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Understanding the Short and Long Run Relationship between Vacant Allotment and Established House Prices: a Case Study of Adelaide, Australia

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Abstract

This study addresses a key issue fundamental to the operation of land and housing markets, that is, the relationship between land and house prices. The study identifies possible causation between established house and vacant allotment prices using the metropolitan area of Adelaide, Australia as a case study. A key outcome of the study is the construction of a Site Adjusted Land Price Index against which a Quality Adjusted House Price Index is compared. The lead lag relationships of both indexes are tested using Granger causality estimates to assess whether theoretical Ricardian concepts still hold in a modern urban land market. The results show that there is a lagged effect of land prices on house prices and that this is significant at an interval of eight lag periods. The results also imply that the lead lag relationship between established house and vacant allotment prices is not unidirectional. This suggests that, while a change in house prices leads to a change in land prices in the short run, the long run position is for increasing land prices to lead to a delayed increase in house prices. Rising house prices do not simply and solely reflect a shortage of land. There are suggested effects both immediate from house to land and delayed from land to house, particularly in a rising market.

Keywords

Land price index, Granger causality

Introduction

In Australia a number of agencies have called for greater research into the relationship between land and house prices including the Australian Housing Supply Council (2009; 2010), the Australian Property Council (2007) and the Housing Industry Association (HIA) (2009). A key rationale for the reporting of land prices lies within the context of housing affordability. One factor considered critical to the determination of housing affordability is land costs in that cheaper land should result in a more affordable housing market. In the recent government literature (Housing Supply Council, 2009; 2010) and invariably in the industry material (Moran, 2008; Day, 2009; UDIA, 2009; APC, 2007) the link between rising land prices across Australia and rising house prices is understood to be fundamental. A first step in understanding the relationship between land and house prices, however, is an appropriate land price index. While the establishment of median house prices and a hedonic house price index is well researched (Rossini, 2002, 1996; Rossini & Kershaw, 2006), the construction of a vacant land index is significantly more problematic. Substantially more vacant urban land is sold only once as a vacant site (after which it is developed) and greater percentages are sold in multiple transactions and under circumstances which might be considered non-market. In this study a Site Adjusted Land Price Index is first constructed and then compared to an equivalent Quality Adjusted Housing Price Index as a means of establishing any relationship between the two indexes. The analysis is undertaken for Adelaide, the state capital of South Australia for a 25 year time period from 1985 to 2010. The metropolitan area of Adelaide has been selected as a case study for the construction and analysis of the land price index as it is recognized by the development industry as one of the best managed capital cities in terms of vacant land supply (HIA, 2009) within Australia.

Literature

Government inquiries into housing affordability in Australia have recognised the key role that demand drivers, such as income levels, cheaper finance, and population growth play in determining house prices. Both the Productivity Commission into First Home Ownership (Australian Government Productivity Commission 2004) and the Reserve Bank of Australia (RBA) (Ellis 2006) were of the opinion that a general surge in demand had led to a widespread escalation in house prices with Ellis (2006) concluding that an “untrammelled supply of extra dwellings would not have prevented a large increase in Australian house prices over the last decade”. Ellis (2006), Otto (2007) and Costello and Rowley (2009) have

all identified a weak or non-existent relationship between land supply and house price growth. Yet, according to recent government literature (National Housing Supply Council, 2009) and industry material (Moran, 2006; Day, 2009; UDIA, 2009; PCA, 2007) rising house prices across Australia are understood to be fundamentally a result of rising land prices through restricted land supply. This is despite the general recognition that the rate at which new houses can be built (the flow of housing) is very small relative to the existing stock of dwellings (approximately 2 per cent) and that as a result house prices across the wider Australian economy could rise or fall irrespective of what is happening to the supply of new homes (Ellis, 2006).

The theory of land pricing is based on the model developed by David Ricardo who in the 19th century suggested that the fundamental value of land was derived from the returns, or 'rent' surplus that it produced. Ricardo offered what was then the revolutionary idea that the price that was paid for land was determined by the returns that could be achieved from it. Inherent in the Ricardo model is the assumption that land is inelastic in supply, that in time it will be given over to its optimum use and that the expectation of returns from land drive the level of demand. Within the Ricardian approach land is said to *have* value whereas housing or other so called improvements merely *add* value. This Ricardian model was later supplemented by the neoclassical approach which recognised that both demand and supply factors worked together to achieve an equilibrium point in terms of price (Evans, 2004). This approach would tend to suggest that there is causation from land to house prices (Cheung et al, 2009) and that any increase in land prices will be reflected in higher house prices, in that land costs are included in house prices. The neoclassical approach assumes that land supply is not restricted and that all sites have potentially a variety of uses. Any move away from the equilibrium, that is a rise in land prices, will be the result of either restrictive land regulations or extra demand for land at a particular location. In contrast the Ricardo concept of 'rent' surplus was used by Alonso (1964) and Muth (1969) to identify land values as being the result of development value minus development costs and a required profit margin. This approach has become more generally known as the residual, development or hypothetical form of land valuation and is traditionally understood to be the technique used by developers to formulate their expectation of value, costs and financial viability (Guy & Henneberry, 2002). The residual method identifies the value of land to be purchased as that amount which is left after all costs plus a profit margin have been deducted from the estimated value of the completed housing development. The residual value identifies for the developer the amount that should be paid for the land which can be compared to the asking price to determine whether the housing development is feasible or not. Developers look to the

already existing housing market to establish a likely selling price for their product. Since the supply of houses for sale in an area is usually dominated by established properties (up to 90 per cent) developers are considered to be 'price takers' (Oxley, 2004). From this approach it would seem that the price paid for the land is a function of the expected selling price of the development which has been largely derived from the existing housing market. Price formation occurs first in the housing market with price rises moving to the land market. Hence, following this line of argument, land prices are fundamentally a product of house prices (Appraisal Institute, 1992).

