new lease contracts.

It is no surprise therefore, that agricultural land values have been increasing in Malta at 15% p.a. over the past 25 year-period.

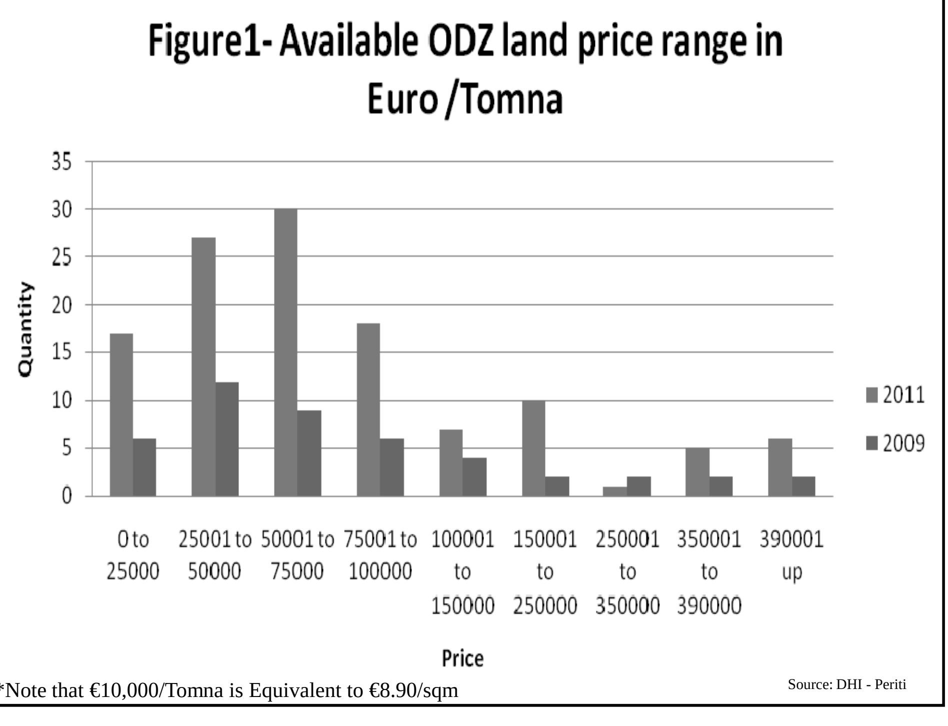
See readings 2-1 & 2-2

# e AGRICULTURAL PROPERTY - 2

**TABLE 1 - Range of advertised prices (€/tomna) in Estate Agents' lists**

| | Advertised Lists | Present Market Values | Bare Agricultural Land |
|---|---|---|---|
| **MALTA** | €13,000 - €625,000 | €6,000 - €70,000 | €12,000 (€10.75/m²) |
| **GOZO** | €7,000 - €435,000 | €5,000 - €60,000 | €4,500 (€4.00/m²) |

This farmland in the UK averages out at €1,500/tomna as compared to Malta's bare agricultural land which has been valued at €12,000/tomna. On the other hand the average yield of agricultural leases is taken at 1% for Malta, whilst this is given at 2.3% for the UK

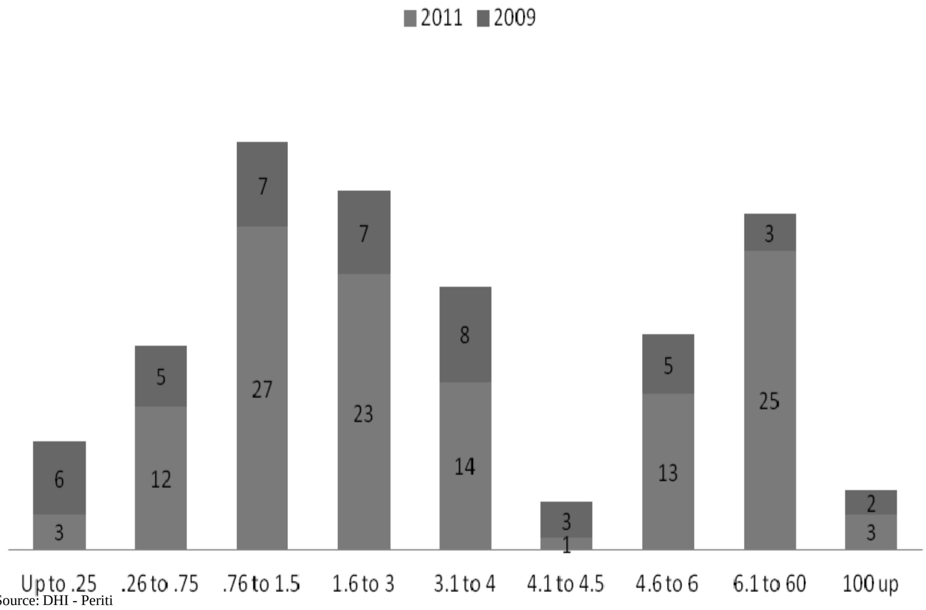



*Note that €10,000/Tomna is Equivalent to €8.90/sqm

Source: DHI - Periti

Nº

**Figure 2 – ODZ Areas for sale in No of Tmien**




Source: DHI - Periti

# AGRICULTURAL LEASES (RELETTING) ACT 1967 – 1

**KTP Valuation Standards (2012) Appendix F**

1. Lease based on comparison :–

   By comparison with conditions of lease prevailing in comparable field in the same part of the Island, having regard principally to the average quality and depth of the soil, the nature of the subsoil, the direction in which sloping land is facing, the accessibility to the road, and its distance from the closest village.

# REPOSSESSION OF FIELD - 2

The Board shall allow the lessor's application if the lessor proves that:

(A) he requires the agricultural land to be used for agricultural purposes by himself personally or by any member of the family personally for a period of not less than four consecutive years; or

(B) he requires the agricultural land, provide it is not irrigable land, for the construction thereon of buildings for dwelling, business or industrial purposes; or

(C) the agricultural land was sublet or the lease thereof transferred without the consent of the lessor to any person other than a co-tenant thereof or a member of the family; or

(D) during the two years immediately preceding the date of termination, the field was allowed to lie fallow for at least twelve consecutive calendar months; or

(E) during the two years immediately preceding the date of termination, the tenant has failed, in respect of two or more terms, to pay the rent; or

(F) during the two years immediately preceding the date of termination, the tenant being bound to repair and maintain the walls of the agricultural land, failed to fulfil such obligation or deliberately or through negligence caused or allowed damage, other than damage of small importance, to any fruit trees in the agricultural land.

# Compensation due on Agricultural Fields:- 3

## - Periti Agrimensori

(a) The tenant shall receive a fair compensation in respect of any agricultural improvements carried out by the tenant or by a member of the family in the said agricultural land during the period of eight consecutive years immediately preceding the date of termination .

(b) Where the lessor resumes possession of the agricultural land, he shall pay to the tenant a fair compensation as provided, and, in addition an amount equal to the value of the products gathered by the tenant or by a member of the family from the said agricultural land or part thereof, after deduction of the expenses incurred towards its cultivation, in the last four years immediately preceding the date of termination. Provided that there shall not be deducted as part of such expenses the cost of the tenant's own labour or the labour of any member of the family in the agricultural land or part thereof.

**THE DILEMMA NOW IS HOW TO VALUE FIELDS HELD on Agricultural lease?**

# AGRICULTURAL LEASES vs FARM OWNERSHIP - 1

Thirty out of 40 farmers, in FAO 1998 report, wanted to expand by leasing or buying additional land but giving preference to purchasing rather than leasing the land. The average price of acceptable lease per tomna was €13.75/tomna for Malta and €14/tomna for Gozo and the average purchasing price per tomna were €4,350/tomna in Malta and €625/tomna in Gozo. To be noted that Government holdings on lease fetch €9.35/tomna, whilst holdings on emphyteutical grants have been extended at €58.25/tomna.

This latter is considered impossible to grow low income crops such as wheat and barley with intensity cropping necessary. In the absence of an agreement to increase rent, tenant can always hold onto present rental value. If litigation arises the Court fixes the rental value according to the "lease prevailing in comparable fields in same part of the Island".

TABLE 2 – Acceptable purchase prices & rental amounts to farmers (1998) -

| €/1tomna | Malta Range | Malta Average | Gozo Range | Gozo Average |
|---|---|---|---|---|
| Purchase Price | 690-18,500 | 4,350 | 575-2,560 | 1,460 |
| Lease Amount | | 13.75 | | 14 |
| Capitalization Rate | | 0.315% | | 0.96% |

# AGRICULTURAL LEASES vs FARM OWNERSHIP - 2

These acceptable lease agreements at €14/tomna as per 1998 are to be compared with average Government holdings fetching €9.35/tomna p.a. whilst Government holdings on emphyteutical grants in 2001 were increased from €2.50/tomna p.a. up to €58.25 p.a. Old private agricultural leases average out at €4/tomna.

These grants were originally valued to stand at €291.25/tomna p.a. considered as at 2001 to yield 5% of market value, but then agreement was reached on the acceptable figure at €58.25/tomna p.a. working out at a yield of 1%. This being in consonant with the Gozitan farmer's expectation of Capital Return rate as noted in table 2.

At the present agricultural land value acceptable to farmers at €12,000/tomna, at a 1% capitalization rate, present lease values should work out at €120/tomna.

Since in 2001 consensus amongst the Authorities and the farmers were arrived at €58.25/tomna p.a, the bare value of agricultural land may be achieved by capitalizing at 1%. This gives a value of €5,825/tomna.

Although agricultural land is noted to appreciate at 15% p.a., (Appendix F VS2012) a more sustainable rate of increase to bare agricultural land is taken at 6.25 % p.a.(Table 4) Thus presently bare agricultural land is valued at:

**€5,825/tomna @ 1.0625 ^9 = € 12,000 /tomna**.

# AGRICULTURAL LAND WITH HOPE VALUE

The property consists of 20 tmien of agricultural land on the outskirts of a growing town. The farm adjoining the property has recently been allocated in the local plan for residential development

It is in the greenbelt and is currently used for arable farming.

There is comparable evidence of land being sold at €17,500/tomna for agricultural use.

Developable residential land @ €1,250/m² is considered achievable in 10 years

| | | |
|---|---|---|
| Agricultural Value 20T@€17,500/T | = | €350,000 Plus Hope Value |
| Assumed land value of €1,250,000/T | = | €25,000,000 |
| Total increase in value | | **€24,650,000** |
| Deferred 10yr at 10% ($1/1.10^{10} = 0.386$) | = | €9,503,642 |
| But say ¼ of its value | | €2,375,910 |

# DEVELOPMENT LAND COMPARATIVE LAND RATES

Malta's land rates for fairly good residential areas for 4 storey alloweable development heights vary between €850 /m² up to €1,250/m², whilst this rate for a 6-storey internal land zone residential development equates to a land rate of €2,000/m². These land rates are to be compared to prime residential sea front land for 8 floors at €8,500/m² whilst prime internal residential land at 5 floors works out at €3,500/m².

The land value rate for a 5-storey land zone for Qawra developments is noted from listings to vary from €1,125/m² up to €2,850/m², averaging out to €1,450/m². Applying a 15% discount a fair inland land rate for this locality is presently taken at €1,250/m²

These residual land rates are to be compared to similar in UK

Varying between €140/m² (Nottingham) up to

€540/m² (Croydon)

# Frontage/Area Rule for Plots on a 32m depth - ZONING

An old established rule for New York works out at:

4 : 3 : 2 : 1

For each 7m depth of Plot

Can this be used to estimate a corner plot?
In Central District Areas it was noted that plots shed 8.5% of their value over 300m

This is similar to the zoning method of rental value for high street shops with a front unit taken at 4m X 9m.

The halving principle is applied for inner units or on upper stories

See readings 2-3

# Frontage & Halving Principle Examples

A building plot 6m X 28 m was sold for €200,000.

What is the value of an adjacent plot measuring 4.5m X 18m

Value of 1 portion given at: €200,000/10 = **€20,000**

Value of adjacent plot €20,000 (4+3+1)4.5,/6.5m = **€110,770**

How to value a Corner Plot 7m deep X 18m frontage?

What about internal land for Internal Development?

# LAND APPORTIONMENT

## KTP Valuation Standards 2012 – Para 7.13

- **Value of land could be requested in audited accounts as no depreciation is applied to land values:-**
- **Para 7.13.5 The informal apportionment to assess the depreciable amound must be established by one of the following procedures;**

1. **By deducting from the valuation of the asset the value of the land for its existing use at the relevant date. In many instances there will be ample evidence of land values upon which notional apportionment can be Made.**
2. **Where this does not apply, by making an assessment of the net current replacement cost of the buildings to reflect the value of the assets to the business at the date of valuation.**
3. **For commercial Premeses the Residual Valuation Method**

**See Readings 2-4**

# GENERAL BASIS OF RESIDUAL VALUATION

**SITE VALUE = Valuation on Completion – Cost of Work – Profit**

- **FOR MALTA site value approximates to 27% of Completed Market Value.**
- **Profit varies from 15% up to 25% of Completed Value.**
- **Cost of work includes for interest charges incurred during development period & estate agent fees on sale.**

## LAND/RESIDENTIAL DATABASE – 1

It is noted that over this 30-year period land values have increased by 4 ¼ times more than property values. This steep differential between rises in land values as compared to property values commenced in 1987 but shot up in 1992, as clearly indicated in Table 3 below.

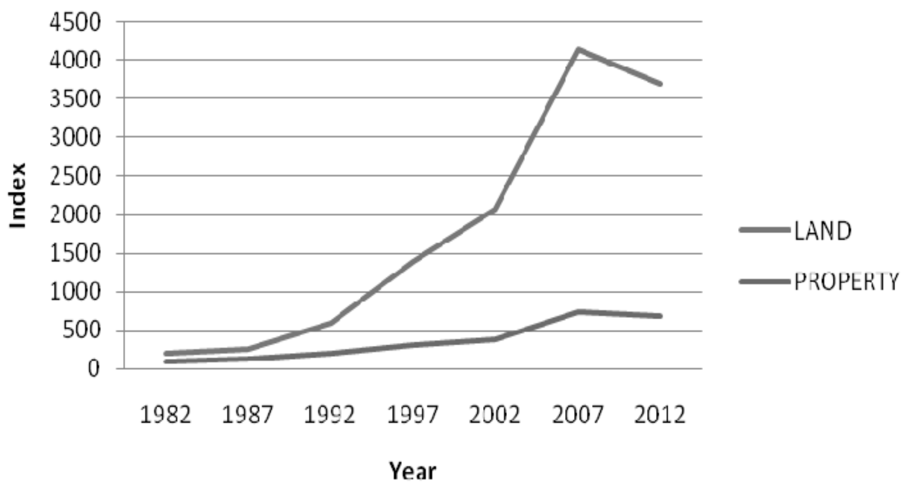
| YEAR / TYPE | 1982 | 1987 | 1992 | 1997 | 2002 | 2007 | 2012 | % OVER 30 YEARS pa | % 2007 TO 2012 pa |
|---|---|---|---|---|---|---|---|---|---|
| RESIDENTIAL | 100 | 130 | 216 | 314 | 386 | 743 | 696 | 7.32% | -1.31% |
| LAND | 100 | 120 | 369 | 1080 | 1680 | 3400 | 3000 | 14.05% | -2.47% |

**TABLE 3: LAND/PROPERTY INDEX 1982-2012**

Source: DHI Periti in-house valuations (2012)

## LAND/RESIDENTIAL DATABASE – 2

**FIGURE 3: LAND/PROPERTY INDEX 1982-2012**




Source: DHI Periti in-house valuations: (2012)

## LAND/RESIDENTIAL DATABASE - 3

| LAND VALUE % | | RESIDENTIAL VALUE % | |
|---|---|---|---|
| PERIOD | % | PERIOD | % |
| 1992 -2002 | 16.37% | 1992 -2002 | 6.00% |
| 2002 - 2012 | 5.97% | 2002 - 2012 | 6.07% |
| 1992 - 2012 | 11.27% | 1992 - 2012 | 6.62% |
| 2007 - 2012 | -2.47% | 2007 - 2012 | -1.31% |

**TABLE 4 - LAND Vs RESIDENTIAL VALUE INCREASES**

Source: DHI Periti in-house valuations: (2012)

The economic importance for Land Reclamation in Malta is outlined here

## LAND/RESIDENTIAL DATABASE - 4

**EXAMPLE No. 1 – landed property:-**
What is the present day value of a building plot purchased in 2007 at €245,000?

€245,000 X 3,000/3,400 = €216,000 (12% decrease)

**EXAMPLE No. 2 – landed property:-**
What is the present day value of a building plot purchased in 2002 at €85,000?

€85,000 X 3,000/1,680 = €151,755 (78.5% increase)

JPIF
31,2

118

Received January 2012
Accepted March 2012

# Pricing of New Zealand dairy farmland

Song Shi and Iona McCarthy
*School of Economics and Finance, Massey University, Palmerston North, New Zealand*

## Abstract

**Purpose** – The purpose of this paper is to investigate the relationship between dairy farmland prices and farmland rental incomes in New Zealand from 1982 to 2009.

**Design/methodology/approach** – Using the net cash income received under a 50/50 share-milking agreement to proxy the net cash rent, the paper attempts to explore the prices and rental incomes relationship using the present value model and then apply them in a pool regression model to show how farmers formulate their price bids.

**Findings** – Results show that over the long-term dairy farmland price growth tends to be in line with rental growth. However, there is substantially higher growth in land prices in relation to the rental growth since 2002. Moreover, the risk premium placed by farmland owners on future rental cash flows since 2002 appears substantially below the historical average. The research further shows that farmers nowadays place more emphasis on the current season's payout than historical incomes in their price bids.

**Practical implications** – As a consequence the recent high land prices will be extremely sensitive to a permanent change to the low interest rate environment and future growth of dairy income. A policy recommendation is also highlighted.

**Originality/value** – The results of this paper indicates that the rapid price appreciation for New Zealand dairy farmland since 2000s might give rise to bubbles.

**Keywords** Dairy farmland prices, Rental growth, Capital gain, Present value model, New Zealand, Farms

**Paper type** Research paper

## 1. Introduction

The price paid for dairy farmland in New Zealand increases at a real rate of close to 10 per cent compound per annum between 2000 and 2009 (Hargreaves and McCarthy, 2010). This rapid price increase prompts commentary that farm buyers' expectation of continuing growth in the value of land may not be sustainable (Wilson, 2009; Eves and Painter, 2008). In New Zealand dairy farmers consistently earn around 93 per cent of their gross income from milk sales DairyNZ (2002-2012)[1], thus milk income is a critical component in dairy farmland pricing. Gross milk income earned in a dairy season is derived as the product of dairy company payout and annual production. Steady production gain has been made over the past three decades but gross milk payout prices have become increasingly volatile. Figure 1 shows the milk production and real gross milk payout from 1982 to 2009.

Journal of Property Investment & Finance
Vol. 31 No. 2, 2013
pp. 118-134

1463-578X
DOI 10.1108/14635781311302564

The authors thank the Editor, Nick French, and two anonymous referees for many useful comments. The authors also thank Andrea Bennett, Bob Hargreaves and David Tripe for valuable comments on earlier versions of this paper. They are also grateful to Matthew Newman and Angie Fisher from DairyNZ for kindly providing the farmland income data.

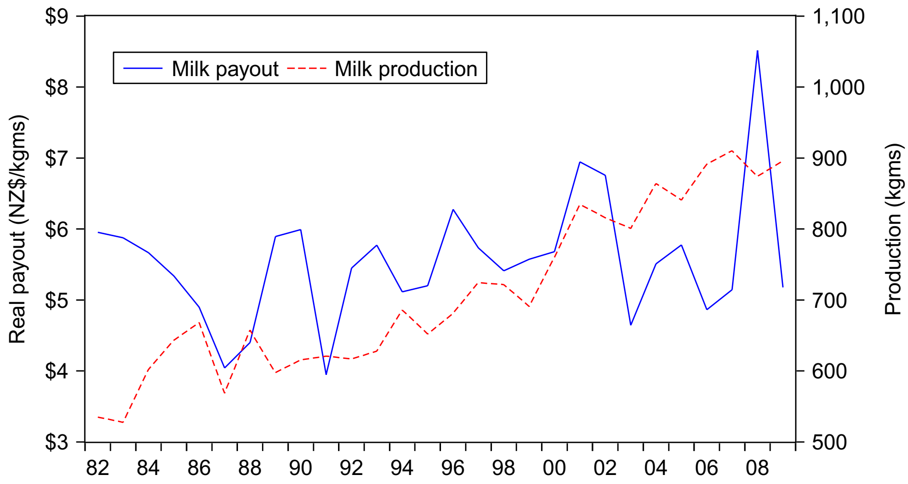



**Figure 1.**
Milk production and real gross milk payout

The reason for this recent increase in farmland price may include high milk payouts in 2002 and 2008 and increased demand for milk products from the developing world (Delgado, 2003). However, in New Zealand farming business is characterised by cycles. Rapid increases in dairy land prices in the early 1980s and 1990s were followed by significant declines as shown in the New Zealand rural property sales statistics (Valuation New Zealand, 1980-1997; Quotable Value Ltd, 1998-2011). The recent volatility in world dairy commodity prices may have increased the risk of greater volatility in land prices. The real national average dairy farmland prices and real farmland rents are shown in Figure 2.

In this paper we seek to explore two important questions. First, what is the relationship between dairy farmland rents and farmland prices? Under the traditional present value model, an asset price is defined as the expected present value of future

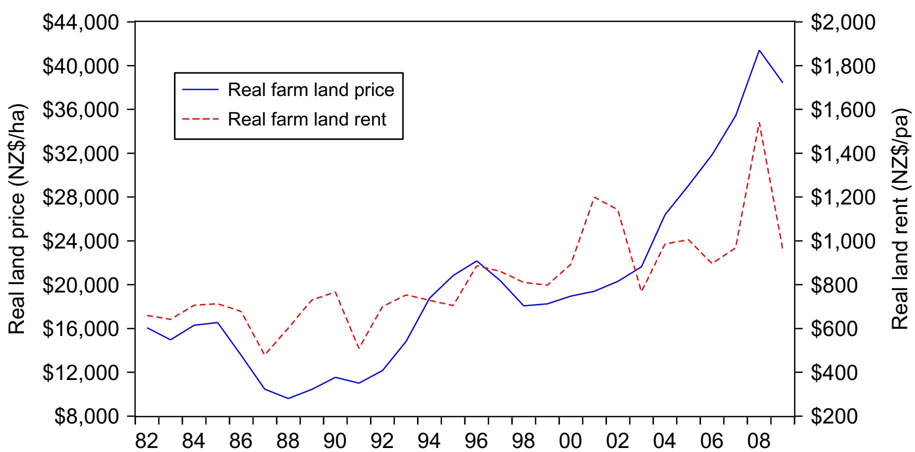



**Figure 2.**
Dairy farmland real prices and real rents

cash flows. Many studies show that net farmland rent is the primary determinant of farmland prices (Vantreese *et al.*, 1986; Alston, 1986; Seed *et al.*, 1986; Melichar, 1979). There can be a short-term deviation between net farmland rents and prices, but in the long-term farmland prices are mean reverting to the above defined fundamental values (Falk, 1991; Falk and Lee, 1998). When asset prices are traded consistently over their fundamental values over a long period of time, mainly due to market speculation on future growth, an asset bubble will manifest itself. Shiller (2011) warned that farmland might be the subject of the next bubble, we want to check whether the recent high growth in dairy farmland prices is in line with the land income. Second, it is interesting to know how farmers formulate their bid prices when international commodity prices for dairy products are volatile. Information efficiency on future payouts has been greatly improved over time. If farmers rely too much on the current season's payout in their price bidding, it is likely that the price they paid will simply reflect any current bubble in the market. As a result prices may get disconnected from underlying fundamentals of the assets and encourage speculative forces to play on the market.

There is very little research in New Zealand dairy farmland prices. Unlike farmers in North America, where an active farmland leasing market exists, most of the farmland owners in New Zealand are also the farm business operators. Their income return provides a reward to labour and all farm assets including: land and buildings, livestock, dairy company shareholding and plant and machinery. Thus, it is difficult to disaggregate the net return to the land component. This paper is in an effort to establish the net return of holding dairy farmland (land and buildings) in New Zealand. The study is considered important as it examines the dairy farmland's net return under the modern asset-pricing framework and thus adds to the literature on the farmland bubble debate. Moreover, a study of the dairy farmland market in New Zealand should have broad interest as New Zealand has been dominant in world trade of dairy products. Over the last two decades New Zealand's share of world dairy trade has been over 30 per cent and the New Zealand based company Fonterra is now responsible for more than one third of international dairy trade (http://fonterra.com)[2].

We use a unique data set under a typical 50/50 share-milking agreement to proxy the net land rental received by farmland owners in this study. We examine dairy farmland prices and net rents for various sub-periods over time by using the present value model. Furthermore, transaction land prices are regressed against net rental incomes and other variables to determine on how farmers formulate their price expectation when commodity prices are increasingly volatile. In contrast to most North American studies, which use direct land rental data (cash rent or net cash rent) for their analysis, we expect our use of a proxy which is directly linked to farm milk incomes will more timely reflect the net rental income received by farmland owners and thus may provide a better understanding of investment returns by holding dairy farmland in New Zealand.

The remainder of the study is organised as follows: Section 2 reviews the New Zealand dairy industry. Section 3 presents the theoretical framework and regression models used in this research. Section 4 describes the data utilised. Section 5 reports the empirical results. Section 6 provides a conclusion.

## 2. New Zealand dairy industry

There have been significant structural industry changes over the study period. One of the most important changes was the deregulation of the New Zealand economy that began in 1984 (Sandrey and Reynolds, 1990; Evans *et al.*, 1996; Lattimore, 2006). Prior to 1984 New Zealand Government subsidies ensured minimum income levels; farmers received a clear signal of the total milk payout at the beginning of each farming season and total farm income levels were stable. From 1984 New Zealand underwent wide economic reforms. For the agricultural sector this meant rapid removal of subsidies and incentives (assistance had come from supplementary minimum product prices, producer board subsidies, and interest and taxation concessions). There was a period of adjustment through the mid- to late-1980s as gross farm incomes fell while farm operating costs and interest rates increased. Lattimore (2006) reported a 25 per cent fall in dairy farmer income, mainly due to increasing interest rates and the removal of fertiliser subsidies. He also noted that this had a significant impact on farmland prices with a 50 per cent decline in real dairy farmland values from 1985 to 1987 (Figure 2).

