

# Over-valued or over-looked? A theoretical and empirical investigation of agricultural land values against profitability in Aotearoa New Zealand

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# Over-valued or over-looked?

## A theoretical and empirical investigation of agricultural land values against profitability in Aotearoa New Zealand

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### Abstract

We investigate whether New Zealand's rural land is over-valued when compared to its agricultural profitability. First, we develop a theoretical time-series framework showing that a positive profit shock in one agricultural land use should raise the value of land in that use, inducing land-use change. On average, the present value of expected future profits from national rural land should have a one-to-one relationship with the value of agricultural land when both are weighted by respective land use share.

Second, we develop an empirical application using a new nationally consistent dataset of rural property sales and average agricultural profits for the period 1980-2012. Using a novel two-stage least squares approach to account for endogeneity, we find a positive relationship between the present value of expected agricultural profitability and rural land values. Furthermore, we cannot reject the hypothesis that this relationship is one-for-one, indicating that New Zealand's rural land does not appear to be over-valued. Our time-series methodology provides a roadmap for studies in other jurisdictions.

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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 statement is correct, the implications would be profound. The article goes on to suggest that New Zealand’s (NZ) farms are overpriced relative to the income that can be generated from farming. This would suggest a gross misallocation of one of the country’s most important economic resources – rural land. This paper asks the question: Is NZ’s rural land over-valued when compared to its agricultural profitability?

The academic contributions of this paper are twofold. First, we develop a theoretical framework that explores how land values respond to land-use specific profit shocks. Second, we develop a novel empirical application of this theoretical framework, using a nationally consistent dataset of rural property sales and average agricultural profits for the period 1980-2012.

In our theoretical framework, a positive profit shock in one agricultural land use raises the value of land in that use, inducing land-use change. On average, the present value of expected future profits from national rural land should have a one-to-one relationship with the value of agricultural land when both are weighted by respective land use share.

In our empirical analysis, we estimate and test for this long-run equilibrium relationship at the national level. The sparse research into rural land values in NZ has tended to exploit spatial variation in the productive characteristics of the land and the level of local amenities to explain cross-sectional variation. By contrast, we take a time series approach in this paper. We examine how the national-level average price of rural land reacts to changes in average expected agricultural profitability. This time series approach allows for a framework that can, in future, be applied in countries without access to detailed panel data. We use an instrumental variable approach, as observed profit data are a noisy measure of expected profitability (due to the short-run influence of factors outside a farmer’s control, such as weather). We identify permanent, exogenous shocks to expected profitability by exploiting temporal variation in the export prices that farmers receive for their output. This variation is plausibly internationally determined with the exception of NZ dairy prices. To account for this, we use the United States of America’s (USA) wheat price as a proxy for NZ dairy prices. We are unable to reject a one-for-one relationship between land values and the present value of profitability. To back out the effect of permanent shocks to agricultural profitability on rural land values, we study the difference between time trend coefficients in two specifications. These are built using either time-varying or fixed land-use weights in calculating the profit variables. The difference between these coefficients gives us an estimate of the effect of gradual land-use change on land values and is our coefficient of most interest. In our primary specification, we find that average rural land values grew by \$201 per year, after controlling for profitability. We can attribute \$91 of this increase to the effects of realised land use change, with the remainder being due to other, non-agricultural specific drivers of land values (such as

amenity values, option values, or asset values). However, we find only weak evidence of co-integration between the sale price and the present value of profitability, likely due to the low power of co-integration tests in small samples, meaning these results can only be preliminary.

The rest of the paper is structured as follows. Section 2 reviews the related international and domestic literature. Section 3 details our theoretical framework and Section 4 introduces the data. Section 5 provides a descriptive analysis of the period in question, while section 6 describes the formal empirical strategy and results. Section 7 concludes.

## **2 Literature Review**

The level of rural land prices relative to farm incomes is a topic of extensive discussion among economists. The productivity or profitability of the land has been found to be a key driver of rural land values internationally (for example: Borchers, Ifft, & Kuethe, 2014; Burt, 1986; Falk, 1991; Shaik & Miljkovic, 2010). From the USA, Lee & Rask (1976) and Pope & Goodwin (1984) document similar concerns over the value of rural land in the US during the 1970s and Falk (1991) provides evidence that rural land prices in Iowa overreact to changes in rents. Here in New Zealand, Eves & Painter (2008) question the sustainability of increases in rural NZ land prices during the 2000s. They find that the price-earnings ratio of rural land here was more than twice that of Australia, one of the only other developed economies with minimal or no support for the agricultural sector. They also express doubt that agricultural profitability could grow fast enough to justify land prices. Hargreaves & McCarthy (2010) also argue that rural land in NZ is overvalued relative to earnings potential. They predict a downward adjustment in land prices.

The relationship between rural land values and irrigation areas in NZ is another which has been explored. Grimes and Aitken (2008) use hedonic regressions to estimate the value of irrigation rights in the MacKenzie District, a drought-prone region in the central South Island of New Zealand. They find that the value of irrigation rights is capitalised into land values, and the irrigation premium is between 15% and 50% (depending on whether sales or valuation data is used and on the physical characteristics of the farm).

Numerous studies have investigated non-agricultural drivers of land values. Pope and Goodwin (1984), noting that rural land values in many areas of the USA were above the level implied by profitability, turn their attention to examining additional potential drivers of rural land values. They focus on what they call 'consumptive demand', a concept analogous to amenity value, arguing it is larger than had previously been recognised. Many studies since have employed hedonic price equations to estimate how various lifestyle and natural amenities are reflected in rural land values (see for example Bastian, McLeod, Germino, Reiners, & Blasko, 2002; Borchers et al., 2014; Ma & Swinton, 2012; Uematsu, Khanal, & Mishra, 2013). Stillman (2005) estimates hedonic price equations for NZ rural land to examine the cross-sectional drivers of the change in land values over the period 1989-2003, finding that

land values increased most in less populated areas with comfortable climates and a higher level of local amenities (both built and natural).