This elemental understanding has been supported in empirical work carried out by Ball (1983), Bramley and Watkins (1996), Dipasquale and Wheaton (1996), Leishman et al (2000), Gillen and Fisher (2002), Ooi and Lee (2007), Li (2009) and Altuzza and Esteban (2011). Fundamentally these studies found that price movements in the land market are influenced by what happens in the housing market. While the calculations involved in determining the present value of a staged housing development require considerable financial sophistication, the basic premise remains that land prices are considered a residual after the deduction of development costs and desired profits from predicted revenues (Adams et al, 2009). Thus changes in market activity such as rising or falling prices in the existing housing market should be reflected in prices paid for land.

Leishman et al (2000) and Adams et al (2009) have extended the approach by focusing on developer behaviour and suggest that uncertainty and attitudes to risk are key influences on land prices. Developers are considered to be risk averse with bids for land made more on current house prices rather than forecast values. This results in land values being underestimated as uncertainly leads to a collective conservatism (Leishman et al 2000). However the downside of this approach can be that in a constrained land market taking too conservative a view will undermine their chances of success. This is particularly so when demand is strong and house prices are rising. In this environment developers will bid more competitively for land with current prices strong and their profit margins ensured. However if the market turns developments, even with ample land supply, will be mothballed as forecast returns fail to cover even marginal costs (Adams et al 2009). In a falling market price paid for land may be based more on forecast house prices while, in a rising market, current prices prevail.

Thus the housing market cycle impacts directly on developer behaviour and on prices paid for land. As well constraints on land supply, through planning restrictions or for other

reasons, can increase expectations of higher house prices, promote competition and drag land prices up (Adams & Watkins, 2002). As such higher land prices are being reflected in higher house prices. Ooi and Lee (2007) suggest that such cross-market interactions cannot be ignored. Kim et al (2008) suggest that the relationship between house and land prices may be bi-directional with higher house prices leading to a greater demand by developers for land, for which they are willing to pay a higher price. However restricted land supply and stringent land use regulations can also explain any causality from land to house prices.

This study attempts to examine if any such relationship between house and land prices can be identified within the Australian housing market using the metropolitan area of Adelaide as a case study. It is innovative in that establishing the nature of the long run relationship, and identifying any possible causation between house and land prices, has not been attempted before for the Australian housing market, largely because of the lack of an appropriate land price index. This paper explains how such an index has been constructed before testing the relationship of house and land prices for an Australian metropolitan area over time. After the construction of the land price index the lead lag relationships of a Site Adjusted Land Price Index are compared to an equivalent Quality Adjusted Housing Price Index and tested using Granger causality estimates to assess whether the theoretical concepts as discussed above are valid in a dynamic urban land market.

Method

This paper reports on over 121,833 vacant land transactions for a 30 year time period from 1981 to 2010 and some 404,549 detached dwelling transactions between 1985 (when building size data was available) and 2010 for metropolitan Adelaide. The property transaction data for 1981 to 1992 was obtained from the Valuer General SA and the data from 1993 to November 2010 from the State Government SA and RP Data (2010). The methodology first describes the steps used to clean the data. Next the equations used to adjust land and house prices to create a Site Adjusted Land Price Index and a Quality Adjusted Housing Price Index are described. Finally the lead lag relationships of the two indexes are tested using Granger causality estimates. This approach is based on the procedure suggested by Engle and Granger (1987) and utilised by Ooi and Lee (2007) in a similar study involving house and land prices in Singapore.

One of the basic starting points when working with property transaction data and creating a time series is that the data needs to be “cleaned” to remove observations that might not reflect the true market position. Typically this process will simply be reported as "removing non-market transactions”. However in practice the method used to collect the data and the

level of information available will have a significant impact on how data is cleaned. The requirements for cleaning will therefore vary by jurisdiction and by land-use. The major problem concern with cleaning is the typical Type I and Type II error problem in statistics. Insufficient cleaning may result in a biased time series by including sales transactions which do not properly reflect the position of the market. Over cleaning will dramatically reduce the sample size and may systematically remove properties and so skew the results.

The establishment of median house prices and a hedonic house price index within Adelaide is well researched and the authors have significant experience in the creation of such time series data. However vacant land creates a different problem. Significantly more vacant urban land is sold only once as a vacant site (after which it is developed) and greater percentages are sold in multiple transactions and under circumstances which might be considered non-market. For this study a number of cleaning options were available and as a preliminary step a number of these for both the housing and vacant land market were trialled. As such the cleaning steps involved one or more of the following approaches.

Sales tagged as "OTHER LAND" or "nonmarket transactions" were removed. The first tag referred to sales involving more than one parcel of land or more than land; for example the sale of several parcels of land under one contract price. The second tag refers to transactions where the government authority deems the sale to be nonmarket; for example they involve related parties. As well sales in development zones which are most probably designated for commercial-industrial activities were removed as they may reflect non-residential prices. Next restrictions were placed upon land and building sizes. In practice this is an essential process when using a hedonic price index as both of these variables are important “adjusters” in the model and must be included. As building areas were not recorded prior to 1985 data from 1981 to 1984 was dropped when using this restriction. Restrictions were also made based on comparing the sale price to the assessed capital value (AS ratio) of a property. A number of different ratio ranges were trialled in this study. The most broad of these removed sales only if the AS ratio was less than .3 (that is sale price is 3/10ths of the capital value) or greater than three (that is sale price is 3 times the capital value). Narrower ratio ranges were also trialled in the cleaning process. A further restriction that could be used for vacant land is to remove sales where the assessed capital value does not equal the assessed site value. Technically for unimproved vacant land these should be identical. These cleaning criteria and their impact on the data base are tabled below (Table 1) which shows the volumes of transactions for various different cleaning steps.