From 1989 onwards farmers adjusted quickly to farming without subsidies and productivity gains were significant. Johnson and Forbes (2000) report total productivity growth increasing from 0.7 to 1.9 per cent per annum after subsidies were removed in 1985. The FAO Index of International Dairy Product Prices shows an increase in international prices for dairy products in the early 1990s. As reported by Jaforullah and Whiteman (1999) this increasingly good outlook for the New Zealand dairy industry encouraged conversion of land (predominantly in the South Island) to dairying; the number of milking cows increased rapidly from 2.3 million in 1990, to 3.3 million in 2000 (DairyNZ, 2010). Over this time land prices increased steadily although checked by the Asian crisis in 1997.

Changes in the dairy companies have also been pivotal in improving efficiencies of the manufacturing sector in dairying (Conforte *et al.*, 2008; Evans, 2004). In 1981 there were 42 separate dairy companies but the need for economies of scale and improved coordination of production and marketing led to company mergers and acquisitions. By 1996 there were 13 dairy companies and this reduced to four in 2000. The capital structure of dairy companies is another factor that has had an impact on farmland price. New Zealand dairy farmers own shares in their dairy company in proportion to milk supplied. Until the late-1990s this shareholding had a nominal par value representing a right to supply and did not provide a true reflection of the value of dairy company assets. It was likely that the value of off-farm assets was being capitalised into farmland prices (Rauniyar *et al.*, 1999). The assets were unbundled from 1998 and the company Fonterra now has a fair value share price that is determined independently, based on the projected business and projected sustainable earnings of the company (Constitution of Fonterra Co-operative Group Ltd, 2010).

Since the early of 2000s the FAO Index of International Dairy Product Prices shows increased volatility in the market for dairy commodities, spiking in 2007/2008 and falling rapidly in early 2009. Over this time there has been a very rapid rise in the value of dairy farm land (Figure 2). Information on current dairy product price trends will be of considerable importance to dairy farm purchasers. The New Zealand company Fonterra announces a forecast payout per kilogram milk solids in May, at the beginning of the dairy season, which is then revised each quarter. This provides an indication of earnings for the dairy season but is subject to change depending on market conditions. In 2008 it introduced globalDairyTrade, an internet-based electronic trading platform for cross-border trade in commodity dairy products. This gives farmers a credible and transparent means of following product price trends on a monthly basis. The characteristics of New Zealand dairy industry over the studied period are summarised in Table I.

## 3. Theoretical frame work

### *3.1 Present value model*

The analytical framework of this paper follows the present value model, developed in finance to estimate the fundamental value of an asset. The model relates the price of an asset to its expected future cash flows discounted to the present at an expected discount rate. If it is assumed the discount rate is constant, the current asset price P at time *t* is written as follows:

$$P_t = E_t\left[\sum_{i=1}^{n} \frac{D_{t+i}}{(1+R)^i}\right] + E_t\left[\frac{P_{t+n}}{(1+R)^n}\right] \quad (1)$$

where $D_t$ is the dividend or cash flow at time *t* and *R* is the expected discount rate.

| | 1982-1985 (Peak → downturn) | 1986-1993 (Trough → upturn) | 1994-2001 (Peak → downturn) | 2002-2009 (Trough → upturn) |
|---|---|---|---|---|
| Policy changes Industry conditions | 1984: deregulation, removal of subsidies | Importance of environmental issues, introduction of the Resource Management Act 1991 | 1997: impact of Asian crisis 1998: share standards increased 2001: restructuring of industry and formation of Fonterra | Fonterra established 2008: introduction of globalDairyTrade |
| Lending criteria | Subsidised government lending until 1984/1985 | Deregulation of the banking sector in 1986 with rapidly rising, interest rates until 1987, falling back to pre-1984 levels by 1992 | Increased rural lending, interest rates relatively stable then decreasing in 1999 | Stable interest rates, readily available credit until the global financial crisis |
| Farm profitability | Stable | Decreasing in 1986 and 1987 with increased business risk, major drought in 1989. Improving productivity gains, payout drop in 1991 | Continuing productivity gains, payout decrease in 1997 and 1998 | Increasing volatility in payout, peak payouts in 2002 and 2008 |
| Farmland prices | Stable from 1982, declining rapidly from 1985 | Lowest prices in 1988, slow increase until early 1990s then more rapid increase | Decline slightly and then recover | Very rapid increase in prices until 2008 |
| Sales volume | Low, average 200 sales per annum | Medium, average 700 sales per annum | High, average 1,200 sales per annum | Medium, average 770 sales per annum |

**Table I.**
Characteristics of the sub-time periods

In the finance literature the first term is often called the fundamental value and the second term is the price bubble. When $n$ is sufficiently large, the second term will converge to 0. The model implies that the current asset price is simply the present value of all expected future cash flows, discounted at a constant rate.

When dividends $D_{t+i}$ are expected to grow at a constant rate G, we obtain the well-known Gordon growth model (or constant growth model) as follows:

$$P_t = \frac{(1+G)D_t}{R-G} \quad \text{or} \quad P_t = \frac{D_{t+1}}{R-G} \tag{2}$$

where $G$ is the constant growth rate of cash flows and is less than $R$.

The denominator of $R - G$ in equation (2) is the capitalisation rate and equation (2) is also known as the capitalisation method for valuing income producing properties. One feature of the above formula is that it assumes a constant expected discount rate R and growth rate G. The assumption may contradict the widely established evidence that the investor's expected rate of return will vary over time (Campbell *et al.*, 1997), but it is useful in examining parallel relationships inherent in the asset-pricing model. Melichar (1979) argued that for an asset with a growth return, real capital gains arise in two different ways. First changes in the value of R, G, or D result in a new equilibrium value P. Land prices P are high when incomes D are expected to grow or when incomes are discounted at a low rate R. Second if the growth rate G is greater than 0, value P will increase each year at the growth rate G, even though the values of G and R are unchanged. For example, if the asset's real income grows at 2 per cent per annum, it follows that the asset's price will grow by 2 per cent per annum as well, assuming the discount rate stays constant over time. A constant annual real capital gain due to constant income growth is an inherent feature implied by the above present value model.

### *3.2 Estimation of farmland owners' expected future rents*

A straight forward method to approximate future rental income to landowners, $D_{t+1}$, is to use the current rent $D_t$. For an individual farmland owner, his or her expected rental income in the next period can be defined as follows:

$$E_{i,t}[D_{i,t+1}] = D_{i,t} + \mu_{i,t} \tag{3}$$

where $D_{i,t+1}$ is the expected next period rent for farmer $i$ and $\mu_{i,t}$ is the idiosyncratic effect associated with the individual farmer.

In addition to estimates of the current period income at individual farm levels in the above equation (3), Ahrendsen (1993) suggested using the industry average income to replace the estimates of income at individual farm levels. The rearranged equation is as follows:

$$E_{i,t}[D_{i,t+1}] = \overline{D}_{i,t} + \mu_{i,t} \tag{4}$$

where $\overline{D}_{i,t}$ is the average industry rental income for the current period t, and $\mu_{i,t}$ is the idiosyncratic effect associated with the individual farmer.

In this study we follow the approach of Goodwin *et al.* (2011) and rely on both past and current information to approximate expected future income. In particular, we use the Akaike information criterion (AIC) to decide on how many years of past income to include in the calculation of approximate expected future income.

*3.3 Dairy farmland price formation*

We adopt a pooled cross-section regression model to estimate the relationship between the current farmland price and future income. The basic regression equation can be expressed as follows:

$$P_{i,t} = c + \overline{D}_{i,t} + Dis_i + Area_i + regional\ \ dummies \tag{5}$$

where $P_{i,t}$ is individual farm sale price including land and buildings, $\overline{D}_{i,t}$ is the estimated district level farmland rental income at sale for the *i*th property, $Dis_i$ is the distance of *i*th property to the nearest town/city and $Area_i$ is the land area of *i*th property.

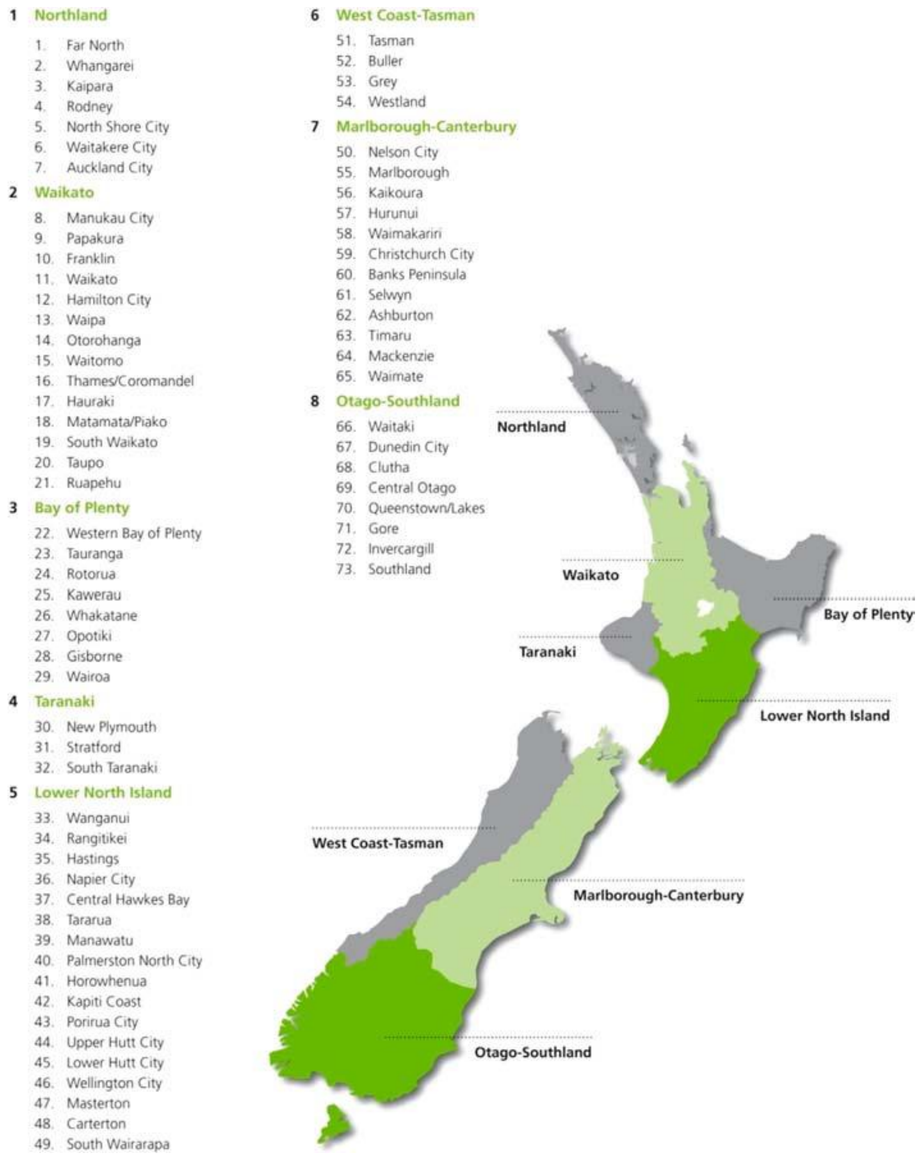
We include the distance variable in the equation as previous research has indicated farmland values can be influenced by the degree of urbanisation. Cavailhès and Wavresky (2003) found farm landowners expectation about conversion to urban uses had a large impact on farmland prices in peri-urban belts. As well, Shi *et al.* (1997) found farmland values in West Virginia were inversely related to the distance from urban centres. Finally we employ land area and regional dummy variables in the regression. Larger land parcels will generally have a lower land price per hectare. Regional dummies take account of regional differences such as the attractiveness of region's climate, soil and population density.

## 4. Data and preparation

We obtain all farm sales recorded as being used for dairying, which had sold between the 1982 and 2009 farming years, from the Headway Systems database. The database records every property sale in New Zealand as soon as conveyancing is completed. The sales ranged in standard of improvements from sales with minimal buildings to fully improved dairy units. As a consequence the total farm sale price includes both land and buildings in this study.

Any erroneous data was identified and removed. This included non-market sales, duplicate sales and transactions with a sale price less than NZ$100 per hectare or greater than NZ$1,000,000 per hectare. Following the initial data clean-up, we further restricted our analysis to farms between 20 and 500 ha in size with a gross income multiplier between 1 and 20. By restricting the farmland size and income multiplier, we further eliminated any uneconomic farmland sales and minimised the influence of building values on farm sale prices. This produced a database of 22,301 farm sales over 28 farming years from 1982 to 2009. We then match this sales data to the average district income data sourced from DairyNZ[3]. In general, the districts experience uniform climatic conditions and low variability of productive land capacity. Figure 3 shows the regional locations with districts listed under DairyNZ.

Our empirical approach involves estimating the net cash rents received by landowners. We used the unique *DairyNZ Economic Survey* data to proxy the net cash rents. The survey includes a random sample of 300-500 dairy farms which is stratified by region and by herd size, and covers both owner-operated farms and farms under a typical 50/50 share-milking agreement as detailed by Jaforullah and Whiteman (1999). The two survey groups are very similar in terms of farm size and milk produced. Under a 50/50 share-milking agreement, landowners and share-milkers each receive 50 per cent of the milk revenue. Landowners own the land and share-milkers own the




**Source:** DairyNZ Economic Survey 2009-2010

**Figure 3.**
Location map of eight dairy regions

livestock, farm machinery and provide the labour. Operating costs for landowners relate mainly to ownership and maintenance of the land and buildings and include: fertiliser, re-grassing, weed and pest control, repairs and maintenance to farm improvements, administration, insurance, rates plus a 25-50 per cent share of power, grazing, feed and dairy expenses. We estimate the net cash rents by deducting the identified landowner-borne costs from 50 per cent of the gross milk income. At a national level the owner-borne cost ranged from 20 to 35 per cent of the total farm milk income over the study period depending on specific farming years. We use an average of 27 per cent of total milk income to represent the long-run owner-borne operating expenses to derive the net income return to dairy farmland. The method is consistent with the long-term investment characteristics of farmland.

Also we assign a distance variable to each sale. The estimated distance data set, provided by QuickMap Custom Software Ltd, is a linear measurement of the distance from each sale property to the nearest town or city with a population of over 9,000. Finally, all farmland sale prices and incomes are reported in 2009 equivalent real values using the producer price index for dairy farming published by Statistics New Zealand. Summarised statistics for the analysed data set are presented in Table II.

## 5. Empirical results

### *5.1 Historical dairy farmland price appreciation and income growth*

Table III presents the summarised results of farmland rent growth and farmland price appreciation including onsite buildings over the past 28 years. From 1982 to 1985, the estimated annual real net rental growth (column A) was 2.8 per cent while the real growth in farmland price (column D) was 1.2 per cent. From 1986 to 1993 annual real net rental growth was 3.7 per cent but farmland prices depreciated in real terms by 0.3 per cent per annum. From 1994 to 2001, the average real rental

**Table II.** National annual summary statistics of dairy farmland, 1982-2009

| Variable | Years | Mean | Median | Maximum | Minimum | SD |
|---|---|---|---|---|---|---|
| No. of annual farm sales | 28 | 833 | 874 | 1,821 | 133 | 464 |
| Farm size (ha) | 28 | 73.2 | 66.7 | 98.2 | 56.4 | 13.5 |
| Production (kg/ha) | 28 | 711 | 683 | 910 | 527 | 117 |
| Real payout (NZ$/kg) | 28 | 5.55 | 5.54 | 8.52 | 3.95 | 0.90 |
| Real net farmland rental (NZ$/ha) | 28 | 824 | 768 | 1,541 | 479 | 220 |
| Real farmland price (NZ$/ha) | 28 | 19,958 | 18,514 | 41,421 | 9,608 | 8,517 |

**Table III.** Estimated farmer's returns to land and buildings, 1982-2009

| Period[a] | Average annual real net rental growth rate (%) (A) | Average annual net capitalisation rate (%) (B) | Estimated average annual discount rate[b] (%) (C) | Average annual real land price growth rate (%) (D) |
|---|---|---|---|---|
| 1982-1985 | 2.8 | 5.5 | 8.3 | 1.2 |
| 1986-1993 | 3.7 | 7.0 | 10.7 | −0.3 |
| 1994-2001 | 6.9 | 5.7 | 12.6 | 4.0 |
| 2002-2009 | 1.4 | 4.4 | 5.9 | 9.2 |
| Overall | 3.9 | 5.7 | 9.6 | 4.0 |

**Notes:** [a]We use financial year rather than the calendar year in estimating farmer's returns; a typical financial year for farming will run from 1 June to 31 May in the following year in New Zealand; for example, an annual return for the farming year of 1982 is actually measured from 1 June 1981 to 31 May 1982; the reason of using a financial year to estimate returns is because payout is calculated/announced in a farming year; [b]discount rate is derived by column (A) plus column (B) growth was strong at 6.9 per cent per annum, while the average real farmland price growth was lower at about 4.0 per cent per annum. From 2002 to 2009, the average real rental growth was slow at 1.4 per cent per annum but the real farmland price appreciation was much higher at 9.6 per cent per annum. Our result suggests that New Zealand dairy farm investment has been characterised by cycles, with land price growth less than rental growth until the recent rapid increase in dairy farmland price since 2002.

Average annual net capitalisation rates for the four sub-time periods are reported in column B in Table III. The rates are estimated as the ratio of net land rents over land prices. On average, the net capitalisation rate was 5.7 per cent over the study period and ranged from 4.4 to 7.0 per cent. Discount rates were then estimated by adding the income growth rate (column A) to the net capitalisation rate (column B) (see equation (2) for the relationship between discount rate, capitalisation rate and income growth rate). The estimated discount rates (required rates of return for owning farmland) are presented in column C of Table III. In theory the discount rate is normally assumed to be constant over time due to the long-term investment characteristics of farmland and the high transaction costs (Burt, 1986). However, our results show it may vary over time due to substantial changes in policy or market fundamentals. The discount rate was lower in early 1980s, when the dairy farm market was protected by government subsidies. Government subsidies/payments can be viewed as a more stable source of income by farmers, requiring a lower discount rate than market based returns (Weersink *et al.*, 1999). From 1986 to 2001, the discount rate ranged from 10.7 to 12.6 per cent and dropped considerably to 5.9 per cent per annum in the 2002-2009 cycle. The result shows that the required discount rate in the dairy farming sector is fairly low over the recent time when compared to the historical average.

To see if the observed discount rates in the dairy farmland market are consistent with market fundamentals such as real interest rate charges, we compare discount rates to real residential first mortgage floating rates, and five and ten year government bond yields. Table IV shows that farmland owners demand a substantially lower risk premium for the required discount rate since 2002. The risk premium is merely 0.1 per cent above the equivalent residential floating mortgage rate and 2.7 per cent

**Table IV.** Average annual discount rates, mortgage rates and government bond yields for selected periods

| Period | Average annual discount rate (%) | Average annual residential first mortgage floating rate (%) | Risk premium to residential first mortgage floating rate (%) | Average annual five years govt. bond (%) | Risk premium to five years govt. bond (%) | Average annual ten years govt. bond (%) | Risk premium to ten years govt. bond (%) |
|---|---|---|---|---|---|---|---|
| 1982-1985 | 8.3 | 4.5 | 3.8 | | | | |
| 1986-1993 | 10.7 | 7.1 | 3.6 | 4.9 | 5.8 | 4.7 | 6.0 |
| 1994-2001 | 12.6 | 7.1 | 5.5 | 5.1 | 7.5 | 5.1 | 7.4 |
| 2002-2009 | 5.9 | 5.7 | 0.1 | 3.2 | 2.7 | 3.2 | 2.7 |
| Overall | 9.6 | 6.3 | 3.2 | 4.6 | 5.0 | 4.5 | 5.0 |

**Notes:** Interest rates and bond yields are obtained from the Reserve Bank of New Zealand; yields for five and ten years government bonds are not available prior 1985 above the five and ten year government bond rates. Prior to 2002 the risk premium was 3.6-5.5 per cent above first mortgage interest rates and 6.0-7.5 per cent above five and ten year government bond rates. We expect the recent extreme low risk premium required by farmland owners may be due to optimistic expectation of future income growth leading to continuing capital growth boosted by readily available credit, a low interest rate environment and promising demand growth for dairy products from developing countries (Sullivan and Aldridge, 2011). This indicates the recent high dairy farmland price will be extremely sensitive to a permanent change in the expected risk premium required for dairy farming.

### *5.2 Formation of farmland price expectations*

We pooled cross-section farmland sales data, land rental incomes and other land variables in a regression analysis. In order to determine how many years of historical land rents should be taken into account for approximating landowner's expected future land income, we used the AIC criterion on the estimated farmland rental income. Our results indicate an optimal number of three years. So we use the average of the preceding three years rental income to approximate the landowner's expected rental income $\overline{D}_{i,t}$. In New Zealand dairy farmers do not know final milk payout until near the end of the farming season. However, this situation has improved over time as the company Fonterra announces a forecast payout now at the beginning of the dairy season and updates this on a quarterly basis. We were interested to see if this improved information on the current season income had an effect on farmland price, and if so how this has evolved over time. Summary statistics and definitions for the key variables for the regression analysis are presented in Table V.

It is possible that the current rental income and past rents are correlated over time, however this should not be a big problem in this analysis. As shown in Figure 2 and Table I market rents have been volatile for this New Zealand data set, the correlation between the current rent and the average past three-year rents are relatively low. Unfortunately, dropping the current rent variable that might belong in the population

| Variable | Definition | Mean | SD |
|---|---|---|---|
| Real farmland price | Adjusted to 2009 farming year's equivalent real values by PPI deflation (NZ$/ha) | 20,809 | 13,679 |
| Real farmland rent | Proxied farmland rent using 50/50 share-milking agreement (NZ$/ha) | 890 | 266 |
| Land area | Farm size (ha) | 76.7 | 57.9 |
| Distance | Linear distance to the nearest town or city with a population of over 9,000 (km) | 29.4 | 19.2 |
| *Regional dummy* | | | |
| 1 | Northland (used as the control region in the regression) | | |
| 2 | Waikato | | |
| 3 | Bay of Plenty | | |
| 4 | Taranaki | | |
| 5 | Lower North Island | | |
| 6 | West Coast-Tasman | | |
| 7 | Marlborough-Canterbury | | |
| 8 | Otago-Southland | | |

**Table V.**
Regression variable definition and summary statistics, 1982-2009

model could lead to bias, particularly in modelling the recent farmland prices. The regression results are presented in Table VI.

The results in Table VI for model 1 show that past three-year average farmland rental incomes were not statistically important (at 10 per cent significance level) in determining farmland prices during the 1982-1985 and 2002-2009 time periods, but were statistically significant for the 1986-1993 and 1994-2001 time periods. One possible explanation is during the early 1980s, the government supplementary minimum price scheme was in place and the minimum payout announced at the beginning of each dairy season. This provided certainty and farmland owners did not need to look beyond the current season income to formulate their current land price. When the government supplementary minimum price was removed in 1985, information on the current season payout became much less certain and farmers might place more emphasis on historical incomes when formulating their current land price bid. After the formation of the company Fonterra information on past incomes was not significant. This also could be due to the volatility of the global dairy market (Briggs *et al.*, 2011). A volatile market tends to make any past payouts of little relevance to estimation of the current season's payout.

The results for regression model 2 are shown in Table VI. The prediction of farmland price was improved over model 1 (see the improved $R^2$ statistics) by inclusion of both current and historical rental incomes, in particular for the time period from 2002 to 2009. Results of this analysis show how current and historical rental incomes have changed in importance for farmland price determination over time. From 1982 to 1985, the net effect from both current and past income information cancelled out each other. This could imply under the regime of government subsidies farmer's expected future incomes were stable. From 1986 to 1993 government subsidies had been removed and both current and past land income were equally important in forecasting the expected future income. From 1994 to 2001 historical income was more important due to increasing market volatility. From 2002 information on the current season's payout has been greatly improved with farmland price being mostly determined by the current season income.

Interestingly, our results show there is a U-shape for the relationship between distance to town/city and dairy farmland prices over the whole study period. As shown in the model 2 of Table VI in the beginning period of 1982-1985, an additional 1 km away from the town/city will decrease a land price by about NZ$129 per hectare. This figure dropped to about NZ$61 and NZ$83 in the subsequent two periods, but increased to NZ$126 in the period of 2002-2009. The findings imply urban influences on farmland prices have varied over time. This could be due to the change in demand (or policy) on land-use in New Zealand (Jaforullah and Whiteman, 1999). Nevertheless, farm buyers are paying a premium for land close to city/town when formulating their bid prices, despite the strict land-use policy in New Zealand to preserve rural areas for agriculture rather than to develop them into urban uses.