Another non-agricultural driver of rural land values is the value of the option to convert rural land into a non-agricultural land use (such as housing). This has also been investigated widely, though literature is sparse for NZ. Capozza & Helsley (1989; 1990) develop a model of urban growth that has been used to decompose rural land values into rents from agricultural production and rents from future land conversion. Hardie, Narayan, & Gardner (2001) find that rural land values in the Mid-Atlantic region of the US are more responsive to changes in nearby house prices than they are to changes in profitability. Plantinga, Lubowski & Stavins (2002) find that the option value of irreversible and uncertain land development is capitalised into rural land values for counties in the contiguous US. Livanis *et al.* (2006) account for three effects of urban expansion on rural land values: the effects of rural land conversion, the effect of urban proximity on agricultural returns, and the speculative effect of rural land conversion risk. They find evidence consistent with all three effects on rural land values in the continental US. In New Zealand, Brower, Meguire & DeParte (2012) provide evidence of the option value of land conversion for South Island pastoral leases that underwent tenure review. These properties are large high-country stations that were used for extensive sheep/beef farming and were leased long-term from the Crown. Since 1992, the leaseholders have been able to apply to purchase part of their lease, while ceding the balance to the conservation estate. By 2008, leaseholders had purchased over 100,000 hectares from the Crown for \$6.9 million. Less than half of this land was then sold by the new freeholders for over \$135 million, by 2012. The authors conclude that the process of tenure review gave rise to significant rents, suggesting Crown valuation had failed to account for the value of the subdivision option when selling the properties.

Our approach is related to that of Shigeto, Hubbard, & Dawson (2008) and Shaik & Miljkovic (2010), who use pure time-series approaches to examine the relationship between agricultural returns and rural land values. Shigeto, Hubbard, & Dawson (2008) estimate a vector-error correction model (VECM) between rural land prices and rental rates at the national level in Japan over the period 1955-2000. They find evidence of co-integration between rental rates and land prices, and cannot reject the null hypothesis of a unitary long-run elasticity between rents and land prices. This result is consistent with long-run efficiency in the market for rural land. Shaik & Miljkovic (2010) also estimated a VECM, using aggregate USA data over the period 1933-2006. Their model includes farm real estate values, farm receipts (defined as the value of crop and livestock produced net of farm programme payments), the real interest rate, and farm programme payments (i.e. government support programmes). They find one co-integrating relationship between farm real estate values, farm receipts, farm programme payments, and the real interest rate, concluding that farm receipts cause farm real estate values and farm programme payments. Farm receipts have a positive and significant influence on farm real estate values in the short run, however the authors do not report the co-integrating regression, which is the relevant regression when examining long-run market efficiency.

Our use of movements in commodity prices to identify the effect of exogenous shocks also complements the work of Grimes and Hyland (2013). The authors estimate the short- and long-term impact of agricultural commodity price shocks on house prices and housing investment across Territorial Authorities in New Zealand<sup>1</sup>, using a structural panel vector auto-regression (VAR) model. They find that housing prices in urban areas do feel the effects of agricultural commodity price shocks. We complement their analysis by focusing explicitly on rural land prices, where the impact of a commodity price shock on rural land values is through its effect on expected farm profitability.

### 3 Theoretical framework

We modify the work of Campbell & Shiller (1987) on present valuation models for a rural land value setting. Our theoretical framework begins similarly to Capozza & Helsley (1990).<sup>2</sup>

We model rural land values as follows:

$$v_{ijt} = \int_{t=1}^{\infty} \pi_{ijt} e^{-rt} dt \quad (1)$$

where  $v_{ijt}$  denotes value and  $\pi_{ijt}$  expected future profits, of land parcel  $i$  in use  $j$  at time  $t$ , and  $r$  is the real discount rate (which we initially assume to be constant).<sup>3</sup> We assume that land owners are risk neutral, the discount rate is fixed and certain, and that land use choices and adjustment are instantaneous.

We further assume that quality of the land can be summarised by a single time invariant indicator. Expected future profits are then modelled as a land use specific function of the quality of the land and a land use specific profit parameter. We can then express profits as:

$$\pi_{ij} = \pi_j(a, \theta_j)^4 \quad (2)$$

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<sup>1</sup> Territorial Authorities are the second-tier of local government in New Zealand, below Regional Councils.

<sup>2</sup> Given this, a profit shock in one land use should have two effects: it should directly raise the value of land already in that use, and it should induce land-use change toward the more profitable land use, changing the value of the land that does change (or might change) land use in response to the profit shock.

<sup>3</sup> This means we assume initial land use is fixed infinitely far into the future. We make this simplifying assumption to allow us to show more clearly the effect of a permanent profit shock.

<sup>4</sup> The profit function is the same for all  $i$  parcels that are in use  $j$ .

where  $a$  denotes quality of the land and  $\theta_j$  is a profit parameter. Profits within a land use thus vary only by land quality. We assume the profit parameter has an equal effect on expected future profits  $\forall t$ . Profits are differentiable in both land quality and the profit parameter, where  $\frac{\partial \pi_j}{\partial \theta_j} \geq 0$  and  $\frac{\partial \pi_j}{\partial a} \geq 0 \forall j$  such that higher quality land is more profitable. The land owner chooses land use to maximise their expected future profits, i.e. the land use choice will be  $j$  if:

$$\pi_j(a, \theta_j) \geq \pi_k(a, \theta_k), \forall k \quad (3)$$

This condition defines a set of critical values for land quality (for fixed  $\theta_j$ ), at which each land use  $j$  becomes more profitable than any land use  $k$ , where  $k \neq j$ . We assume there is a well-defined ordering of land uses according to land quality. This ensures that the  $a_{jk}^c$  are unique.

$$a_{jk}^c = a \quad \text{s.t.} \quad \pi_j(a, \theta_j) = \pi_k(a, \theta_k) \quad (4)$$

$a_{jk}^c$  is the lowest value of  $a$  for which a land owner will choose use  $j$  over use  $k$ . The subscripts of the critical values indicate that the value represents the lower limit of land quality for land use listed first, and the upper limit of land quality for the land use listed second. These critical values will be functions of the profit parameter  $a_{jk}^c = f(\theta_j, \theta_k)$ , where  $\frac{\partial a_{jk}^c}{\partial \theta_j} \leq 0$  and  $\frac{\partial a_{jk}^c}{\partial \theta_k} \geq 0$ . A positive profit shock to land use  $j$ , causing a rise in  $\theta_j$  then lowers the critical value, as  $j$  is now more profitable on lower quality land (which was previously used for use  $k$ ). A positive profit shock in land use  $k$  will raise the critical value, as use  $k$  becomes more profitable on higher quality land that was previously in use  $j$ .

Without loss of generality, we assume that the quality of the land  $a$  takes values from the closed interval  $a \in [0,1]$ , which are drawn from some distribution described by the function  $\psi(a)$ .  $0 < \psi(a) < 1$ , differentiable on the interval  $[0,1]$ . We define the cumulative distribution function  $\Psi(a) = \int_0^a \psi(\mu) d\mu$ , with  $\Psi(1) = \int_0^1 \psi(a) da = 1$ .

