Examining Patterns in and Drivers of Rural Land Value

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Abstract

It has been claimed that rural land is overvalued, relative to the profitability of the land in agricultural production. This focus on the earnings potential of the land, while important, fails to consider the non-agricultural specific drivers of rural land values, such as amenity value or the value of a long-run conversion option. We provide a simple test of a Ricardian model of rural land values in New Zealand over the period 1980-2012. A Ricardian model stipulates that the value of rural land is equal to the present value of expected future rents from land ownership. We interpret rents to include the changes in land values due to changes in the market price of amenities and changes in the value of the long-run conversion option. We find no evidence that the price of rural land overreacts to changes in expected profitability – we cannot reject the hypothesis that this relationship is one-for-one when we allow for the possible influence of amenity and option values. Our findings do not support the idea that actors in the market for rural land act irrationally.

JEL codes

Type codes

Keywords

Rural land values; Ricardian model; agriculture;

Contents

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1. Introduction

"One of our most important sectors, agriculture, appears to be one of our least commercially rational." (Gawith 2010). If this quote from a New Zealand Herald article is true, the implications would be profound. The article goes on to suggest that New Zealand's farms are overpriced, relative to the income that can be generated from farming. This would suggest a gross misallocation of one of our most important economic resources – rural land.

Other authors, such as (Hargreaves and McCarthy 2010), have also suggested that rural land in New Zealand is overvalued relative to earnings potential. They predicted a downward adjustment was forthcoming. This certainly occurred during the Global Financial Crisis, but farmland prices have resumed their upward trend during the recovery phase. (Eves and Painter 2008) also questioned the sustainability of the growth in rural land prices over the early 2000s. They found that the price earnings ratio of farmland in New Zealand was more than twice that of Australia, one of the only other developed economy with minimal or nil support for the agricultural sector. They expressed doubt that agricultural profitability could grow fast enough to justify the price of the land.

As well as being a critical input into agricultural production, rural land is also a key asset in New Zealand. The total value of rural land in the year ended 30 June 2013 that we include in our sample is over $54 billion, compared to the total market capitalisation of the NZX at the end of 2013 was around $80 billion. Given the importance of rural land in New Zealand, it seems surprising how little attention it has received in the academic literature.

Aside from the two studies listed above, which use simple techniques and calculations, most of the analysis of rural land values in New Zealand has examined cross-sectional variation. (Stillman 2005) estimated hedonic equations to examine the cross-sectional drivers of the changes rural land values between 1989 and 2003 across space. His findings showed that land values increased most in less populated areas with comfortable climates and a higher level of local amenities. Somewhat surprisingly, he found that although the distribution of land uses had changed over the study period, this was essentially uncorrelated with changes in land values. Land use is largely determined by the productive characteristics of the land, and the changing economic context in which these decisions occur (e.g. commodity prices, input prices, technological advances). (Grimes and Aitken 2008), also using hedonic analysis, estimated the value of irrigation rights in the MacKenzie District in central Canterbury – a farming region that is prone to drought. Irrigation rights are attached to the farm; when a farm is sold, the right to water is sold as well. The authors found that farms with water rights received a larger price premium if the land was flat with poorly draining soils, the land was drier, and the farm is located closer to a town.

(Brower, Meguire, and DeParte 2012) showed evidence of the third potential driver of rural land values – a real option value. They examined the process of tenure review for the South Island pastoral leases. South Island pastoral leases are large extensive pastoral properties, which were owned by the crown and leased to farmers. Since 1992, the leaseholders have been able to apply to purchase part of their lease, while ceding the balance to the conservation estate. During the tenure review process, the Crown sold over 100,000 hectares (ha) of land for $6.9 million. Less than half of this land was then sold by the new freeholders for over $135 million. The authors conclude that the process of tenure review gave rise to significant rents, as the new freeholders sold their newly acquired land for subdivision.

Of the three papers discussed above, only (Grimes and Aitken 2008) consider the role of agricultural specific factors in driving rural land prices – namely irrigation rights. We complement the existing literature on the drivers of rural land values in New Zealand by examining the relationship between agricultural profitability and rural land values over time, allowing for amenity values and option values to also influence values. Our analysis also complements that of (Grimes and Hyland 2013), who showed that agricultural commodity price shocks significantly affect urban house prices, and that this house price impact is larger than the impact in rural areas. Our analysis focuses on how movements in profitability are reflected in the price of rural land.

We do this by estimating an equilibrium relationship between the per hectare sale price of rural land and the present value of expected future profits from agricultural production over the period 1980-2012. To control for factors that systematically affect the amenity or option value of the land, we include a linear time trend. Our empirical model is consistent with a Ricardian model of land values, where the value of land is equal to the present value of expected future rents from rural land ownership. This includes the returns from agricultural production, as well as the rents that flow from amenities and option values. To get a better understanding of the relationship between exogenous, permanent shocks to agricultural profitability and rural land values, we also estimate IV regressions, using agricultural commodity prices isolate the exogenous variation in profits that affect a farmer's expectations about the future.

Our results are in line with a simple Ricardian model of rural land values. Profits alone explain around 10% of the variation in land values over the period; this raises to 20% when the profit series also reflects changes in land use over the period. In our main specifications, we find a strong, positive and proportional relationship between the present value of profits and the per hectare sale price of rural land over the period. The different weighting schemes we apply to our profit series, time varying to reflect land-use change and fixed weight, allow us to do a simple decomposition of the trend estimate into growth we attribute to increases in the value of amenities and increase in the value of a long-run conversion option. Together, these factors increase land values by about 3.5% per year, with 2.5 percentage points of this due to growth in amenity values and the remainder due to growth in long-run conversion options.

The rest of the paper is structured as follows: Section 2 covers our Ricardian conceptual framework, while Section 3 outlines the empirical methodology (3.1) and data (3.2) used in this study. Results are present in Section 4, while Section 5 concludes.

2. Conceptual framework

A basic theory of rural land values relates the value of rural land to the profitability of the land in its highest and best use. This Ricardian theory posits that the value of rural land is equal to the sum of discounted expected economic profits (rents) from production (Capozza and Helsey 1989). This can be expressed formally as:

$$LV_{ijt} = \sum_{s=0}^{\infty} \frac{E\pi_{ij^*,t+s}}{(1+r)^s}$$

Where *i* denotes the land parcel and *j* denotes the land use. Profit is determined by a standard profit function:

$$\pi_{ijt} = p_{jt} Q_{ijt} - c_{ijt}(Q_{ijt})$$

Where p_{jt} is the output price of commodity *j* in time *t*, Q_{ijt} is the output of commodity *j* from land parcel *i* in time *t*, and c_{ijt} is the input cost of producing commodity *j* on land parcel *i* in time *t*. The input cost is expressed as an increasing function of output produced. * indicates that profit is maximised at each point in time by optimally choosing land use and the level of inputs.