Regional results confirm the desirability of the different dairying regions across New Zealand. Our results show a consistent premium is paid for land in the Waikato which is the predominant dairying region having a favourable climate for low cost grass production, but less favourable prices in the South Island regions of Canterbury and Southland due to a shortened growing season and colder winter temperatures (see model 2 of Table VI). Finally we show there is a negative relationship between

**Table VI.**
Results of OLS estimations of farmland price

| | Model 1 (past income only) | | | | Model 2 (both past and current incomes) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1982-1985 | 1986-1993 | 1994-2001 | 2002-2009 | 1982-1985 | 1986-1993 | 1994-2001 | 2002-2009 |
| *Dependant variable is individual real farmland price per hectare* | | | | | | | | |
| Constant | 21,796** | 6,722** | 14,773** | 31,943** | 18,689** | 3,049** | 14,832** | 14,168** |
| Current rent (NZ$/ha) | | | | | 16.738** | 10.876** | 1.838** | 21.984** |
| Average past three-year rent (NZ$/ha) | −4.613 | 14.374** | 8.708** | −2.011 | −16.383** | 10.795** | 6.563** | 0.670 |
| Land area (ha) | −61.296** | −34.046** | −42.532** | −46.504** | −61.904** | −33.452** | −42.847** | −48.427** |
| Distance (km) | −124.282** | −60.509** | −83.513** | −139.099** | −129.922** | −61.357** | −83.804** | −125.650** |
| *Regional dummy* | | | | | | | | |
| Waikato | 8,899** | 3,504** | 6,246** | 16,145** | 7,849** | 1,280** | 6,284** | 7,460** |
| Bay of Plenty | 2,170* | −615 | 3,259** | 8,195** | 1,699 | −2,312** | 3,287** | 1,073 |
| Taranaki | 3,174* | 1,379** | 4,366** | 10,363** | 1,501 | −864* | 4,379** | 2,813 |
| Lower North Island | −1,134 | −604 | 487 | 5,893** | −1,795 | −1,877** | 444 | −1,691 |
| West Coast-Tasman | 426 | 431 | 522 | 2,221* | 842 | 108 | 537 | −1,352 |
| Marlborough-Canterbury | −1,157 | −1,344** | −471 | 12,494** | −1,432 | −2,427** | −566 | −4,417** |
| Otago-Southland | −2,667 | −1,976** | 749 | 6,209** | −3,200 | −3,070** | 647 | −4,895** |
| Observations | 851 | 5,628 | 9,668 | 6,154 | 851 | 5,628 | 9,668 | 6,154 |
| Adjusted $R^2$ | 0.397 | 0.303 | 0.261 | 0.230 | 0.404 | 0.326 | 0.262 | 0.330 |

**Notes:** Signficance at: *5 and **1 per cent levels:

$$\text{Model 1}: P_{it} = c + \overline{D}_{i,t-3} + Dis_i + Area_i + regional\ \ dummies$$
$$\text{Model 2}: P_{it} = c + \overline{D}_{i,t} + \overline{D}_{i,t-3} + Dis_i + Area_i + regional\ \ dummies$$

where $P_{it}$ is individual farm sale price including land and buildings; $\overline{D}_{i,t-3}$ is the average of the preceding three years district rental income at sale for the *i*th property; $\overline{D}_{i,t}$ is the estimated district level farmland rental income at sale for the *i*th property; $Dis_i$ is the distance of *i*th property to the nearest town/city; $Area_i$ is the land area of *i*th property farmland price per hectare and farm size. For the last ten to 15 years an additional 1 ha will decrease a land value by about NZ$33 to 62 per hectare in real terms.

## 6. Conclusions

First this paper studied the relationship between dairy farmland rents and farmland prices in New Zealand from 1982 to 2009. Farmland rents were proxied using the net rent received by landowners under a standard 50/50 share-milking agreement. We found over the long-term (over multiple farming cycles) dairy farmland price growth tends to be in line with rental growth. However, our research shows a higher than expected market land price and rent alignment since 2002. Dairy farmland prices have appreciated at about 9.2 per cent per annum in real terms while land rents have only increased by about 1.4 per cent annually. Moreover, the risk premium placed by farmland owners on future cash flows appears substantially below the historical average. Based on our findings, we argue that recent dairy farmland prices may be overvalued in New Zealand. As a consequence the recent high land prices will be extremely sensitive to a permanent change to the risk premium required for dairy farming, which is largely influenced by the global demand growth for dairy products and interest rate movements.

Second the paper considered how farmers formulate bid price of farmland with increased volatility of farmland rental. We found that dairy farmers nowadays are critically reliant on the current income information to formulate their bid prices. Dairy farmers normally do not know final milk payout until near the end of the farming season. In the past when market prices were volatile, farmers tended to use an historical average to formulate their price expectations. Our research shows this situation has improved over time and the company Fonterra now announces a forecast payout at the beginning of each dairy season and updates this on a quarterly basis in New Zealand. However, when farmers rely too much on the current level of payout it might cause a speculative market where prices paid for farmland will simply reflect any current bubble in dairy commodity prices. Since in the long-term farmland prices are mean reverting to their fundamental values, our results show that the recent dairy farmland market appears to give rise to bubbles.

This study has some important policy implications. The current high farmland price is of concern for the financial stability of the dairy sector in New Zealand (Reserve Bank of New Zealand, 2011). Statistics from the Reserve Bank of New Zealand show that debt levels within the agricultural sector (particularly in the dairy sector) have doubled since 2004. As OECD figures show, around 97 per cent of all milk produced in New Zealand is exported, thus the New Zealand dairy sector is very reliant on the international demand for products, so any soft global demand will have a magnified negative impact on the local agricultural economy. As reported by Hargreaves and Williamson (2011) farmers who are deeply indebted will have difficulty meeting their loan repayment in the event of a severe downturn. Therefore, the Reserve Bank has been prudent in recently revising the capital requirements for farm lending to safeguard financial stability in the event of a significant fall in farmland price. Finally the dairy farming market needs to be informed of the risk that high commodity prices and favourable interest rates may not continue in the future.

For future research, the impact of changing rural land uses and the finding that urban influences on farmland prices have varied over time could be explored further.

It would also be worthwhile to include the cost and availability of credit in the model as this is likely to be of importance in farmland pricing.

## Notes

1. DairyNZ is an industry good organisation representing New Zealand dairy farmers. Statistical information is collected annually by DairyNZ. Prior to 2007 data was collected by the New Zealand Dairy Board (until 1984), and then by Livestock Improvement Corporation.
2. Fonterra Co-operative Group Ltd processes approximately 90 per cent of New Zealand's milk production; currently the New Zealand Government regulates the behaviour of Fonterra to ensure efficient operation of dairy markets in New Zealand.
3. Milk production is reported on per effective hectare basis in the DairyNZ data set. For converting the income per effective area to income per total farm area, we adopted a ratio of 0.9 in this study.

## References

Ahrendsen, B.L. (1993), "A structural approach to estimating rate of return expectations of farmers", *Journal of Agriculture and Applied Economics*, Vol. 25 No. 2, pp. 56-68.

Alston, J.M. (1986), "An analysis of growth of US farmland prices, 1963-82", *American Journal of Agricultural Economics*, Vol. 68 No. 1, pp. 1-9.

Briggs, P., Harker, C., Ng, T. and Yao, A. (2011), "Fluctuations in the international prices of oil, dairy products, beef and lamb between 2000 and 2008: a review of market-specific demand and supply factors", Discussion Paper No. 2011/02, The Reserve Bank of New Zealand, Wellington.

Burt, O.R. (1986), "Econometric modeling of the capitalization formula for farmland prices", *American Journal of Agricultural Economics*, Vol. 68 No. 1, pp. 10-26.

Campbell, J.Y., Lo, A. and Mackinlay, A. (1997), *The Econometrics of Financial Markets*, Princeton University Press, Princeton, NJ.

Cavailhès, J. and Wavresky, P. (2003), "Urban influences on periurban farmland prices", *European Review of Agricultural Economics*, Vol. 30 No. 3, pp. 333-57.

Conforte, D., Garnevska, E., Kilgour, M., Locke, S. and Scrimgeour, F. (2008), "The key elements of success and failure in the NZ dairy industry", Research Report No. 313, Lincoln University, Christchurch.

Constitution of Fonterra Co-operative Group Ltd (2010), 30 June, available at: www.fonterra.com/wps/wcm/connect/8729b280440c128b85849f9906727cef/Constitution.pdf?MOD=AJPERES

DairyNZ (2002-2012), *DairyNZ Economic Survey*, DairyNZ, Hamilton.

DairyNZ (2010), *New Zealand Dairy Statistics 2009-2010*, DairyNZ, Hamilton.

Delgado, C.L. (2003), "Rising consumption of meat and milk in developing countries has created a new food revolution", *The Journal of Nutrition*, Vol. 133 No. 11, pp. 3907-10.

Evans, L. (2004), "Structural reform: the dairy industry in New Zealand", paper presented at APEC High Level Conference on Structural Reform, Tokyo, Japan.

Evans, L., Grimes, A., Wilkinson, B. and Treece, D. (1996), "Economic reform in New Zealand 1984-95: the pursuit of efficiency", *Journal of Economic Literature*, Vol. 34 No. 4, pp. 1856-902.

Eves, C. and Painter, M. (2008), “A comparison of farmland returns in Australia, Canada, New Zealand and United States”, *Australia and New Zealand Property Journal*, Vol. 1 No. 7, pp. 588-98.

Falk, B. (1991), “Formally testing the present value model of farmland prices”, *American Journal of Agricultural Economics*, Vol. 73 No. 1, pp. 1-10.

Falk, B. and Lee, B.-S. (1998), “Fads versus fundamentals in farmland prices”, *American Journal of Agricultural Economics*, Vol. 80 No. 4, pp. 696-707.

Goodwin, B.K., Mishra, A.K. and Ortalo-Magné, F. (2011), “The buck stops where? The distribution of agricultural subsidies”, NBER Working Paper No. 16693, National Bureau of Economic Research, Cambridge, MA.

Hargreaves, D. and Williamson, G. (2011), “Stress testing New Zealand banks’ dairy portfolios”, *Reserve Bank of New Zealand Bulletin*, Vol. 74 No. 2, pp. 15-25.

Hargreaves, R.V. and McCarthy, I.A. (2010), “Is New Zealand farm land worth what it will produce?”, *Australia and New Zealand Property Journal*, Vol. 2 No. 6, pp. 365-74.

Jaforullah, M. and Whiteman, J. (1999), “Scale efficiency in the New Zealand dairy industry: a non-parametric approach”, *The Australian Journal of Agricultural and Resource Economics*, Vol. 43 No. 4, pp. 523-41.

Johnson, R. and Forbes, R. (2000), “Recent productivity trends in New Zealand primary sectors: agricultural sector and forestry and logging sector”, MAF Technical Paper No. 2000/20, Ministry of Agriculture and Forestry, Wellington.

Lattimore, R. (2006), “Farming subsidy reform dividends”, NZ Trade Consortium Working Paper No. 45, The New Zealand Trade Consortium in Association with the New Zealand Institute of Economic Research, Wellington.

Melichar, E. (1979), “Capital gains versus current income in the farming sector”, *American Journal of Agricultural Economics*, Vol. 61 No. 5, pp. 1085-92.

Quotable Value Ltd (1998-2011), *Rural Property Sales Statistics*, Quotable Value Ltd, Wellington.

Rauniyar, G.P., Dooley, A.E. and Parker, W.J. (1999), “Trends in dairy farm sales and factors influencing dairy land prices in New Zealand (1990-1997)”, *Australasian Agribusiness Review*, Vol. 7, Paper 1.

Reserve Bank of New Zealand (2011), *Financial Stability Report*, Reserve Bank of New Zealand, Wellington, May.

Sandrey, R. and Reynolds, R. (1990), *Farming Without Subsidies: New Zealand’s Recent Experience*, New Zealand Ministry of Agriculture and Fisheries, Wellington.

Seed, P.G., Sandrey, R.A. and Ward, B.D. (1986), “A study of the determinants of fattening and grazing farm land prices in New Zealand, 1962-1983”, Research Report No. 186, Agricultural Economics Unit, Lincoln University, Christchurch.

Shi, Y.J., Phipps, T.T. and Colyer, D. (1997), “Agricultural land values under urbanizing influences”, *Land Economics*, Vol. 73 No. 1, pp. 90-100.

Shiller, R.J. (2011), “Bubble spotting”, Project Syndicate, available at: www.project-syndicate.org/commentary/shiller76/English (accessed 12 November 2011).

Sullivan, R. and Aldridge, T. (2011), *The Outlook for Commodity Prices and Implications for New Zealand Monetary Policy*, Reserve Bank of New Zealand, Wellington, available at: www.rbnz.govt.nz/research/econresearch/4363112.html (accessed 10 October 2011).

Valuation New Zealand (1980-1997), *Rural Property Sales Statistics*, Valuation New Zealand, Wellington.

Vantreese, V.L., Skees, J.R. and Reed, M.R. (1986), "Using capitalisation theory to model farmland prices", *North Central Journal of Agricultural Economcis*, Vol. 8 No. 1, pp. 135-42.

Weersink, A., Clark, S., Turvey, C.G. and Sarker, R. (1999), "The effect of agricultural policy on farmland values", *Land Economics*, Vol. 75 No. 3, pp. 425-39.

Wilson, K. (2009), *Rural Report*, The National Bank of New Zealand, Wellington.

**About the authors**

Dr Song Shi is a Senior Lecturer in Property at School of Economics and Finance, Massey University. His prime research expertise is in the areas of asset pricing, investment, valuation of stigma and house price indexing. Song Shi is the corresponding author and can be contacted at: s.shi@massey.ac.nz

Mrs Iona McCarthy is a Lecturer at School of Economics and Finance, Massey University. Her expertise is in the area of rural farmland valuation and management.

JPIF
28,3

198

Received December 2009
Accepted March 2010

# Role of farm real estate in a globally diversified asset portfolio

Gilbert Nartea
*Department of Accounting, Economics and Finance, Faculty of Commerce, Lincoln University, Christchurch, New Zealand, and*
Chris Eves
*School of Urban Development, Faculty of Built Environment and Engineering, Queensland University of Technology, Brisbane, Australia*

## Abstract

**Purpose** – This paper seeks to examine the benefits of further diversifying a global portfolio of financial assets with New Zealand farm real estate (FRE).

**Design/methodology/approach** – The paper compares efficient sets generated with and without FRE using portfolio theory.

**Findings** – The results show that given the predominantly negative correlation between FRE and financial assets, the risk-return tradeoffs of portfolios of financial assets can be improved significantly. The diversification benefits measured in terms of risk reduction, return enhancement, and improvement in the Sharpe performance ratios are robust under a number of FRE risk-return scenarios as well as under high and low inflationary periods. Using five and ten-year rolling periods it also finds that FRE is a consistent part of risk efficient portfolios. Consistent with the results reported in Lee and Stevenson, for the UK real estate the risk reduction benefits of diversifying with FRE are larger than the risk enhancement benefits.

**Practical implications** – The results suggest that FRE takes on a consistent role of risk-reducer rather than a return-enhancer in a globally diversified portfolio. FRE appears to deserve more serious consideration by investment practitioners that it has been accorded in the past.

**Originality/value** – The study examines the role of direct real estate in a globally diversified portfolio of financial assets.

**Keywords** Diversification, Farms, Real estate, New Zealand, Portfolio theory

**Paper type** Research paper

## 1. Introduction

The poor performance of global stock markets in recent years has ignited renewed interest in alternative investments to enhance return and reduce risk (Lee and Stevenson, 2006) through effective diversification. With increased globalisation one obvious avenue is international equity diversification, the benefits of which have been well documented (see for example, Levy and Sarnat, 1970; Harvey, 1991; Li *et al.*, 2003; Meyer and Rose, 2003; Fletcher and Marshall, 2005; Phengpis and Swanson, 2004). However, with increased globalisation comes increased economic and financial integration leading to increased positive correlations among international equity markets with the consequent decline in the benefits from international diversification (Kearney and Lucey, 2004).

Real estate returns on the other hand has traditionally been shown to have a low correlation with financial assets and are therefore regarded as excellent vehicles for diversification (see Seiler *et al.*, 1999 for an excellent review). Farm real estate (FRE) in

Journal of Property Investment & Finance
Vol. 28 No. 3, 2010
pp. 198-220

1463-578X
DOI 10.1108/14635781011048858

particular appear to have a consistently low correlation with returns from financial assets with several North American studies suggesting the desirability of adding farm real estate (FRE) to a mixed portfolio of financial assets (Barry, 1980; Kaplan, 1985; Young and Barry, 1987; Moss *et al.*, 1987; Lins *et al.*, 1992; Painter, 2000; Eves and Newell, 2007). However few have tested the robustness of these benefits.

Barry (1980) finds that US farmland has low systematic risk relative to other assets, and is therefore a good candidate for risk reduction in well-diversified portfolios. Kaplan (1985) also argues that US farmland's high return and low correlation with US stocks and bonds makes it an ideal asset for diversification. Young and Barry (1987) find Illinois farmland to be negatively correlated with US stocks, corporate, government, and municipal bonds as well as T-bills and certificates of deposit. Using mean-variance (EV) analysis they show that Illinois farmers could reduce the relative variability of their farm's rate of return some 15 to 25 per cent by allocating up to 25 per cent of their investment portfolio in financial assets. Moss *et al.* (1987) likewise find that aggregate US farmland is negatively correlated with corporate and government bonds and T-bills and moderately positively correlated with US stocks. Using EV analysis they form risk-efficient portfolios that contained 30 to 68 per cent farmland. Lins *et al.* (1992) also used EV analysis to investigate the effect of adding US farmland and international stocks to a portfolio of US stocks, bonds and business real estate. They find that, portfolio performance could be enhanced, by including US farmland in the mix. In Canada, Painter (2000) investigates the benefits of adding Saskatchewan farmland to a portfolio of Canadian and international stocks and Canadian T-bills and long-term bonds. He finds that Saskatchewan farmland is negatively correlated with all financial assets considered in the study and is part of the efficient set for medium and high-risk portfolios.

In New Zealand Nartea and Dhungana (1998) report that NZ dairy farm returns are negatively correlated with NZ bond yields and weakly positively correlated with NZ share returns and suggest that farmers look towards diversifying into financial assets. Nartea and Pellegrino (1999) use EV analysis to investigate the benefits of diversifying a sheep and beef farm with investments in New Zealand shares. They document a negative correlation between farmland and share returns over the period 1966 to 1996 and report that a portfolio consisting of 16 to 25 per cent shares and 75 to 84 per cent farmland could reduce risk by as much as 20 per cent as compared with investing in farmland alone. Updating Nartea and Pellegrino's (1999) data set, and incorporating investor risk preferences, Nartea and Webster (2008) use data from 1966-2003 and report that NZ farmers with high degrees of risk aversion would gain utility by adding NZ financial assets to their portfolio dominated by farm real estate. In a related study, Nartea and Eves (2008) using data from 1995-2005 found that adding direct real estate, in particular retail property and farm real estate, to a portfolio of NZ financial assets provided significant return enhancement and risk reduction benefits that are robust even when real estate return variance is increased six-fold or when real estate returns are reduced by 20 per cent, suggesting that real estate can reasonably be expected to be a consistent part of risk efficient portfolios.

In spite of these findings anecdotal evidence suggests that investment practitioners allocate a negligible portion of their portfolios to farm real estate. One reason for this could be the suggestion that real estate form part of mixed asset portfolios in theoretical studies due to the understatement of real estate risk and/or due to inflation (Webb and Rubens, 1987; Michaud, 1989; Fisher *et al.*, 1994; Corgel and deRoos, 1999).

The purpose of this paper is three-fold. First we quantify the benefits of adding New Zealand farm real estate to an already diversified mixed portfolio of international financial assets using EV analysis of modern portfolio theory. Second we test the robustness of these benefits under several scenarios and third, we test the consistency of FRE being part of the efficient set. Our approach is to use historical data for returns of different asset classes to generate risk efficient sets. We then compare efficient sets generated with and without farm real estate to determine the magnitude of return enhancement keeping risk constant, as well as the level of risk reduction while maintaining level returns. We also compare mean Sharpe ratios generated from equally spaced portfolios in the efficient sets. Then we perform robustness tests of diversification benefits under several FRE risk-return scenarios. We also test the robustness of diversification benefits for two periods, one characterised by low inflation and the other by high inflation. Finally we use five and ten-year rolling periods to test if FRE is a consistent part of the efficient set.

## 2. Research design and data

### *2.1 The model*

We start with a portfolio of New Zealand T-bills, bonds, and shares and we show the benefit of diversifying globally with eight international equity markets. Then we investigate the benefits of adding direct farm real estate (FRE) (as opposed to Real Estate Investment Trusts) to the mix. This increased diversification is expected to expand the risk efficient frontier by shifting it northwest. Hence we investigate the incremental impact of the addition of FRE by examining the magnitude by which portfolio returns increase keeping risk constant, and the amount by which portfolio risk is decreased without diminishing returns. We also measure the improvement in the Sharpe ratio (Sharpe, 1966), which is defined as excess return per unit of risk. Excess return is the return above the risk-free rate and risk is defined as standard deviation of returns.

We use the traditional full-covariance EV analysis as developed by Markowitz (1952) to form risk efficient investment portfolios. A risk efficient portfolio is defined as a combination of assets, which maximises the expected returns for a given level of risk (measured as variance or standard deviation), or one that minimises the risk level for a desired expected rate of return. Risk-efficient portfolios can be generated, by solving the following quadratic formulation:

$$\text{Min}\ \sigma_p = \left(\sum\sum x_i \sigma_{ij} x_j\right)^{0.5} \tag{1}$$

subject to:

$$\sum x_i E(r_i) \geq Z \tag{2}$$

$$\sum x_i = 1 \tag{3}$$

$$x_i \geq 0 \tag{4}$$

where $\sigma_p$ is the portfolio standard deviation, $x_i$ is the proportion of asset $i$ in the portfolio, $E(r_i)$ is the expected return of asset $i$, $\sigma_{ij}$ is the covariance between assets $i$ and

$j$ (variance of asset $i$ if $i = j$), and $Z$ is the expected portfolio return, which is varied parametrically to obtain the risk-efficient set. The last constraint restricts short selling in this model to reflect the fact that FRE cannot be sold short.

Time series data relating to annual rates of return on shares, bonds, T-bills and FRE are obtained for the period spanning 1989 to 2005. Another data series of annual rates of return on shares and FRE is gathered for the period 1974-2003 for the robustness test involving high and low inflationary periods. The period 1974-1988 is typified by high inflation while 1989-2003 is characterised by low inflation. Annual rates of return are calculated as the sum of the current return and the capital gain expressed as:

$$R_{it} = D_{i1} + (V_{i1} - V_{i0}/V_{i0} \quad (5)$$

where $R_{it}$ is the total rate of return in year $t$ for the $i$th asset, $D_{i1}$ is the current return, $V_{i0}$ is the asset value at the beginning of each year, and $V_{i1}$ represents the asset value at the end of the year.

We make no distinction between realised and unrealised capital gains since retaining the asset and earning only "unrealised" capital gain, is no different from selling it at year end, "realising" the capital gain, and immediately reinvesting by buying the asset back.

### *2.2 Ordinary shares, government bonds, and T-bills*

Ordinary shares are represented by country indices as reported in Datastream. The country indices that are considered in this study represent Austral-Asia (New Zealand, Australia, Hong Kong, Japan, and Singapore), North America (The USA), and Europe (France, Italy, and the UK). All returns are converted to NZ$. Bonds are represented by Datastream NZ ALL lives government bond index, and T-bills are represented by the NZX90 Bank Bill Index obtained from the New Zealand Exchange (NZX).

### *2.3 Farm real estate*

Farm real estate is represented by sheep and beef operations on grazing farmland. Sheep and beef operations are the dominant agricultural activity in NZ covering approximately two-thirds of the 15.5 million hectares of land under occupation as of 2004.

The total return on farm real estate is the sum of the production rate of return and the capital gain. The production rate of return is the weighted average rate of return on assets for all classes of sheep and beef farms as reported in the Meat and Wool New Zealand web site (www.meatandwoolnz.com) and the New Zealand Sheep and Beef Farm Survey (New Zealand Meat and Wool Board Economic Service, 1975, 1976, 1977, 1978, 1979, 1989, 1992, 2000). The Survey involves roughly 500 to 550 farms per year. A sheep and beef farm is defined as a privately operated farm, which winters at least 750 sheep or their equivalent stock units in terms of sheep and cattle stock. At least 80 per cent of the stock units on the property had to be sheep and/or beef cattle and at least 70 per cent of the farm revenue had to be derived from sheep or sheep and beef cattle. To the extent that farm rates of return are estimated from group averages, our results are likely to understate the degree of variability faced by the individual farm. This issue will be addressed in the robustness tests to follow.

The capital gain component is represented by the annual percentage change in the grazing land price index (Quotable Value Limited, 2005; Valuation New Zealand, 1982, 1988).

## 3. Empirical results

### *3.1 Comparative risk and return measures*

Table I shows the mean, standard deviation, and coefficient of variation (CV) of the annual returns of farm real estate, T-bills, bonds, and the nine equity markets from 1989 to 2005. The data reveals that with the exception of Hong Kong and France, FRE outperformed all share markets considered earning a higher mean annual rate of return at a lower standard deviation or risk. On a risk-adjusted basis, FRE clearly outperformed all share markets. Only 90 day T-bills and bonds outperformed FRE on a risk-adjusted basis. This is clearly illustrated in Table I by the reward-to-risk ratio, which is the expected return per unit of risk (ie mean annual rate of return divided by the standard deviation). Table I shows that farm real estate has a reward-to-risk ratio that is 33 per cent better than Australian equities, which posted the highest reward-to-risk ratio among the share markets considered in the study.

Using the coefficient of variation as a measure of risk, T-bills and bonds are the least risky among the assets considered followed by FRE. Share returns are evidently more variable that T-bills, bonds, and FRE. Among the share markets considered, Japan exhibited the highest variability while Australia had the lowest. The variability of total FRE returns is apparently due to the capital gain component, which also accounts for 71 per cent of total return.

Figure 1 illustrates the relationship among farm real estate and NZ financial assets. FRE returns are clearly more volatile than T-bills and bonds but more stable than NZ equities. FRE returns also appear to have a longer price cycle than financial assets, consistent with the results in other countries (see for example, Painter, 2000).