Data restrictions mean that most empirical work on rural land values is based on average profits and average land values, so we explicitly include the averaging process in our framework. The average profit within use  $j$  is given by:

$$\bar{\pi}_{jt}(a, \Theta) = \int_{a_{jk}^c(\theta_{jt}, \theta_{kt})}^{a_{lj}^c(\theta_{lt}, \theta_{jt})} \pi_{jt}(a, \theta_{jt}) \psi(a) da \quad (5)$$

where  $\Theta = [\theta_1, \dots, \theta_j, \dots, \theta_J]$ . The dependence on the profit parameters arises from the dependence of the critical values on these.



We define the average land value for each land use as:

$$\bar{v}_{jt} = \int_{t=1}^{\infty} \bar{\pi}_{jt}(a, \Theta) e^{-rt} dt \quad (6)$$

where  $\bar{v}_{jt}$  is the average value of land in use  $j$  at time  $t$  and  $\bar{\pi}_{j,t}(a, \Theta_t)$  is the average profit of land use  $j$  at time  $t$ . Substituting yields:

$$\bar{v}_{jt} = \int_{t=1}^{\infty} \int_{a_{jk}^c(\theta_{jt}, \theta_{kt})}^{a_{ij}^c(\theta_{it}, \theta_{jt})} \pi_{jt}(a, \theta_{jt}) \psi(a) e^{-rt} da dt \quad (7)$$

Finally, we define  $\omega_j$ , the land use weights that are used to construct final national-level weighted average.

$$\omega_{jt} = \int_{a_{jk}^c(\theta_{jt}, \theta_{kt})}^{a_{ij}^c(\theta_{it}, \theta_{jt})} \psi(a) da = \Psi(a_{ij}^c(\theta_{it}, \theta_{jt})) - \Psi(a_{jk}^c(\theta_{jt}, \theta_{kt})) \quad (8)$$

with  $\sum_j \omega_{jt} = 1$ . These allow us to define weighted national level average land values:

$$V_t = \sum_{j=1}^J \omega_{jt} \cdot \bar{v}_{jt} \quad (9)$$

See Appendix 1 for a derivation of the above for a two-land use case.

So far we have viewed land as a productive asset that is an input into agricultural production.

However, as discussed in section 2, amenity and option values are also important.

Rural land also functions as a home site for the farmer and their family. A parcel of land with a higher level of non-productive 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, and hence more valuable (see, for example Bastian et al., 2002; Borchers et al., 2014; Ma & Swinton, 2012; Stillman, 2005). We therefore include a term in our expression of average land values to account for the influence of non-productive local amenities.

$$V_t = \sum_{j=1}^J \omega_{jt} \cdot \bar{v}_{jt} + \bar{M}_t \quad (10)$$

where  $\bar{M}_t$  is the market value of the amenities possessed by the average land parcel. These amenities could include an attractive climate, 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.

Finally, we have so far neglected the option to convert the land to a non-agricultural use, such as housing. Rural land values may therefore reflect the value of the option to convert (Capozza & Helsley 1989; 1990). We amend our framework to include a third term, which reflects the present value of the expected future rents from urban conversion (net of conversion costs) averaged across all rural land parcels.

$$V_t = \sum_{j=1}^J \omega_{jt} \cdot \bar{v}_{jt} + \bar{M}_t + \bar{r}_{jt} \quad (11)$$

Here  $\bar{r}_{jt}$  is the present value of average expected rents from urban conversion. This expands the flow of benefits to rural land ownership beyond agricultural profitability.

Our framework shows one reason why earlier studies of the relationship between rural land values and agricultural profitability found that land values tend to overreact to changes in profitability. This reason is namely that land use responds to changes in relative profitability., so a failure to account for land-use change in some way forces its effect into the error term. Land-use change will be positively correlated with average profitability and land values, leading to an upward bias in the coefficient on profits.

## 4 Data

### 4.1 Rural land values

Our land value data come from comprehensive property valuation and sale databases produced by Quotable Value New Zealand (QVNZ).<sup>5</sup> QVNZ is New Zealand's largest valuation and property information company.

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The QVNZ sales database contains meshblock<sup>6</sup> level information on the number of sales, sale price, and land area sold, categorised by land use. This dataset is available for the period 1980-2012. QVNZ data operate on a June year, so the 2012 data reflect the 12month period ending 30 June 2013.

The QVNZ valuations data contains meshblock 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.<sup>7</sup> 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. QVNZ has conducted these legally required property valuations for the majority of local councils since 1989, and collected the information from the councils for which they did not conduct valuations to form a complete national sample. These valuations are used by councils for the purpose of local government property taxes (rates), and each property in New Zealand will be re-valued at least once in a given three-year period. Valuations depend on the physical characteristics of the property, the economic conditions at the time, and recent sales in the area (Nagel, 2013).

## **4.2 Rural land use profitability**

We focus our attention on dairy and sheep/beef profitability, as we have reliable data over our time period for these two agricultural activities.<sup>8</sup> Dairy and sheep/beef farming also account for the majority of agricultural exports and the majority of rural land in New Zealand.

Our profitability data come from two sources. Our sheep/beef profit data come from Beef and Lamb New Zealand.<sup>9</sup> 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 Ministry for Primary Industry's (MPI) Monitor Farm Reports.<sup>10</sup> We use the estimated economic farm surplus for their nationally representative dairy farm.<sup>11</sup> Our dairy profit data are available from 1982.

## **4.3 Meshblock information**

We define rural areas to be meshblocks (the smallest geographic unit defined by the New Zealand Government) where the majority of the land is in sustained agricultural production.

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<sup>6</sup> See section 4.3

<sup>7</sup> Examination of land use areas of rural properties in the valuations data shows a significant jump in land use areas around 1994. This is not plausible, given the other land use data available for this time period.

<sup>8</sup> National level estimates of forest profitability are available only from 1996, as this is when the first GIS maps of forestry are available. Horticultural and arable profits are available only from 2000. We include these land uses in our main land values variable. We tested the robustness of our results to excluding forestry, horticulture, and arable land. Inclusion of these land uses does not affect the results.

<sup>9</sup> Formerly Meat and Wool Economic Service.