Table 1 Volume of transactions for various data cleaning steps

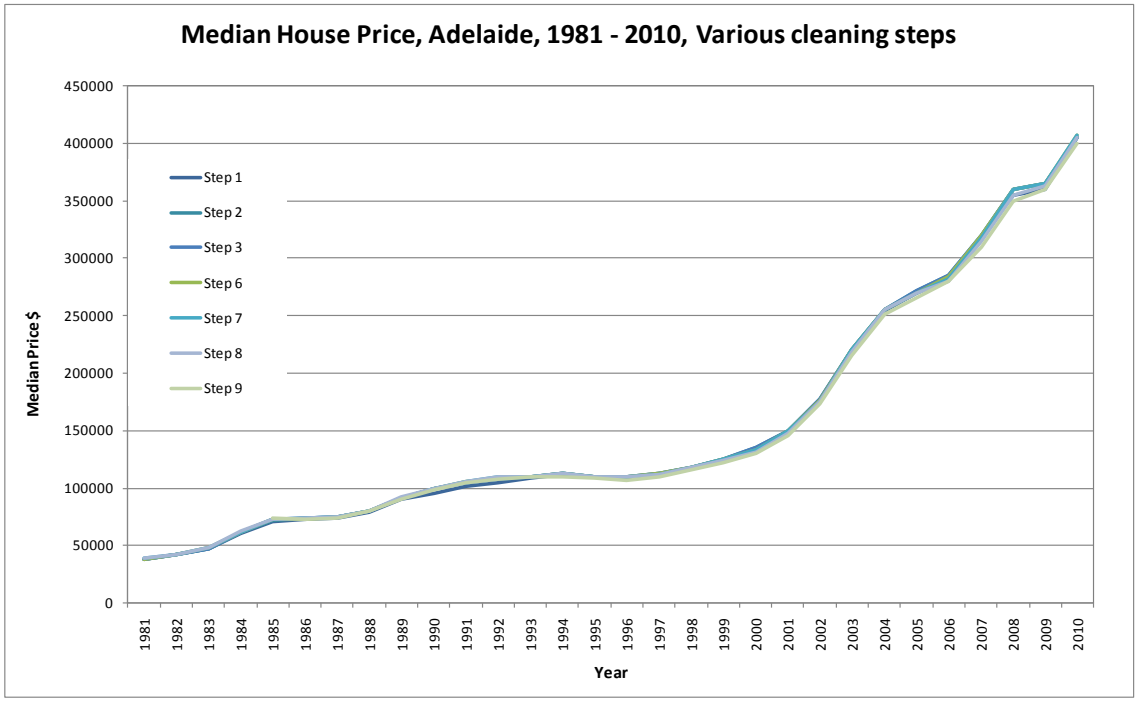
Step	"Cleaning" steps	# House Sales	% of Total	# Land Sales	% of Total
1	All Sales of that Land Use	581955	100%	169412	100%
2	Remove "OTHER LAND" and VG non-markets	527342	91%	141760	84%
3	Remove "OTHER LAND", VG non-markets and COM IND	521166	90%	135953	80%
4	Remove "OTHER LAND", VG non-markets, COM IND and restrict land size.	N/A	N/A	121833	72%
5	Remove "OTHER LAND", VG non-markets, COM IND, restrict land sizes and CV=SV.	N/A	N/A	72398	43%
6	Remove "OTHER LAND", VG non-markets, COM IND, AS Ratio <.3 AS Ratio >3	502098	86%	61014	36%
7	Remove "OTHER LAND", VG non-markets, COM IND, AS Ratio <.5 AS Ratio >2.5	495856	85%	49755	29%
8	Remove "OTHER LAND", VG non-markets, COM IND, AS Ratio <.6 AS Ratio >2	482578	83%	42943	25%
9	Remove "OTHER LAND",VG non-markets, COM IND, AS Ratio <.6 AS Ratio >2 ,restrict land and building sizes.	404549	78% *	N/A	N/A

* This percentage is of the houses sold from 1985 onwards when building size data was available.

For housing the minimal cleaning is probably at Step 3, that is the removal of clearly nonmarket transactions and probable commercial industrial zone properties. This results in around 10 percent of houses and 20 percent of vacant land sites being removed. Further cleaning effects for housing leads to a further reduction of 12 percent (78 percent of the original sales) at the most extreme point where properties outside of a narrow AS ratio band and restricted land and building sizes. Within land sales however additional cleaning has a dramatic effect upon the sample size and the use of assessed value indicators (either CV equals SV or any of the AS ratio ranges) results in sample sizes dropping below 50 percent and down to as low as 25 percent. This size of reduction in the sample leads to an a-priori rejection of using AS ratio cleaning for vacant land transactions although it is probably very useful for housing.

The significant issue is how cleaning the data affects the time series. To give some indication of the effect of cleaning on the time series the mean and median price is calculated for both housing and vacant land using each cleaning process and the results are compared on a visual basis. Figure 1 shows the time series of median house prices across Metropolitan Adelaide between 1981 in 2010 using various cleaning steps.