Figure 2 compares FRE returns with US and Australian share market returns and shows that FRE returns are less variable and also appears to have a longer price cycle than the equity markets.

| | Mean annual rate of return[a] (%) | Rank | Standard deviation (%) | Coefficient of variation (%) | Reward-to-risk ratio | Rank |
|---|---|---|---|---|---|---|
| Farmland | | | | | | |
| Production return | 2.41 | | 1.28 | 0.53 | | |
| Capital gain | 12.14 | | 11.12 | 0.92 | | |
| Total return | 14.58 | 3 | 10.99 | 0.75 | 1.33 | 3 |
| 90 day T-bills | 8.32 | 11 | 3.19 | 0.38 | 2.63 | 1 |
| Bonds | 9.56 | 10 | 4.98 | 0.52 | 1.92 | 2 |
| New Zealand | 11.52 | 8 | 13.33 | 1.16 | 0.86 | 5 |
| Australia | 12.24 | 6 | 12.29 | 1.00 | 1.00 | 4 |
| USA | 14.42 | 4 | 23.85 | 1.65 | 0.61 | 6 |
| UK | 12.94 | 5 | 22.59 | 1.75 | 0.57 | 7 |
| Japan | 1.96 | 12 | 27.76 | 14.20 | 0.07 | 12 |
| Hong Kong | 17.56 | 1 | 31.40 | 1.79 | 0.56 | 8 |
| Singapore | 10.93 | 9 | 29.87 | 2.73 | 0.37 | 10 |
| France | 15.92 | 2 | 30.52 | 1.92 | 0.52 | 9 |
| Italy | 11.70 | 7 | 34.32 | 2.93 | 0.34 | 11 |

**Note**: [a] All figures in nominal terms

**Table I.**
Risk and return measures for farm real estate and financial assets, 1989-2005

*3.2 Correlation matrix*

Table II displays the pair wise correlation coefficients of the asset classes and shows that FRE returns are negatively correlated with all equity markets considered except for New Zealand, and are also negatively correlated with T-bills and bonds. These coefficients suggest that significant gains in risk efficiency could be obtained by adding FRE to a mixed portfolio of financial assets.

As a matter of interest, the correlation between share markets ranged from a low of −0.18 between New Zealand and Italy to a high of .90 between the US and the UK. New Zealand and the US also posted among the lowest correlation coefficients at −0.17. Overall, Table II shows the New Zealand share market is negatively correlated with the US and European markets and weakly positively correlated with the Australian and Asian markets, while the US share market appears to be highly correlated with the European markets and weakly correlated with the Australian and Asian markets.

*3.3 Benefits of diversification*

Risk-efficient investment portfolios were obtained by solving equation (1) subject to equations (2), (3), and (4) for alternative values of $Z$. Based on the risk efficient sets, the benefits of diversification are measured by the magnitude of:

- risk reduction;
- return enhancement; and
- improvement in excess return per unit of risk as measured by the Sharpe ratio.

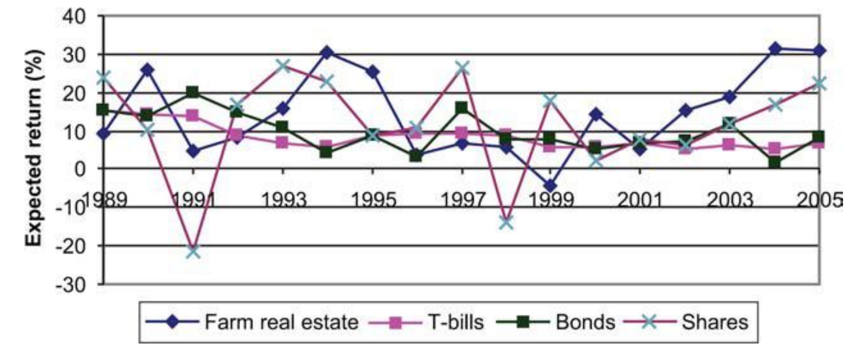



**Figure 1.** Annual return for farm real estate and the New Zealand financial assets

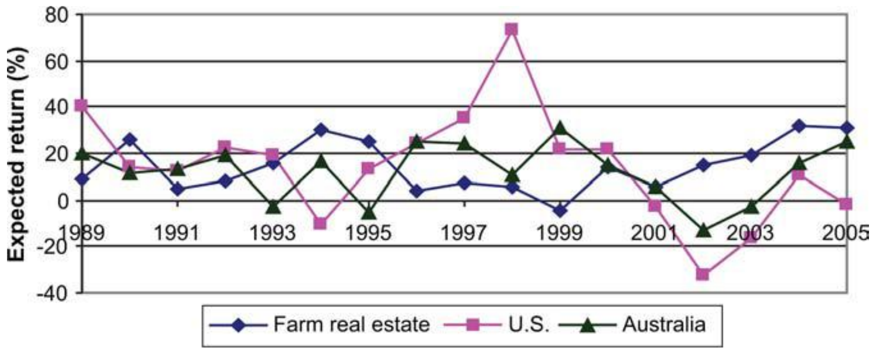



**Figure 2.** Annual return for farm real estate and selected share markets

**Table II.**
Correlation of farm real estate and financial asset returns, 1989-2005

| | Farm real estate | 90-day T-bills | Bonds | New Zealand | Australia | USA | UK | Japan | Hong Kong | Singapore | France | Italy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Farm real estate | 1.00 | −0.18 | −0.29 | 0.29 | −0.26 | −0.44 | −0.23 | −0.05 | −0.16 | −0.18 | −0.12 | −0.08 |
| 90 day T-bills | | 1.00 | 0.72 | −0.22 | 0.17 | 0.41 | 0.37 | −0.16 | 0.11 | 0.15 | 0.28 | 0.18 |
| Bonds | | | 1.00 | −0.13 | 0.01 | 0.19 | 0.16 | −0.29 | 0.23 | 0.00 | 0.01 | −0.29 |
| New Zealand | | | | 1.00 | 0.22 | −0.17 | −0.14 | 0.29 | 0.33 | 0.42 | −0.11 | −0.18 |
| Australia | | | | | 1.00 | 0.44 | 0.43 | 0.32 | 0.60 | 0.58 | 0.37 | 0.32 |
| USA | | | | | | 1.00 | 0.90 | 0.28 | 0.18 | 0.13 | 0.83 | 0.75 |
| UK | | | | | | | 1.00 | 0.05 | 0.21 | −0.01 | 0.91 | 0.81 |
| Japan | | | | | | | | 1.00 | 0.32 | 0.55 | 0.21 | 0.18 |
| Hong Kong | | | | | | | | | 1.00 | 0.50 | 0.16 | −0.13 |
| Singapore | | | | | | | | | | 1.00 | 0.07 | −0.03 |
| France | | | | | | | | | | | 1.00 | 0.89 |
| Italy | | | | | | | | | | | | 1.00 |

Figure 3 shows the efficient frontier for investments involving:

- only NZ financial assets;
- NZ financial assets and international equities; and
- NZ financial assets, international equities, and NZ FRE.

The efficient frontier comprised only of NZ financial assets is clearly dominated by the frontier, which includes international equities. Figure 3 also shows that further gains are possible with the inclusion of FRE in the mix.

*3.3.1 Risk reduction.* Table III shows the risk reduction benefits of diversifying a mixed asset portfolio of international financial assets with FRE. The risk reduction benefits are determined by comparing risk at points of identical returns for portfolios in the efficient sets with and without FRE. Efficient portfolios without FRE are shown in Panel A while those with FRE are displayed in Panel B. Panel B shows that the risk reduction benefits are economically significant and are most pronounced at portfolio returns in the range of 12 to 15 per cent. Over this range of returns, annual risk levels can be halved by holding FRE in a mixed asset portfolio in amounts ranging from 35 to 67 per cent of the total mix. In terms of basis points, the benefits are equivalent to a risk reduction of 408 to 886 points. The gains in risk reduction decline sharply at both ends of the efficient frontier, but even at modest allocations of FRE seen at the lower end of the frontier ranging from 9 to 24 per cent of the total portfolio, reduction in risk still ranges from 11 to 40 per cent or 34 to 220 basis points.

*3.3.2 Return enhancement.* The return enhancement benefits are shown in Table IV. These benefits are measured by comparing returns of portfolios with and without FRE at identical levels of risk (standard deviation). Panel A shows the efficient portfolios without FRE while Panel B displays the efficient portfolios with FRE. The return enhancement benefits shown in Panel B are also economically significant but are generally lower than the risk reduction benefits. FRE allocation and its marginal impact on portfolio returns is highest for portfolios with risk in the range of 6 to 12 per cent. At these risk levels, an allocation of 54 to 64 per cent FRE results in a 17 to 23 per cent increase in returns or the equivalent of a 228 to 285 basis point increase in annual

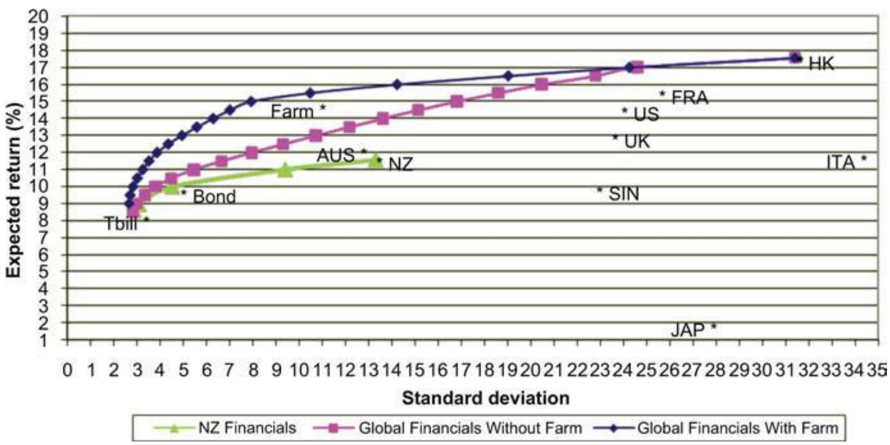



**Figure 3.**
Efficient sets, with and without farm real estate, 1989-2005

**Table III.**
Risk efficient portfolios (risk reduction)

| Assets | Portfolio 1[a] | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Panel A. Efficient portfolios without farm real estate* | | | | | | | | | | | |
| 90 day T-bills | 90.1 | 70.9 | 12.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bonds | 0.0 | 13.8 | 60.6 | 54.5 | 36.5 | 18.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Equities | 9.9 | 15.3 | 27.2 | 45.5 | 63.5 | 81.5 | 95.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| Expected return (%) | 8.5 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 17.6 |
| SD (%) | 2.9 | 3.0 | 3.8 | 5.5 | 8.0 | 10.7 | 13.6 | 16.8 | 20.5 | 24.6 | 31.4 |
| *Panel B. Efficient portfolios with farm real estate* | | | | | | | | | | | |
| Farm real estate | 9.4 | 16.8 | 24.2 | *35.1* | *47.3* | *59.1* | *66.7* | 43.6 | 6.9 | 0.0 | |
| 90 day T-bills | 79.9 | 46.1 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Bonds | 3.1 | 25.5 | 43.4 | 44.8 | 28.6 | 12.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Equities | 7.6 | 11.6 | 15.7 | 20.1 | 24.1 | 28.4 | 33.3 | 56.4 | 93.1 | 100.0 | |
| Expected return (%) | 9.0 | 10.0 | 11.0 | *12.0* | *13.0* | *14.0* | *15.0* | 16.0 | 17.0 | 17.6 | |
| SD (%) | 2.7 | 2.9 | 3.3 | 3.9 | 5.0 | 6.3 | 8.0 | 14.2 | 24.3 | 31.4 | |
| Reduction in risk (%)[c] | 11.1 | 25.3 | 40.1 | *51.2* | *53.8* | *53.7* | *52.7* | 30.4 | 1.4 | 0.0 | |
| Reduction in risk (basis points)[d] | 33.5 | 96.6 | 219.5 | *408.2* | *578.5* | *733.0* | *886.4* | 623.1 | 33.6 | 0.0 | |

**Notes**: [a]Global Minimum Variance Portfolio (MVP); [b]Maximum Expected Return Portfolio (MRP); [c]percentage increase in return relative to the corresponding portfolio with the same expected return in the efficient set without farm real estate; [d]basis point increase in return relative to the corresponding portfolio with the same expected return in the efficient set without farm real estate

| Assets | 1 | 2 | 3 | 4 | Portfolio 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Panel A. Efficient portfolios without farm real estate* | | | | | | | | | | |
| 90 day T-bills | 70.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bonds | 13.8 | 50.4 | 29.7 | 10.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Equities | 15.3 | 49.6 | 70.3 | 89.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Expected return (%) | 9.0 | 11.2 | 12.4 | 13.5 | 14.5 | 15.3 | 16.1 | 16.9 | 17.3 | 17.5 |
| SD (%) | 3.0 | 6.0 | 9.0 | 12.0 | 15.0 | 18.0 | 21.0 | 24.0 | 27.0 | 30.0 |
| *Panel B. Efficient portfolios with farm real estate* | | | | | | | | | | |
| Farm real estate | 18.9 | *56.3* | *63.9* | *53.5* | 40.7 | 28.9 | 18.3 | 7.6 | 0.0 | 0.0 |
| 90 day T-bills | 35.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bonds | 32.9 | 16.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Equities | 12.9 | 27.4 | 36.1 | 46.5 | 59.3 | 71.1 | 81.7 | 92.4 | 100.0 | 100.0 |
| Expected return (%) | 10.3 | 13.8 | 15.2 | 15.7 | 16.1 | 16.4 | 16.7 | 17.0 | 17.3 | 17.5 |
| SD (%) | 3.0 | *6.0* | *9.0* | *12.0* | 15.0 | 18.0 | 21.0 | 24.0 | 27.0 | 30.0 |
| Increase in return (%)[a] | 14.4 | *22.5* | *23.0* | *17.0* | 11.3 | 7.0 | 3.4 | 0.5 | 0.0 | 0.0 |
| Increase in return (basis points)[b] | 130.0 | *252.9* | *285.0* | *228.0* | 163.0 | 107.0 | 55.0 | 8.0 | 0.0 | 0.0 |

**Notes**: [a] Percentage increase in return relative to the corresponding portfolio with the same risk (standard deviation) in the efficient set without farm real estate; [b] basis point increase in return relative to the corresponding portfolio with the same risk (standard deviation) in the efficient set without farm real estate

**Table IV.** Risk efficient portfolios (return enhancement)

returns. Like the gains in risk reduction, the risk enhancement benefits decline at both ends of the efficient frontier but the decline is more pronounced at the higher end.

*3.3.3 Increase in the Sharpe ratio.* On each efficient set with and without FRE, Sharpe ratios are computed for 35 portfolios defined by return levels ranging from 9 to 17.5 per cent in 0.25 per cent increments[1]. Table V reports the Sharpe ratios of the efficient portfolios with and without FRE and shows an increase in the ratio as a result of the addition of FRE to a mixed asset portfolio. Consistent with the results on risk reduction and return enhancement, portfolios with returns around 12 to 15 per cent benefit the most from the inclusion of FRE in mixed asset portfolios. These portfolios registered an increase in the Sharpe ratio of more than 100 per cent relative to the corresponding portfolios without FRE.

Tests of the statistical significance of differences in mean Sharpe ratios provide more robust evidence of diversification benefits. The mean Sharpe ratio becomes a summary measure of the excess return per unit of risk using the 35 equally spaced portfolios spanning the entire efficient set. The mean Sharpe ratios are compared using the parametric *t*-test and the non-parametric Wilcoxon signed rank test. The bottom panel of Table V shows that the mean Sharpe ratio of efficient portfolios that include FRE is 71 per cent higher than that without it, with both the parametric and nonparametric tests indicating a significant difference at the 1 per cent level, strongly confirming the presence of diversification benefits.

### *3.4 The role of FRE in mixed asset portfolios*

Two points are evident from these results. First, the magnitude of the benefits from diversification with FRE, whether it is risk reduction or return enhancement, clearly

| Return level (%) | Sharpe ratio Without FRE | With FRE | Per cent increase in Sharpe ratio |
|---|---|---|---|
| 9.00 | 0.23 | 0.25 | 12.27 |
| 9.25 | 0.29 | 0.34 | 17.41 |
| 9.50 | 0.35 | 0.43 | 23.08 |
| 9.75 | 0.40 | 0.51 | 28.78 |
| 10.00 | 0.44 | 0.58 | 31.03 |
| 10.25 | 0.47 | 0.66 | 39.12 |
| 10.50 | 0.48 | 0.72 | 48.03 |
| 10.75 | 0.49 | 0.77 | 56.65 |
| 11.00 | 0.49 | 0.81 | 66.67 |
| 11.25 | 0.48 | 0.86 | 77.42 |
| 11.50 | 0.48 | 0.90 | 87.61 |
| 11.75 | 0.47 | 0.93 | 97.57 |
| *12.00* | 0.46 | 0.94 | *105.13* |
| *12.25* | 0.45 | 0.95 | *109.71* |
| *12.50* | 0.45 | 0.96 | *113.73* |
| *12.75* | 0.44 | 0.95 | *115.45* |
| *13.00* | 0.44 | 0.94 | *114.00* |
| *13.25* | 0.43 | 0.93 | *117.05* |
| *13.50* | 0.43 | 0.92 | *117.11* |
| *13.75* | 0.42 | 0.91 | *116.61* |
| *14.00* | 0.42 | 0.90 | *115.87* |
| *14.25* | 0.41 | 0.89 | *115.59* |
| *14.50* | 0.41 | 0.88 | *115.34* |
| *14.75* | 0.40 | 0.87 | *115.52* |
| *15.00* | 0.40 | 0.84 | *110.00* |
| 15.25 | 0.39 | 0.76 | 94.29 |
| 15.50 | 0.39 | 0.68 | 77.14 |
| 15.75 | 0.38 | 0.61 | 60.48 |
| 16.00 | 0.37 | 0.54 | 44.37 |
| 16.25 | 0.37 | 0.48 | 29.47 |
| 16.50 | 0.37 | 0.43 | 17.70 |
| 16.75 | 0.36 | 0.39 | 8.23 |
| 17.00 | 0.35 | 0.36 | 1.23 |
| 17.25 | 0.33 | 0.33 | 0.00 |
| 17.50 | 0.30 | 0.30 | 0.00 |
| Mean Sharpe ratio | 0.41 | 0.70 | |
| Std dev. of Sharpe ratio | 0.06 | 0.23 | |
| *t*-stat | | 9.156* | |
| Wilcoxon signed rank | | 528* | |

**Notes**: FRE, farm real estate. *t*-stat (signed rank) is the parametric (non-parametric) test statistic in comparing the difference in the mean Sharpe ratios with and without FRE; *Indicates significance at the 0.01 level

**Table V.**
Sharpe ratios for efficient sets with and without farm real estate

depends on portfolio's position in the frontier. Second, the results also indicate that the gain in return is typically less than the risk reduction benefits, suggesting that FRE would best be used to reduce portfolio risk rather than to enhance return. This result is consistent with those of Lee and Stevenson (2006) and is not surprising given that FRE returns are negatively correlated with financial assets except for New Zealand equities.

Additional insight on the role of FRE in mixed asset portfolios can be deduced from an analysis of the assets that it replaces. Table VI displays the detailed composition of the risk efficient portfolios. Panels A and B show the risk efficient portfolios without FRE and with FRE, respectively, while Panel C summarises the changes in the composition of the portfolios brought about by the introduction of FRE in the mix. Panel A shows that low risk portfolios in the efficient set without FRE are dominated by T-bills and bonds, with bonds taking on a more dominant role as one moves up the efficient frontier. At higher levels of return, equities become more dominant as bonds exit the portfolios. Not all equity markets are represented in the portfolios as NZ, Australia, the US, HK and France dominate the equity markets. The UK and Singapore do not enter the efficient set, while Japan and Italy are kept at or below 5 per cent of the mix and only in portfolios very close to the MVP. This is not surprising as these equity markets either have among the lowest reward-to-risk ratios as shown in Table I or are highly correlated with other equity markets with superior reward-to-risk ratio as is the case of the UK and the US. Panel C shows that the introduction of FRE in the choice set reduces the share of equities in the efficient portfolios for all return levels except those close to the maximum return portfolio (MRP). Again this is not surprising given the superior reward-to-risk ratio of FRE relative to equities as shown in Table I. Interestingly, the amount of T-bills in the efficient portfolios increase, with the introduction of FRE in the mix especially at the lower end of the efficient frontier. This seems to be at the expense of bonds, which has a lower reward-to-risk ratio than T-bills. Towards the median return levels of 12 to 14 per cent the composition of both FRE and bonds in the efficient portfolios increase at the expense of equities. Again this could be explained by the inferior reward-to-risk ratio of equities relative to FRE and bonds. These results suggest that FRE acts as a risk-reducer at the middle to the higher end of the efficient frontier as it replaces the more volatile equities and has a dual role as a risk-reducer and a return-enhancer at the lower end of the frontier as it replaces equities and helps boost returns, as the lower earning T-bills replace bonds.

*3.5 Robustness tests*

It has been argued in the literature that since direct real estate data are appraisal- rather than market-based, they are subject to considerable estimation errors (Michaud, 1989). Consequently it has been suggested that real estate form part of mixed asset portfolios due to the understatement of real estate risk and/or overstatement of returns (Michaud, 1989; Fisher *et al.*, 1994; Corgel and deRoos, 1999). It has also been suggested that inflation plays a role (Webb and Rubens, 1987). In this section we test the robustness of FRE diversification benefits to changes in our original FRE risk and return estimates, as well as to changes in inflationary regimes. Table VII shows the maximum risk reduction, maximum return enhancement, increase in mean Sharpe ratio, and maximum weight attained by FRE in the efficient frontier under the base case and various risk-return scenarios and two inflationary regimes.

*3.5.1 Risk.* To address the issue of possible underestimation of FRE risk, we investigate the effect on the efficient set of a three-fold as well as a six-fold increase in the variance of FRE returns. Figure 4 displays the efficient sets with and without FRE using the original estimate of FRE risk. It also shows the efficient sets when FRE variance is tripled and sextupled. Figure 4 shows that the efficient sets with tripled and sextupled variance still dominate the set without FRE, indicating diversification

**Table VI.** Composition of risk efficient portfolios

| | Portfolio 1[a] | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Panel A. Risk efficient portfolios without farm real estate* | | | | | | | | | | | |
| Composition (%) | | | | | | | | | | | |
| 90 day T-bills | 90.1 | 70.9 | 12.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bonds | 0.0 | 13.8 | 60.6 | 54.5 | 36.5 | 18.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| New Zealand | 8.4 | 11.8 | 15.8 | 21.0 | 27.4 | 33.8 | 40.1 | 28.7 | 12.9 | 0.0 | 0.0 |
| Australia | 0.0 | 2.5 | 6.9 | 14.9 | 11.7 | 8.6 | 5.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| USA | 0.0 | 0.0 | 0.0 | 0.3 | 6.3 | 12.4 | 18.4 | 14.7 | 8.2 | 0.0 | 0.0 |
| UK | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Japan | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hong Kong | 0.0 | 0.0 | 0.0 | 1.4 | 8.2 | 14.9 | 21.7 | 34.3 | 47.0 | 65.9 | 100.0 |
| Singapore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| France | 0.0 | 0.0 | 0.0 | 7.9 | 9.9 | 11.8 | 13.8 | 22.3 | 31.9 | 34.1 | 0.0 |
| Italy | 0.0 | 1.1 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Expected return (%) | 8.5 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 17.6 |
| SD (%) | 2.9 | 3.0 | 3.8 | 5.5 | 8.0 | 10.7 | 13.6 | 16.8 | 20.5 | 24.6 | 31.4 |
| *Panel B. Risk efficient portfolios with farm real estate* | | | | | | | | | | | |
| Composition (%) | | | | | | | | | | | |
| Farm real estate | 9.4 | 16.8 | 24.2 | 35.1 | 47.3 | 59.1 | 66.7 | 43.6 | 6.9 | 0.0 | |
| 90 day T-bills | 79.9 | 46.1 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Bonds | 3.1 | 25.5 | 43.4 | 44.8 | 28.6 | 12.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| New Zealand | 4.8 | 3.6 | 2.9 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Australia | 0.8 | 6.0 | 9.8 | 12.7 | 9.4 | 5.4 | 0.0 | 0.0 | 0.0 | 0.0 | |
| USA | 0.0 | 0.0 | 1.8 | 6.6 | 11.4 | 16.4 | 18.2 | 0.0 | 0.0 | 0.0 | |
| UK | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Japan | 2.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Hong Kong | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 6.6 | 15.1 | 40.5 | 71.5 | 100.0 | |
| Singapore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| France | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.9 | 21.6 | 0.0 | |

(*continued*)

| | Portfolio | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1[a] | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11[b] |
| Italy | 0.0 | 1.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Expected return (%) | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 17.6 | |
| SD (%) | 2.7 | 2.9 | 3.3 | 3.9 | 5.0 | 6.3 | 8.0 | 14.2 | 24.3 | 31.4 | |
| *Panel C. Change in the composition of risk efficient portfolios with the introduction of FRE* | | | | | | | | | | | |
| Return level (%) | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 17.6 | |
| % Change in composition[e] | | | | | | | | | | | |
| Asset class | | | | | | | | | | | |
| Farm real estate | 9.4 | 16.8 | 24.2 | 35.1 | 47.3 | 59.1 | 66.7 | 43.6 | 6.9 | 0.0 | |
| 90 day T-bills | 9.0 | 33.9 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Bonds | −10.8 | −35.1 | −11.1 | 8.3 | 10.1 | 11.9 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Equities | −7.6 | −15.6 | −29.7 | −43.4 | −57.4 | −71.1 | −66.7 | −43.6 | −6.9 | 0.0 | |