<sup>10</sup> An issue with our profit data is that the nature of the 'average' farm changes over time as a result of land-use change. As more land has moved from sheep/beef into dairy, the characteristics of the average farm in each region has changed. Also, with the expansion of dairy farming outside of their traditional areas, the number of regions behind the national average dairy farm changes over time.

<sup>11</sup> The MPI 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.

Our meshblock boundary information is as at 2006, and comes from Statistics New Zealand.

To identify rural areas, we update the approach employed by Stillman (2005). His approach classifies individual meshblocks as either urban, rural, or areas outside the urban/rural dichotomy.<sup>12</sup>

In our analysis, we drop those areas: classified as water by the New Zealand Land Resource Inventory (NZLRI) available from Manaaki Whenua Landcare Research's Soils Portal, meshblocks, where more than 50% of the land area is managed by the Department of Conservation (DOC), and where more than 50% of the land value is assigned to an urban use by QVNZ.<sup>13</sup> Within each meshblock, we extract the land area in any of the main agricultural commodity producing land uses: arable, dairy, pastoral grazing, pastoral fattening/stud, exotic forestry, and horticulture.<sup>14</sup> Land in the other land-use categories is excluded from the analysis.

#### **4.4 Agricultural commodity prices**

We use agricultural commodity prices as our instrument for expected profits. We update and use the export price series constructed in Kerr & Olssen (2012). The authors construct an export unit value for sheep meat, beef meat, and wool using Statistics New Zealand's 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. This export price series also contains dairy and forestry<sup>15</sup> measures. Given the history of agricultural support, the authors weight 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.* (2007). Due to endogeneity concerns around using the dairy price as an instrument, we replace the NZ dairy price with the US wheat price, sourced from the United States Department of Agriculture (USDA).<sup>16</sup> This solves the endogeneity issue. USDA give the average price paid over the season in current USD, which is reliably correlated with the USA dairy price, and unrelated to conditions in New Zealand affecting NZ dairy. We convert these three annual average price series (sheep/beef, dairy and forestry) using the historical exchange rate series from the RBNZ.<sup>17</sup> We then deflate these series using the CPI (available from Statistics New Zealand) such that they are expressed in 2006 NZD.

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<sup>12</sup> These include water MBs that are used to capture people who live in houseboats and production which occurs on the water, and MBs that are predominantly conservation land.

<sup>13</sup> We tested the robustness of our results to including all MBs that recorded a sale of an arable, dairy, sheep/beef, forestry or horticultural property, regardless of their urban/rural classification. Inclusion of these MBs has very little effect on the results.

<sup>14</sup> We include forestry as it is an important sector in some rural areas.

<sup>15</sup> Our forestry measure is the average export prices for logs and pole (000m<sup>3</sup>)

<sup>16</sup> Source: <http://www.ers.usda.gov/data-products/wheat-data.aspx>, Table 20: US and foreign wheat prices.

<sup>17</sup> Source: <http://www.rbnz.govt.nz/statistics/b1>, B1 Monthly (1999-current) and B1 Monthly (1973-1998).

#### 4.5 Additional variables for sensitivity analysis

In some of our specifications, we substitute the standard time trend. In some specifications we use an Australian House Price Index, sourced from the Bank for International Settlements (BIS)<sup>18</sup>. In others we use a series of NZ Real GDP.

We also substitute a long term interest rate in place of our discount rate in some specifications. This rate is the NZ Reserve Bank annual yield on 10-year government bonds<sup>19</sup>.

#### 4.6 Summary statistics

Table 1 presents summary statistics for the levels of the variables, in 2006 NZD. The per hectare sale price ranges from \$2,700 to nearly \$13,000 over the sample period, with a sample average of \$6,400. Average profit over the period is similar to the average sale price, at \$5,800. Both series are quite volatile, with a standard deviation of \$3,000 for the sale price and \$2,100 for profits.

The average ratio of the present value of profits to land values over the period is close to 1, as we would expect in the long run if land values react appropriately to profitability and non-agricultural drivers play a minor role in determining land values. This ratio suggests that the average agricultural return is around 5.5%. The ratio is quite volatile, which is consistent with transitory shocks having an important short-run influence on profits but not on land values. The ratio is also stationary, meaning that shocks to the ratio are transitory - in the long run, the effect of these shocks disappears.

**Table 1: Summary statistics**

	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>	<b>ADF p-val</b>	<b>T</b>
<i>Sale Price</i>	6426	3046	2778	12958	0.2876	31
<i>PV Profits</i>	5840	2143	3313	10670	0.1048	31
<i>ACPI</i>	67	17	49	102	0.2755	31
<i>Profit\Sale price ratio</i>	1.07	0.51	0.34	2.41	0.0591	31

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This table contains summary statistics from our final dataset. *Sale Price* is the per hectare sale price, *PV Profits* is the present value of expected profits per hectare, and *ACPI* is the agricultural commodity price index. ADF p-values are the MacKinnon (1996) approximate p-values for the Augmented Dickey-Fuller (ADF) unit root tests of Said and Dickey (1984).

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<sup>18</sup> Source: [https://www.bis.org/nz/statistics/pp\\_long.htm](https://www.bis.org/nz/statistics/pp_long.htm)

<sup>19</sup> Source: <http://stats.oecd.org/index.aspx?querytype=view&queryname=86#> choosing Monetary and Financial Statistics: Interest Rates, new Zealand, Annual.

## 5 Descriptive analysis

As described in section 3, we construct a national level weighted average of the per hectare sale price. We first calculate 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 this national average.