Output, Q_{ijt}, is determined by an agricultural production function:

$$Q_{ijt} = f(A_{ij}, x_{ijt})$$

Where

$$Q_A > 0$$
$$Q_x > 0, Q_{xx} < 0$$

A_{ij} is the productivity of the land parcel *i* in producing commodity *j*, and x_{ijt} is a composite bundle of inputs used to produce commodity *j* on land parcel *i* in time *t*. Combining these equations gives the following expression for land values:

$$LV_{ijt} = \sum_{s=0}^{\infty} \frac{p_{j,t+s} f\left(A_{ij}, x_{ij,t+s}\right) - c_{ij,t+s}\left(f\left(A_{ij}, x_{ij,t+s}\right)\right)}{(1+r)^s}$$

This theory of land values does not assume that the land use, *j*, is constant through time. As output and input prices change, or as the productive characteristics of the land change (due to past management practices, increased drought due to climate change, introduction of new technology etc.), the highest and best use of the land will change. (Mendelsohn, Nordhaus, and Shaw 1994)) provide an explanation of this phenomenon using temperature as an example. As the average temperature in a region increases, the relative profitability of growing wheat declines, while the relative profitability of another activity (such as grazing livestock) increases. At some point, a rational land owner will switch land use when the benefits to switching (higher discounted future profits) outweigh the costs of switching (conversion costs and profit foregone). This can formally be expressed as:

$$j_t^* = \text{argmax}_\text{j} \left\{ \sum_{s=0}^{\infty} \frac{E\pi_{ij^*,t+s}}{(1+r)^s} : j \in \{\{D, SB, F, C, H\} \mid E_t(\boldsymbol{P}, \boldsymbol{A})\} \right\}, \forall \text{ t}$$

Where *D, SB, F, C, H,* denote dairy, sheep/beef, forestry, crops (arable), and horticultural uses, respectively. A land owner chooses the land use that maximises the stream of discounted future profits, given current expectations around future commodity prices (***P***) and the future suitability of land for different uses (***A***). Conversion costs mean that *j* may not be chosen to maximise *current* profits. Therefore, land values should reflect the profitability of the land in its highest and best use (and expected future use), even if the current land use is different.

This simple Ricardian theory of the value of rural land views land as a productive asset which is an input into the agricultural production function. However, rural land offers the land owner more than an input in production. (Ma and Swinton 2012), in their hedonic analysis of the drivers of farmland values in the US, extend this conceptual framework beyond the sole focus on profits. As well as being a key agricultural input, rural land also functions as a home site for the farmer and their family. A parcel of land with a higher level of local amenities may be a more attractive home site for a farmer and their family than an otherwise identical parcel of land with fewer amenities. Location specific characteristics may mean an individual is willing to pay more (or less) for a particular parcel of land than is implied by the profitability of the land in its highest and best use. The value of rural land can therefore be expressed as:

$$LV_{ijt} = \sum_{s=0}^{\infty} \frac{E\pi_{ij^*,t+s} + V\left(M_{ij^*,t+s}\right)}{(1+r)^s}$$

where M_{ijt} is a bundle of amenities which land parcel i possesses, and $V(.)$ is a value function which places a dollar value on the level of local amenities from the perspective of buyers and sellers. M_{ijt} contains both natural and built amenities which make a particular parcel of land an attractive (or otherwise) home site (amenities do not necessarily increase the value of rural land. For example, being located near a manufacturing site which produces foul smells would generate a negative amenity value, or disamenity). These amenities could include access to the coast or rivers, proximity to schools and other urban amenities (e.g. supermarkets, entertainment venues, off-farm employment), or proximity to native bush or conservation land.

A third driver of rural land values relates to the option to convert the land to a non-agricultural use at some point in the future. In equation 5, we restricted the land use choice to between competing agricultural uses. This neglects the option to convert the land to a non-agricultural use, such as housing. The optimal use for land near the boundary of a city that is expected to grow significantly over the coming years may switch from an agricultural to a non-agricultural use. For land where the option of residential conversion is real, part of the land value will reflect the discounted rents from residential conversion[1]. Therefore, we add a third term to our framework, which reflect the present value of the expected future rents from residential conversion (net of conversion costs). For land where the residential conversion option is not real, the period of conversion, c, will tend to infinity and the second term will drop out of the expression. This is still in the spirit of a Ricardian framework; our interpretation of rents that flow from the ownership of rural land is broader than rents from agricultural production.

$$LV_{ijt} = \sum_{s=0}^{c} \frac{E\pi_{ij^*,t+s} + V\left(M_{ij^*,t+s}\right)}{(1+r)^s} + \sum_{s=c}^{\infty} \frac{R_{iU,t+s}}{(1+r)^s}$$

3. Empirical Framework

3.1. Econometric Methodology

The Ricardian model, described in section 2.1, stipulates an equilibrium relationship between the value of rural land, the expected flow of rents from agricultural production (profits),

[1] By 'real', we mean that it applies only to land which is highly likely to undergo residential conversion in the foreseeable future.

the flow of amenities, and the discounted expected flow of benefits from future land-use conversion. Therefore, we estimate a simple regression of the following form:

$$\log Value\backslash ha_t = \beta_0 + \beta_1 \log EPV\ Profit_t + \beta_2 Trend + \epsilon_t$$

Where $Value\backslash ha_t$ is the value of is rural land in year t, $EPV\ Profit_t$ is the present value of expected future agricultural profits in year t, $Trend$ is a linear time trend and ϵ_t is an error term with standard properties. We use the linear trend to capture the influence of systematic changes in amenity and option values on rural land values[2]. The construction of these variables is described in section 3.2.

Our conceptual framework focuses on expected fundamental profits[3]. Using current profits assumes a certain kind of expectations formation – rational expectations under a random walk. Given that our data measure observed profits, which are affected by random shocks such as weather; we find this an unsatisfactory way to model expected profits. We would expect actors in the market for rural land to recognise that profits will be higher/lower than normal in a particularly good/bad growing year. We assume a form of adaptive expectations, where farmers use both current and past information to form their expectations about the future.

We can think of our profit measure as consisting of two components – a fundamental component, that is affected by input prices, output prices, and productivity. This is the part that corresponds to the expected long-run profitability from our conceptual framework. It also consists of a short-run shock component, which reflects the influence that short-run productivity shocks (such as weather shocks) have on profits in a given period:

$$PV\ Profits_t = PV\ Profits^*{}_t + \eta_t$$
$$\text{where } PV\ Profits^* = f(P, C, Q)$$

Our profit measure does provide information about long-run profitability, but this is measured with error. Measurement error causes attenuation bias in OLS regression; the coefficient on profitability will be biased towards zero. Our main profit measure also includes land-use change. As more land moves into higher valued, more profitable uses, we would expect

2 The trend could also be accounting for the role of alternative asset prices. We would expect that the risk-adjusted return on rural land to be comparable to that of other assets. The trend may be picking up the extra return required to make an investor indifferent between investing in rural land and investing in another asset class.

3 By fundamental profit, we mean the profit as determined by input prices, output prices, and the productivity of the land in sustained agricultural production. This includes the fertility of the soil, the suitability of the climate for a particular land use, and any relevant transport costs.

the average value of land per hectare to increase. The average in later years places a higher weighting on the higher valued land uses and a lower weighting on those with a smaller value. This may not necessarily be the result of changes in relative expected profitability between uses; it may be part of the gradual adjustment of land use to prevailing conditions. Therefore, our main profit variable may overstate the effect of profitability on land values. Land-use change can be thought of as increasing the productivity of the sector. As land moves into more profitable uses, the average profitability of rural land rises. We attempt to separate the effect of land-use change on land values by estimating a specification with fixed land use weights on the profit variable. The effect of land-use change will then be picked up by the trend and we can use the difference between the trend estimate in the fixed weight and time-varying weight specification as a rough estimate of the effect land-use change has on land values.