**Notes**: [a] Global Minimum Variance Portfolio (MVP); [b] Maximum Expected Return Portfolio (MRP)

**Table VI.**

**Table VII.** Sensitivity of diversification benefits to changes in FRE Risk and-return

| | Maximum risk reduction | | | Maximum return enhancement | | | Maximum weight on frontier | Mean Sharpe | Increase in mean Sharpe | | Signed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (%) | Basis points | FRE Weight | (%) | Basis points | FRE Weight | (%) | ratio | ratio[a] (%) | *t*-stat | rank |
| *Panel A* | | | | | | | | | | | |
| Base case without FRE (1989-2005) | – | – | – | – | – | – | 0 | 0.407 | – | – | – |
| Base case with FRE (1989-2005) | 54 | 886 | 67 | 23 | 285 | 64 | 67 | 0.701 | 72 | 9.156* | 0.000* |
| FRE risk scenarios | | | | | | | | | | | |
| Three × variance | 36 | 650 | 48 | 15 | 196 | 47 | 50 | 0.564 | 39 | 9.845* | 561* |
| Six × variance | 28 | 508 | 38 | 11 | 147 | 37 | 38 | 0.514 | 26 | 10.438* | 528* |
| FRE return scenarios | | | | | | | | | | | |
| 13 per cent | 43 | 501 | 54 | 15 | 190 | 57 | 63 | 0.586 | 44 | 8.328* | 528* |
| 12 per cent | 34 | 300 | 55 | 11 | 134 | 55 | 58 | 0.526 | 29 | 7.826* | 528* |
| 11 per cent | 25 | 197 | 17 | 8 | 79 | 40 | 53 | 0.477 | 17 | 7.356* | 435* |
| 10 per cent | 14 | 86 | 30 | 6 | 58 | 15 | 40 | 0.440 | 8 | 6.187* | 276* |
| *Panel B* | | | | | | | | | | | |
| De-smoothed FRE returns | | | | | | | | | | | |
| $\alpha = 0.33$ | 23 | 461 | 34 | 8 | 122 | 33 | 34 | 0.501 | 23 | 14.031* | 595* |
| $\alpha = 0.40$ | 28 | 524 | 40 | 11 | 150 | 41 | 41 | 0.528 | 30 | 12.669* | 595* |
| $\alpha = 0.50$ | 35 | 609 | 48 | 14 | 188 | 48 | 48 | 0.564 | 39 | 11.600* | 561* |
| *Panel C* | | | | | | | | | | | |
| Base case without FRE (1974-1988) | | | | | | | 0 | 0.589 | – | – | – |
| Base case without FRE (1989-2003) | | | | | | | 0 | 0.326 | – | – | – |
| Annual inflation rate (period) | | | | | | | | | | | |
| 13.1 per cent (1974-1988) | | | | | | | 61 | 0.813 | 38 | 6.047* | 228* |
| 2.4 per cent (1989-2003) | | | | | | | 65 | 0.520 | 60 | 6.722* | 323* |

**Notes**: FRE, farm real estate. [a]Increase in corresponding mean Sharpe ratio relative to the base case without farm real estate. The increase in Sharpe ratio corresponding to the two inflation rate periods, 1974-1988 and 1989-2003 are relative to their respective base case without farm real estate. *t* stat (signed rank) is the parametric (nonparametric) test statistic in comparing the difference in the mean Sharpe ratios relative to the base case without farm real estate. The test statistics corresponding to the two inflation rate periods are relative to their respective base case without farm real estate; *Indicates significance at the 0.01 level

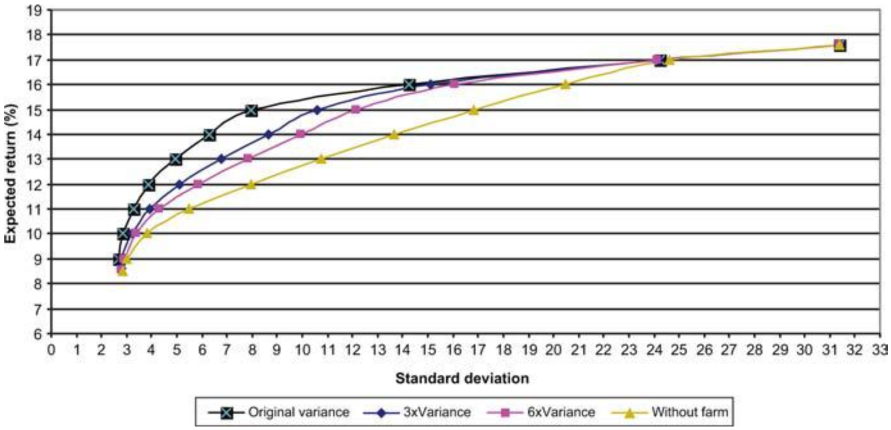



**Figure 4.** Efficient sets for selected farm real estate variance scenarios, 1989-2005

benefits, albeit at a reduced level compared with the base case. Panel A of Table VII quantifies these diversification benefits and shows that though the diversification benefits predictably fall as a result of the rise in the variance of FRE, they are still economically significant. The maximum risk reduction benefits fall from 54 to 36 per cent (28 per cent) when the variance is tripled (sextupled), but these benefits are still equivalent to a 650 (508) basis points reduction in the standard deviation of annual returns. Likewise, the maximum return enhancement benefits fall from 23 to 15 per cent (11 per cent) when the variance is tripled (sextupled) but this is still equivalent to an improvement in annual returns of 196 and 147 basis points, respectively. Table VII also shows that though the proportion of FRE in risk efficient portfolios decreases as its variance is tripled (sextupled), it still attains a maximum weight of 50 per cent (38 per cent) on the efficient frontier compared with 67 per cent in the base case. Finally, Table VII reports a 40 (27) percent improvement in the mean Sharpe ratio even as the variance of FRE is tripled (sextupled). Both the parametric *t*-test and the non-parametric Wilcoxon signed rank test indicate that these improvements are statistically significant at the 1 per cent level. These results indicate that the diversification benefits of including FRE in efficient portfolios remain robust even if FRE return variance is tripled and sextupled from the original level.

*3.5.2 Returns.* Next, we investigate the effect of decreasing FRE's expected return from an initial value of 14.6 per cent down to 13, 12, 11 and 10 per cent. Figure 5 displays the efficient sets for the selected FRE return scenarios. It shows that all efficient sets with FRE dominate the efficient set without FRE. This clearly indicates diversification benefits in spite of a fall in FRE return. These benefits are again quantified in Panel A of Table VII. The maximum risk reduction benefits range from 14 to 43 per cent or 86 to 501 basis points, and are attained by allocating 17 to 55 per cent of the portfolio to FRE. The maximum return enhancement benefits range from 6 to 15 per cent or 58 to 190 basis points per year and are likewise attained by allocating 15 to 57 per cent of the portfolio to FRE. Table VII also shows that despite a fall in FRE returns, FRE still enters the efficient portfolios at a maximum weight of 40-63 per cent. We also report significant improvements in the mean Sharpe ratio ranging from 8 to 44 per cent. These improvements are statistically significant at the 1 per cent level using

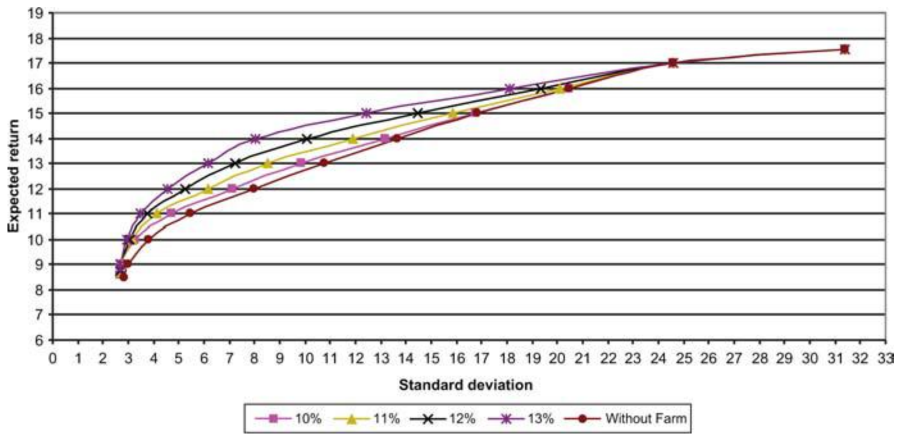



**Figure 5.**
Efficient sets for selected farm real estate return scenarios

both the parametric t-test and the non-parametric signed rank test. These results show that diversification benefits are robust under different FRE return scenarios.

Panel A of Table VII shows further that diversification benefits are more sensitive to a fall the FRE return than to a rise in FRE variance. For example, the effect on maximum risk reduction benefits of a 600 per cent rise in FRE variance is the same as an 11 per cent drop in FRE returns from 14.6 to 13 per cent. In the same way, the effect on the maximum return enhancement benefits of a 300 per cent rise in FRE variance is almost the same as an 11 per cent drop in FRE returns from 14.6 to 13 per cent. Futhermore, the effect of a 300 per cent increase in FRE variance results in a 46 per cent fall in the mean Sharpe ratio from 0.74 to 0.40, while an 11 per cent decline in FRE returns already results to a 40 per cent fall in the same from 0.74 to 0.44. This suggests that errors in the estimation of FRE returns are more critical than errors in the estimation of the variance of returns.

*3.5.3 De-smoothed FRE returns.* To further address the issue of understatement of the volatility of real estate returns when using appraisal-based data as we have here, we de-smoothed the FRE return series using Geltner's (1993) method. Geltner (1993) proposed the following reverse filter to recover the underlying property series from appraisal-based data:

$$R_t^u = [R_t^* - (1-\alpha)R_{t-1}{}^u]/\alpha$$

where $R_t^u$ is the unobserved underlying return, $R_t^*$ is the reported appraisal-based return, and $\alpha$ is a de-smoothing parameter with values between 0 and 1. A value for $\alpha$ of 1 implies no smoothing in the appraisal-based data. Following Geltner (1993), we de-smooth the FRE series using a value of 0.40 for $\alpha$ as well as a lower bound of 0.33, and an upper bound of 0.50.

Table VIII shows the risk and return measures of the appraisal-based FRE series as well as the de-smoothed series. It also shows FRE's correlation coefficients with the various financial assets. The de-smoothed series exhibit both higher return and volatility compared with the appraisal-based data. In particular, the variance increased approximately nine-fold, six-fold, and four-fold as we used $\alpha$ values of 0.33, 0.40, and

**Table VIII.** Risk-return measures and correlation coefficients of appraisal-based and de-smoothed FRE return series

| | Mean | Variance | Correlation coefficient 90 day T-bills | Bonds | New Zealand | Australia | USA | UK | Japan | Hong Kong | Singapore | France | Italy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FRE | 14.58 | 121 | −0.18 | −0.29 | 0.29 | −0.26 | −0.44 | −0.23 | −0.05 | −0.16 | −0.18 | −0.12 | −0.08 |
| FRE_DS33 | 16.31 | 1,049 | −0.31 | −0.28 | 0.33 | −0.29 | −0.34 | −0.11 | 0.11 | 0.00 | −0.18 | 0.07 | 0.09 |
| FRE_DS40 | 15.86 | 691 | −0.32 | −0.27 | 0.33 | −0.28 | −0.32 | −0.10 | 0.13 | 0.02 | −0.17 | 0.10 | 0.11 |
| FRE_DS50 | 15.43 | 428 | −0.30 | −0.29 | 0.33 | −0.29 | −0.36 | −0.14 | 0.08 | −0.03 | −0.18 | 0.04 | 0.07 |

**Notes**: FRE, Farm real estate returns, appraisal -based; FRE_DS33, de-smoothed farm real estate returns with $\alpha = 0.33$; FRE_DS40, de-smoothed farm real estate returns with $\alpha = 0.40$; FRE_DS50, de-smoothed farm real estate returns with $\alpha = 0.50$

0.50, respectively. Therefore using $\alpha$ values of 0.40 and 0.50 roughly corresponds to the earlier FRE risk scenarios that assume a six- and three-fold increase in variance, respectively.

The correlation coefficient of the de-smoothed FRE with the financial assets is less negative for the US, the UK, and Hong Kong while it turned from negative to positive for France, Italy, and Japan, when compared with the correlation coefficient using appraisal-based data. The correlation coefficient remained almost the same for NZ bonds, Australia, and Singapore, and while it became more negative for NZ T-bills. On the whole, de-smoothing appears to have increased the volatility of the FRE return series and generally increased its correlation with the financial assets implying lower diversification benefits relative to that provided by the appraisal-based FRE series.

Panel B of Table VII shows the benefits of diversification using the de-smoothed series. As expected, the results obtained when $\alpha$ was set to 0.40 and 0.50 are very similar to the results of the FRE risk scenarios where variance was increased six- and three-fold, respectively. Risk reduction was in the order of 500 to 600 basis points with FRE attaining a maximum weight of 41 to 48 per cent on the efficient frontier. The mean Sharpe ratio increased by 30 to 39 per cent relative to the base case without FRE and the increase was significant at the 1 per cent level using both the parametric and non-parametric tests. Using an $\alpha$ equal to 0.33 amounted to increasing the FRE return variance nine-fold. Though the maximum risk reduction and return enhancement are lower, FRE still attains a maximum weight of 34 per cent on the efficient frontier. Therefore, even with the de-smoothed series the benefits from diversification with FRE are still evident.

*3.5.4 Inflation.* We also test if inflation plays a role in making FRE an attractive asset for diversification. Our results strongly reject this suggestion given that 1989-2005 is a relatively low inflation period in New Zealand with an average annual inflation rate of 2.5 per cent, yet FRE is a significant component of risk efficient portfolios. As a further test we use a different data set to compare two periods with different inflationary environments. We use only FRE, and equity markets, as we do not have complete data on NZ T-bills and bonds. We consider the period 1974-1988 with an average annual inflation rate of 13.1 per cent in New Zealand, and 1989-2003 with an average inflation rate of 2.4 per cent. Again we reject the inflation explanation as our results in panel C of Table VII show that in the period of high inflation, FRE entered risk efficient portfolios at a maximum of 61 per cent while in the period of low inflation FRE entered risk efficient portfolios at and even higher proportion of 65 per cent. Likewise, we report statistically significant improvements in the mean Sharpe ratio when FRE is included in the mixed asset portfolio, but the magnitude of the improvement is higher in the low inflation period (1989-2003) rejecting the inflation explanation. The mean Sharpe ratio increased by 60 per cent from 0.326 to 0.520 in the low inflation period while it only increased 38 per cent from 0.589 to 0.813 in the high inflation period. These differences in Sharpe ratio are statistically significant at the 1 per cent level in both parametric and non-parametric tests.

Overall, in all risk-return scenarios as well as in the two inflationary regimes considered in this study, FRE enters the risk efficient portfolios at an economically significant level ranging from 15 to 65 per cent while retaining significant risk reduction and return enhancement benefits.

*3.6 Consistency*

Finally, we test if FRE is a consistent part of the efficient set using an adaptation of Lee and Stevenson's (2006) procedure. We generate efficient sets for five and ten-year rolling periods beginning in 1989 and ending in 2005. This test is meant to address the observation in the literature of time-varying equity market correlations (see for example, Solnik *et al.*, 1996; Goetzmann *et al.*, 2002; Meyer and Rose, 2003; Kearney and Lucey, 2004).

The five-year rolling periods are defined as returns from 1989 to 1993, 1990 to 1994, and so on until 2001 to 2005. The ten-year rolling periods are similarly defined as returns from 1989 to 1998, 1990 to 1999, and so on until 1996 to 2005. There are a total of 13 five-year rolling periods and eight ten-year rolling periods. The efficient frontier, generated for each rolling period, is defined by ten portfolios, which are equally spaced, according to expected return, including the MVP (portfolio 1) and the MRP (portfolio 10).

Table IX shows that FRE is a consistent component of the efficient set under both the five and ten-year rolling periods. In the five-year rolling periods, FRE achieved a positive allocation in the efficient portfolios more than 75 per cent of the time at the lower end of the frontier (portfolios 1 to 5). This number declines as we move up the frontier towards the MRP. The mean allocation of FRE in the ten portfolios ranged from 15 to 35 per cent. It has been suggested in the literature that allocating 20 per cent of a mixed asset portfolio to real estate is a viable strategy (e.g. Folger, 1984; Sweeney, 1988). Table IX shows that the mean FRE allocation in the efficient portfolios exceeded this level, 69-77 per cent of the time in the middle portfolios (portfolios 4 to 6) attaining an average allocation ranging from 33 to 35 per cent.

FRE is an even more consistent part of the efficient set in the ten-year rolling periods. FRE attained a positive allocation 100 per cent of the time in eight of the ten efficient portfolios. FRE also exceeded the 20 per cent allocation 100 per cent of the time in the middle portfolios (portfolios 4 to 6) achieving a mean allocation of 38 to 44 per cent with diminishing allocation as we move in either direction towards the upper and lower ends of the frontier.

| | Five-year rolling period | | | Ten-year rolling period | | |
|---|---|---|---|---|---|---|
| | Mean allocation of FRE (%) | Percentage of the time when FRE achieved a positive allocation | Percentage of the time when the allocation of FRE exceeded 20 per cent | Mean allocation of FRE | Percentage of the time when FRE achieved a positive allocation | Percentage of the time when the allocation of FRE exceeded 20 per cent |
| 1MVP | 21 | 85 | 31 | 12 | 100 | 13 |
| 2 | 27 | 92 | 62 | 22 | 100 | 38 |
| 3 | 33 | 77 | 62 | 30 | 100 | 88 |
| 4 | 35 | 85 | 77 | 38 | 100 | 100 |
| 5 | 35 | 77 | 69 | 43 | 100 | 100 |
| 6 | 33 | 69 | 69 | 44 | 100 | 100 |
| 7 | 27 | 69 | 54 | 41 | 100 | 88 |
| 8 | 22 | 62 | 46 | 28 | 100 | 50 |
| 9 | 18 | 46 | 15 | 16 | 50 | 25 |
| 10 MRP | 15 | 8 | 8 | 0 | 0 | 0 |

**Table IX.** Allocation of FRE under two rolling periods

Based on this evidence we conclude that FRE can be expected to be a consistent part of the efficient set.

## 6. Conclusion

This study investigated the benefits of further diversifying a mixed portfolio of international financial assets with farm real estate (FRE). The results show that given the predominantly negative correlation between FRE and financial assets, the risk-return tradeoffs of such portfolios can be improved significantly. The diversification benefits measured in terms of risk reduction, return enhancement, and improvement in the Sharpe ratio are robust under a number of FRE risk-return scenarios as well as under high and low inflationary periods. Using five- and ten-year rolling periods, FRE was found to be a consistent part of efficient portfolios.

The results also show that risk reduction benefits of diversifying with FRE are larger than the risk enhancement benefits. This suggests a role for FRE in mixed asset portfolios that typify more of a risk-reducer rather than a return-enhancer. The practical implication of our findings is that investors can significantly enhance their portfolio risk-return tradeoffs, particularly by reducing risk, through diversification into FRE. FRE therefore appears to deserve more serious consideration by investment practitioners than it has been accorded in the past. We conjecture that such is the result of limited avenues by which they can invest in FRE. Therefore, it is also important to explore ways of making it easier for investment practitioners to invest in FRE probably through the wider introduction and development of unit trusts investing in direct FRE.

### Note

1. The Sharpe ratios are computed using the average annual return of the NZ 90 day T-bills from 1989-2005 as the proxy for the risk-free rate. Different proxies for the risk-free rate were also tried with the same results as those reported.

### References

Barry, P.J. (1980), "Capital asset pricing and farm real estate", *American Journal of Agricultural Economics*, Vol. 62, pp. 549-53.

Corgel, J.B. and deRoos, J.A. (1999), "Recovery of real estate returns for portfolio allocation", *Journal of Real Estate Finance and Economics*, Vol. 18, pp. 279-96.

Eves, C. and Newell, G. (2007), "The role of US farmland in real estate investment portfolios", *Journal of Real Estate Portfolio Management*, Vol. 14, pp. 317-27.

Fisher, J.D., Geltner, D.M. and Webb, R.B. (1994), "Value indices of commercial real estate: a comparison of index construction methods", *Journal of Real Estate Finance and Economics*, Vol. 9, pp. 137-64.

Fletcher, J. and Marshall, A. (2005), "An empirical examination of the benefits of international diversification", *Journal of International Financial Markets Institutions and Money*, Vol. 15, pp. 455-68.

Folger, H.R. (1984), "Twenty per cent in real estate: can theory justify it?", *The Journal of Portfolio Management*, Winter, pp. 6-13.

Geltner, D. (1993), "Estimating market values from appraised values without assuming an efficient market", *Journal of Real Estate Research*, Vol. 8, pp. 325-45.

Goetzmann, W.N., Li, L. and Rouwenhorst, K.G. (2002), "Long-term global market correlations", working paper, National Bureau of Economic Research, Cambridge, MA.

Harvey, C.R. (1991), "The world price of covariance risk", *Journal of Finance*, Vol. 46, pp. 111-58.

Kaplan, H.M. (1985), "Farmland as a portfolio investment", *The Journal of Portfolio Management*, Vol. 11, pp. 73-9.

Kearney, C. and Lucey, B.M. (2004), "International equity market integration: theory, evidence and implications", *International Review of Financial Analysis*, Vol. 13, pp. 571-83.

Lee, S. and Stevenson, S. (2006), "Real estate in the mixed-asset portfolio: the question of consistency", *Journal of Property Investment and Finance*, Vol. 24, pp. 123-35.

Levy, H. and Sarnat, M. (1970), "International diversification of investment portfolios", *American Economic Review*, Vol. 60, pp. 668-75.

Li, K., Sarkar, A. and Wang, Z. (2003), "Diversification benefits of emerging markets subject to portfolio constraints", *Journal of Empirical Finance*, Vol. 10, pp. 57-80.

Lins, D., Kowalski, A. and Hoffman, C. (1992), "Institutional investment diversification: foreign stocks vs US farmland", *Proceedings of Regional Research Committee NC-161, Department of Agricultural Economics, Kansas State University, Manhattan, KS*.

Markowitz, H.M. (1952), "Portfolio selection", *Journal of Finance*, Vol. 12, pp. 77-91.

Meyer, T.O. and Rose, L.C. (2003), "The persistence of international diversification benefits before and during the Asian crisis", *Global Finance Journal*, Vol. 14, pp. 217-42.

Michaud, R.O. (1989), "The Markowitz optimization enigma: is 'optimised' optimal?", *Financial Analysts Journal*, January/February, pp. 31-42.

Moss, C.B., Featherstone, M. and Baker, T.G. (1987), "Agricultural assets in an efficient multi-period investment portfolio", *Agricultural Finance Review*, Vol. 47, pp. 82-94.

Nartea, G. and Eves, C. (2008), "Diversification benefits from New Zealand real estate", *Pacific Rim Property Research Journal*, Vol. 14 No. 1, pp. 27-43.

Nartea, G. and Webster, P. (2008), "Should farmers invest in financial assets as a risk management strategy? Some evidence from New Zealand", *Australian Journal of Agricultural and Resource Economics*, Vol. 52, pp. 183-202.

Nartea, G.V. and Dhungana, B.R. (1998), "Diversifiable and nondiversifiable risk in New Zealand dairy farming", *Proceedings of the NZ Farm Management Society Annual Conference, 18-20 November, Waikato University, Hamilton*, pp. 172-82.

Nartea, G.V. and Pellegrino, J.M. (1999), *Off-farm Investment in Financial Assets as a Risk Response for New Zealand Sheep and Beef Farms*, research report 99/07, Farm and Horticultural Management Group, Division of Applied Management and Computing, Lincoln University, Christchurch.

New Zealand Meat and Wool Board Economic Service (1975), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (1976), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (1977), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (1978), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (1979), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (1989), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (1992), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

New Zealand Meat and Wool Board Economic Service (2000), *The New Zealand Sheep and Beef Farm Survey*, New Zealand Meat and Wool Board Economic Service, Wellington.

Painter, M.J. (2000), "Should Saskatchewan farmland be part of your investment portfolio?", *Canadian Journal of Agricultural Economics*, Vol. 48, pp. 39-50.

Phengpis, C. and Swanson, P.E. (2004), "Increasing input information and realistically measuring potential diversification gains from international portfolio investments", *Global Finance Journal*, Vol. 15, pp. 197-217.

Quotable Value Limited (2005), *Rural Property Sales Statistics*, Quotable Value Limited, Petone.

Seiler, M., Webb, J.R. and Myer, F.C.N. (1999), "Diversification issues in real estate investment", *Journal of Real Estate Literature*, Vol. 7, pp. 163-79.

Sharpe, W.F. (1966), "Mutual fund performance", *Journal of Business*, Vol. 39, pp. 119-38.

Solnik, B., Boucrelle, C. and Le Fur, Y. (1996), "International market correlation and volatility", *Financial Analysts Journal*, Vol. 52, pp. 17-34.

Sweeney, F. (1988), "Twenty per cent in property – a viable strategy?", *Estates Gazette*, 13 February, pp. 26-8.

Valuation New Zealand (1982), *Rural Property Sales Statistics*, Valuation New Zealand, Wellington.

Valuation New Zealand (1988), *Rural Property Sales Statistics*, Valuation New Zealand, Wellington.

Webb, J.R. and Rubens, J. (1987), "How much in real estate? A surprising answer", *The Journal of Portfolio Management*, Spring, pp. 10-14.

Young, R. and Barry, P.J. (1987), "Holding financial assets as a risk response: a portfolio analysis of Illinois grain farms", *North Central Journal of Agricultural Economics*, Vol. 9, pp. 77-84.

## Further reading

Haugen, R. (1990), *Modern Investment Theory*, 2nd ed., Prentice-Hall, Englewood Cliffs, NJ.

Lintner, J. (1965), "The valuation of risky assets and selection of risk investments in stock portfolios and capital budgets", *Review of Economic Statistics*, Vol. 47, pp. 13-37.

## About the authors

Gilbert Nartea is a Senior Lecturer in Finance at Lincoln University, New Zealand. He obtained his BS in agribusiness management (*cum laude*) from the University of the Philippines, MEcon from the University of New England, Australia and PhD in Agricultural Economics from the University of Illinois at Urbana-Champaign, USA. He was a former Assistant Professor in Agribusiness Management at the University of the Philippines. Gilbert Nartea is the corresponding author and can be contacted at: gilbert.nartea@lincoln.ac.nz

Chris Eves is currently the Professor in Property Economics at Queensland University of Technology. He has undergraduate degrees in Agriculture and Business and his PhD was completed at University of Western Sydney in the area of rural property investment performance and the development of an Australian rural property investment performance index, which is updated bi-annually.