**Figure 1: National rural sale price per hectare**

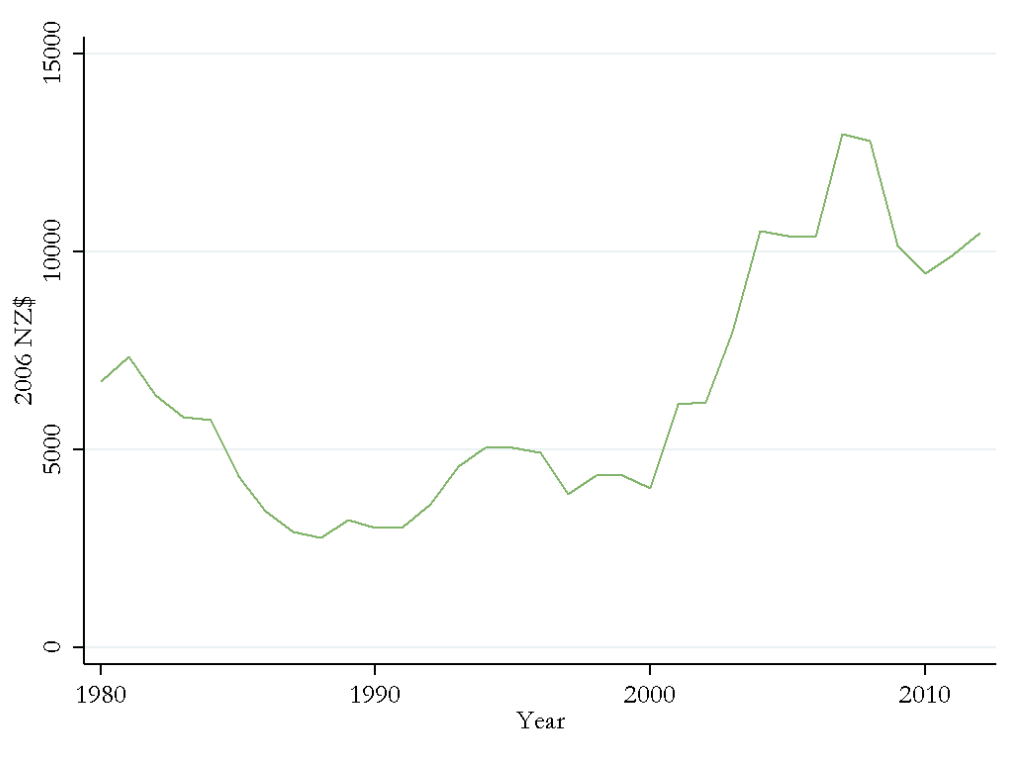


Figure 1 plots the per hectare rural sale price in 2006 NZD. New Zealand began a period of major economic reforms in 1984. These included the removal of agricultural subsidies, which is the likely driver of the sharp decline in rural land prices beginning in 1984. By 1988, the per hectare sale price was around 50% of its 1983 value. 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 coincide with the real estate boom that occurred in many developed economies during the 2000s. From a peak of \$12,500 per hectare in 2008, the sale price fell following the onset of the global financial crisis, and was slightly more than \$10,000 per hectare at the end of our sample period.

Figure 2 shows that dairy profits per hectare (left-hand axis) are in the order of 10 times those of sheep/beef profits (right-hand axis). The two series moved together quite closely over the

sample period. Both series dipped sharply following the removal of agricultural subsidies in 1984. Dairy profits fell from around \$1500/ha to just over \$1000/ha, and sheep/beef profits fell from around \$275/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. The appreciation of the exchange rate after the reforms was part of this effect for exporters.

**Figure 2: Sheep/beef and dairy profits per hectare**

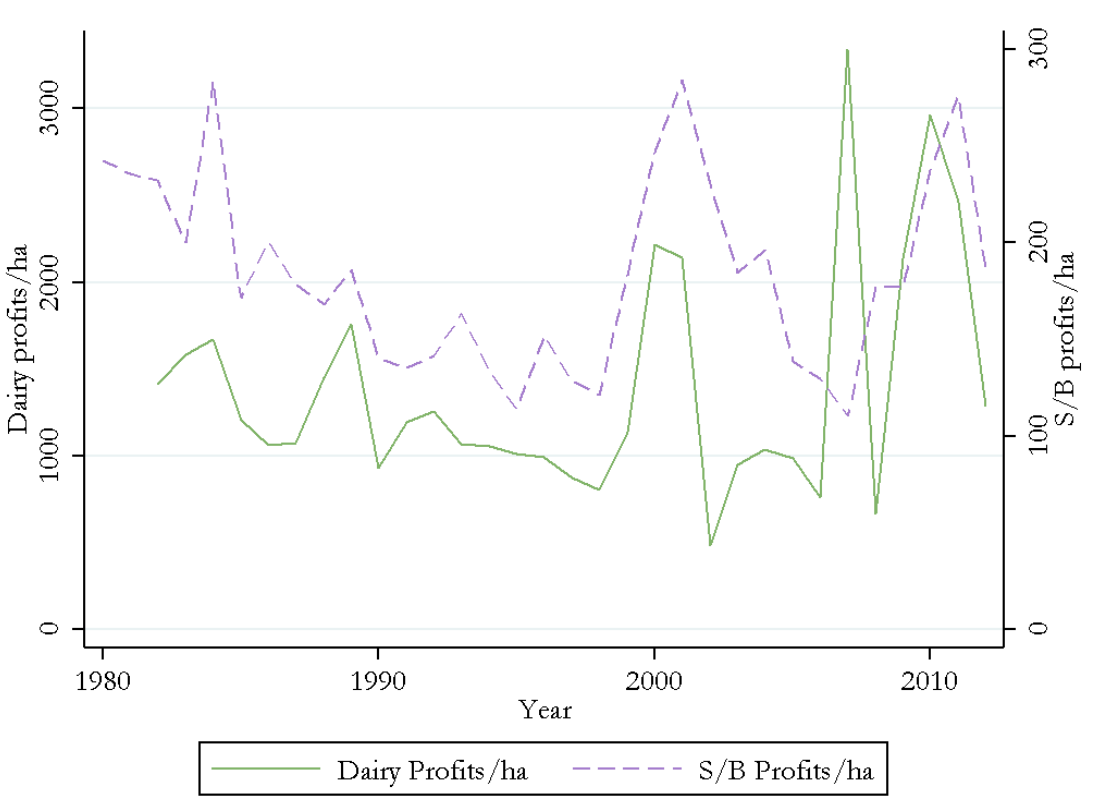


Figure 3 plots the per hectare sale price against the present value of expected profits. We see some co-movement between the two series, though there are times when the PV of expected profit series is above the sale price, such as the post-1984 reform period, and vice versa, most notably in the mid-2000s. The subsidy removal appears to have had a larger impact on land values than on profitability. This could be due to overly pessimistic expectations about the future profitability of the agricultural sector at the time. By the early 1990s, land values had returned to a level implied by profitability, and they remained around this level throughout the 1990s. During the 2000s land values grew strongly without an associated increase in profitability. This could be due to a combination of gradual movement from sheep/beef to dairy in response to expectations of continued high international dairy prices and reversion of the NZ exchange rate and over-optimistic expectations about future profitability. An

adjustment in expectations and a correction in land prices occurred following the GFC, where they returned to a level implied by current profitability.