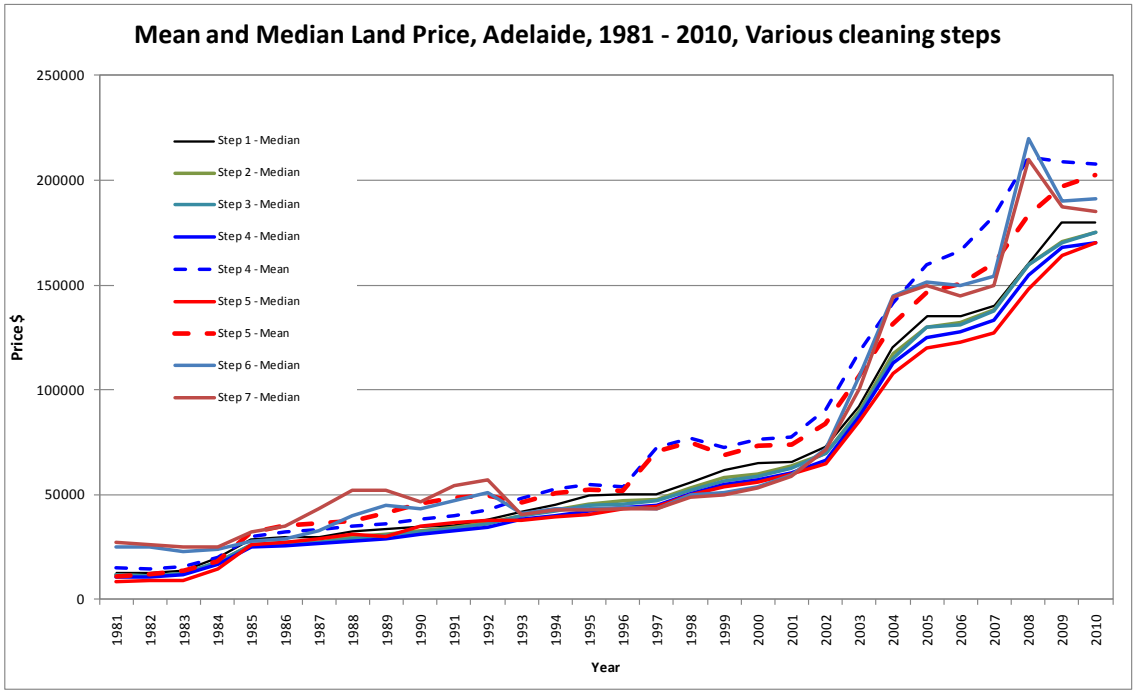
Figure 1 Median house price Adelaide 1981-2010



Source Author analysis based on SA VG, SA State Government & RPData

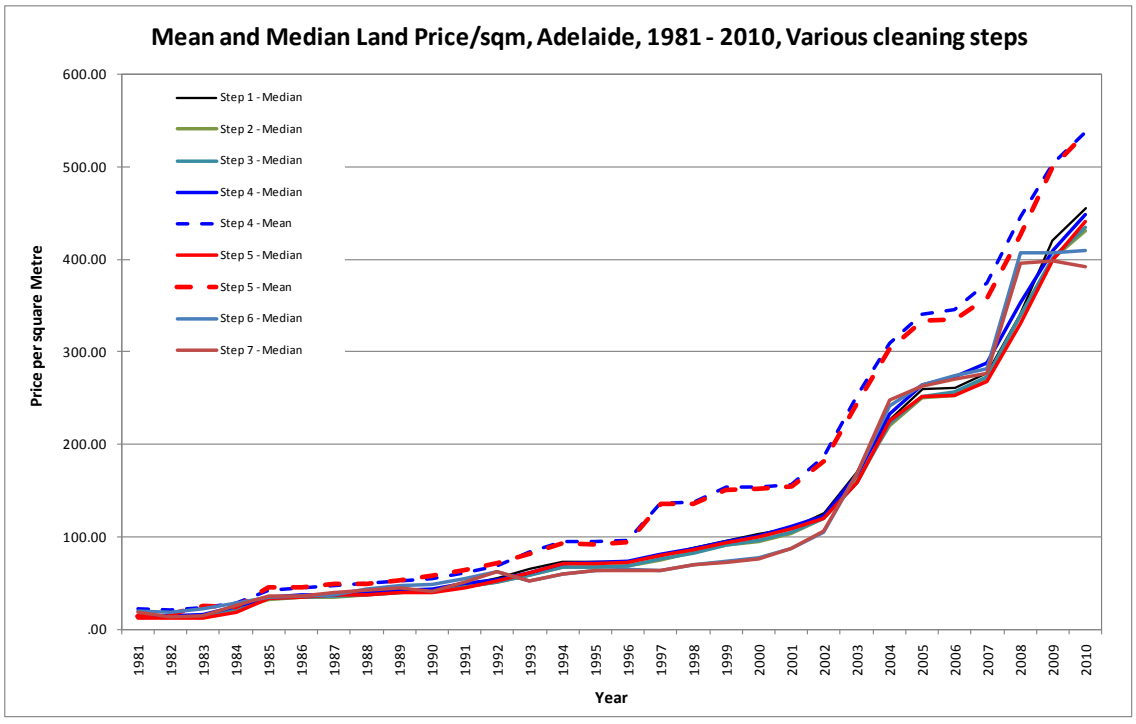
What is immediately noticeable on a visual inspection is that regardless of what cleaning step is used, the time series follows almost exactly the same pattern and that the overall results vary very little. Having said this, one difference is that the 2010 average price for housing in Adelaide varies between $405,000 and $407,000 for the cleaning methods used in Steps 1 to 8 but is only $400,000 when Step 9 is introduced, that is the restricting of land and building sizes. Figure 2 shows the mean and median land price for metropolitan Adelaide over the same period for each cleaning process. Figure 3 shows this same time series where price is calculated on a per square metre basis. Both Figure 2 and Figure 3 show that there is a significant difference in the time series depending upon the cleaning method used and that particular methods, such as using AS ratio cleaning (Steps 6 and 7, Table 1), result in very different outcomes from the other methods and that the results are “lumpy”. These “lumps” seem to relate to periods when large numbers of sales are deleted from particular locations suggesting some bias in site value assessment of vacant allotments which in turn suggests that AS ratio cleaning is inappropriate for vacant land. It is also clear that the mean and median prices showed a somewhat different pattern and that and the price per square metre, using most of the cleaning methods, produced a more consistent result than using land prices only.