# A History of Site Valuation Rules: Functions and Empirical Evidence

*Peter F. Colwell**
*Tim F. Scheu***

***Abstract.*** **It is commonplace to think of the price of land as an amount per unit of area. This may be inappropriate, because it appears that the value of land increases at a decreasing rate as area increases in some situations, and frontage and depth may affect value differently. Various rules have been developed to aid in the process of estimating site value. This paper describes the functional forms of these rules and provides estimates of the parameters of these rules utilizing historical data. The hypotheses that value is a concave function of both frontage and depth cannot be rejected.**

## Introduction

Various rules have been developed by appraisers, judges and assessors to aid in the process of estimating site value. These site valuation rules can be divided into three categories: (1) depth rules; (2) frontage rules; and (3) area rules. A depth rule describes an increasing concave function (i.e., positive first and negative second derivatives) relating value to depth. Similarly, a frontage rule describes an increasing concave function relating value to frontage. Differences in these rules would imply that parcel shape matters. Alternatively if certain of these rules are identical for depth and frontage, then shape appears not to affect value and one is left with an area rule.

It is obligatory for anyone who would suggest that nonlinear site valuation rules are based in reality to explain how this could be possible. For these rules to reflect market prices, transaction costs must stand in the way of arbitrage eliminating nonlinear prices through further subdivision. This point has been clear since Colwell and Sirmans (1978, 1980) but has recently been restated by Brownstone and DeVany (1991).

The purpose of this paper is to trace the development of various site valuation rules, show how some of these rules utilize well-known functions, and to empirically investigate whether historical data support their early development and use. The second section of this paper traces the historical development of site valuation rules and shows that many of these rules, previously available only in tabular form, can be written in terms of their functional forms. Writing out the functions is a helpful step in empirically rejecting or not rejecting the rules. The third section of this paper describes the sales data from the New York City land market during the first half of the 1880s that are used in the fourth section. The fourth section develops the hedonic regression models, the hypotheses to be tested, and analyzes the results. The fifth and

*University of Illinois, 1407 West Gregory Drive, 304B DKH, Urbana, Illinois 61801.
**Hayworth College of Business, Western Michigan University, Kalamazoo, Michigan 49001.
Date Revised—March 1994; Accepted—May 1994.

final section offers some conclusions related to the relevance of the empirical work for the selection and application of site valuation rules.

## Development of Site Valuation Rules

A site valuation rule relates site value to a measure of size. The simplest such rule is that value is proportional to parcel area or, in other words, that the value per unit of area is a constant. This simple rule has been rejected by sophisticated practitioners for at least a century. It is not surprising that the search for more reliable rules (i.e., more accurate predictors of sales prices) has continued throughout this period. While most interest has focused on depth as a measure of size, there has been some interest in nonlinear frontage effects and relatively recent interest in area rules.

### *Depth Rules*

Various depth rules have been established to be used as guides in analyzing the declining marginal contribution of depth to value. The development and use of these depth rules have not proceeded without criticism. Critics claim that to apportion different values to different parts of a parcel of land, all of which is necessary as a unit for the production of income, would be speculative at best. Babcock wrote:

> No great amount of inquiry into the fundamental concept of the depth table seems necessary to me. It seems to me that the value . . . is best discovered by an inquiry into its productivity rather than the depths, etc. (McMichael, 1935: 436).

Yet, depth may be a proxy for a parcel's productivity and productivity may diminish marginally with depth as suggested by depth rules. Whether depth is in fact a proxy for productivity and whether depth rules reflect reality are empirical questions that should not be dismissed out of hand.

### *The Development of Depth Rules*

The development and proliferation of depth rules throughout the country can be traced to a basic need by assessors to use this type of tool where mass appraisal or the separation of value into land and building values is required. In the field of assessment, uniformity is important. During the period of 1900 to 1930 when depth tables were developing very rapidly, the assessment of property values for taxation purposes appeared to be rather crude and subject to corruption (Pollock and Scholz, 1926: 15). The use of depth rules by assessing authorities was promoted as a means by which more standardized assessments would result. By reducing the land assessment problem to one of referring to a table, depth rules simplified and standardized the assessment process.

Depth rules were generally developed by judges and assessors based on their intuition. However, some rules may have been developed from rather extensive empirical evidence. Unfortunately there is insufficient documentation to precisely characterize this empirical evidence.

Although its origins are cloudy, the 4-3-2-1 Rule seems to be the first site valuation rule to gain acceptance (McMichael, 1951: 490). Utilizing a standard depth of 100 feet, it allocates 40% of the total value to the first 25% of standard depth, then 30%, 20% and finally 10% of the total value to each successive 25% of depth.

In 1866, Hoffman introduced the first depth rule to be recognized by the courts. The Hoffman Rule is based on the premise that the front half of a standard depth parcel of 100 feet is worth two-thirds of the total value (Zangerle, 1927: 108). This rule was used for many years in the New York City area. A number of strictly mathematical (i.e., unrelated to any empirical work) inconsistencies in the Hoffman Rule were later pointed out by Neill (Clar, 1936: 157). For example, at a depth of 25 feet, Neill computed two-thirds of the two-thirds of the value, allocated to 50 feet of depth, or 44% of the value. This contrasts with the Hoffman depth rule which allocated only 37.5% of total value to a depth of 25 feet. As real estate editor of the Evening Mail, a New York City newspaper, Neill published his table in 1904. This table became known as the Hoffman-Neill Rule. Neill's critique of Hoffman may have sensitized later rule developers to base their tables on mathematical functions.

Davies elevated the inquiry into site valuation rules to a new level and became the first to apply hedonics to real estate. He felt the use of either the Hoffman Rule, which was full of inconsistencies, or the Hoffman-Neill Rule, which he felt bore no relation to actual land sales, was foolish. In the 1891 edition of the *Diary of the Real Estate Board of New York*, Davies wrote how he developed his depth rule:

> My first effort in the necessary direction was to obtain at great labor the average of the sales of ten thousand, two hundred parcels of varying depths, thus fixing numerous points, through which a curve could be run, and the resultant parabola stated in the formula, easy to remember, and moreover being based on actual sales, not subject to attack as having no foundation (Davies, 1912: 158).

The resultant rule, which became known as the Davies Rule, was the first depth rule not just based on mere intuition and anecdote, but based on actual market data.

Somers continued the tradition begun by Davies by investigating the contribution of varying depths on value in the St. Paul, Minnesota area. He also undertook an empirical investigation of market sales as a basis for his rule. After a "careful study" of over 2,000 parcels, he arrived at a tentative depth rule. He assigned 70% of the total value to the first 50 feet as is the case with the 4-3-2-1 Rule. After testing this curve in "other areas," he slightly modified his results. Somers, in constructing his depth rule, utilized both his empirical results and mathematical analysis. The result is a depth curve that follows a logarithmic function for the first 100 feet and then deviates from this function for depths greater than 100 feet. He later went to Cleveland, Ohio where he was hired by city officials to develop a similar rule for that city. This rule, known as the Cleveland Rule, assigns a percent of value up to depths of 700 feet. The Cleveland Rule and the Somers Rule have the same values for as far in depth as he had carried out the Somers Rule (McMichael, 1951: 505). If indeed

**Exhibit 1**
**Definitions of Variables and Parameters**

| | | |
|---|---|---|
| $A_c$ | = | area of the comparable parcel, |
| $A_s$ | = | area of the subject parcel, |
| $\alpha$ | = | depth elasticity of value, |
| $\beta$ | = | frontage elasticity of value when different from one, |
| $D_i$ | = | the depth in feet of the $i^{th}$ parcel, and |
| $D_s$ | = | the depth in feet of the standard parcel, |
| $F_i$ | = | the number of front feet of the $i^{th}$ parcel, |
| $p$ | = | the price of the first square foot, |
| $P$ | = | price per front foot of the standard depth parcel, |
| $V_c$ | = | value (i.e., price) of the comparable property, |
| $V_i$ | = | value of the $i^{th}$ parcel, |
| $\xi$ | = | area elasticity of value. |

*Source*: Authors

Somers based his rules on empirical evidence, it is absolutely amazing that the evidence was precisely the same in St. Paul and "other areas" as in Cleveland.

Other rules were subsequently developed in other areas of the country. Many of these rules were developed for a particular land use type in a particular city or county. For example, a residential depth rule and a business depth rule were developed for use in Milwaukee, Wisconsin. A nearly complete list of depth rules can be found in McMichael (1951: 489–514).

### *Depth Rule Functions*

Depth rules describe a concave function relating value to depth. Most depth rules shown in tabular form can be written as a mathematical function. Five different functional forms that fit a large number of depth rules are shown in Exhibit 2. Of the five functions, the Cobb-Douglas and logarithmic functions fit most of the depth rules. Of course, the parameters of these functions tend to differ across the various rules.

The extent of concavity varies across the different rules. This variation in concavity is illustrated in two ways. First, three indices of concavity are computed for each rule and shown in Exhibit 2. Second, the proportion of the value of a standard depth parcel at 25% of standard depth and at 75% of standard depth are computed and shown in Exhibit 2. These proportions would appear as percentages in depth rule tables.

Overall convexity is defined as the deviation of the function from a straight line between zero and the standard depth. The Overall Convexity Index (OCI) is as follows:

$$OCI = \frac{2\int_0^{D_s} V_i dD_i}{PF_i D_s} - 1\,, \qquad (1)$$

where the variables are defined in Exhibit 1. The Overall Concavity Index functions exactly like a Gini coefficient does in measuring overall inequality along a Lorenz curve. An Overall Concavity Index of zero indicates a linear relationship (i.e., no concavity), and greater concavity is indicated by a larger index.

The ratio of the negative second derivative to the first derivative is a concavity index that can be evaluated at any point on the function. That is,

$$CI(D_i) = \frac{-\dfrac{d_2 V_i}{dD_i^2}}{\dfrac{dV_i}{dD_i}}. \tag{2}$$

The second and third concavity indices in Exhibit 2 show the results for this measure evaluated at $D_i = .25D_s$ and $D_i = .75D_s$. Here again, zero indicates no concavity, and greater concavity is indicated by a larger index.

The second way the differences in convexity are highlighted is to take the ratio of the value function evaluation at a point to the value of the first foot of depth. That is,

$$\frac{V_i(D_i)}{PF_i}. \tag{3}$$

This index is evaluated at $D_i = .25D_s$ and $D_i = .75D_s$. The results are shown in Exhibit 2. The extent to which $V_i(.25D_s)/PF_i$ deviates from .25 and $V_i(.75D_s)/PF_i$ deviates from .75 indicates the degree of concavity.

### *Comparing Depth Rules*

The depth rules described in Exhibit 2 match the corresponding depth tables with great precision. The authors of the depth tables either used these very functions or borrowed from those who did. Some of the authors actually wrote out the functional form, others provided some hints (e.g., the two-thirds at 50 feet and two-thirds × two-thirds at 25 feet was a giveaway for the Hoffman-Neill Rule). The discovery of the function behind some of the rules required an educated guess (e.g., the 4-3-2-1 Rule is just another version of the sum-of-the-years-digits depreciation schedule).

The depth elasticity of value is indicated by $\alpha$ for each of the depth rules that utilize the Cobb-Douglas function (i.e., Function 1, Exhibit 2). For example, the Hoffman-Neill Rule has a depth elasticity of .585, whereas it is .5 for the Hobbs and Reeves Rules. The Milwaukee Rule falls in between with a depth elasticity of .51. Not surprisingly, the Overall Concavity Index exceeds .32 for all the rules of this type except for the Hoffman-Neill Rule. That is, the Hoffman-Neill Rule shows the least concavity of rules of this type.

A glance at the concavity indices evaluated at one quarter and three quarters of standard depth reveals that the greater concavity occurs "early" in the Cobb-Douglas function. This is true of most, but not all, of the depth rule types as will become clear.

## Exhibit 2
## Depth Rule Functional Forms

| Rule | | $D_s$ | $OCI$ | $CI(.25D_s)$ | $CI(.75D_s)$ | $\frac{V_i(.25D_s)}{PF_i}$ | $\frac{V_i(.75D_s)}{PF_i}$ |
|---|---|---|---|---|---|---|---|
| **1. Cobb-Douglas:** $V_i = PF_i(D_i/D_s)\alpha$ | | | | | | | |
| | $\alpha$ | | | | | | |
| Hobbs | .500 | 125 | .3333 | .0200 | .0067 | .5000 | .8660 |
| Hoffman-Neill | .585 | 100 | .2616 | .0166 | .0055 | .4444 | .8451 |
| Milwaukee | .510 | 100 | .3241 | .0196 | .0065 | .4931 | .8635 |
| Reeves | .500 | 100 | .3329 | .0200 | .0067 | .5000 | .8660 |
| **2. Logarithmic:** $V_i = PF_i(\text{LOG}(1+9D_i/D_s))^{\pi}$ | | | | | | | |
| | $\pi$ | | | | | | |
| Cleveland | 1.07 | 100 | .3256 | .0261 | .0112 | .4884 | .8820 |
| Ill. Apartment | 1.14 | 135 | .2989 | .0244 | .0108 | .4661 | .8748 |
| Ill. Residential | 1.25 | 120 | .2592 | .0218 | .0102 | .4330 | .8636 |
| Leenhouts | 1.71 | 120 | .1188 | .0110 | .0075 | .3182 | .8182 |
| McMahon | 1.36 | 100 | .2222 | .0192 | .0096 | .4022 | .8525 |
| Montreal | 1.11 | 100 | .3102 | .0251 | .0110 | .4755 | .8779 |
| Somers | 1.07 | 100 | .3256 | .0261 | .0112 | .4884 | .8820 |
| Stafford | 1.07 | 100 | .3256 | .0261 | .0112 | .4884 | .8820 |
| **3. Parabolic:** $V_i = PF_i(\psi + \tau D_i/D_s - \theta(D_i/D_s)^2)$ | | | | | | | |
| | $\psi$ $\tau$ $\theta$ | | | | | | |
| 4-3-2-1 | 0.0 1.8 .8 | 100 | .2666 | .0114 | .0267 | .4000 | .9000 |
| M-C | 0.1 1.0 .1 | 100 | .1333 | .0021 | .0024 | .3427 | .7937 |
| **4. Square Root:** $V_i = PF_i((\varphi(\sigma + D_i/D_s))^{.5} - \rho)$ | | | | | | | |
| | $\sigma$ $\varphi$ $\rho$ | | | | | | |
| Davies | .0352 1.45 .226 | 100 | .2284 | .0175 | .0064 | .4170 | .8410 |
| **5. Jerret:** $V_i = PF_i(2D_i/(D_i/D_s))$ | | | | | | | |
| Jerret | | 100 | .2274 | .0160 | .0114 | .4000 | .8571 |

*Source*: Authors

The final two indices show that the variation among the Cobb-Douglas depth rules at three quarters of standard depth is relatively trivial compared to the variation at one quarter of the standard depth.

A larger family of depth rules with greater variation in concavity employs a logarithmic function as shown in Exhibit 2 for Function 2. The Leenhouts Rule is nearly linear with $\pi = 1.71$ and the OCI=.1188 ($\pi = 2.21$ yields an OCI of approximately zero). The Cleveland-Stafford-Somers Rule is the most concave of this type with the OCI close to the maximum OCI found among the Cobb-Douglas type rules.

Again the concavity is greater "early" in the function, but the differences between concavity at one quarter and three quarters of standard depth are less for the "Logarithmic" rules than those found for the Cobb-Douglas rules. The final two indices show that although the variation in the "Logarithmic" rules is much greater at three quarters of standard depth than that of the Cobb-Douglas depth rules, this variation is still relatively small compared to the variation among the "Logarithmic" rules at one quarter of the standard depth.

Both the Martin-Chicago (M-C) and 4-3-2-1 Rules are parabolas as shown by Function 3 in Exhibit 2. The Martin-Chicago Rule reaches its maximum at 500 feet of depth, well beyond most standard depths and certainly beyond its own 100 foot standard depth. The 4-3-2-1 Rule reaches its maximum at 112.5 feet, however the function is only thought to apply up to a standard depth of 100 feet. Beyond 100 feet of depth, the 4-3-2-1 Rule does not appear to follow any function. The vertical intercept for the Martin-Chicago Rule does not go through the origin, but curiously allocates 10% of value to parcels with no depth. Still, the Overall Concavity of the Martin-Chicago Rule is very small, second only to the Leenhouts Rule. The curiosity is that these parabolic rules display more concavity "late" in the function than "early" in the function. This is in contrast with all the other depth rules. The 4-3-2-1 Rule is shown by the last index to deviate more from the linear at three quarters of standard depth than any other rule.

The Davies and Jerret Rules are each unique. While one can appreciate the appeal of the computational simplicity of the Jerret Rule in an age prior to calculators and computers, one wonders how Davies was able to concoct such a convoluted form let alone estimate its parameters as he indicated he was able to do. These rules are very similar to each other in overall concavity and in their concavity at the first quarter of standard depth. As with all but the parabolic rules, the concavity declines from the first quarter to that found at the third quarter of standard depth. However, this difference is practically nothing for the Jerret Rule.

### *Frontage Rules*

While many depth rules were developed and used by assessors and appraisers, little is found in the literature that explicitly addresses frontage rules. Implicitly, the developers of depth rules assumed that value is proportional to frontage, ceteris paribus. Ross, a Los Angeles appraiser, developed a frontage rule for which he devised a table to show the effect of frontage on value while holding depth constant (McMichael, 1951: 498). The Ross Rule for residential parcels uses standard depths of 125 to 150 feet and categorizes residential parcels into four different classifications. In general, for all classes of residential property, increasing frontage results in marginally declining value. It is a curiosity that according to the Ross Rule, at some point for each of the classifications, increasing frontage actually results in absolutely declining value.

### *Area Rules*

There is a rather large empirical literature that indicates there may be area rules (i.e., a concave relationship between land value and the area of the parcel; see Asabere, Nov. 1981, Aug. 1981; Asabere and Colwell, 1984, 1985; Asabere and Huffman, Summer 1991, Spring 1991; Brownstone and DeVany, 1991; Colwell and Sirmans, 1980). In the appraisal literature, Dilmore has developed several area rules to assist in adjusting for disparities in size between a subject property and a comparable property (Dilmore, May–June 1976, May 1976, 1971). The development of these area rules was also intended to increase the number of comparable properties (i.e., by providing the means for making adjustments) and reduce the problem of inconsistencies arising from adjustments for size.

The area rules are based on the premise that increases in area cause decreases in unit price. After testing several types of curves, Dilmore found the "learning curve" is best suited for land prices. The learning curve is a Cobb-Douglas function and its parameter is an elasticity coefficient.

Dilmore defines the ratio of comparable to subject unit prices as follows:

$$\frac{A_c^{\xi}/A_i^{\xi}}{A_c/A_i} = \frac{V_c/A_c}{V_i/A_i}, \tag{4}$$

where variables and parameters are defined in Exhibit 1. Simplifying equation (4) and solving for $V_i$ yields:

$$V_i = \frac{V_c}{A_c^{\xi}} A_i^{\xi}, \tag{5}$$

where $V_c/A_c^{\xi}$ equals an estimate of the price of the first square foot, based upon the sale of a comparable parcel. All Dilmore has contributed is an expression for the value of the first square foot in lieu of estimation via regression.

For rectangular parcels, Dilmore's approach can be interpreted as nothing more than having a depth rule and a frontage rule of the Cobb-Douglas type, where the frontage and depth elasticities are identical as follows:

$$V_i = \frac{V_c}{F_c^{\xi} D_c^{\xi}} F_i^{\xi} D_i^{\xi}. \tag{6}$$

If $\xi$ equals one in equations (4), (5) and (6), value is proportional to area, depth and frontage. This implies that prices are linear and it is a useful construct to think of the value per square foot. Another way to think about this is that constant returns in parcel area implies increasing returns to scale in frontage and depth. That is, doubling both frontage and depth quadruples value if $\xi$ equals one, but doubling both also quadruples area.

If $\xi$ is between zero and one in equations (4), (5) and (6), value increases at a decreasing rate with increases in area, depth, or frontage. This means that prices are nonlinear and value per square foot is not a particularly useful construct. It also means that the commonly used value per front foot is also not a particularly useful construct.

### *Combining Frontage and Depth Rules*

There is no theoretical reason for frontage and depth elasticities to be equal. If anything, there is a theoretical reason for the frontage elasticity to exceed the depth elasticity (Colwell and Cannaday, 1990; Colwell and Scheu, 1989). If these elasticities differ, then the frontage rule differs from the depth rule as in equation (7).

$$V_i = pF_i^{\beta} D_i^{\alpha}, \tag{7}$$

where $\beta \neq \alpha$.

If $\beta$ is between zero and one in equation (7), then frontage too has a diminishing marginal impact on value. This assumption has been utilized in the theory of Colwell and Scheu (1989) and Colwell and Cannaday (1990). The empirical justification for this view is to be found in Kowalski and Colwell (1986) and, to a lesser extent, in Colwell and Scheu (1989).

If $\beta$ equals one as in the various rules specified in Exhibit 2, then the price of frontage is linear. This would imply that it makes sense to discuss the price per front foot (as is frequently done for commercial or for lakefront property) assuming that depth is constant.

## Data

The data are analyzed to determine whether the early development and use of depth rules are empirically justifiable. The data consist of vacant land sales in New York City during the period 1800 to 1885 (Real Estate Record Association, 1880–1884). The use of this historical data is particularly significant in that the early development and use of depth rules took place in New York at approximately this time (i.e., with Hoffman earlier and Neill later).

The data consist of 187 vacant land sales from a sample area of the New York market. Each of the observations front on avenues. The sales data for parcels that front on streets were omitted from the sample because nearly all the observations were either at the standard depth or at twice the standard depth (i.e., through-block parcels) and thus do not exhibit sufficient variation in depth to be informative about depth rules. In New York City, streets run east and west and avenues run north and south. The New York avenue data sample area is bounded by First Avenue and Eleventh Avenue on the east and west, respectively, and 50th Street and 120th Street on the south and on the north, respectively. In addition to the selling price of each parcel, other variables were recorded. These include the frontage and depth, the date of sale, and the parcel's address. A location variable was computed from the address and historical accounts of the location of peak value.

The location of a parcel of real estate is an important factor to consider in estimating the parcel's value. Some major location factors that were present in New York City for the period 1880 through 1884 are distance to the central business district, proximity to the intersection of 50th Street and 5th Avenue, proximity to Central Park and distance from either the East River or the Hudson River.

During the study period, the area north of 59th Street was the outskirts of town. Further development depended upon the growth of the mass transit system. It was

**Exhibit 3**
**Summary Statistics for Parcel Dimensions**

| Variable | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|
| *D* | 102.38 | 31.03 | 62.30 | 313.00 |
| *F* | 66.87 | 35.90 | 10.10 | 176.70 |

*Source*: Authors

also during this time that Madison Avenue and Fifth Avenue north of 50th Street started to become fashionable. In August 1879, Vanderbilt purchased property between 51st and 52nd Streets adjacent to Fifth Avenue (Real Estate Record Association, 1898: 81). His purchases were imitated by a number of his friends and other investors. This sector continued north to the park. For many years there was a reluctance to develop adjacent to the park. Its marshy ground had been used as a dumping site for raw sewage, a practice that continued even after it officially became a park. Central Park was also inhabited by the homeless.

During the sample period, proximity to either the East River or Hudson River also had a negative effect on value. There are several reasons for this influence that can be gathered from the historical accounts. The first reason was that with very little commercial activity taking place in the area there was no incentive to develop the waterfront for shipping and receiving goods. Another reason for the negative influence on value was the crime rate. The waterways were the most accessible and fastest transportation arteries and enhanced the opportunity for criminal getaways. The final factor for this negative influence was the climate. It was colder and more damp along the waterfront than it was inland. The technology for heating homes was still fairly primitive, so in order to find a less harsh climate, people preferred to live away from the water. Based on the historical record, the intersections of 50th Street and 5th Avenue appears to be the point where local land values were highest. If the point of maximum value were farther south, it would not matter much for the creation of a location variable because no observations are included below 50th Street.

One of the more profound data questions is whether there is sufficient variation in the parcel dimensions, especially depth, found in the sample. There appears to be no such problem with the avenue data, as can be seen in Exhibit 3. Nevertheless, one wonders whether the apparent variation in depth is merely the result of a very few extreme observations. In fact, 70 out of 187 observations have depths other than 100 feet. Thus, we believe that reliable estimates of the influence of depth are obtainable.

## Regression Models, Hypotheses and Results

### *Models*

All of the variables and hypotheses developed in the prior sections are brought together in Exhibit 4. These models differ only with respect to the depth rule or depth rule family represented. In Models I and II, the critical depth parameters $\alpha$ and $\pi$ are

**Exhibit 4**
**The Empirical Models**

| Model Number | Model |
|---|---|
| I | $\ln V_i = \lambda + \beta \ln F_i + \alpha \ln(D_i/D_s) + \delta U_i + \omega T$ |
| II | $\ln V_i = \lambda + \beta \ln F_i + \pi \ln(LOG_i) + \delta U_i + \omega T$ |
| III | $\ln V_i = \lambda + \beta \ln F_i + \zeta \ln(4\text{-}3\text{-}2\text{-}1_i) + \delta U_i + \omega T_i$ |
| IV | $\ln V_i = \lambda + \beta \ln F_i + \zeta \ln(M\text{-}C_i) + \delta U_i + \omega T_i$ |
| V | $\ln V_i = \lambda + \beta \ln F_i + \zeta \ln(DAVIES_i) + \delta U_i + \omega T_i$ |
| VI | $\ln V_i = \lambda + \beta \ln F_i + \zeta \ln(JERRET_i) + \delta U_i + \omega T_i$ |

where

$\ln V_i$ = the natural log of the selling price of parcel *i* in dollars,
$\ln F_i$ = the natural log of the frontage of parcel *i* in feet,
$\ln(D_i/D_s)$ = the natural log of the ratio of the depth of parcel *i* to the depth of a standard parcel,
$U_i$ = the distance in thousands of feet from 50th Street and 5th Avenue,
$T_i$ = the time in months from January of 1880 to the sale of parcel *i*,
$\ln(LOG_i)$ = the natural log of the logarithmic type of depth rule excluding the parameter $\pi$, $(LOG(1+9D_i/D_s))$
$\ln(4\text{-}3\text{-}2\text{-}1_i)$ = the natural log of the *4-3-2-1* depth rule (with a linear approximation beyond 100 feet of depth), $(1.8D_i/D_s - .8(D_i/D_s)^2)$ for $D_i, < 100$ and $(1 + .0032(D_i - 100))$ for $D_i, > 100$
$\ln(M\text{-}C_i)$ = the natural log of the Martin-Chicago depth rule, $(.1 + 1\,D_i/D_s - .1\,(D_i/D_s)^2)$,
$\ln(DAVIES_i)$ = the natural log of the Davies depth rule, $((1.45(.0352 + D_i/D_s))^{.5} - .226)$, and
$\ln(JERRET_i)$ = the natural log of the Jerret depth rule, $(2D_i/(D_i + D_s))$.