**Figure 3: Rural sale price per hectare and present value of profits per hectare**



We now examine the immediate post-1984 period in more detail. 1984 is when agricultural subsidies were removed and is the most easily identifiable permanent profit shock in our sample period. Table 2 shows how both land values and average profits fell following the removal of subsidises.

**Table 2: Effect of 1984 subsidy removal**

	Change relative to 1984 values	
	1987	1988
<i>Sale price</i>	-2,810 (-49%)	-2,972 (-52%)
<i>PV Profits</i>	-2,740 (-37%)	-2,279 (-31%)



Average land values declined \$2810 (49%) between 1984 and 1987. The PV of profits fell by a similar amount, \$2740. The proportional decline in profits is smaller than that for land values as the PV of profits has higher than the sale price in 1984. By 1987, land values had declined further, while there was some rebound in profits. This rebound was driven by increases in dairy profits between 1987 and 1988.

## 6 Empirical strategy and results

### 6.1 Two-stage least squares framework

We use a two stage least squares (2SLS) time series regression framework to model the observed average sale price per hectare of rural land using average profits per hectare weighted by land use. We instrument these profits using a plausibly exogenous agricultural commodity price index (ACPI) to account for the endogeneity between sale prices and profitability. To back out the effect of permanent shocks to agricultural profitability on rural land values, we study the difference between time trend coefficients in two specifications. These are built using either time-varying or fixed land-use weights in calculating the profit variables. The difference between these coefficients gives us an estimate of the effect of gradual land-use change on land values, and is our coefficient of most interest.

Our 2SLS framework is modelled as follows.

$$PV Profits_t = \alpha_0 + \alpha_1 wACPI_t + \alpha_2 t + \zeta_t$$

where  $wprofit_t^{pv}$  denotes a weighted present value of average profits by land use, and  $ACPI_t$  is an agricultural commodity price index. We construct  $wprofit_t^{pv}$  as below:

$$PV Profits_t = (weights \cdot profit_{jt})/r$$

where  $weights$  may be either constant (set at their 1982 values) or dynamic,  $j = [1, 2]$  denotes land use type, where 1 = dairy and 2 = sheep or beef, and where  $r$  denotes some real discount rate.  $t$  is a linear time trend  $t = 1, \dots, T$  and  $\zeta_t$  an error term. In the time-varying specification, the effects of gradual land use change are partially captured by the profit series. In the fixed-weight specification, the trend will also capture the gradual movement into more profitable land uses.

This gives us the first stage result:

$$PV \widetilde{Profits}_t = \hat{\alpha}_0 + \hat{\alpha}_1 ACPI_t + \hat{\alpha}_2 t$$

Our second stage is modelled as follows:

$$Sale\ Price_t = \beta_0 + \beta_1 PV \widetilde{Profits}_{t-1} + \beta_2 t + \varepsilon_t$$

The difference between  $\beta_1$  using either fixed or dynamic land use weights is our variable of most interest, giving us an estimate of the effect of gradual land-use change on land values.

## 6.2 Results

Table 3 reports the key empirical results. Column 1 reports the ordinary least squares (OLS) estimates of the relationship between land values and profits. Columns 2 and 3 present the two stage least squares (2SLS) estimates of the relationship between the levels of land values and profits, using agricultural commodity prices as an instrument for profits.

The estimated coefficient in column 1 is small and insignificant. This is consistent with measurement error in profits causing attenuation bias. In column 3, the effects of land-use change are captured by the profit series, while in column 4 these effects are picked up by the trend term. In both columns, we find a statistically significant, positive relationship between land values and profits. We cannot reject the null hypothesis that this relationship is dollar-for-dollar in either specification.<sup>20</sup> We did expect the coefficient estimate in column 2 to be smaller than that in column 3, as the estimate in column 2 includes the effect of realised land-use change. The trend estimate is higher in column 3 than that in column 2, consistent with the trend capturing the effects of realised land-use change. Table 4 reports a similar finding when we use a time-varying discount rate to construct the present value of profits.

We use the differences in the trend estimates to provide a back-of-the-envelope calculation for the effects of realised land-use change on land values. The difference between the trend estimates in columns 2 and 3 is \$91. Our analysis indicates average rural land values grow by \$201 per year, after controlling for profitability. We can attribute \$91 of this increase to the effects of realised land use change, with the remainder being due to other, non-agricultural specific drivers of land values (such as amenity values, option values, or asset values).

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<sup>20</sup> We recognise that an ordinary t-test of cointegrating parameters is not the appropriate test. Under the null hypothesis of no cointegration, the residuals from these regressions are non-stationary, meaning that an ordinary t-statistic is not asymptotically normally distributed under the null. The asymptotic distribution will have excess weight in the tails.

**Table 3: Regression estimates of the relationship in levels between land-use weighted average rural land values and the present value of average profits**

	(1)	(2)	(3)	(4)
	OLS	2SLS	2SLS	
	Fixed land-use weights	Dynamic land-use weights	Fixed land-use weights	Difference (2) - (3)
	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>	
<i>PV Profits<sub>t-1</sub></i>	0.061 (0.168)	1.627*** [0.614]	1.736*** [0.557]	
<i>Trend</i>	260.7*** (52.79)	110.8 [83.01]	201.9*** [68.22]	\$91
<i>Constant</i>	-514,660*** (104,868)	-224,398 [164,285]	-405,629*** [135,835]	
<i>T</i>	31	31	31	
$\beta_1 = 1$	0.000	0.307	0.187	
<i>EG stat.</i>	-2.780	-3.088	-3.264	

This table contains the regression outputs for different specifications modelling the observed average value of rural land (the sale price) by the present value of expected profits in NZ between 1980-2012. Heteroscedasticity and autocorrelation (HAC) adjusted standard errors are shown in parentheses. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5% and 10% levels. Estimation was carried out using ordinary least squares for columns 1; columns 2 and 3 were estimated using two-stage least squares (2SLS). 2SLS estimation was carried out using the ivreg2 command in Stata (Baum et al. 2007). The excluded instrument from the 2SLS estimation is an agricultural commodity price index. Column (2) contains estimates where the profitability measure was calculated using dynamic land use weights, whereas column (3) uses fixed weights.  $\beta_1=1$  is the two-sided p-value for testing the null hypothesis that  $\beta_1=1$ , i.e. that there is a proportional relationship between the present value of profits and rural land values. EG is the Engle-Granger statistic for testing co-integration.