We correct for any bias in our main results using an instrumental variables estimation strategy. We use export commodity prices as an instrument for profits. A good instrument should have two properties: instrument relevance and instrument validity. A relevant instrument is highly associated with the endogenous variable. Commodity prices are a key component of the profit function and are an obvious choice for an instrument. (Woods and Coleman 2012) provide evidence that New Zealand farmers have very little control over the price they receive for their output. Commodity prices are taken as given by the individual farmer, i.e. they are exogenous[4]. Therefore, commodity prices satisfy the second condition for an instrument – instrument validity, which requires that the instrument must influence the left-hand side variable only through its effect on the endogenous right-hand side variable. It seems reasonable to assume that commodity prices influence land values only through their influence on profitability, as farmers take commodity prices as given when making their land-use and production decisions.

Profit shocks due to weather are best thought of as transitory shocks in this context. Farmers would not take the profits associated with a particularly good/bad growing year as representative of the profitability of their land in an 'average' year. In a well-functioning land market, agents should see through such transitory shocks. Commodity price shocks can be thought of as permanent exogenous shocks to profitability as these are set internationally. Once land use and production decisions are made, they are difficult or costly to adjust to changing commodity prices throughout the growing or milking season. Therefore, they should not affect

[4] (Kamber, McDonald, and Price 2013) provide evidence that suggests that drought in New Zealand can affect the global dairy price, at least in the short run. However, a drought is a productivity shock that is common to all farmers. The decline in dairy production, the likely cause of the global price rise, was caused by an aggregate supply shock that affected a large number of farmers, and was not the result of any individual farmers exercising market power.

the quantity of output produced, only the revenue the farmer earns from selling the output. By instrumenting profits with commodity prices, we are isolating the permanent shocks to profitability, which should affect a farmer's expectations about the future.

3.2. Data

3.2.1. QVNZ Sales and Valuations Data

The source of our data on land values is a comprehensive property valuations and sales database from Quotable Value New Zealand (QVNZ). QVNZ is New Zealand's largest valuation and property information company and has conducted legally required property valuations for the majority of local councils (they collect the information from the councils for which they don't conduct valuations to form a complete national sample) since 1989.

The QVNZ sales database contains meshblock (MB) level information on the number of sales, sales price and land area sold by land use category[5]. Our interest is on the value of rural land; we focus on the value of the 'rural' land use categories: arable, dairy, pastoral grazing, pastoral fattening/stud, exotic forestry, and horticulture[6]. This dataset is available for the period 1980-2012[7]. Unlike the valuations data, the sales data covers the period of major economic reform in New Zealand. One feature of the reforms was the removal of subsidies to agriculture beginning in 1984, which had a significant impact on agricultural profitability (Evans et al. 1996). We are interested in examining the drivers of rural land values over time, we focus our attention on the sales data as this gives us a larger sample size (33 observations as opposed to 22).

The QVNZ valuations data provides MB level information on the number of assessments, capital, land and improved value, and the land area assessed by land use category over the period 1989-2012. The land use category is intended to reflect the land's "highest and best use", or the purpose for which the property would be sold. This is assessed by property valuers and depends on the physical characteristics of the property and the economic conditions prevailing at the time[8]. Valuations are used by councils for the purposes of local government property taxes (rates). Each local council is typically valued every three years, meaning that each property in New Zealand will be re-valued at least once in a given three year period.

[5] A meshblock is the smallest geographic unit for which Statistics New Zealand (SNZ) release data publicly.

[6] Where we analyse trends by land use category, we combine pastoral grazing and pastoral fattening into one category, pasture.

[7] QVNZ data are on a June year, so the 2012 data are for the 12 month period ending 30 June 2013.

[8] (David Nagel 2013, pers. comm.)

There are some fundamental differences between the QVNZ sales and valuations data. The sales data are based on market transactions and reflect actual decisions made by buyers and sellers. The valuations data are based on recent sales in the area, but reflect the valuer's best estimate of what the property would sell for given current market conditions.

The scope of the two data sources also differs. The valuations data encompasses the universe of properties in New Zealand. The sales data, on the other hand, only records information when a sale takes place. Only a sub-sample of the universe of properties is actually sold during a particular time period, and these are not necessarily representative of the universe of properties. This is more of an issue when considering rural properties, as these are sold less frequently than residential properties. As we use the sales data to construct our measure of land values over the period, we examine the representativeness of the sales data for the subsample of the sales data where we have reliable data on property valuations.

3.2.2. Constructing the land value variable

Our focus is on examining the drivers of rural land. As well as narrowing our attention to rural land use categories, we also restrict our attention to areas that can be defined as rural. In defining rural areas, we employ an update of the approach employed by (Stillman 2005). His approach classifies individual MBs as either urban areas, rural areas or areas outside the urban/rural dichotomy (these include water MBs which are used to capture people who live in houseboats and production which occurs on the water and MBs which are predominantly conservation land). In our analysis, we drop the MBs classified as water by the New Zealand Land Resource Inventory (NZLRI), MBs where more than 50% of the land area is managed by the Department of Conservation (DOC), and MBs where more than 50% of the land value is assigned to an urban use by QVNZ.

We construct a national level weighted average of the per hectare sale price and capital value. We first estimate the average per hectare sale price at the national level by land use. To partially correct for any selection bias in the sales data, we use the proportion of land within each QV use category from the valuations data to weight the sales data when constructing the national average. We have valuations data only from 1994 onwards, so we need another source of land areas in order to construct this average for the sales data. We use the Statistics New Zealand (SNZ) based land use shares data from (Kerr and Olssen 2012) to construct the weights for the earlier part of the sales data[9]. Finally, we express our land values variables in constant (2006) dollars by deflating by the CPI. Our land value variable can therefore be thought of as

Table 1 compares the characteristics of the valuations and sales data. We are looking for differences between the sales and valuation data that may indicate a systematic selection bias in the sales data. Table 1 compare the two datasets by examining the average size of a property and the average proportion of sales/assessments by QV use category[10].

Table 1: comparing the Sales and valuations data[11]

	Sales	Valuations
Average Size (ha)		
All uses	107.2	166.2
Arable	70.8	82.4
Dairy	69.4	71.2
Pastoral	147.8	214.6
Forestry	133.1	474.8
Horticulture	11.3	14.4
Proportion of Sales/Assessments		
Arable	3.7%	3.1%
Dairy	25%	27%
Pastoral	56%	69%
Forestry	2.4%	4.3%
Horticulture	13%	7.5%

As can be seen Table 1, there are some differences between the sales and valuations data. We see that the average rural property sold tends to be smaller than the average rural property by

[9] Kerr and Olssen 2012 have data on dairy, sheep/beef and forestry areas. We do not have a sheep/beef category, but this category shows strong correlation with our pastoral category, so we use the sheep/beef category to construct the weights for pastoral land. For arable and horticultural, we extrapolate the weights by using the mean of their share over the period which we have valuations data.

[10] Figure 9 in the appendix plots the proportion of sales and assessments by QV use category.

[11] Figures in this table are calculated over the period 1994-2012. Conversations with Property IQ indicate that pre-1994, the valuations data cannot be considered reliable. When we examine the proportion of assessments for the pastoral land use category, we see a surprisingly low share of assessments is for pastoral properties. This is surprising, given that pastoral land uses are the dominant rural land uses in NZ.

approximately 60 hectares. This is primarily driven by the difference in pastoral and forestry categories. The average size for a pastoral property in the sales data is almost exactly 67 hectares less than the average pastoral property from the valuations data. For forestry, the difference is more extreme. The average forestry property sold is over 300 hectares smaller than the average forestry property. For the other land uses, the differences are very minor.