*Source*: Authors

to be estimated directly. In Models III through VI, a depth parameter, $\zeta$, is to be estimated that bends the rule if it deviates from one. If $\zeta$ is greater than one, it indicates that, in reality, the depth relation is less concave than the rule, whereas it is more concave than the rule if $\zeta$ is less than one. Model I represents the Cobb-Douglas family of depth rules. The depth rules in Models (II) through (VI) are named explicitly. The frontage rule in all models is of the Cobb-Douglas type. The location variable was included in all models. This variable was computed as the linear distance between the point of hypothesized maximum value and the parcel. Finally, the time variable (i.e., month of sale) was used in all models.

### *Hypotheses*

The purpose of the regression estimates is to provide for tests of the following hypotheses:

- We expect a coefficient on the log of frontage between zero and one indicating a concave frontage rule;
- we expect a coefficient on the log of the depth ratio in Model 1 between zero and one indicating a concave depth rule;

- we expect that a coefficient on the log of the depth ratio in Model 1 is between .5 and .585, the range of elasticity found in the Cobb-Douglas depth rules;
- we expect that the coefficient on the log of depth is less than that on the frontage in Model I indicating that area rules are not justified because frontage elasticity is greater than depth elasticity and that the cited theory and empirical work is confirmed;
- we expect the coefficient on the depth rule variable in Model II to fall between 1.07 and 1.71, the range found in the "Logarithmic" depth rules;
- we expect the coefficient on the depth rule variable in Models III through VI to equal 1.0 indicating the concavity in the rule is found in the data;
- we expect the coefficient on the location variable to be negative indicating that values fall with distance from the point selected as the peak;
- we expect the coefficient on the time variable to be positive indicating that values typically were increasing during the sample period.

There can be no nested test (e.g., Box-Cox and Box-Tidwell) to identify the functional forms that produce log likelihood estimates insignificantly different from that which maximizes the log-likelihood function. The reason is that all the functional forms considered do not belong to a single family of functions in the sense that each can be considered a special case of a more general function.

### *Results*

The regression results support the notion of concave site valuation rules (i.e., diminishing marginal contributions of frontage and depth). Exhibit 5 shows the results of the regression analysis. All of the coefficients are significantly different from zero at the 95% level of confidence. The *t*-ratio for each estimated coefficient is shown in parentheses. While the results indicate that there is a concave depth rule, there is a question of whether there is a concave frontage rule. Furthermore it is not possible to reject the hypothesis that there is a concave area rule.

The coefficient on depth is significantly less than one in Model I. Note that this is properly a one-tailed test. The indication is that it is not possible to reject the hypothesis that there is a depth rule like those that were developed about the same time as the study period. While this coefficient is slightly outside the range found among the Cobb-Douglas rules, it is almost precisely the magnitude of the implied coefficient in the Hoffman-Neill Rule. If a question remains about the robustness of this result, because it is thought that depths seldom deviate from the standard depth, it is possible to re-estimate the model with all standard depth parcels omitted. Even though depth appears quite variable (see Exhibit 3), only seventy observations are at depths other than 100 feet. Re-estimating Model I using only these seventy observations yields

$$\underset{\phantom{(0)}}{\ln V_i} = 6.824 + \underset{(6.105)}{.8451 \ln F_i} + \underset{(2.284)}{.567 \ln D_i/D_s} - \underset{(4.416)}{.083 U_i} + \underset{(3.531)}{.012 T_i}. \quad (8)$$

The depth elasticity coefficient is virtually unchanged by this procedure. It is peculiar that the rate of appreciation is doubled, but the other coefficients are also virtually unchanged. It is safe to say that the data are sufficiently variable to reveal the influence of depth on value.

In Model II, the coefficient on the depth variable is between the extremes found in the depth rules using the Logarithmic functional form. It is, however, not significantly different than either extreme magnitude (i.e., 1.07 and 1.71). Also, it is not significantly different than the magnitude that produces zero overall net concavity (i.e., 2.21). Of course, this result raises the question of whether the value-depth function is indeed concave; however it should be recognized that the test of a difference from 2.21 is not strictly a test of whether the function is linear (i.e., zero overall net concavity cannot be equated to linearity if the function can be part convex and part concave).

Looking at the results for the 4-3-2-1 and Martin-Chicago Rules (i.e., Models III and IV) gives the impression that the true model is more concave than the Martin-Chicago Rule and less concave than the 4-3-2-1 Rule. That is, the coefficient for 4-3-2-1 is substantially greater than one and the coefficient for Martin-Chicago is substantially below one. However, these coefficients are not significantly different from one in either case. Thus, it is not possible to state that the true model differs from either of these rules.

The coefficient on the Davies Rule (Model V) is almost exactly one, indicating that the concavity of the Davies Rule matches that found in the sample data almost exactly. Finally, the coefficient on the Jerret Rule (Model VI) is close to one and certainly not significantly different from one. Thus, it is impossible to reject the hypothesis that the Jerret Rule is correct.

The coefficient on frontage is significantly less than one in Models I through VI. This indicates that it is possible to reject the hypothesis that there is a linear frontage rule. It should be remembered that the depth rule creators, with only one exception, believed that value is proportional to frontage. This finding to the contrary should be viewed as a deviation from the received doctrine. However, the magnitude of the deviation is not large.

Despite the fact that the frontage and depth elasticity estimates in Model I are of the approximate hypothesized absolute and relative magnitudes, the difference between them is not statistically significant. One way to produce this test is to substitute lot area for the depth ratio variable. The result of this re-estimation of the model is as follows:

$$\underset{}{\ln V_i} = 4.528 + \underset{(.730)}{.1861 \ln F_i} + \underset{(2.559)}{.589 \ln Ai} - \underset{(-8.801)}{.087 U_i} + \underset{(2.571)}{.006 T_i}. \tag{9}$$

The test is then whether the coefficient on the frontage variable is significantly different from zero if the alternative hypothesis is that the frontage elasticity is different than the depth elasticity, or significantly greater than zero if the alternative hypothesis is that frontage elasticity is greater than depth elasticity. The result shows that it is not possible to reject the hypothesis that there is an area rule. That is, both alternative hypotheses are rejected.

It was hypothesized that, north of 50th Street, parcel values decline with distance from the intersection of 50th Street and 5th Avenue, holding other things constant. We find that value decreases 8.7% per 1,000 feet of distance. This is the right order of magnitude for the study period. Mills found that unit values decline by 49% and 33% per mile for Chicago in 1857 and 1873, respectively (1971).

**Exhibit 5**
**Regression Results**

| Model | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| $\bar{R}^2$ | .505 | .504 | .505 | .505 | .505 | .503 |
| **Variables** | | | | | | |
| $\ln F_i$ | .775<br>(9.863) | .778<br>(9.905) | .777<br>(9.882) | .776<br>(9.876) | .776<br>(9.873) | .781<br>(9.941) |
| $\ln(D_i/D_s)$ | .589<br>(2.559) | | | | | |
| $\ln(LOG_i)$ | | 1.545<br>(2.468) | | | | |
| $\ln(4\text{-}3\text{-}2\text{-}1_i)$ | | | 1.405<br>(2.509) | | | |
| $\ln M\text{-}C_i)$ | | | | .763<br>(2.525) | | |
| $\ln(DAVIES_i)$ | | | | | 1.002<br>(2.538) | |
| $\ln(JERRET_i)$ | | | | | | 1.228<br>(2.375) |
| $U_i$ | −.087<br>(−8.801) | −.087<br>(−8.788) | −.087<br>(−8.794) | −.087<br>(−8.796) | −.087<br>(−8.798) | −.087<br>(−8.801) |
| $t_i$ | .006<br>(2.571) | .006<br>(2.574) | .006<br>(2.579) | .006<br>(2.575) | .006<br>(2.572) | .006<br>(2.571) |
| Constant | 7.242 | 7.233 | 7.232 | 7.239 | 7.233 | 7.241 |

*Source*: Authors

Based on the historical record, it was hypothesized that parcel values were increasing during the sample period. The empirical results support this hypothesis. The coefficient on the time of sale variable is significantly different from zero (and, of course, significantly positive in all models). The coefficient indicates that parcel value was growing at a compound rate of .6% per month.

## Conclusions

The site valuation rules analyzed in this paper are divided into three categories: depth rules, frontage rules, and area rules. The functional form can be found for a large number of depth rules. These forms are specified where possible. Frontage rules, on the other hand, are generally neglected in the literature. We assume that frontage rules, if they exist, take the form of a Cobb-Douglas function. Similarly, area rules are assumed to be Cobb-Douglas functions in which the frontage and depth elasticities are identical. The use of historical data is shown to be significant in that the early development and use of depth rules took place in New York City, the place of our study, at approximately the time of our study.

The results provide support for the development and use of depth rules. We are neither able to reject any of the depth rules nor are we able to distinguish among them in any meaningful way. That is, we cannot rank the rules. We cannot even identify the best rule. Of course, the rules are quite similar. That is, their differences represent a range of concavity, none are linear and none are convex. The magnitudes of the coefficient estimates suggest that the degree of concavity found in the market falls within the range found in the various rules.

The results also provide support for the use of frontage rules. That is, we cannot reject the hypothesis that there is a concave frontage rule in the market. Unfortunately perhaps, the developers of depth rules generally assumed that the frontage relation is linear. Thus, our results are in conflict with depth rule doctrine.

We cannot say that the depth elasticity differs significantly from the frontage rule. Therefore, it is not possible to reject the hypothesis that there is an area rule (i.e., shape does not matter). The estimated area rule suggests that value is a concave function of parcel area.

The next logical step would be to test the relevance of these site valuation rules for contemporary usage. Kowalski and Colwell (1986) and Colwell and Scheu (1989) provide the first steps in this direction by considering the relevance of the Cobb-Douglas frontage and depth rules for valuing land. Kowalski and Colwell's results show a pronounced concave depth rule as well as a concave frontage rule on data from the Detroit area between 1975 and 1983. Colwell and Scheu's results show pronounced concave depth rules but possibly linear frontage rules in Champaign-Urbana, Illinois between 1970 and 1974 as well as in Bloomington-Normal, Illinois between 1975 and 1982. The similarities of the magnitudes of frontage and depth elasticities across these studies, and between these studies and the present study, suggest that site valuation rules have relevance across time and space. However, more empirical work is needed to truly demonstrate the stability of these relationships.

## References

Asabere, P. K., The Price of Urban Land in a Chiefdom: Empirical Evidence on a Traditional African City, Kumasi, *Journal of Regional Science*, November 1981, 21, 521–39.

———, The Determinants of Land Value in an African City: The Case of Accra, Ghana, *Land Economics*, August 1981, 57, 385–97.

——— and P. F. Colwell, Zoning and the Value of Urban Land, *Real Estate Issues*, Summer/Spring 1984, 9, 22–27.

———, A Relative Lot Area Hypothesis: An Empirical Note, *Urban Studies*, August 1985, 22, 355–57.

Asabere, P. K. and F. E. Huffman, Zoning and Industrial Land Values: The Case of Philadelphia, *AREUEA Journal*, Summer 1991, 154–60.

———, Historic Districts and Land Values, *Journal of Real Estate Research*, Spring 1991, 6, 1–7.

Bonbright, J. C., *The Valuation of Property*, New York: McGraw-Hill, 1937.

Brownstone, D. and A. DeVany, Zoning, Returns to Scale, and the Value of Undeveloped Land, *Review of Economics and Statistics*, November 1991, 63, 699–704.

Chicoine, D. L., Farmland Values at the Urban Fringe: An Analysis of Sales Prices, *Land Economics*, August 1981, 57, 353–62.

Clar, H. F., *Appraising the Home*, Englewood Cliffs, N.J.: Prentice-Hall, 1936.

Colwell, P. F. and R. E. Cannaday, Optimization of Subdivision Development, *Journal of Real Estate Finance and Economics*, June 1990, 3, 195–206.

Colwell, P. F. and T. F. Scheu, Optimal Lot Size and Configuration, *Journal of Urban Economics*, July 1989, 26, 90–109.

Colwell, P. F. and C. F. Sirmans, Area, Time, Centrality and the Value of Urban Land, *Land Economics*, November 1978, 54, 514–19.

———, Non-Linear Urban Land Prices, *Urban Geography*, April–June 1980, 1, 141–52.

Davies, W. E., Technical Information for Real Estate Experts, *Diary of the Real Estate Board of New York*, 1912, 54, 156–61.

Dilmore, G., Size Adjustment Tables, *Real Estate Appraiser*, May–June 1976, 42, 23–27.

———, Land Size Adjustments, *Right of Way*, May 1976, 23, 44–45.

———, *The New Approach to Real Estate Appraising*, Englewood Cliffs, N.J.: Prentice-Hall, 1971.

Hoffman, M., *A Digest of the Charters and Statutes of and Relating to the Corporation of the City of New York*, New York: Edmund Jones and Co., 1966.

Hurd, R. M., Principles of City Land Values, in *Real Estate Record and Guide*, New York: RERA, 1924.

International Association of Assessment Officers, *Assessing and the Appraisal Process*, Chicago: Chicago Press, 1973.

Knowles, J. and J. E. Pervear, *Assessors Real Estate Appraisal Manual*, Northeast Harbor, Maine: Knowles and Associates, 1964.

Kowalski, J. G. and P. F. Colwell, Market versus Assessed Values of Industrial Land, *AREUEA Journal*, Summer 1986, 14, 361–73.

Kowalski, J. G. and C. C. Paraskevopoulos, The Impact of Spatial-Temporal Interactions on Industrial Land Values, *Urban Studies*, August 1991, 28, 577–83.

Kuehnle, W. R., *Valuation of Real Estate for Ad Valorem Tax Purposes*, Chicago: Chicago Press, 1954.

McMichael, S. L., *McMichael's Appraising Manual*, Englewood Cliffs, N.J.: Prentice-Hall, 1951.

———, Depth Tables, *Journal of the American Institute of Real Estate Appraisers*, 1935, 430–41.

Mills, E. S., The Value of Urban Land, in H. S. Perloff, editor, *The Quality of the Urban Environment*, 229–53. Baltimore: Johns Hopkins, 1971.

Pollock, W. W. and K. H. Scholz, *The Science and Practice of Urban Land Valuation*, Philadelphia: Manufacturers Appraisal Co., 1926.

Real Estate Record Association, Real Estate Building and Architecture in New York City, in *Real Estate Record and Guide*, New York: RERA, 1898.

———, *Real Estate Record and Guide*, New York: RERA, 1880–1884.

Ring, A. A., *The Valuation of Real Estate*, Englewood Cliffs, N.J.: Prentice-Hall, 1970.

Spengler, E., *Land Values in New York*, New York: Columbia University Press, 1930.

Todd, C. L., Depth Tables, *Assessors Journal*, October 1971, 37–54.

Waring, G. E., *Social Statistics of Cities*, Part 1, New England and the Middle States, Washington, D.C.: Government Printing Office, 1886.

Zangerle, J. A., *Principles of Real Estate Appraising*, Cleveland: McMichael Publishing Co., 1927.

*This research was funded, in part, by grants from the Office of Real Estate Research at the University of Illinois, Urbana-Champaign.*

PRACTICE BRIEFING

# Apportionment in property valuation: should we separate the inseparable?

Dave Hendriks
*Jones Lang LaSalle, The Hague, The Netherlands*


## Abstract

**Purpose** – Property valuers are often asked to allocate portions of the market value of a property to parts of the subject property. This paper aims to illustrate that the market value of a property cannot be divided into a market value for the land and a market value for the improvement.

**Design/methodology/approach** – Apportionment methods that exist in practice are briefly addressed and shortcomings are identified. Also theory that was developed for valuation and apportionment purposes is discussed and evaluated. From a combination of theory and practice conclusions are drawn and recommendations are made.

**Findings** – The combination of theory and practice show that the existing apportionment methods are unreliable tools for property analysis. Some suggestions are made concerning tools that might replace apportionment in property analysis.

**Practical implications** – Apportionment plays an important role in property investment and finance decisions. Due to the International Financial Reporting Standards (IFRS) apportionment will have a strong role to play in financial reporting and through this it will influence management and investment decisions indirectly. This paper shows that apportionment methods are not reliable and that important decisions should not be based on results from apportionment methods. Valuers should no longer supply these apportionments unless the client fully understands the shortcomings of the method used. On the other hand, clients, their advisors and auditors should no longer ask for value apportionments, as there are far more reliable alternatives.

**Originality/value** – The property profession has been struggling with apportionment theory for years. At this time IFRS introduces a strong need for value apportionment. Therefore, this is the time for the property profession to thoroughly investigate the shortcomings of existing apportionment methods and to come up with alternatives. This paper is an attempt to do just that.


**Keywords** Asset valuation, Property, Real estate

**Paper type** Conceptual paper

## 1. Introduction

Companies with interests in property have various reasons to obtain insight in the value components of a property. One reason can result from tax-related issues. Companies often write off buildings by basing their calculation on the value of the improvement disregarding the value of the land. This method relies on the assumption that land does not wear out and does not need to be written off. Another reason to analyse a property and establish a division between the value of land and the value of improvements arises when determining the risk structure of the investment. Many investors have found that land investments involve different risks than investments in improvements. Therefore, owners and capital lenders have often sought for clarity

Journal of Property Investment & Finance
Vol. 23 No. 5, 2005
pp. 455-470

1463-578X
DOI 10.1108/14635780510616043

about what part of their capital is invested in buildings and what part is invested in land.

Currently the International Accounting Standards Board (IASB) is debating whether IAS 17 should include directives to split property leases into a part for land and a part for building. Although this might not directly be a valuation issue, many of the same issues arise.

In many different ways the notion that property merely consists of land and building and that therefore value can be structured in the same manner asserts its influence on today's economy.

### *1.1 Aim of the paper*

This paper focuses on the question whether the market value of a property can be split into a value for land and a value for the building. One of the issues that arise is what the difference is between land value and the portion of the market value that can be allocated to the land. That even raises the question of whether land value is the same as the value of a site.

Another fundamental difficulty is how to look at a building without land. A first thought might be to compare the value of the building without land to the value of a building on land that is owned by another party[1]. However, this would transfer some qualities of the land to the building, as its location is a quality of the land and not a quality of the building.

To address these issues, first some property valuation background will be discussed. Then I give an inventory of apportionment methods that are used in the European property market. In addition I have summarised my attempts to apportion property value through the allocation of cash flows. After this summary of practical approaches, apportionment theory is addressed. Finally I have translated my findings into suggestions, in an attempt to contribute to standardisation.

## 2. Background

### *2.1 Property valuation*

*2.1.1 Definitions*. Current valuation practice finds its roots in 18th and 19th century classical economics as formulated by Adam Smith, Ricardo and John Stuart Mill. The comparison between a good and what someone would be prepared to give up to obtain it, is what founds valuation analysis of today. The concept of a good that is traded for a certain price under certain conditions is our starting point. For the purpose of this paper I have adopted the definition of market value, as suggested by the International Valuation Standards Committee (IVSC) and as supported by the Royal Institution of Chartered Surveyors (RICS, 2003): the estimated amount for which a property should exchange on the date of valuation between a willing buyer and a willing seller in an arm's-length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently and without compulsion.

It is one thing to agree on a definition of market value. It is a completely other thing to agree on how to come to a market value. Over the last decades many valuation methods have been used and professional practice has ended up supporting a few of them, when it comes to market value. An important step that underlies these methods is the view that economic benefit can be measured by establishing a market rent[2]. Again the definition as suggested by the IVSC and as supported by the RICS was adopted in this paper (RICS, 2003): the estimated amount for which a property, or a space within a property, should lease (let) on the date of valuation between a willing lessor and a willing lessee on appropriate lease terms in an arm's-length transaction after proper marketing wherein the parties had acted knowledgeably, prudently and without compulsion.

*2.1.2 Discounted cash flow*. If market rent enables us to measure economic benefit during a certain period (the period of the lease), then a big step towards the market value of the property was taken. If, besides income, a reliable view of yearly costs related to the property can be obtained and one has a reasonable idea about the future development of income and costs, a net cash flow can be projected. This should include a sale or exit value of the property at some time. When a cash flow is prepared, the market value of the property can be found by calculating net present values for each cash flow item using an appropriate discount rate[3]. It is important to realise that a discount rate should be a result of the evaluation of risk that derives from the projected cash flows.

The discounted cash flow method is a very common valuation tool for investment property.

*2.1.3 Capitalisation*. As discounted cash flow calculations can be quite extensive and were extremely difficult to do before spreadsheets became a common good, a way to approach the discounted cash flow method in a simple manner was developed soon enough. Using initial yields, a capitalisation of gross or net income results in a value as well[4].

### *2.2 Apportionment*

When we discuss apportionment of market value there are two main concerns[5].

*2.2.1 Market evidence*. It is of fundamental importance to examine the consequences of the usage of the term market value. Market value was defined earlier, but the following crucial issue was not addressed. As apportionment requires the market value of a property to be split into a value of the land and a value of the improvement, it suggests that market values can be produced for these two components. That leads to the following difficulty: there may be a market for land that can deliver comparables for valuation of the land under consideration, but there is no market for buildings without land (or location). Therefore, a market value of a building without land, based on market evidence, is impossible to produce.

*2.2.2 Inseparability*. An essential quality of property is that the improvement and the land are inseparable. This is why it is not likely for property investors to invest in mobile homes or caravans. The inseparability is the reason for its own investment profile, based on land, the continuous process of optimisation of its use, lease agreements and other value influencing factors. The fact that a whole has a certain value, does not mean that the two parts that make up the whole add up to the same value. Especially when the two are inseparable. When a vase brakes in two, the two parts are not likely to amount to the same value as the vase as a whole.

## 3. Apportionment in practice

In international valuation practice, two apportionment methods can be distinguished. Both methods aim to divide the value of a property into a building portion and a land portion.

*3.1 Residual apportionment theory*

The most commonly used methods to apportion value into a building and a land portion are based on residual apportionment theory. This theory is based on the assumption that if one value portion (either land or building) is calculated, the rest of the value is the other portion. There are various methods that result from this. These methods can be divided into two groups. The first group of methods include the ones that start by calculating the value of the land and consider the rest to be the value of the improvement. The other group consists of the methods that start by calculating the value of the improvements and consider the rest to be the value of the land.

*3.2 Proportional apportionment theory*

As residual apportionment theory, proportional apportionment theory is based on the assumption that building and land together represent the total property. However, instead of calculating one portion and accepting the rest as the other portion, methods based on this second theory assume there to be a relationship between the value portion for the land and the value portion for the improvement. This means that ratios are used to find both value portions. This can be based on verifiable historic costs or market evidence like land values and building costs. Also simplified methods appear in the market, based on this theory. In some cases an estimated ratio or previously agreed ratios are used to find one of the two portions.

In order to discuss apportionment as it is practiced throughout Europe, I have made an inventory of methods and divided them into two groups. On one side there are methods that are based on the value of the improvement and consider the rest to be value of the land. On the other side there are methods that start with the valuation of land and name the remainder as value of the improvement. Below the methods are mentioned and commented on.

*3.3 Apportionment practice starting with value of improvements*

As buildings without land (or location)[6] simply are not traded on any market, the valuation of a "bare building" requires some creativity. To calculate the value of the land and simply labelling the rest as value of the building (as will be illustrated in the paragraph "Market apportionment practice starting with value of the land") is one way. Other ways are used in the market as well.

*3.3.1 Historic building cost*. Quite a simplistic way of finding a value for the building is see what the realisation of the building cost when it was built. These historic building costs, even when they are corrected for inflation, have most likely lost all relation with the current market value. There could have been many reasons for these costs to differ from the costs that would be involved in the realisation of the building at this moment or from the price one would be willing to pay for the building. Therefore, this method is unreliable and scarcely used for the purpose of finding the buildings contribution to the market value of the property. In Example 1 (Table I) an office building is used to illustrate this method.

*3.3.2 Replacement cost*. Instead of using historic building costs, it is more interesting to see what the costs are that are involved in the realisation of the building at this moment. At least this eliminates any incidental stroke of good fortune or unexpected financial setback that influenced the historic building costs, as well as, changes in prices and perhaps building methods and options. Important to realise, however, is that

| | |
|---|---|
| *Value total* | |
| Surface gfa | 1,200 |
| Ifa/gfa | 83.33 per cent |
| Surface lfa | 1,000 |
| Rent/$m^2$ | 200 |
| Rent | 200,000 |
| Gross yield | 8.00 per cent |
| Value | 2,500,000 |
| *Value improvement* | |
| Historic building cost | 1,200,000 |
| *Value land* | |
| Rest | 1,300,000 |

**Table I.**
Example 1: historic building cost

the use of this method could lead to the situation in which an old building that requires refurbishment in the near future ends up with a larger share of the market value than it deserves. This method is illustrated in Example 2 (Table II).

*3.3.3 Depreciated replacement cost*. In order to compensate for obsolescence the replacement cost can be adjusted for depreciation. If the value of the building would be based on the depreciated replacement cost[7] at least the contribution of the building to the market value of the property would decrease over time, which seems fair in the light of writing off and depreciation theory. In Example 3 the basics of this method are set out (Table III).

There is a great danger in using costs as a basis for valuation, as value is a completely different concept. However, as the only trade in buildings without land concern buildings yet to be realised, it does seem appropriate to use building costs as a reference. Furthermore, we must realise that this depreciation process is much more complicated than establishing a depreciation percentage per annum, a lifespan and an exit value. Buildings that are well maintained and have reached a certain age or have a certain specific quality may have added value. For example this appears to be the case for some monumental buildings or properties with an historical feel.

It must be said, therefore, that value development of a building is not automatically downward.