Table 4 presents our robustness results. Our results are robust to using the real interest rate on 5-year government bonds as our discount rate and are robust to replacing the trend with real GDP or an Australian house price index. We use an Australian house price index as it is credibly exogenous to NZ's rural land market, while being closely linked to NZ's housing market (Grimes et al., 2010). We do find evidence of co-integration in one of our robustness specifications – see column (2) of Table 4.

**Table 4: Robustness checks - 2SLS estimates with time-varying discount rate and alternative control variables**

	(1)	(2)	(3)	(4)	(5)	(6)
	Time-varying discount rate		Alternate time trends			
Land use weights:	dynamic	fixed	dynamic	fixed	dynamic	fixed
	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>	<i>Sale Price<sub>t</sub></i>
<i>PV profits<sub>t-1</sub></i>	1.014** [0.453]					
<i>PV profits<sub>t-1</sub></i>		1.144** [0.472]				
<i>PV profits<sub>t-1</sub></i>			1.628** [0.817]		1.374* [0.709]	
<i>PV profits<sub>t-1</sub></i>				1.434** [0.559]		1.252** [0.518]
<i>Time</i>	-59.13 [75.48]	14.49 [59.41]				
<i>Real GDP<sub>t</sub> (millions)</i>			0.0505 [0.0376]	0.0849*** [0.0231]		
<i>AU HPI<sub>t</sub></i>					12.99 [8.588]	20.67*** [5.363]
<i>Constant</i>	119,585 [149,429]	-27,242 [117,782]	-8,352** [3,567]	-9,603*** [2,703]	-3,855 [3,253]	-3,425 [2,264]
<i>T</i>	31	30	31	31	31	31
$\beta_1 = 1$	0.975	0.760	0.442	0.438	0.597	0.626
EG $\tau$ -stat	-3.639	-4.610**	-3.326	-3.347	-3.212	-3.486

This table contains the regression outputs for different specifications modelling the observed average value of rural land (the sale price) by the present value of expected profits in NZ between 1980-2012. Heteroscedasticity and autocorrelation (HAC) adjusted standard errors are shown in parentheses. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5% and 10% levels. Estimation was carried out using two stage least squares (2SLS). 2SLS estimation was carried out using the ivreg2 command in Stata (Baum *et al.* 2007). The excluded instrument from the 2SLS estimation is an agricultural commodity price index. AU HPI is an Australian House Price Index (see data section).  $\beta_1 = 1$  is the two-sided p-value for testing the null hypothesis  $\beta_1 = 1$ , i.e. a proportional relationship between the present value of profits and rural land values. EG is the Engle-Granger test statistic.

While we cannot reject a 1-for-1 relationship between land values and price-induced shocks to profitability, our large standard errors mean we cannot rule out behaviour consistent with land values over- or under-reacting to profitability. We find no evidence of co-integration between land values and profitability; this is likely due to the low power of co-integration tests in small samples. Standard inference is invalid in the absence of co-integration, making it difficult to draw truly meaningful conclusions about the size of the relationship.

## 7 Discussion and Conclusions

We conduct a test of a present valuation 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 profits from agricultural production and the flow of benefits from the lifestyle amenities that the land possesses. The rural land market is also influenced by the urban housing market as rising house prices increase the returns from subdividing and converting rural land into lifestyle blocks or suburban housing.

Our focus in this paper is how land values react to price-induced shocks to profitability. We develop a theoretical framework that traces the pathways through which a profit shock influences land values. Profit shocks affect land values in two ways: through a direct effect on the profitability of land in the land-use that experiences the profit shock, and by inducing land-use change. We test the implications of our model both descriptively and empirically and our findings are consistent with our model. The ratio between land values and the present value of agricultural profitability is one on average, and the removal of agricultural subsidies lead to similar sized declines in land values and profitability. We use a 2-stage estimation procedure to estimate the relationship between land values and price-induced shocks to profitability. Our strategy uses commodity prices as an instrument for profits. We find a positive relationship between the present value of expected 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; large standard errors and a lack of strong evidence of co-integration make it difficult to make meaningful statements about the true size of the relationship. While we find a relationship between land values and profitability, we also find evidence consistent with amenity values and option values playing a role in determining the price of rural land.

Our results should be regarded as preliminary. While we cannot reject a one-for-one relationship between land values and the present value of profitability in the long run, our estimates are quite imprecise. More data will allow for more precise estimates of the relationship and a more robust test of the hypothesis that land values and the present value of profitability increase one-for-one. Our main result is robust to a range of specification checks. In Allan and Kerr (forthcoming), we use panel data to re-estimate the relationships in this paper. We find much stronger evidence of a 1-for-1 relationship between land values and price-induced shocks to profitability.

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## Appendix 1 – Two land use case derivation

We are interested in how average land values respond to a permanent shock to the profitability in one land use. In a case with only two land uses, taking the derivative of  $v_t$  with respect to  $\theta_{1t}$  yields:

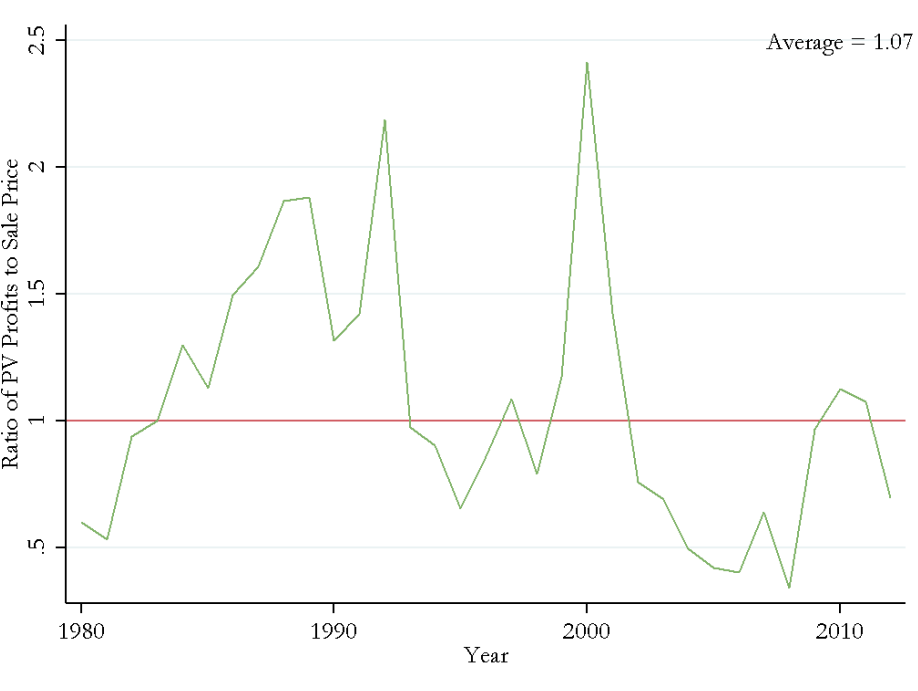
$$\begin{aligned}
 \frac{\partial V_t}{\partial \theta_{1t}} = & \int_{a_{12}^c(\theta_{1t}, \theta_{2t})}^1 \psi(a) da \left( \int_0^\infty \int_{a_{12}^c(\theta_{1t}, \theta_{2t})}^1 \frac{\partial \pi_{1,t}(a, \theta_{1t})}{\partial \theta_{1t}} \psi(a) e^{-rt} da dt \right. &>0 \\
 & \left. - \int_0^\infty \pi_{1,t}(a_{12}^c(\theta_{1t}, \theta_{2t}), \theta_{1t}) \psi(a_{12}^c(\theta_{1t}, \theta_{2t})) \frac{\partial a_{12}^c(\theta_{1t}, \theta_{2t})}{\partial \theta_{1t}} e^{-rt} dt \right) &>0 \\
 & - \frac{\partial \Psi(a)}{\partial a_{12}^c(\theta_{1t}, \theta_{2t})} \frac{\partial a_{12}^c(\theta_{1t}, \theta_{2t})}{\partial \theta_{1t}} \left( \int_0^\infty \bar{\pi}_{1,t}(a, \Theta_t) e^{-rt} dt - \int_0^\infty \bar{\pi}_{2,t}(a, \Theta_t) e^{-rt} dt \right) &>0 \\
 + & \int_0^{a_{12}^c(\theta_{1t}, \theta_{2t})} \psi(a) da \int_0^\infty \left( \pi_{2,t}(a_{12}^c(\theta_{1t}, \theta_{2t}), \theta_{2t}) \psi(a_{12}^c(\theta_{1t}, \theta_{2t})) \frac{\partial a_{12}^c(\theta_{1t}, \theta_{2t})}{\partial \theta_{1t}} \right) e^{-rt} dt &<0
 \end{aligned}$$

The first term is the direct effect of the profit shock in use 1. The average profits already in land use 1 increase as a result of the shock. The second term adjusts for the fact that the average has changed as a result of land-use change. The third term is the net effect of land-use change. Land moving from use 2 to use 1 lose the profits from use 2, but gain the profits associated with use 1. The final term adjusts the average profits in use 2 for the fact that the best quality land in use 2 has moved to use 1.



**Appendix 2 – Ratio of present value of profits to sale price**

**Figure 4: Ratio of PV of profits to sale price**



**Appendix 3 – Log specification**

Table 5 reports the results for the log specification. We find a statistically significant, positive relationship between land values and profits, and cannot reject the null hypothesis of a unitary elasticity, which we would expect from our theoretical framework if other drivers of land values play a minor, trend stationary, role. The estimate in column 3, where the effects of land-use change are captured by the trend, is smaller than that in column 2, consistent with our expectations. The difference between the trend estimates in these columns is 1.2 percentage points. Column 3 indicates that land values grow by 3.3%, 1.2 percentage points of which we attribute to realised land-use change. The remainder is likely due to long-run growth in amenity, option, and/or asset values. Our results suggest that agriculture has generated an average annual return of 8.8% over the period. 5.5 percentage points of this are the returns from agricultural production. The remaining 3.3 percentage points are a mixture of land-use change and non-agricultural drivers.

**Table 5: 2SLS estimates of the relationship in logs between land-use weighted average rural land values and the present value of average agricultural profits**

	(1)	(2)	(3)	(4)
	OLS	2SLS	2SLS	
	Fixed land-use weights	Dynamic land-use weights	Fixed land-use weights	Difference (2) - (3)
	$\ln Sale Price_t$	$\ln Sale Price_t$	$\ln Sale Price_t$	
$\log PV Profits_{t-1}$	0.131 (0.147)	1.512*** [0.565]	1.390*** [0.440]	
<i>Trend</i>	0.038*** (0.00827)	0.0208 [0.0128]	0.0328*** [0.0105]	1.2pp
<i>Constant</i>	-69.06*** (16.00)	-48.18** (22.65)	-68.79*** (20.24)	
<i>T</i>	31	31	31	
$\beta_1 = 1$	0.0000	0.364	0.375	
<i>EG</i> $\tau - stat$	-3.367	-3.429	-3.22	

See notes from Table 4.

#### Appendix 4 – First-stage regression results

Table 6 reports the results from the first stage regressions, as well as first-stage diagnostic tests. Columns 1 and 2 report the results for the first stage estimates of the results reported in columns 3 and 4 of Table 3, while columns 3 and 4 report the first stage results for the results in columns 5 and 6 of Table 3. We report two diagnostic tests for the first stage regressions from Kleibergen & 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 & 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.<sup>21</sup> With

<sup>21</sup> Stock and Yogo (2005), Table 2. Stock and Yogo (2005) do not provide critical values based on relative bias for the case of one endogenous regressor and one excluded instrument.

test statistics of between 8.6 and 16.7, 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 20% in column 1, 15% in columns 2 and 3, and 10% in column 4. 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 model is identified for all models reported here.

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

	(1)	(2)	(3)	(4)
	Dynamic land use weights	Fixed land use weights	Dynamic land use weights	Fixed land use weights
	$PV Profits_t$	$PV Profits_t$	$\ln PV Profits_t$	$\ln PV Profits_t$
$ACPI_t$	67.25*** [23.83]			
$ACPI_t$		63.24*** [17.44]		
$\ln ACPI_t$			0.894*** [0.278]	
$\ln ACPI_t$				0.926*** [0.228]
$Year$	176.1*** [57.40]	111.2*** [38.98]	0.0264*** [0.00838]	0.0201*** [0.00685]
$Constant$	-350,339*** [115,681]	-221,254*** [78,502]	-47.66** [17.59]	-34.20** [14.23]
$T$	31	31	31	31
$R^2$	0.256	0.255	0.252	0.267
K-P rK LM stat	5.610	7.885	5.926	8.523
K-P rK LM p-val	0.0179	0.00499	0.0149	0.00351
K-P rk F-stat	7.961	13.15	9.319	16.48
EG $\tau$ stat	-4.330**	-4.179**	-5.090***	-4.437**

Notes: HAC standard errors in parentheses. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.



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