Figure 2 Mean and median land price, Adelaide 1981-2010



Source Author analysis based on SA VG, SA State Government & RPData

Figure 3 Mean and median land price/sq metre Adelaide, 1981 - 2010



Source Author analysis of SA VG, SA State Government & RPData

After consideration of the various cleaning processes the study adopted the following cleaning approach. In each instance “other land”, nonmarket transactions and probable commercial-industrial zoned properties were removed. In the case of land transaction, size restrictions were then imposed and only land transactions when the land was between 50 m² and 1500 m² were included. For housing the same land area restriction was imposed and only properties with a building area between 30 m² and 500 m² were included. In addition, housing where the sale price was greater than twice the capital assessed value or less than .6 of the assessed value were removed. This resulted in 78 percent of all sales involving a detached or semi-detached house being included in the analysis and 72 percent of land transactions. Next, as the only physical attribute available for the vacant land sales was site area in square metres, this was used, together with the site area squared to allow for diminishing marginal returns, to produce a Site Adjusted Land Price Index. For housing the building area, building area squared and building age were used to produce a Quality Adjusted House Price Index.

The hedonic models in this study use an OLS process with the natural logs of land and house prices regressed against a series of physical attributes for a 30 year time period from 1981 to 2010. This allows the exponents of the beta values to be expressed as premiums. The OLS model is an exponential form consistent with Ooi & Lee (2006) and Ooi, Sirmans & Turnbull (2006). For both houses and land the models were specified as

$$Y = e^{b_0 + b_1 d_1 .... b_n d_n + \theta_1 X_1 ..... \theta_3 X_n}$$

Where Y = a vector of property transaction prices

b_0 = a constant

$d_{1...}$ d_n = dummy variable for quarter 1 to quarter n

b_1 …b_n = price index for quarter 1 to quarter n

X_1..X_n= an array of physical attributes

θ_1 …θ_n = price index for physical attribute 1 to attribute n

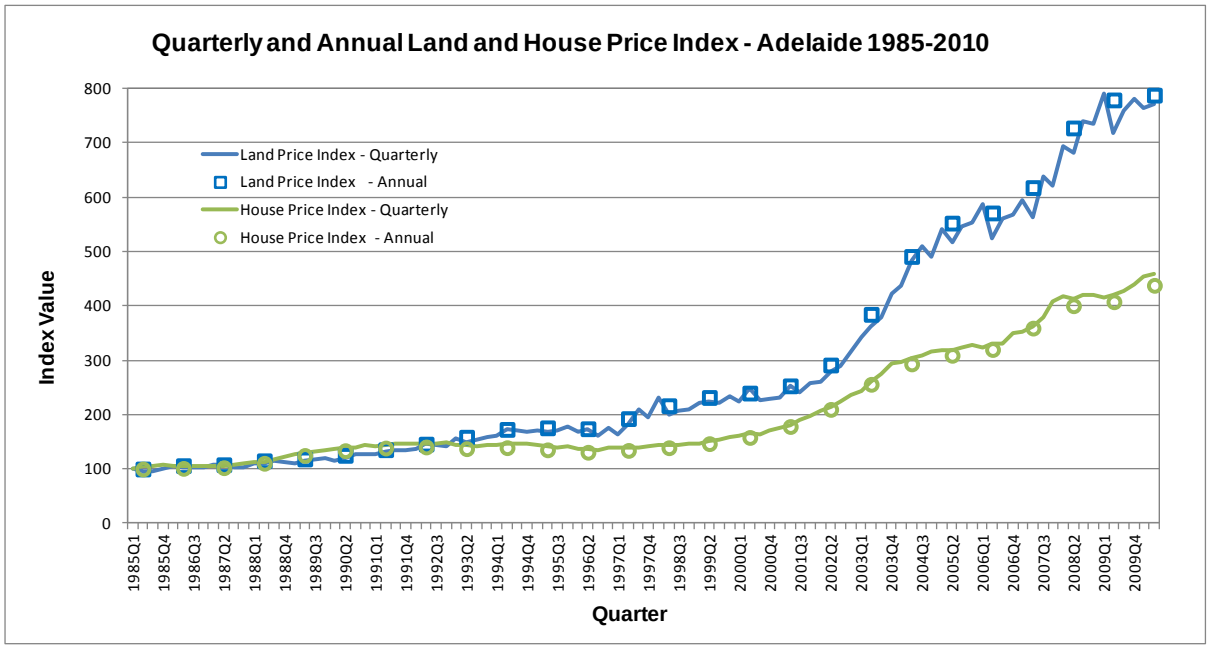
Finally, the lead lag relationships between the indexes were tested using the methodology adopted by Engle and Granger (1987) and utilised by Ooi and Lee (2007) in a similar study involving house and land prices in Singapore. Data for this procedure was based on the quarterly hedonic price indices as described above for the period 1985 to 2010. The indices were first converted to natural logarithms to reduce problems with heteroscedasticity and analysed in a series of steps. The first step examined the series using correlograms. These

highlight structural components in the data and provide a visual gauge of the likelihood of each series having a unit root. If the data shows signs of non-stationarity the augmented Dicky-Fuller is used to establish if the series are statistically stationary or have unit roots. If the data are stationary then the causal relationship can be established using the original data and the Granger causality test in a Vector Auto regression (VAR) framework. In the event that the data have unit roots the Johansen test for cointegration is used to test if the two series have a long run relationship. If the series are cointegrated the Granger causality test must then be estimated in a restricted VAR known as the Vector Error Correction (VEC) framework.