There are also some differences between the proportion of rural properties sold and assessed by QV use category. Pastoral properties are slightly under-represented in the sales data, while horticultural properties are slightly over-represented. Forestry is also slightly under-represented in the sales data.

Figure 1 plots the 3-year moving average of the national average per hectare sale price and per hectare capital value for rural properties. We use a 3-year moving average for the valuations data as only roughly one-third of the country is valued in any given year. Using a 3-year moving average ensures that each year's observation reflects the latest valuation for the entire country. For comparability, we also create a moving average of the sale price series. The per hectare sale price is uniformly greater than the per hectare assessed capital value. This could be due a systematic negative bias in the estimated capital value of each property, or because higher value properties within each land use category tend to be sold more frequently. Nevertheless, the two series show a high degree of co-movement. This is expected, given that recent sales inform the valuation estimates.

Figure 1: 3-year moving average of national rural sale price per hectare and rural capital value per hectare

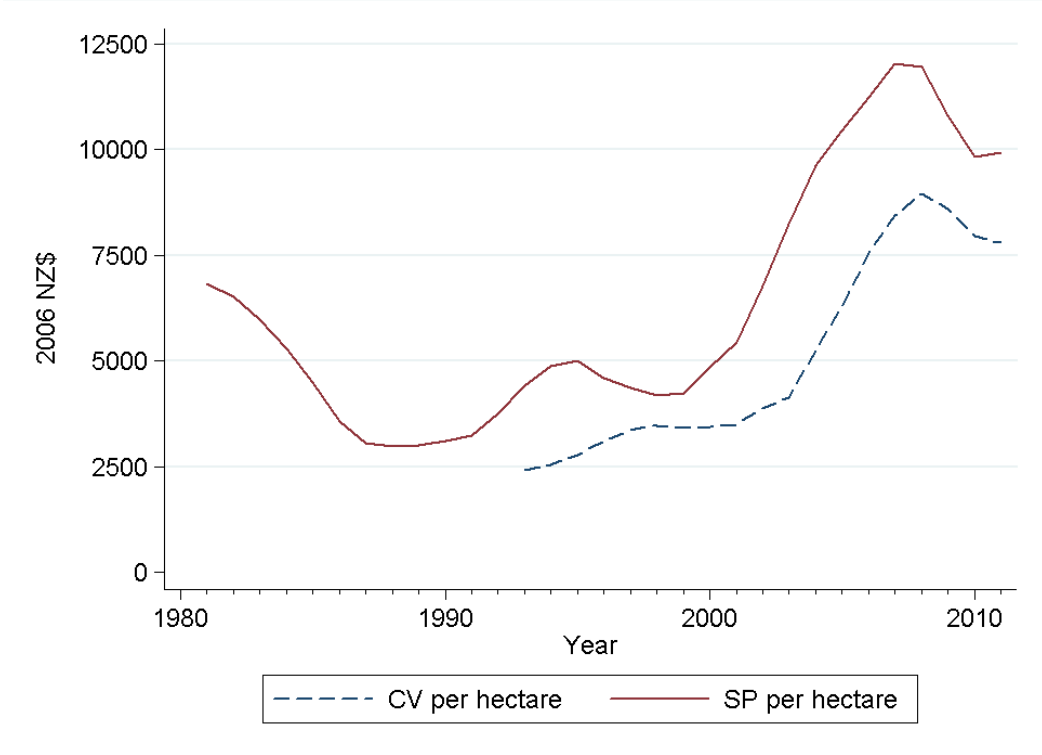

Figure 2: National rural sale price per hectare

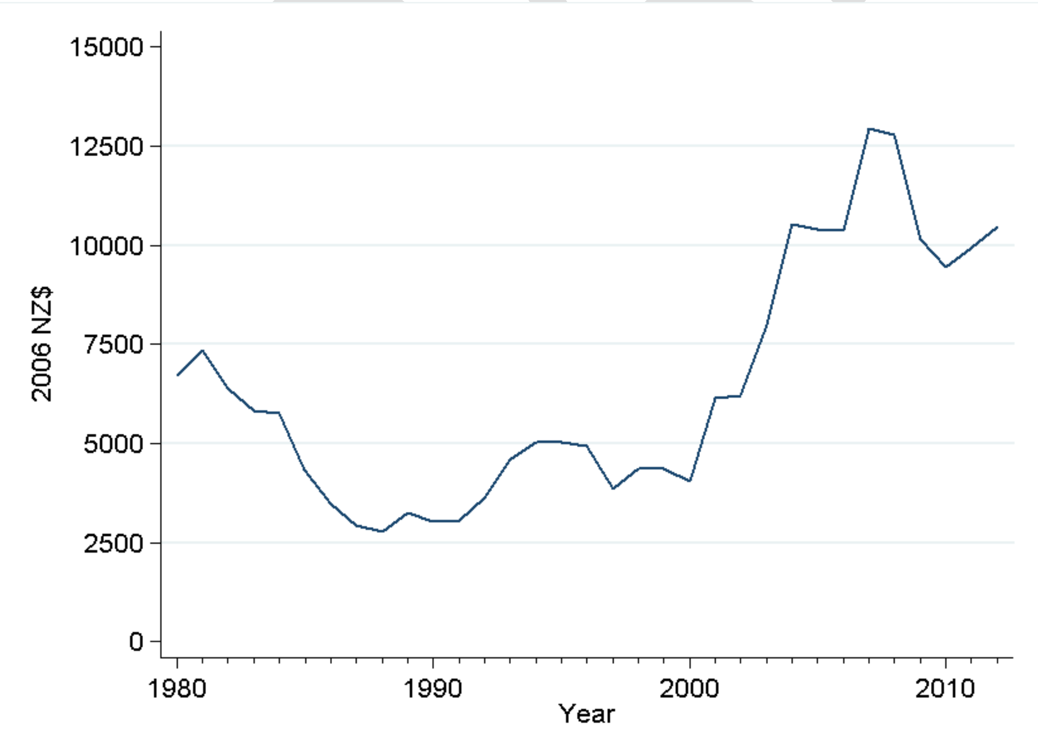

Figure 2 plots the unsmoothed per hectare rural sale price. One of the most striking features of the series is the sharp decline that occurred during the latter half of the 1980s. New Zealand began a period of major economic reforms in 1984. These included the removal of agricultural subsidies, which is the likely driver of the sharp decline in rural land prices beginning in 1984. By 1988, the per hectare sale price was around 50% of its value in 1983. Land values did not return to their pre-reform levels until 2003. In the mid-late 2000s we see large increases in the per hectare sale price, which forms part of the general property boom which occurred worldwide in the 2000s. The sale price fell from a peak of $12,500 per hectare in 2008, following the onset of the global financial crisis, and was slightly more than $10,000 per hectare at the end of our sample period.

3.2.3. Profit and commodity price data

Our profitability data come from two sources. We focus our attention on dairy and sheep/beef profitability, as we have good data over a long time horizon for these two agricultural activities. Dairy and sheep/beef farming also account for a vast majority of agricultural exports and account for the majority of rural land in New Zealand. Our sheep/beef profit data come are from Beef and Lamb New Zealand[12]. We use the earnings before interest and tax (EBIT) per hectare for Beef and Lamb's average sheep/beef farm. This series runs from 1980-2012. Our dairy profit data come from the MPI Monitor Farm Reports. We use the estimated economic farm surplus for their nationally representative dairy farm[13]. Our dairy profit data are available from 1982. We construct an average of the two profit series, weighted by each farm type's current share of land area[14]. Following our conceptual framework, we construct a present value of profits series. The results presented in Section 4 use a 5.5% real discount rate. This is the approximate real interest rate charged on business lending over the period 1998 to 2012[15].