*3.3.4 Market value of a building on leasehold land[8]*. Some argue that, when a building is owned by one party and the land is owned by a second party, the market actually delivers comparables that could allow us to value buildings without land. When the owner of a building has the right to use the land of another party and is required to pay a market rent for that right, one could state that a purchaser would only buy the building without the land.

| | |
|---|---|
| *Value total* | |
| Value | 2,500,000 |
| *Value improvement* | |
| Surface gfa | 1,200 |
| Building costs/$m^2$ | 1,500 |
| Building costs | 1,800,000 |
| *Value land* | |
| Rest | 700,000 |

**Table II.**
Example 2: replacement cost

That seems to be true. However, the market rent that is paid for the right to use the land is based on market conditions. That means that if conditions differ from market standards, the value of the total is affected, without the value of the land being influenced. That results in an influence on the remainder, or the alleged value of the building. So a tenant in the building that pays a rent that is higher than the market rent, results in a higher value of the total, a stable land value and a higher value of the building. This method, therefore, supports the idea that changes in value due to tenancy agreements should be incorporated in the value of the improvement, even though there does not seem to be any reason for that assumption. More on this issue is stated in section 3.6.

*3.4 Apportionment practice starting with value of land*

*3.4.1 Land value*. As this paragraph deals with land values as a basis for apportionment, we will first have a look at the definition of land value. The term land value is used in different contexts. Land value can mean the market value of a plot of land. However, in that case the term market value would be more appropriate. The term land value ought to be used to refer to the value of a cleared and fully serviced site. Therefore, land value can be defined as follows: the market value, assuming that the site is cleared and fully serviced and that the property is not subject to any contract.

*3.4.2 Comparative land valuation*. This method to come to a value of land is very simple to use. It is based on the comparison of sites and the prices that have been paid for those sites. One way to compare the sites is to use a price per $m^2$ land. That way, a parcel of 200 $m^2$ that was sold for €40,000 can be a good reference for a neighbouring parcel of 150 $m^2$. The price per square metre can even be adjusted for individual differences.

A slightly more sophisticated comparative method is based on using prices that were paid for parcels of land, taking into account the development possibilities. This would result in a price per square metre gross floor area of the optimal development. For example a site that would enable the owner to build 1,000 $m^2$ of office space could be compared to a site that would allow 1,200 $m^2$ of office space. Using this method, not only the size of a parcel but also the planning conditions can be reflected. A simple illustration of this method is set out in Example 4 (Table IV).

As a method of land valuation it can be difficult to use if it is hard to find comparable land transactions, as each parcel has its own unique possibilities. As a method of apportionment, the main issue is whether the market value of the total property less the thus calculated value of the land would result in a value for improvement. And on what use would the calculated land value be based? Would one

| | |
|---|---|
| *Value total* | |
| Value | 2,500,000 |
| *Value improvement* | |
| Replacement cost | 1,800,000 |
| Depreciation | 800,000 |
| Department replacement costs | 1,000,000 |
| *Value land* | |
| Rest | 1,500,000 |

**Table III.**
Example 3: depreciated replacement cost

base the calculation on the current use as optimal use, or would it be better to base the calculation on the real optimal use? I will address this issue later in this paragraph.

*3.4.3 Residual land valuation*. Residual land valuation is often used to calculate the land value. This method is based on the assumption that land is purchased in order to develop it. With that in mind, land value is simply calculated by predicting the sale revenues and subtracting all development costs. As the development costs include development profits, the amount that remains is the maximum amount that can be paid for the land[9]. This land valuation method reflects the fundamentals on which property valuation and the theory of land economics are based. An important disadvantage of this method is that it is very difficult to use, as slight changes in input result in substantial changes in output. As an apportionment tool, the same issue applies as for comparative land valuation. A straightforward illustration of this method is set out in Example 5 (Table V).

*3.4.4 Land valuation as an apportionment tool*. In some cases the contribution of land to the market value of the property is quite clear. This is the case when the land is developed optimally or if there is nothing that stands in the way of optimal development[10]. Optimal development is achieved when the development that underlies the residual land valuation is actually realised. When such a development is completed, the market value less the building costs equal the land value. It can be argued that the value of the building then equals the building costs. If only part of the optimal development is realised and the rest can simply be added to the existing structures, optimal development can still be achieved without endangering the land's contribution to market value. Land's contribution to market value is also clear when the property needs redevelopment and all improvements should be demolished. The market value of the property is then a result of the land value and the demolition costs. Therefore, if the land value is subtracted from the market value, the value of the building will be negative and equal the demolition costs. We can conclude that, as long as the optimal development underlies the market value, land's contribution to market value actually equals land value.

Other situations may arise. It is possible that land value does not automatically equal the land's contribution to the market value of the property. When optimal development of land requires demolition of buildings that are far from obsolete, the loss of capital can be too high for this scenario to be the most profitable. The highest value[11] is achieved when the existing building is retained, even though the possibilities offered by the land are not fully utilised. There is a method that enables the use of a residual land valuation in establishing the apportionment of market value between land and buildings. If the calculation of the land value is done using the assumption that the existing building is the optimal development for the land, a value results that reflects the contribution of the land in the actual market value. It remains true that the land offers more than currently utilised, but the fact is that optimal development is economically impossible because the

| | |
|---|---|
| *Value total* | |
| Value | 2,500,000 |
| *Value land* | |
| Price comp. site | 1,200,000 |
| *Value improvement* | |
| Rest | 1,300,000 |

**Table IV.** Example 4: comparative land valuation

| | |
|---|---|
| *Value total* | |
| Value | 2,500,000 |
| *Value land* | |
| Surface gfa | 1,600 |
| lfa/gfa | 83.33 per cent |
| Surface lfa | 1,333 |
| Rental value/m$^2$ | 225 |
| Rental value | 300,000 |
| Gross yield | 7.50 per cent |
| Value let | 4,000,000 |
| Void | 150,000 |
| Value void | 3,850,000 |
| Realisation costs | 2,400,000 |
| Land | 1,450,000 |
| *Value improvement* | |
| Rest | 1,050,000 |

**Table V.**
Example 5: residual land valuation

land is polluted[12] with a less than perfect improvement. This leads to the need for utilised land value, which can be defined as follows:

The land value, assuming that existing improvements equal the optimal improvements for the land under consideration. In practice the comparison between an optimal improvement and an existing improvement is quite complicated to make. A difficulty using this method is that utilised land value is calculated based on a new development, since land value is based on the possibility to realise a new development on the site under consideration. This means that rental values for a new development are used and that a yield is used that would be appropriate for a new development. The calculation also does not take into account existing leases. Therefore, it should be decided in what manner an existing improvement is comparable to a new development and in what way the two situations differ as there are value components other than land or improvement that influence the market value of a property. Please see in Example 6 (Table VI) how this method can lead to a different outcome from the one resulting from the method as set out in Example 5.

| | |
|---|---|
| *Value total* | |
| Value | 2,500,000 |
| *Value land* | |
| Surface gfa | 1,200 |
| lfa/gfa | 83.33 per cent |
| Surface ifa | 1,000 |
| Rental value/m$^2$ | 200 |
| Rental value | 200,000 |
| Gross yield | 8.00 per cent |
| Value let | 2,500,000 |
| Void | 100,000 |
| Value void | 2,400,000 |
| Realisation costs | 1,800,000 |
| Land | 600,000 |
| *Value improvement* | |
| Rest | 1,900,000 |

**Table VI.**
Example 6: utilised land valuation

*3.5 Value contribution by other components*

Apportionment of value between land and improvements suggests that these two components are responsible for the total value of a property or that additional components can be appointed to one or the other. Even though the list of value influencing factors is endless, as indicated above, there are several important factors that do not just influence the value of improvements or the value of land.

*3.5.1 Planning*. The restrictions that result from planning regulations have an influence on the value of property. The regulations might restrict the height of a development, it might set a maximum gross floor area to be developed or limit the use of a site to (for instance) industrial use. These restrictions often have a negative effect on the value of a site. On the other hand, the fact that the use of a neighbouring site is limited as well might have a positive effect on the value of a site. That will depend on whether the neighbouring site would be used for competitive purposes or for supportive purposes. The influence of planning on the value of a property is easily regarded as site related, as the site carries the restrictions. However, in setting the restrictions often the current use of the site and its environment is kept in mind. For example existing buildings are often considered in city planning. It would be very difficult to decide what the influence of local planning is on the value portion of the land and to the value portion of the building. One could, therefore, argue that planning can be a value factor by itself.

*3.5.2 Monumental status*. Local legislation that provides monumental status to a property obviously influences the value as well. A less than optimal improvement that would be fit for redevelopment in economical sense might be kept from redevelopment by monument legislation. If a monumental building is protected from alterations, the land value of the site cannot be fully utilised, since the optimal development cannot take place. It is possible that a monumental property has a total value that is less than the land value alone. In that case it could be argued that the value of the improvement is negative. This could also lead to the conclusion that the building has a value, but that the monumental status itself is a negative value factor. However, there are countries in which the owners of monumental buildings can apply for subsidies and tax advantages, which could lead to a positive influence on the value.

*3.5.3 Lease*. In the valuation of investment property, leases are an important part of the equation. The valuation of a vacant property is based on its ability to produce rent in the future. This ability is based on market references. Therefore, such a valuation will be based on market rents and market conditions. If there is an existing lease agreement and the rent and other conditions differ from market standards, it might lead to a change in value. It will often be impossible to find out why a different rent was agreed than to be expected and if you can find out, it is often impossible to decide for what part the building was responsible for that and to what extent it was a land issue. Leases, therefore, can be considered as separate value factors that cannot be split into a land and a building part[13].

*3.5.4 Others*. As discussed in Section 3.6 there are many components that make up an investment in property. Many of these are not just land or building aspects. Separating all aspects that cannot be appointed to one or the other from the value before apportioning it, leads to a very theoretical exercise that can never be done correctly and that will not lead to a workable answer in the end. I consider this to be another way not to go.

*3.6 Allocation of cash flows*

As value of investment property is based on the assessment of cash flows, it seems logical to search for an apportionment solution in the cash flow structure. In order to split the value in a land and a building element based on cash flow allocation, all value influencing factors should be appointed to one or the other, or logically divided between the two. Since, investors are a strong buying force on the commercial property market, it is fair to say that property value originates from the expected cash flow that derives from the property.

The largest cash flow element is often rental income, deriving from lease contracts. If a split in value should be accomplished, this cash flow element needs to be apportioned between land and building.

If the rental value of a building would be split up into many different aspects for which a tenant would be willing to pay rent, these aspects could be appointed to either land or building. Aspects like the pleasant environment, the accessibility of the site and the presence of various services in the area increase the rental value and can clearly be appointed to the land. Then things like excellent climate control, a prestigious appearance and a profitable relationship between lettable and useful floor area increase the rental value as well and are unmistakeably caused by the building. Having said this, the amount that each aspect is responsible for will be very hard to come up with, since combinations of different aspects might influence the impact of a single aspect and small variations in the many little amounts might lead to rents that simply do not apply.

Another difficulty that should not be overlooked is the following. Current rental income often differs from the estimated rental value. It is the result of past negotiations between the property owner and the tenant, perhaps increased by a few indexes. This difference (a positive or a negative topslice) cannot really be appointed to one or the other, without knowing the ins and outs of the negotiations that led to that rent.

Many maintenance costs seem to be fairly easy to appoint, for building repairs clearly have to do with the improvement rather than the land. However, since land value is created through the development possibilities for a site, land value allows for future maintenance. The location of a property has not only effect on building costs, but also on the costs of maintenance. Fore maintenance might involve different costs in Poland than in London and a building on quicksand involves much more maintenance than a building on clay. Does that justify appointing part of the maintenance costs to the land?

An unimproved site can have a rental value as well. However, a capitalisation of this rent will rarely be higher than the land value based on development. If it is, then development would not be improvement and the optimal use would be to leave it unimproved. If the site is developed, the capitalised rental value of that site in unimproved state is not likely to have any relation with the land value.

I believe it is fair to conclude that attempts to allocate cash flows do not contribute towards a solution.

## 4. Apportionment in theory

*4.1 Rust*

Rust (1996) described three methods for calculating land value. For these methods he uses the assumption that the value of the property ($V_p$) equals the value of the land ($V_l$)

plus the value of the improvement ($V_i$). That could be represented as follows.

$$V_p = V_l + V_i$$

This formula represents the assumption that the values of two parts (land and improvement) simply equal the value of the combination.

*4.2 Kruijt*

B. Kruijt published formulas for the valuation of property (Kruijt, 1989), based on the assessment of future net income during an exploitation period, an exit value for the land and an exit value for the improvement. Underlying this formula there is the assumption that the value of a property equals the value of the land plus the value of the improvement, as the formula uses an exit value that exists of inflated land value and depreciated improvement value. Knowing that determining an exit value is merely a theoretical exercise, this approach might be as effective as any other. However, the suggestion that land value increased by depreciated improvement value equals the total value of the property does not add up theoretically. It suggests that net income from an investment in property decreases as a building ages and increases as land value goes up. One of the most important factors in investment property valuation is disregarded, namely the lease contract(s). Facts as that the realisation of a long lease results in less risk and, therefore, in a lower yield and that an actual rent that differs significantly from the estimated rental value influences the value are disregarded in the equation.

Besides the valuation formula, he formulated an equation that states that the total value of a property at time $t = 0$ ($P_0$) equals the value of the land at time $t = 0$ ($G_0$) plus the value of the improvement at time $t = 0$ ($Ge_0$). He formulated it as follows:

$$P_0 = G_0 + Ge_0$$

At first sight, the formula does not differ much from the one formulated by Rust. However, the time element does contribute somewhat. If we would set $t = 0$ at the moment of realisation, the formula would make sense. If the above just calculates the value upon realisation, the problems concerning changes in land and improvement values like depreciation and land value increase hardly exist any longer. There is only the realisation period in which markets may influence land value or building costs. And the latter will only have effect on the equation if we agree that the value of an improvement will be based on the costs that are involved in replacing it on the market for built improvements or the market for unbuilt improvements alike. Since, most realisation periods are much shorter than most exploitation periods, these changes have significantly less influence in this equation and can be disregarded for the purpose of this discussion. If we believe that land value can be calculated as a residual from the total value and the costs involved in realisation of the project, this formula can be accepted. It does not take into account leases in any way, but for a newly developed property this is not necessary. Even when we realise that often properties are pre-let, the assumption that a building will be delivered to a purchaser in a vacant state is quite realistic. If necessary, the valuation can be adjusted for the lease afterwards. It is the added value of a lease, among other things, that is impossible to split between land and improvement.

Besides lease contracts there is another factor that complicates Kruijt's equation. The improvement might not be the optimal improvement for the land. If the land value is based on the optimal improvement and a far from optimal improvement was realised, the improvement might have a negative value influence.

*4.3 Marshall*

Even in 1890 the problem of mismatch between a site and its improvement was recognised in apportionment theory. A. Marshall argues that it is quite reasonable to split the rent for a total property into an annual site value and an annual building value, based on the costs of the land and the costs of constructing the building (Marshall, 1910). He uses a "current rate of income" to capitalise rents and arrive at a value. This would result in value portions. However, he realises that this can only work if the improvement remains appropriate to its site. As an example he uses a residential plot on which a warehouse might be needed. He does not mention all the other ways in which the exact fit of an improvement and its site might change. Nor does he tackle the problem of a total rent that does not equal the normal return for the site and its improvement.

*4.4 Changes in suitability of improvement*

If we accept the notion that we can define the optimal development for a site, we should realise that the moment the improvement is developed and starts to age, it will move away from being the optimal development. This does not just happen because of changes in development possibilities, but also because of the simple fact that the building becomes old and out of date. A few examples are shown to illustrate this point. Please note that these examples are based on the assumptions that no repairs of any kind take place.

The effect of for instance aging on the suitability of a building on its site is shown in Figure 1. The suitability of the building on its site will drop over time, assuming that no additional investments will take place to compensate for the wearing out of the building. The suitability will drop to zero, as in the end the site will have to be cleared in order for it to be redeveloped. The suitability will not go below zero. Mostly a property will be invested in through repairs and renovation. When its suitability drops, a property is likely to be redeveloped before its suitability actually drops to zero.

Figure 2 again shows the effect of aging on the suitability of a building on its site. In addition, it shows what happens to the suitability when it becomes possible to develop more building(s) on the site under consideration. The improvements that were realised in the past no longer represent a close to optimal development. This results in a decrease of the suitability of the building. Also the time until the moment at which it becomes economically feasible to demolish the existing building and replace it by a new optimal development is likely to decrease.

Finally, Figure 3 shows what happens when the optimal development of a site changes in such a way that it immediately becomes feasible to demolish the existing building and redevelop the site. The total value of the property, in that case, exists of the land value (taking into account the optimal development) less the demolition costs of the current building. This means that a change in zoning can cause an immediate obsolescence of a perfectly good building.

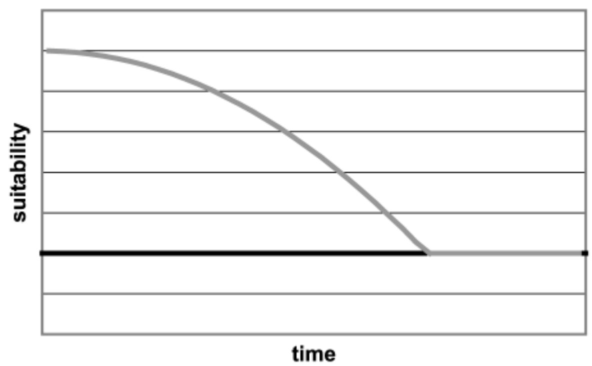



Figure 1.

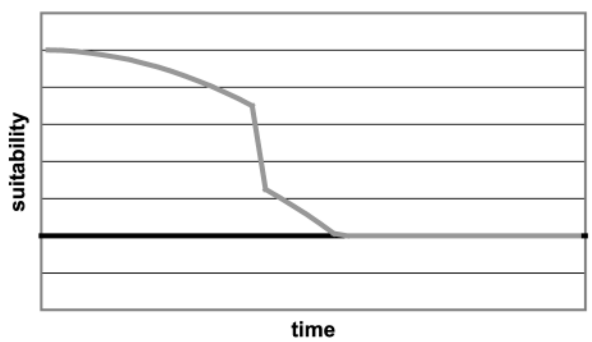



Figure 2.

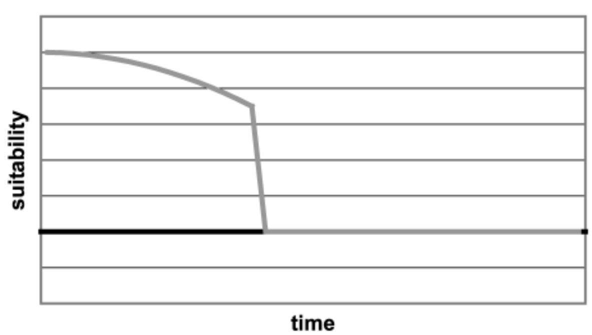



Figure 3.

If we accept the development of the suitability over time, it becomes clear that Marshall's view on the impossibility to apportion value to the improvement and the land becomes relevant at an earlier stage than he suggested. Not only a big change in development options brings this problem about, but also the simple effects of aging result in this impossibility.

## 5. Recommendations

### *5.1 International financial reporting standards*

For financial reporting purposes, there does not seem to be a need to split leases or other interests in property into a land and an improvement part. Whether a property lease qualifies as an operational or a financial lease can be assessed much better when it is based on the total property than when it is on the basis of apportioned value parts.

### *5.2 Bank valuation*

When a valuation is needed for bank lending or other finance purposes, often apportionment is requested. Since, no two seem to agree on one commonly used apportionment method, it is obvious that all valuers will use different methods and often come up with different numbers. A bank, therefore, will base lending decisions on unreliable value analysis. In this paper I hope to have shown that there is not one way to perform apportionment and that one should even doubt whether apportionment is theoretically possible.

In order to be able to produce reliable advise for lenders and finance professionals another product can be offered. If a bank knows what the land value of a site is, and it can be made transparent what the current utilisation of that land value is, a bank has much more information than when an apportionment is reported. This is the purpose of the utilisation ratio. The utilisation ratio ($u$) equals utilised land value ($V_{\mathrm{lu}}$) divided by land value ($V_{\mathrm{l}}$). This is shown below.

$$u = \frac{V_{\mathrm{lu}}}{V_{\mathrm{l}}}$$

This delivers insight in the optimisation that has been achieved through development of the site. This utilisation ratio alone does not give insight in the dimensions of value destruction. If $u = 1$, the site is fully improved or optimised. If the ratio is rather low, it is important to know whether the site can be further improved without having to destroy valuable improvements. There might be enough room to further develop towards the optimum without having to demolish existing structures. In order to gain insight in the way in which that extra development land adds value to the total property, the utilisation option is defined. Utilisation option ($o$) equals the land value of those parts of the site that can still be improved ($V_{\mathrm{li}}$) divided by the total land value of the site ($V_{\mathrm{l}}$). This equation is shown below.

$$o = \frac{V_{\mathrm{li}}}{V_{\mathrm{l}}}$$

When $u + o = 1$, no value has been lost through poor development. In that case part of the site is well developed and the rest of the site is still suitable for development. If $u + o < l$, value was lost through less than optimal development. It theory the value is there, but cannot be disclosed without value destruction. This latent land value ($V_{\mathrm{ll}}$) can be calculated by multiplying the land value by the land value latency ratio. This is written as follows.

$$V_{\mathrm{ll}} = V_{\mathrm{l}} \times l$$

As a result the latent land value ratio ($l$) can be calculated as well. It equals the difference between the sum of $u + o$ and 1. This is summarised in the following equation.

$$u + o + l = 1$$

The ratios as mentioned above should give property stakeholders objective insight in land and improvements and how these influence current value.

## Notes

1. In The Netherlands this is a common situation for some municipalities have sold leasehold interests in land, a perpetual right to use the land for a yearly rent (in Dutch: erfpacht).
2. An introduction to the concept of rent as a surplus can be found in Fraser (1993).
3. For an introduction to the calculation of net present values, to the concept of discounted cash flows or to discount rates see for instance Brealey and Myers (2000).
4. An extensive introduction to various capitalisation methods can be found in Have (1993).
5. These were also addressed by the RICS in their response to the International Accounting Standards Board of 13 September 2002 regarding IAS improvements. This response can be found on www.rics.org.uk.
6. It is important to realise that a building without land does not have a location either! This results in difficulties concerning market rent and yield comparables.
7. A definition of Depreciated Replacement Cost and accompanying commentary can be found in Royal Institution of Chartered Surveyors (2003).
8. This refers to the Dutch land leasehold (erfpacht) system.
9. For a more detailed introduction to residual land valuation I refer to Issac (1996).
10. In this paper no allowances are made for taxes that disturb economic theory. For this specific example I have not taken into account Dutch purchasing tax that would be payable on a property after first use had commenced and would not be payable on development land. These rules differ from country to country and adding them to the equation does not seem to help the analysis forward.
11. "Highest value" sounds like there could be more market values. Obviously there is only one market value. What is meant here is that different cash flow scenario's in combination with a proper discount rate could lead to different values, indicating which scenario would be most profitable to pursue.
12. In this context I mean economic pollution. All changes to the land can be categorised as either improvement or pollution. Adding value to the land would then be improvement and lowering the value of the land can then be called pollution.
13. I realise that the International Accounting Standards Board is proposing to do just that in IAS 17. For the purpose of deciding whether a lease is a financial or an operational lease, IASB suggests to split a lease into a building and a site portion. Each lease "part" should then be evaluated separately.

## References

Brealey, R.A. and Myers, S.C. (2000), *Principles of Corporate Finance*, McGraw-Hill Higher Education, Boston, MA.

Fraser, W.D. (1993), *Principles of Property Investment and Pricing*, Macmillan, London.

Have, G.G.M. (1993), *Taxatieleer onroerende zaken*, Stenfert Kroese, Houten.

Isaac, D. (1996), *Appraisal and Finance*, Macmillan, London.

Kruijt, B. (1989), "De waardering van grond en gebouwen", *Economische Statistische Berichten*, March.

Marshall, A. (1910), *Principles of Economics: an Introductory Volume*, Macmillan, London.

Rust, W.N.J. (1996), "Methode voor berekening waarde grond vaak gebaseerd op onzin", *Vastgoedmarkt*, February.

The Royal Institution of Chartered Surveyors (2003), *RICS Appraisal and Valuation Standards (5th edition) – Practice Statement 3*, London.

## Further reading

Berhout, T.M. (2002), *Fiscaal afschrijven op vastgoed*, Kluwer, Deventer, Naarden.

Cadman, D. and Topping, R. (1995), *Property Development*, E&FN Spon, London.

de Kousemaeker, F.J.M. (1998), *Praktijkaspecten vastgoed; leidraad voor studie en praktijk*, Samson, Alphen aan den Rijn.

Harvey, J. (1998), *Urban Land Economics*, Macmillan, London.

International Accounting Standards Board (2002), *International Accounting Standards 2002*, IASB Publications Department, London.

Needham, B. *De waarde van grond, bebouwd en onbebouwd*, Waardebepaling Vastgoed.

Needham, B. (1996), "The valuation of building leases on developed land", paper presented at the Third Conference of the European Real Estate Society, Belfast.

Ratcliffe, J. and Stubbs, M. (1996), *Urban Planning and Real Estate Development*, UCL Press, London.

Rees, W.H. (1992), *Valuation: Principles into Practice*, 4th ed., Estates Gazette, London.

Royal Institution of Chartered Surveyors (1995), *RICS Appraisal and Valuation Manual – Practice Statement 4*, 4th ed., RICS Business Services Limited, London.

Royal Institution of Chartered Surveyors, *Response to the International Accounting Standards Board of 13 September 2002 Regarding International Accounting Standards improvements*, available at: www.rics.org.uk

Rust, W.N.J., Seyffert, F., den Heijer, A.C. and Soeter, J.P. (1997), *Vastgoed financieel*, Management Studiecentrum, Vlaardingen.

Van Horne, J.C. and Wachowicz, J.M. Jr (2001), *Fundamentals of Financial Management*, Prentice-Hall, Upper Saddle River, NJ.