Results

When the two indexes are plotted an increasing gap is clearly evident between the rates of growth in vacant land prices as against detached house prices across metropolitan Adelaide (Figure 1). Using 1985 as the base year Figure 1 shows relative price increases for vacant land and for detached dwellings for the metropolitan area over a 25 year period. There can be no doubt about the rising cost of vacant land relative to detached dwellings on improved sites. The period of the South Australian Government Urban Land Trust from 1981 to 1996, which largely adopted a land banking role, would appear consistent with modest increases in the rate of house price and land price growth.

Figure 4 Quality Adjusted House Price Index & Site Adjusted Land Price Index Adelaide



Source Author analysis of SA VG, SA State Government & RPData

However, as of 1996 and coincidently with the introduction of a more profit orientated South Australian Government Land Management Corporation, there is an increase in the rate of land price growth in metropolitan Adelaide which then escalates in 2001/2002 to surge again in 2007/2008. Both these periods are associated with federal and state government subsidies to first home buyers which, overall, tended to inflate house prices, initially at the lower end of the market, but with knock on effects throughout the wider housing market. Given that increasing house prices could largely determine prices paid for vacant land the link between the two markets appears strong. The results, testing this hypothesis, are discussed below.

Correlograms

First, correlograms for the house and land price index are shown in Figure 5 to Figure 5 in the Appendix. The chart is based on the ordinary data for both series and shows autocorrelations and partial autocorrelations near 1 at a single period lag, with the autocorrelations slowly moving to zero. For both series the correlogram of differenced data show small autocorrelations and partial autocorrelations at one lag that quickly move to zero; all indications that the data is probably stationary at first difference although the autocorrelations for the house price index move more slowly to zero and may imply that second difference are required to induce stationarity. These indicate that the house and land price series are likely to have unit roots.

Unit Root Tests

Next the Augmented Dickey Fuller (ADF) test (Table 2) is used to test for the unit root in both series. The results of the test for both the land and house price indexes show that the hypothesis that the series contain unit roots cannot be rejected for the data in its raw form (on the level) but that the hypothesis can be rejected at a 90% level of confidence for the house price index and at the 99% level for land price index in terms of the first differences. In order to induce stationarity (at a 95% level of confidence) first differences are required for the land price index and second differences for the house price index. The house price index is stationary at second differences with a 99% level of confidence (Table 2). The Akaike Information Criterion (AIC) indicators recommend a 3 lag structure for the first difference model of the land price index and a 6 lag structure for the second difference model of the house price index.

Table 2 - Augmented Dickey-Fuller test

Time Series	Ordinary data (Level)	First Differences	Second Differences	AIC recommended Lag length
Land Price Index	5.93	-2.86***	-	Lag Length 3 (1st diff model)
House Price Index	1.87	-1.70*	-5.40***	Lag Length 6 (2nd diff model)

*** Significant at 99% -critical value -2.59

** Significant at 95% -critical value -1.94

* Significant at 90% -critical value -1.1

Johansen Cointegration Test

As the ADF test shows that the data is not stationary without differencing, the Johansen test is used to establish if the data is cointegrated. If it is cointegrated then the cointegrating equation can be considered as a long-run equilibrium relationship between the land and house price indexes. The Johansen test is indicated in Table 3 and shows the eigenvalue and trace statistics. The trace test indicates one integrating equation and supports the cointegration of the two indices at a 95% level.

Table 3 - Johansen Cointegration Test

Hypothesized		Trace		Max-Eigen	
No. of CE(s)	Eigenvalue	Statistic	Prob.	Statistic	Prob.**
None *	0.117504	13.96460	0.0263	12.37516	0.0313
At most 1	0.015927	1.589438	0.2434	1.589438	0.2434

Trace test indicates 1 cointegrating equation at the 0.05 level denotes rejection of the hypothesis at the 0.05 level MacKinnon-Haug-Michelis (1999) p-values

Vector Error Correction Model and Granger Causality

In the presence of cointegration, the Granger causation test cannot be estimated in a simple VAR model but requires the model to be specified in the more restricted vector error correction (VEC) framework. In the VEC model the long-run relationships between the land and house price index should converge and the short-run variations can be examined

through the correction coefficients which measure the speed of adjustment between the two series. The VEC model is estimated using the number of lag periods suggested by the AIC approach without a deterministic trend and the results are indicated in Table 4.

Table 4 - Vector Error Correction model

Cointegrating Eq:	CointEq1	
HPI(-1)	1.000000	
LPI(-1)	-1.419270	
Error Correction:	ΔHPI	ΔLPI
CointEq1	-0.0055***	-0.0051***
ΔHPI(-1)	0.2023	0.4371
ΔHPI(-2)	0.37670	0.5665
ΔHPI(-3)	-0.0559	0.0019
ΔHPI(-4)	0.2524	0.3856
ΔHPI(-5)	0.1041	0.1719
ΔHPI(-6)	-0.1640	-0.5361
ΔHPI(-7)	-0.0488	0.3171
ΔHPI(-8)	0.2757	-0.0598
ΔLPI(-1)	-0.0614**	-0.5735
ΔLPI(-2)	-0.0214**	0.0074
ΔLPI(-3)	-0.0077**	0.0238
ΔLPI(-4)	-0.0904**	0.0312
ΔLPI(-5)	-0.0864**	0.0820
ΔLPI(-6)	-0.1081**	0.0723