The present value series is smoothed using an asymmetric 3-year moving average, using two years of lagged data as well as the current year's data. By doing this, we are assuming that agents in land markets have adaptive expectations with respect to the long-run profitability of the land. (Lubowski, Plantinga, and Stavins 2008), in their analysis of land-use decisions in the US, also assumed that farmers used current and historic information in forming their expectations about future earnings[16]. Figure 3 plots the smoothed per hectare profit data for sheep/beef and dairy farms.

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[12] Formerly Meat and Wool Economic Service.

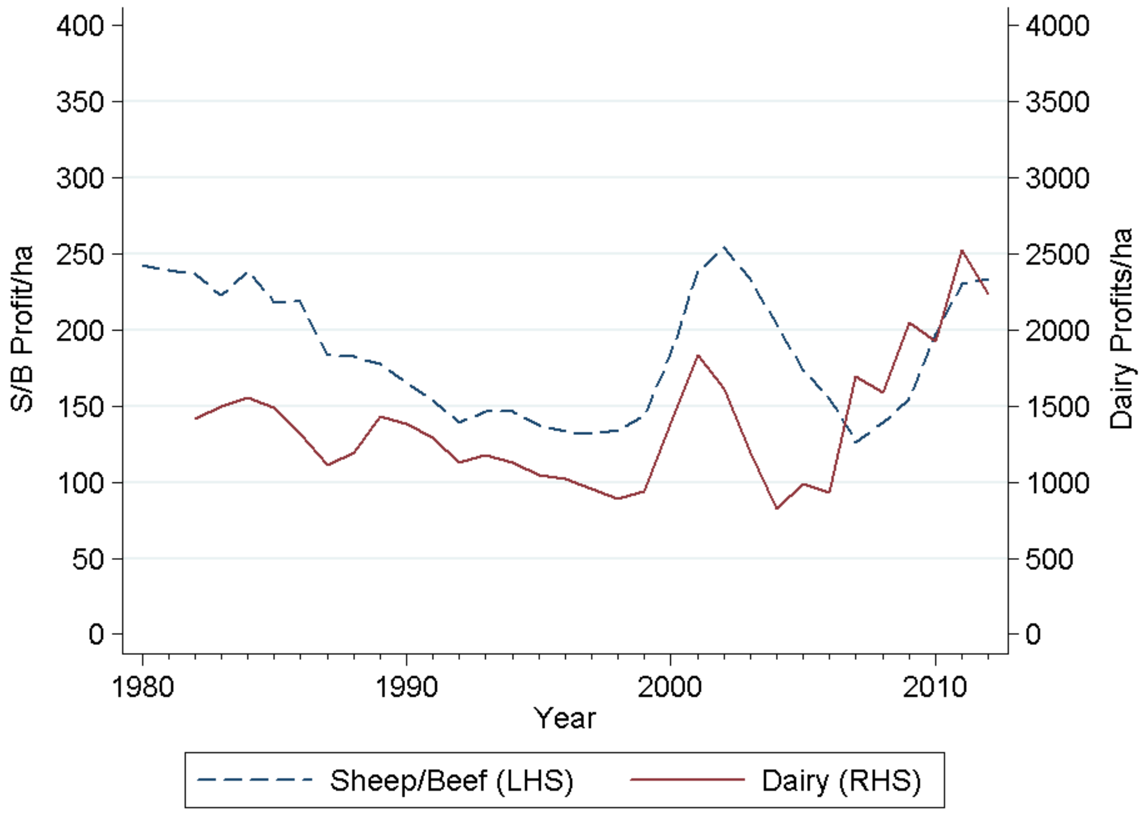
[13] The MAF Monitor Farm Reports only report the economic farm surplus from 1999. To obtain the estimates used prior to this, we take the cash farm surplus (before interest) and deduct personal drawings. Given the information provided pre 1999, this is the closest approximation to the economic farm surplus.

[14] This means the weights applied to our profit series include land-use change. We also construct two fixed weight profit series, using land-use shares at the beginning and end of the sample period.

[15] 1998 is the earliest period for which the Reserve Bank report business lending rates.

One key issue with our profit data is the regional coverage of the dairy profit numbers when computing a national average. Over time, the MPI Monitor Farm regions have been updated to better reflect the distinct conditions and characteristics of farms in different regions. For example, prior to 1991, the only South Island region with dairy profit data was the West Coast/Nelson region. Therefore, while we present national series, the number of regions and the weights applied to each region in calculating the national series does change over the sample period.

Figure 3: profits per hectare for sheep/beef and dairy Farms



As can be seen from Figure 3, dairy profits per hectare are in the order of 10 times those of sheep/beef profits. The two series moved together quite closely until the early to mid-2000s. Both series dipped sharply following the removal of agricultural subsidies in 1984, with dairy profits falling from around $1500/ha to just over $1000/ha, and sheep/beef profits falling from almost $250/ha to around $175/ha. (Evans et al. 1996) present data showing declines of a similar magnitude in real net revenue per head for sheep and beef cattle.

We use agricultural commodity prices as our instrument for profits. We use the export price series constructed in (Kerr and Olssen 2012). The authors construct an export unit value for sheep meat, beef meat, wool and logs using SNZ overseas merchandise trade data. To create a composite meat/wool price, they create a trade weighted average of the sheep-meat, beef and wool prices. Milk solid prices are from the Livestock Improvement Corporation (LIC). Given the history of agricultural support, the authors adjust these export unit prices for the amount of assistance given to each agricultural sector, using estimates on the extent of support from (Anderson et al. 2008). We have profit data only for meat/wool and dairy, so these are the prices we focus on. In the analysis in section 4, we create a composite agricultural commodity price index. This is a simple average of the two commodity prices, weighted by that commodity's share of agricultural exports. Figure 2 plots the two commodity price indices used in this paper[17].

Figure 4: Agricultural commodity price indices (Base 1983=100)

Summary statistics for the (log) first differences of the variables are provided in Table 2. We present statistics for the first differences as unit root tests indicate our variables are non-stationary.

[17] In our estimation, we assume price expectations are made in the same way as profit expectations. We test the robustness of our results to other specifications of expectations. These are reported in Appendix 2.

Table 2: Summary statistics

	Mean	Std. Dev.	Min	Max	ADF p-value	T
$\Delta\log Value/Ha$	0.0139	0.1630	-0.2854	0.4206	0.2369	32
$\Delta\log PV\ PROFITS_t$	0.0268	0.1498	-0.3173	0.3599	0.1370	32
$\Delta\log ACPI_t$	-0.0146	0.1206	-0.3277	0.2217	0.1163	32

Notes: *SP/Ha* is the per hectare sale price, *PV PROFITS* is the (smoothed) present value of profits, *ACPI* is the agricultural commodity price index and *HPI-AU* is the Australian house price index. ADF p-values are the (MacKinnon 1996) approximate p-values for unit root tests.

Unit root tests cannot reject the presence of unit roots in our land values, profit and commodity price data, indicating they are non-stationary. In general, applying OLS to non-stationary variables produces spurious results. However, if the variables are cointegrated, then least squares techniques produce valid results. As we are estimating an equilibrium relationship between profits and land values, the two variables should be cointegrated. To check this, we test for cointegration using the (Engle and Granger 1987) 2-step procedure.

4. Results

Figure 5: Rural sale price per hectare and present value of profits per hectare

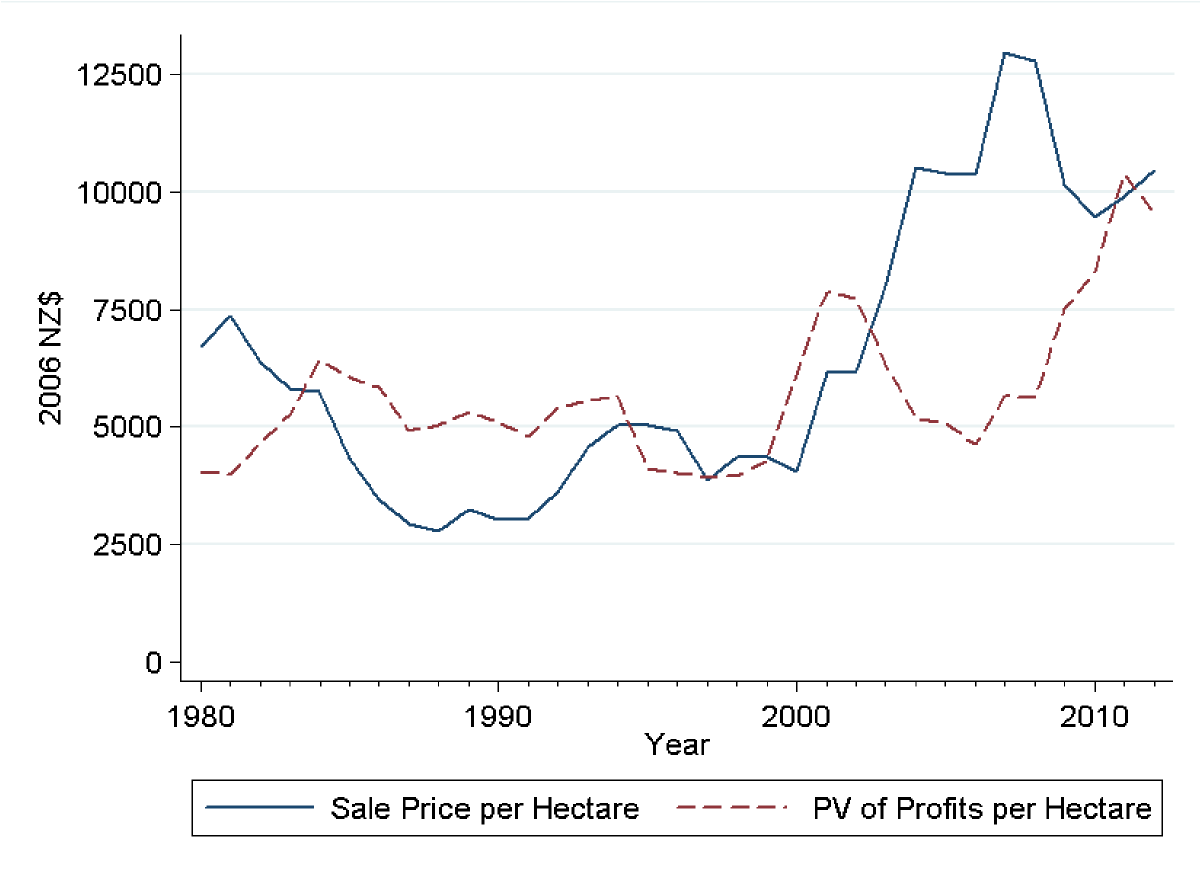


Figure 5 plots the per hectare sale price against the smoothed present value of profits series. There is some evidence of co-movement between the two series. There are times when our weighted average PV of profit series is above the sale price and vice versa. The average ratio of the two over the sample period is 1. The relationship between the levels of these two variables is rather remarkable, especially given the rhetoric around land prices being too high, relative to the income that the land can generate that appeared during the period of convergence (2003-2011) (e.g. Gawith 2010, Eves and Painter 2008). We now explore this relationship more formally.

Table 3 reports the results from estimating equation 1. The first 3 columns report the results for the three weighted profit series when the linear time trend is excluded, while columns 4, 6, and 8 add a linear trend to the regressions in columns 1-3.

The results in columns 1-3 show a strong, positive relationship between the present value of profits per hectare and the per hectare sale price of rural land. The basic results suggest that a 10% increase in the present value of agricultural profits is associated with an 8% increase in the value of rural land. This effect falls to around a 6-7% increase in response to a 10% increase in profits when the effects of land use change is removed from the profit series. Profits alone explain approximately 10% of the variation in land values over the sample period. This rises to 20% when land-use change is included.

The coefficient on profits falls when a linear time trend is included in the regression. The coefficient on the trend is remarkably similar across the three specifications – the factors that vary systematically over time lead to increases in land values in the order of 3.8% per annum. Including a linear time trend has improved the fit of the models drastically, as expected. Profits, together with the other systematic, time varying factors, explain around 60% of the variation in land values. In column 4 of Table 3, the coefficient on profits falls to 0.22 and is no longer statistically significant. The fall in the coefficient is not as marked for the two fixed-weight profit models in columns 6 and 8. If actors in the land market are fully rational, we would expect a one-to-one correspondence between the present value of expected future profits and land values. Our OLS results are consistent with the land market *under-pricing* changes in agricultural profitability. The results for the profit series, which are smoothed prior to estimation to better approximate expected fundamental profits and reduce the influence of short-run, transitory shocks to productivity, are still consistent with measurement error in the profit series causing attenuation bias in the coefficient estimate. The cointegration tests generally reject the null hypothesis of non-cointegration, indicating that the regressions represent a valid long-run relationship between profits and land values. In cases where the null hypothesis cannot be rejected, the test statistic is close to the calculated 10% critical value. In general, the test statistics for the regressions estimate using 2SLS are greater than those from the OLS regressions. The test statistics are also higher for the specifications including a fixed-weight profit series, particularly the initial weight series.

Table 3: OLS and 2SLS regression results for land values and the present value of agricultural profitability

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV	(6) OLS	(7) IV	(8) OLS	(9) IV
log $PV\ PROFITS_{\mathrm{t}}$	0.848***			0.222	1.256***				
	(0.17)			(0.207)	(0.406)				
log $PV\ PROFITS_{\mathrm{t,1982}}$		0.675**				0.4849**	1.096***		
		(0.254)				(0.231)	(0.283)		
log $PV\ PROFITS_{\mathrm{t,2012}}$			0.718**					0.4042*	1.098***
			(0.263)					(0.228)	(0.417)
$Trend$				0.037***	0.024**	0.039***	0.037***	0.038***	0.034***
				(0.0086)	(0.011)	(0.007)	(0.007)	(0.008)	(0.007)
$Constant$	1.321*	2.907	2.256	-51.33***	-50.566***	-72.77***	-74.68***	-70.49***	-69.2***
	(1.50)	(2.19)	(2.36)	(16.9)	(19.2)	(13.7)	(13.9)	(14.5)	(14.3)
T	31	31	31	31	31	31	31	31	31
R^2	0.192	0.089	0.120	0.583	-	0.618	-	0.609	-
$EG\ \tau$-stat	-3.643	-4.284**	-4.019*	-3.584	-3.661	-3.787*	-4.212**	-3.605	-3.825*

Notes: HAC standard errors are in parentheses. ***, **, * and + indicate statistical significance at the 1%, 5%, 10% and 15% levels, respectively. The estimation method for columns labelled OLS is ordinary least squares; for columns labelled IV is two stage least squares. 2SLS estimation was carried out using the ivreg2 command in Stata (Baum, Schaffer, and Stillman 2007) The excluded instrument from the 2SLS estimation is our agricultural commodity price index. $EG\ \tau$-stat is the (Engle and Granger 1987) test statistic for testing the null hypothesis that the variables are not cointegrated. These were compared against critical values calculated from (MacKinnon 2010), Table 3.