ΔLPI(-7)	-0.0411**	-0.0255
ΔLPI(-8)	0.0324**	-0.0182
R-squared	0.4531	0.4152
Adj. R-squared	0.3380	0.2921
Sum sq. resids	0.0238	0.1826
S.E. equation	0.0177	0.0490
F-statistic	3.9368	3.3735
Log likelihood	252.60	157.86
Akaike AIC	-5.0667	-3.0293
Schwarz SC	-4.6037	-2.5663

*** Significant at 99%

** Significant at 95%

The causal relationship between house price and land price has been tested using the VEC Granger causality/block erogeneity Wald test with the results shown in Table 5. Lead lag analysis of the land index using the VEC model against a Quality Adjusted House Price Index shows the error correcting coefficient to be significant in both models and supports the proposition that these two variables are cointegrated (Engle & Granger 1987; Luo et al 2007). The Wald test (Table 5) shows that there is support for the proposition that House Prices Granger causes land prices but not that Land Prices Granger causes house prices. Where change in the house price index is the dependent variable the Wald test fails at even a 90% confidence level. However in the equation where change in land price index is the dependent variable change in house price index is significant at 95%. This then supports the Ricardian land rent hypothesis that an increase in prices for established properties causes an increase in the residual value of land for developers and hence drags land prices upwards through demand by developers. Developers will not pay more for land than that which accords with the going rate of established house prices. At least in the short run. This is consistent with similar work by Ooi and Lee (2007) for Singapore and for Li (2009) for Bejing and is an important empirical finding for the Australian housing market in that is suggests that house prices and decreasing housing affordability do not simply reflect across

the board limitations on land supply or a particular set of land management policies. Rather that rising land prices are fundamentally due to a strong demand for housing.

Table 5 - VEC Granger Causality - Wald tests

Dependent variable: ΔHPI			
Excluded	Chi-sq	df	Prob.
ΔLPI	12.003	8	0.1510
Dependent variable: ΔLPI			
Excluded	Chi-sq	df	Prob.
ΔHPI	16.955	8	0.0306**

** Significant at 95%

However in contrast to the Singapore findings (Ooi & Lee, 2007) the results for Adelaide show that there is a lagged effect of land prices on house prices and that this is significant at an interval of 8 lag periods. This suggests that, while a change in house prices leads to a change in land prices in the short run, the long run position is for increasing land prices to lead to a delayed increase in house prices. This is consistent with the findings of Kim et al (2008) and Altuzarra & Esteban (2011) who suggest that over the longer term land supply restrictions and land management policies can result in rising land prices being included in house prices. It also accords with the classic view of economic substitution where buyers see the inflated cost of new houses (due to increased land prices in previous periods) as a substitute for increased established houses prices. It may also reflect developer expectations in a rising market, of prevailing high house prices, resulting in strong competition for land accentuated by supply constraints (Adams et al 2009). Thus Ricardian expectations of house to land price impacts are reinforced by land supply constraints as understood within the neoclassical model.

Also in contrast to the Singapore findings (Ooi & Lee, 2007) the response to deviations from the long-run equilibrium in this study is extremely slow in both the Adelaide house and land markets. Both show significant corrections in the next period but these are in the order of 1%. There are two possible explanations for this.

Prices in the Adelaide house market, over the period from 1985 to 2010, have shown an almost continuous progression with almost no negative differences and the market is

notoriously sticky with prices continuing to rise prior to and after the GFC in 2008 through 2010. While market values may drop considerably very few owners sell houses (or land) in periods of economic downturn preferring to hold on their property rather than face an economic loss by reducing their prices. As well the high level of low-density development with a myriad of micro-developers means that few developers are exposed to significant losses though holding assets and hence few properties transact in down periods as owners and developers decide to "wait out" any crisis. As well developer expectations in a falling market (Adams et al 2009) may reflect forecast house prices which are substantially below current prices with a subsequent reluctance on the part of developers to enter the market for land.

Conclusion

This paper has presented details of the construction of a Site Adjusted Land Price Index which has allowed for a consistent, and for Australia, innovative analysis of the relationship between house and land price change over time. It shows that the relationship between house prices and land prices is not necessarily unidirectional. Rising house prices do not simply and solely reflect a shortage of land. There are suggested effects both immediate from house to land and delayed from land to house, particularly in a rising market. However competition for land, if augmented by developer expectations of rising house price, is likely to impact on housing affordability. As illustrated by comparison of the house price and land price indexes there can be no doubt about the rising cost of vacant land in Adelaide relative to detached dwellings on improved sites. However further work on developer behaviour within Australia, especially with respect to the dynamic of market cycles and the importance of current versus forecast housing values within the framework of planning policy, is required to augment these suppositions.