We correct for the attenuation bias by implementing an instrumental variables estimation strategy. We use agricultural commodity prices as an instrument for the present value of profits[18]. The results from estimating equation 1 using 2SLS are reported in columns 5, 7, and 9 of Table 3. The coefficient on profits is now much closer to one, as we would expect given our conceptual framework. It is also statistically significant in all three specifications[19]. We cannot

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Table 6 in the appendix reports the first stage regressions, as well as first-stage diagnostic tests, for the IV regressions in Table 3.

19 See

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1. Appendix 1 – Implied reduced form and first-stage results

Table 5 reports the results from estimating equation 1 using agricultural commodity prices as our measure of agricultural profitability. Column 1 reports the results from estimating the same equation as in column 1 of Table 3, but replacing the present value of profits with commodity prices. Column 2 reports the results from including a linear trend. The regression in column 2 is the implied reduced form of the regressions in columns 5, 7, and 9 of Table 3. The coefficient on commodity prices is not statistically different from 1, as we would expect if commodity prices are capturing exogenous changes in profitability. The coefficient is slightly smaller than the equivalent coefficients in Table 3, and the trend estimate is slightly higher. We attribute this to the fact that commodity prices will not capture changes in profits that result from productivity growth. As the trend enters the first stage regression for the results in Table 3, reject the null hypothesis of a one-to-one relationship between changes in the present value of profits and land values in any of the three IV specifications. These results are consistent with the land market appropriately pricing changes in the present value of expected profitability. The trend coefficient is remarkably similar to those estimated using OLS, particularly for the two specifications with the fixed-weight profit series.

The coefficient on profits falls slightly when we exclude land-use change from the profit series. The effect of land-use change is then picked up by the linear trend. Land-use change can be thought of as a component of productivity growth in the rural sector, where land moves into more profitable land uses as economic conditions dictate. Removing the influence of land-use change from the profit series means that the profit series captures only the within land-use sources of productivity growth, such as improved animal breeding, more efficient fertiliser use etc. We use the difference in the trend estimate between the current and fixed land-use share specifications to provide a rough decomposition of the trend growth rate into growth that can be attributed to amenity value and option value, and growth that can be attributed to gradual land-use change.

When land-use change is included in the profit series, the trend growth in land values is estimated to be 2.4% per annum. As incomes rise the demand, and therefore price paid, for amenities will also rise. The average annual growth rate of real GDP in New Zealand over our sample period was 2.46%, which is remarkably close to the trend estimate when land-use change is included in the profit series[20]. Therefore, we interpret the trend estimate in column 5 of Table 3 to be the growth in rural land values due to growth in the market value of amenities and/or growth in the long-run conversion option. When we allow the trend to pick up the effect of land-use change on land values, the trend estimate increases to 3.7% per annum, as in column 7 (3.4% in column 9), an increase of 1.2 (0.9) percentage points. We attribute this difference to growth in land values resulting from gradual land use change improving the average profitability of the sector.

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the instrumented profit series will also include productivity growth. In these regressions, however, productivity growth is captured by the trend.

Table 5 in the appendix for the results from estimating an alternative specification, using agricultural commodity prices as the measure of profitability. We present results for the implied reduced form of the regressions in Table 3, as well as results assuming rational expectations when commodity prices follow a random walk.

[20] When we replace the linear time trend with the log of real GDP in the regressions, we find a one-to-one proportional relationship between GDP and land values, consistent with the trend estimate and the average annual GDP growth rate.

As further evidence of the role amenity and option values in determining rural land values, we explore the relationship between the credit market and the land market. The credit market provides access to the funds required to make the necessary capital investments when changing land use i.e. it allows land owners to exercise the option to convert to more profitable land uses in response to changes in relative profitability. These funds will be easier to access when credit is more freely available. Credit is more freely available when the economy is, and is expected to continue, performing well. Credit availability could therefore signal that the market price of amenities is higher. Together, these imply that land values should be higher during times when credit is freely available.

As our measure of credit availability, the ratio of impaired assets to gross lending, is available only from 1990, we do not include our measure of credit availability in equation 1 directly. Instead, we take the residuals from the regression reported in column 5 of Table 3 and regress these on our measure of credit availability. The regressions reported in Table 3 are based on 31 observations; including credit availability in these regressions would reduce the sample size to 22 observations. Using the residuals from the regression reported in column 5 allows us to examine the effect of credit availability land values while controlling for profitability. The results are reported in Table 4.

Table 4: Land values and credit availability

$\frac{impaired\ assets}{gross\ lending}_{t-1}$	-0.076***
	(0.02)
$Constant$	0.154
	(0.116)
T	22
R^2	0.183

We find a statistically significant negative relationship between land values (controlling for profitability) and credit availability. A higher ratio of impaired assets to gross lending implies the credit market is tighter or credit is less freely available; land values tend to be lower when credit is less freely available. This result is consistent with the credit market facilitating land-use change and that the market value of amenities tends to be higher when credit is more freely available[21]. Given the small sample size, however, this result is far from conclusive. It is

[21] An alternative interpretation of this result is that when credit availability is restricted, buyers may not be able to access sufficient capital to place a high enough bid on the property in order to induce a sale. If the ability to

nevertheless consistent the results presented in Table 3; while profitability explains a significant proportion of the variation in land values over time, amenity and option values also play a key role in determining rural land prices.

5. Conclusions

We conduct a simple test of a Ricardian model of rural land prices, where the value of land is equal to the present value of expected future 'rents' from land ownership. Rents from rural land ownership include the obvious profits from agricultural production; the rents also include the flow of benefits from the lifestyle amenities that the land possesses. The rural land market is also influenced by the urban housing market – rising house prices increase the returns from subdividing and converting farmland into lifestyle blocks or suburban housing. Much of the discussion about irrationality in the land market says that land is overpriced relative to the income generated from the land in agricultural activities (e.g. Gawith 2010, Hargreaves and McCarthy 2010). This focus on the earnings potential of the land, while important, is too narrow a focus to conclude that actors in one of New Zealand's most important markets act irrationally.

We find a strong, positive relationship between the present value of agricultural profitability and rural land values at the national level over the period 1980-2012. Furthermore, we cannot reject the hypothesis that this relationship is one-for-one; we find no systematic tendency for the rural land market to over-react to changes in profitability of the agricultural sector. While we find a strong relationship between land values and profitability, we also find evidence consistent with amenity values and option values playing a key role in determining the price of rural land. Land values tend to be higher when incomes are rising, meaning people may be willing to pay more for amenities. This could also reflect a general trend in asset prices. Land-use change also impacts the value of rural land as it improves the average profitability of the sector.