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Appendix

Figure 5 - Correlogram Ln House Price Index – original data - on the level

Sample: 1985Q1 2010Q2

Included observations: 102

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|*******	.|*******	1	0.970	0.970	98.804	0.000
.|*******	.|. |	2	0.940	-0.019	192.45	0.000
.|*******	.|. |	3	0.909	-0.020	281.00	0.000
.|******|	.|. |	4	0.879	-0.012	364.58	0.000
.|******|	.|. |	5	0.847	-0.042	443.02	0.000
.|******|	.|. |	6	0.814	-0.037	516.21	0.000
.|******|	.|. |	7	0.779	-0.053	583.92	0.000
.|***** |	.|. |	8	0.743	-0.035	646.17	0.000
.|***** |	.|. |	9	0.706	-0.034	703.01	0.000
.|***** |	.|. |	10	0.667	-0.055	754.32	0.000
.|***** |	.|. |	11	0.628	-0.019	800.35	0.000
.|**** |	.|. |	12	0.593	0.027	841.75	0.000
.|**** |	.|. |	13	0.558	-0.002	878.86	0.000
.|**** |	.|. |	14	0.524	-0.012	911.92	0.000
.|**** |	.|. |	15	0.490	-0.017	941.14	0.000
.|*** |	.|. |	16	0.458	0.023	967.03	0.000
.|*** |	.|. |	17	0.427	-0.020	989.75	0.000
.|*** |	.|. |	18	0.396	-0.010	1009.6	0.000
.|*** |	.|. |	19	0.365	-0.047	1026.6	0.000
.|** |	.|. |	20	0.333	-0.018	1040.9	0.000

Figure 6 - Correlogram Ln House Price Index – original data - first differences

Sample: 1985Q1 2010Q2

Included observations: 101

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|*** |	.|*** |	1	0.377	0.377	14.762	0.000
.|*** |	.|*** |	2	0.465	0.376	37.446	0.000
.|** |	.|. |	3	0.221	-0.041	42.629	0.000
.|*** |	.|** |	4	0.397	0.242	59.565	0.000
.|* |	.|. |	5	0.212	-0.001	64.417	0.000
.|* |	*|. |	6	0.160	-0.147	67.205	0.000
.|. |	.|. |	7	0.064	-0.039	67.656	0.000
.|** |	.|* |	8	0.228	0.202	73.451	0.000
.|* |	.|. |	9	0.099	-0.047	74.557	0.000
.|* |	.|. |	10	0.124	-0.017	76.322	0.000
.|. |	.|. |	11	-0.008	-0.038	76.329	0.000
.|* |	.|* |	12	0.194	0.145	80.749	0.000
.|. |	*|. |	13	-0.014	-0.167	80.773	0.000
.|* |	.|* |	14	0.140	0.105	83.127	0.000
.|. |	.|. |	15	-0.007	0.052	83.133	0.000
.|* |	.|. |	16	0.165	0.014	86.462	0.000
.|. |	.|. |	17	0.022	-0.049	86.521	0.000
.|. |	*|. |	18	0.028	-0.079	86.617	0.000
.|. |	.|. |	19	-0.062	-0.049	87.098	0.000
.|. |	.|. |	20	0.046	0.013	87.367	0.000

Figure 7 - Correlogram Ln Land Price Index – original data - on the level

Sample: 1985Q1 2010Q2

Included observations: 102

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|*******	.|*******	1	0.972	0.972	99.181	0.000
.|*******	.|. |	2	0.945	0.019	193.99	0.000
.|*******	*|. |	3	0.915	-0.086	283.68	0.000
.|******|	.|. |	4	0.886	0.014	368.72	0.000
.|******|	.|. |	5	0.858	0.003	449.29	0.000
.|******|	*|. |	6	0.826	-0.091	524.74	0.000
.|******|	.|. |	7	0.795	-0.013	595.29	0.000
.|******|	.|. |	8	0.763	-0.021	660.92	0.000
.|***** |	.|. |	9	0.732	0.015	722.12	0.000
.|***** |	.|. |	10	0.701	-0.041	778.78	0.000
.|***** |	.|. |	11	0.670	-0.003	831.18	0.000
.|***** |	.|. |	12	0.639	-0.029	879.31	0.000
.|**** |	.|. |	13	0.611	0.045	923.83	0.000
.|**** |	.|. |	14	0.581	-0.056	964.56	0.000
.|**** |	.|. |	15	0.553	0.007	1001.9	0.000
.|**** |	.|. |	16	0.523	-0.048	1035.6	0.000
.|**** |	.|. |	17	0.494	0.000	1066.1	0.000
.|*** |	*|. |	18	0.462	-0.082	1093.0	0.000
.|*** |	.|. |	19	0.430	-0.014	1116.7	0.000
.|*** |	.|. |	20	0.399	-0.022	1137.3	0.000

Figure 8 - Correlogram Ln Land Price Index – original data - first differences

Sample: 1985Q1 2010Q2

Included observations: 101

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
***|. |	***|. |	1	-0.474	-0.474	23.384	0.000
.|** |	.|* |	2	0.328	0.133	34.693	0.000
*|. |	.|* |	3	-0.140	0.076	36.779	0.000
.|* |	.|* |	4	0.145	0.089	39.023	0.000
.|. |	.|* |	5	-0.007	0.107	39.029	0.000
.|. |	.|. |	6	0.038	0.047	39.184	0.000
.|. |	.|. |	7	-0.019	-0.022	39.223	0.000
.|. |	*|. |	8	-0.013	-0.066	39.243	0.000
.|. |	.|. |	9	0.021	-0.018	39.292	0.000
.|. |	.|. |	10	0.011	0.030	39.306	0.000
*|. |	*|. |	11	-0.095	-0.110	40.340	0.000
.|. |	*|. |	12	0.002	-0.104	40.340	0.000
.|. |	.|. |	13	0.006	0.024	40.344	0.000
*|. |	*|. |	14	-0.091	-0.084	41.330	0.000
.|* |	.|* |	15	0.160	0.141	44.425	0.000
*|. |	.|* |	16	-0.085	0.129	45.314	0.000
.|. |	*|. |	17	-0.007	-0.072	45.321	0.000
.|* |	.|. |	18	0.076	0.072	46.053	0.000
.|. |	.|* |	19	-0.001	0.077	46.054	0.000
.|. |	.|. |	20	0.002	-0.040	46.054	0.001