We also find tentative evidence of a link between the credit market and the rural land market. Specifically, we find that land values tend to be higher when credit is more freely available, after controlling for profitability. We interpret this tentatively as further evidence of the role amenity and option values play in the rural land market. When the economy is performing well, and is expected to continue performing well, credit tends to be more freely available. Incomes also tend to be rising; meaning the market value for amenities should also be

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bid is restricted sufficiently, we should see a decrease in the number of properties sold. This could still influence the rate of land-use change if land sales are a predictor of land-use conversion.

rising. It may also signal that the value of the potential for conversion to a non-agricultural use is higher during good economic times.

Our analysis is conducted at the national level – we are therefore assuming that the hypothesised drivers have a consistent impact across the country. This is clearly an unrealistic assumption. In our current work, we are exploring how various physical characteristics of the land, which relate to the productivity of the land, the bundle of amenities and the likelihood for future conversion drive cross-sectional variation in land values. Future work will consider the role of both time series and cross-sectional drivers of land values. This will enable us to better categorise

Overall, our results are not consistent with systematic irrationality in the land market. However, as our analysis is based on only 30 observations, we cannot conclusively conclude that the rural land market is therefore rational in the long run. Nevertheless, our main conclusion is robust to a range of robustness and specification checks. Our results show that land values respond to changes in agricultural profitability in a way consistent with economic theory, while emphasising the role of drivers that are not specific to the agricultural sector. Price-earnings ratios, while important from a business perspective, do not provide sufficient information to conclude that actors in the market for rural land are irrational.

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7. Appendix 1 – Implied reduced form and first-stage results

Table 5 reports the results from estimating equation 1 using agricultural commodity prices as our measure of agricultural profitability. Column 1 reports the results from estimating the same equation as in column 1 of Table 3, but replacing the present value of profits with commodity prices. Column 2 reports the results from including a linear trend. The regression in column 2 is the implied reduced form of the regressions in columns 5, 7, and 9 of Table 3. The coefficient on commodity prices is not statistically different from 1, as we would expect if commodity prices are capturing exogenous changes in profitability. The coefficient is slightly smaller than the equivalent coefficients in Table 3, and the trend estimate is slightly higher. We attribute this to the fact that commodity prices will not capture changes in profits that result from productivity growth. As the trend enters the first stage regression for the results in Table 3, the instrumented profit series will also include productivity growth. In these regressions, however, productivity growth is captured by the trend.

Table 5: Land values and agricultural commodity prices

	(1)	(2)	(3)	(4)
$\log ACPI_{t-1}$	0.159	0.999***		
	(0.395)	(0.271)		
$\log ACPI_{t,adaptive}$			0.146	1.259***
			(0.407)	(0.308)
$Trend$		0.043***		0.045***
		(0.006)		(0.006)
$Constant$	7.978***	-81.368***	8.025***	-94.742***
	(1.704)	(11.631)	(1.748)	(11.758)
T	32	32	31	31
R^2	0.004	0.61	0.002	0.724

Table 6 reports the results from the first stage regression, as well as first-stage diagnostic tests.

Table 6: First stage regressions for the present value of agricultural profitability

	(1)	(2)	(3)
$\log ACPI_{t,adaptive}$	1.002***	1.149***	1.146***
	(0.188)	(0.131)	(0.151)
$Trend$	0.020***	0.011***	0.014***
	(0.004)	(0.002)	(0.003)
$Constant$	-35.18***	-18.31***	-23.27***
	(7.819)	(6.049))	(7.247)
T	31	31	31
R^2	0.5695	0.6517	0.3903
K-P Wald rK F-statistic	28.55	76.82	57.75
K-P rK LM statistic	11.8***	16.4***	14.85***

Commodity prices are strongly positively associated with profits in the first stage regression.

Table 6 also reports two diagnostic tests for the first stage regressions from (Kleibergen, and Paap 2006). The Wald rK F-statistic is a test of weak instruments, i.e. that the excluded instruments (in our case, agricultural commodity prices) are only weakly associated with the endogenous explanatory variable (present value of profits). This statistic is compared to the critical values compiled by (Stock and Yogo 2005). Weak instruments cause bias in IV coefficient estimates, and also induce size distortions in conventional Wald tests. Given we only have one endogenous regressor and one excluded instrument, we compare this test statistic to the Stock-Yogo critical values based on size distortions in Wald tests[22]. With test statistics of

[22] (Stock and Yogo 2005) do not provide critical values based on relative bias for the case of one endogenous regressor and one excluded instrument.

28.55, 76.82, and 57.75, we can reject the null hypothesis of weak instruments at the 5% level, based on a maximum allowable actual size of a 5%-Wald test of 10% all models (critical value 16.38). The rK LM test statistic tests for under-identification i.e. that the excluded instruments are relevant. With this test, we can reject the null hypothesis that the coefficient in the second stage equation is under-identified (irrelevant instrument) in favour of the alternative that the coefficient is identified (relevant instruments). As our equation is exactly identified (the number of instruments equals the number of endogenous regressors), we cannot test for the validity of our instruments. Instruments are valid if they are uncorrelated with the error term in the second stage regression. Instead, we rely on the argument that individual New Zealand farmers have no influence over global commodity prices for the validity of our approach.

8. Appendix 2 – Robustness

Table 7 below reports the results from replacing the time trend with the log of real GDP or an Australian house price index to control for general factors that may influence land values. The hypothesis that the coefficient on profits is equal to one cannot be rejected in either of these specifications. These factors could influence either the amenity or option value of the land, or could simply reflect a general trend in asset prices.

Table 7: IV estimates with alternative control variables

	GDP_t		$Aus\ HPI_t$	
$\log PV\ PROFITS_t$	1.225**		1.171***	
	(0.560)		(0.453)	
$\log PV\ PROFITS_{t,1982}$		0.982***		1.109***
		(0.363)		(0.369)
$\log GDP_t$	1.046**	1.480***		
	(0.449)	(0.253)		
$\log Aus\ HPI_t$			0.346**	0.514***
			(0.158)	(0.101)
$Constant$	-28.429***	-37.199***	-3.18	-3.326
	(8.445)	(5.927)	(3.451)	(3.058)

T	31	31	31	31

Table 8 below reports the IV estimates for specifications using alternative expectations formation mechanisms. In both columns it is assumed that both profits and commodity prices follow a random walk; this means that this year's expectations about next year's profits/prices are simply this year's profits/prices. Column 1 assumes that this year's profits/prices are known with certainty and therefore uses this year's profits as the expectation for future profits. Column 2 assumes that this year's profits/prices are not known with certainty and therefore uses last year's profits/prices as the expectation for both this year's and future profits/prices. Column 3 assumes adaptive expectations for profits, and rational expectations under a random walk for commodity prices.

Table 8: IV estimates with alternative expectations formation mechanisms

	(1)	(2)	(3)
$\log(EPV\ Profits_t)$	1.902**		
	(0.944)		
$\log(EPV\ Profits_{t-1})$		1.419**	
		(0.712)	
$\log(EPV\ Profits_{adaptive})$			1.820***
			(0.441)
$Trend$	0.005	0.016	0.014
	(0.015)	(0.015)	(0.010)
$Constant$	-35.658	-17.755	-35.265
	(26.138)	(26.127)	(17.235)
T	32	33	31

Notes: HAC standard errors in parentheses. The estimation method for columns 1 and 2 is 2SLS. Column 3 uses OLS the fitted values from a regression of current profits on current prices (including a trend). Expected profits are then calculated and entered into an OLS regression of land values on expected profits and the time trend. The standard errors for column 3 are therefore biased downwards.